

## BIO-DATA with List of Publications (18 Annexure)

1. **Name:** SANKAR KUMAR PAL, FNA, FASc, FNASc, FNAE, FTWAS, FIEEE, FIAPR, FIFSA, FIRSS, FAAIA, FAIIA  
Member of European Academy of Sciences and Arts
2. **Date of birth:** 13th of September 1950
3. **Present Designation:** ANRF Prime Minister Professor, Govt. of India, hosted at IIIT Bhubaneswar  
**President**, Indian Statistical Institute  
Emeritus Professor, Indian Statistical Institute  
AICTE Distinguished Chair Professor  
**(Former Director and Distinguished Scientist,**  
Indian Statistical Institute)
4. **Address:**

<i>Office:</i> Center for Soft Computing Research Indian Statistical Institute 203, B.T. Road, Kolkata 700 108, India  Tel: 91-33-2575-2041 91-33-2575-3101 E-mail: <a href="mailto:sankar@isical.ac.in">sankar@isical.ac.in</a> ; <a href="mailto:sankarpal@yahoo.com">sankarpal@yahoo.com</a> Fax: 91-33-2578-8699, 91-33-2578-3357 URL: <a href="https://www.isical.ac.in/~sankar">https://www.isical.ac.in/~sankar</a>	<i>Residence:</i> B-4 Lake View Park P.O. ISI Kolkata 700 108, India  Tel: 91-33-2577-2030 91-33-2464-8775
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### 5. Academic Qualifications:

- i: B.Sc.(Hons)/ 1969/ Physics/ Calcutta University.
- ii: B.Tech./1972/ Radio Physics and Electronics/ Calcutta University.
- iii: M.Tech./1974/Radio Physics and Electronics/ Calcutta University.
- iv: Ph.D./ 1978-79/ Thesis: Studies on the Application of Fuzzy Set Theoretic Approach in Some Problems of Pattern Recognition and Man-Machine Communication by Voice/ Radio Physics and Electronics/ Indian Statistical Institute, Calcutta University. (*Work carried out at Indian Statistical Institute (ISI), Calcutta as its enrolled PhD student, but the thesis submitted to Calcutta University as ISI was not empowered to offer degree at that time in Computer Science/ Electrical Science*).
- v: Ph.D. and DIC/ 1982/ Thesis: Fuzzy Set Theory in Gray Tone Image Processing/ Electrical Engineering/ Imperial College of Science and Technology, London University.

### Post-Doctoral Research:

- vi: Imperial College of Science & Technology, Electrical Engineering Dept., London (1981-83)
- vii: University of California, Dept. of Computer Science, Berkeley, CA (1986-87)

- viii: University of Maryland, Center of Automation Research, College Park, MD (1986-87)
- ix: NASA Johnson Space Center, Information Technology Division, Houston, TX (1990-92 & 1994)

## 6. Posts Held:

- i: Senior CSIR Research Fellow, Electronics and Communication Sciences Unit (ECSU), Indian Statistical Institute, Calcutta from March 1975 to December 1976.
- ii: Computer Engineer, ECSU, Indian Statistical Institute, Calcutta from December 1976 to December 1981.
- iii: Commonwealth Scholar, Electrical Engineering Department, Imperial College, London from October 1979 to October 1981 (on leave from ISI).
- iv: MRC Post-doctorate Fellow, Electrical Engineering Dept., Imperial College, London from November 1981 to April 1983 (on leave from ISI).
- v: Visiting Research Fellow (on invitation), School of Electrical and Electronics Engineering, Leicester Polytechnic, Leicester, England from 1st July 1981 to 31st July 1981 (on leave from Imperial College).
- vi: Associate Professor, ECSU, Indian Statistical Institute, Calcutta from January 1982 to May 1987.
- vii: Guest Teacher in Computer Science, Calcutta University from 1983 to 1986.
- viii: Fulbright Visiting Scientist in the Computer Science Division, University of California, Berkeley and in the Center for Automation Research, University of Maryland, College Park from September 1986 to January 1987 (on leave from ISI).
- ix: Professor, ECSU, Indian Statistical Institute, Calcutta from June 1987 to March 1993.
- x: Professor-in-Charge of Physical & Earth Sciences Division, Indian Statistical Institute, Calcutta for the period 1988-90.
- xi: **NRC-NAS (USA) Guest Investigator to work as Resident Research Associate at NASA Johnson Space Center**, Houston, Texas from January 1990 to March 1992, and February 1994 to June 1994 (on leave from ISI).
- xii: Professor and Head, Machine Intelligence Unit, Indian Statistical Institute, Calcutta from March 1993 to June 1998.
- xiii: **Distinguished Speaker of IEEE Computer Society (USA)** for Asia Pacific Region to visit 16 universities in Australia, New Zealand, Singapore, Hong Kong, China and Bangladesh and deliver distinguished talks during July 1998, June 2000, July 2003, November 2012, to mention a few.
- xiv: Jawaharlal Nehru Fellow, Machine Intelligence Unit, Indian Statistical Institute, Calcutta from September 1993 to August 1995.
- xv: **Distinguished Scientist** and Head, Machine Intelligence Unit, Indian Statistical Institute, Calcutta from July 1998 to July 2005.
- xvi: Visiting Professor, Department of Computing, Hong Kong Polytechnic University, Hong Kong from March 1999 to June 1999, from November 2000 to January 2001, and from December 2002 to January 2003 (on leave from ISI).
- xvii: Visiting Scientist, Department of Computer Science and Computer Engineering, La Trobe University, Melbourne, Australia during June and July 2002 (on leave from ISI).
- xviii: Visiting Scientist, Information Technology Division, US Naval Research Lab., Washington DC, USA, from June to August 2004 (on leave from ISI).
- xix: Principal Investigator, Center for Soft Computing Research, ISI, Kolkata from October 2005 to September 2015.
- xx: **Director** and Distinguished Scientist, Indian Statistical Institute from August 2005 to July 2010.

- xxi: Visiting Professor, Department of Applied Science, University of Naples Parthenope, Naples, Italy during April and May 2010 (on leave from ISI).
- xxii: Sir J.C. Bose National Fellow, Indian Statistical Institute, Kolkata from April 2007 to September 2018 (with full fellowship grant till Sept 2015, and thereafter only with contingency grant).
- xxiii: Founding President, Kolkata Chapter of INAE (Indian National Academy of Engineering, July 2007 - Oct 2017).
- xxiv: Distinguished Scientist and Former Director, Indian Statistical Institute from August 2010 to September 2015.
- xxv: INAE (Indian National Academy of Engineering) Chair Professor from April 2013 to March 2015.
- xxvi: Mentor, National Institute of Technology (NIT), Patna (to mentor the Computer Science and Engineering Department), September 2014 to September 2017.
- xxvii: Raja Ramanna Fellow, Department of Atomic Energy, Govt. of India from October 2015 to September 2018.
- xxviii: Emeritus Professor, Indian Statistical Institute, Kolkata from September 2018 to date.
- xxix: **INSA (Indian National Science Academy) Distinguished Professor** from October 2018 to August 2020.
- xxx: Scholar-in-Residence, IIT Jodhpur (to mentor AI and Data Science research) from May 2019 to November 2024.
- xxxi: **National Science Chair**, SERB-DST, Govt. of India from August 2020 to October 2025 (last three months was extended only with research grant).
- xxxii: AICTE (All India Council for Technical Education) Distinguished Chair Professor from September 2021 to date.
- xxxiii: **President**, Indian Statistical Institute from September 2022 to date.
- xxxiv: Vice-President, International Artificial Intelligence Industry Alliance (AIIA), Hong Kong from December 2023 to date.
- xxxv: Adjunct Faculty (Professor), Atal Bihari Vajpayee – Indian Institute of Information Technology and Management, Gwalior (ABV-IIITM Gwalior) from Oct 2024 to date.
- xxxvi: Visting Distinguished Professor, IIT Indore from August 2025 to date.
- xxxvii: **Prime Minister Professor, ANRF** (Anusandhan National Research Foundation), Govt. of India, hosted at IIIT Bhubaneswar, February 2026 to date.

## 7. Awards, Prizes and Honours:

- A: **Shanti Swarup Bhatnagar Prize** for the year 1990 in Engineering Sciences. (*This is the most coveted award for a scientist in India*)
- : Jawaharlal Nehru Fellowship for the year 1993
- : Hari Om Ashram Prerit Vikram Sarabhai Research Award for the year 1993 in Electronics/Telecommunication/Informatics/Automation
- : NASA Space Act Tech Brief Award from NASA Inventions and Contributions Board, USA., 1993
- : IEEE Trans. Neural Networks Outstanding Paper Award from IEEE Neural Networks Council (USA), 1994
- : NASA Patent Application Award from NASA Inventions and Contributions Board, USA, 1995
- : Distinguished Speaker of IEEE Computer Society (USA) for Asia Pacific Region, 1998
- : Ram Lal Wadhwa Gold Medal from IETE (The Institution of Electronics and Telecom. Engineers), India, 1997
- : **Distinguished Scientist**, Indian Statistical Institute, 1998 (*He is the first person*

- outside Statistics & Mathematics to receive this honor from ISI)*
- : Om Prakash Bhasin Award in Electronics and Information Technology from Bhasin Foundation for Science and Technology, 1998 (*Award is given by the Prime Minister of India*)
  - : **G. D. Birla Award** for Scientific Research from K. K. Birla Foundation, 1999 (*Award is given to only one considering all branches of science – basic, applied, medical etc.*)
  - : **Khwarizmi International Award (1st winner)** from the Iranian Research Organization for Science and Technology (IROST), Islamic Republic of Iran, 2001 (*Award is given by the President of Iran*)
  - : Syed Husain Zaheer Medal from Indian National Science Academy (INSA), 2001
  - : FICCI Award in Engineering and Technology from the Federation of Indian Chambers of Commerce & Industry, 2001-2002
  - : 5<sup>th</sup> “Distinguished Information Technology (IT) Lecture”, Ministry of Communication and Information Technology, Government of India, New Delhi, 2003
  - : 1st “Bengal Science Lecture” under the National Program “*Year of Scientific Awareness 2004*”, Calcutta, organized by the Science & Technology Council and Department of Science & Technology, Government of West Bengal, India, 2004
  - : **Director**, Indian Statistical Institute for the term August 2005 to July 2010 (*He is the first Computer Scientist, as well as first person outside Statistics and Mathematics to become its Director after its inception in 1931*)
  - : P.C. Mahalanobis Birth Centenary Award (Gold Medal) for lifetime achievements and contributions in Science and Technology from the Indian Science Congress Association, 2006 (*Award is given by the Prime Minister of India at Indian Science Congress*)
  - : Illustrious Alumnus of the Institute of Radio Physics and Electronics, University of Calcutta, 2006
  - : J.C. Bose National Fellowship of the Government of India, 2007
  - : Vigyan Ratna Award from Science and Culture Organization, West Bengal, 2008
  - : P.C. Mahalanobis Memorial Medal from Indian Science News Association, 2010
  - : **Padma Shri** in 2013, conferred by the President of India, for distinguished service in Science and Engineering. (*This is one of the highest civilian awards of the Nation*)
  - : INAE (Indian National Academy of Engineering) Chair Professor, 2013
  - : IETE (The Institution of Electronics and Telecom. Engineers, India) Diamond Jubilee Medal, 2013
  - : Faraday Memorial Lecture award of the IEEE Hyderabad Section, Hyderabad, India, 2013
  - : IEEE (USA) Fellow Class Golden Jubilee Medal, 2014
  - : Prof. S.N. Mitra Memorial Award from Indian National Academy of Engineering (INAE), 2015
  - : Raja Ramanna Distinguished Fellowship, Department of Atomic Energy, Government of India, 2015
  - : Jawaharlal Nehru Birth Centenary Lecture award from Indian National Science Academy (INSA), 2017
  - : IEEE Tencent Rhino-Bird International Expert 2017
  - : **Distinguished Professorial Chair**, Indian National Science Academy (INSA), 2018 (*One of the highest scientific honors that the Academy confers on*)
  - : Emeritus Professor, Indian Statistical Institute, 2018
  - : Scholar-in-Residence, IIT Jodhpur, 2019
  - : **National Science Chair: Scientific Excellence**, SERB-DST, Government of India, 2020 (*He is one of the inaugural/first recipients*)
  - : First Prof. C. Mohan Gold Medal Award for Excellence in Soft Computing from the

- Soft Computing Research Society, 2020
- : AICTE (All India Council for Technical Education) nominated AICTE Distinguished Chair Professor, 2021
- : 14<sup>th</sup> **President**, Indian Statistical Institute from September 2022 to date (*He is the first Ex-employee of ISI being elected to hold this honorable Chair after its inception in 1931*)
- : 30<sup>th</sup> Prasanta Chandra Mahalanobis Memorial Lecture award at 30th West Bengal State Science & Technology Congress, Department of Science and Technology and Biotechnology, Government of West Bengal, India, 2023
- : Distinguished Alumni Award 2023 from Ramkrishna Mission Vivekananda Centenary College, Calcutta 700118 (*This award was given first time to an alumnus in the history of 60 years of the college since its inception in 1963*)
- : Elected Vice-President, International Artificial Intelligence Industry Alliance, Hong Kong, 2023
- : Indian National Science Academy Distinguished Lecture-2 Fellow under Engineering & Technology, 2024
- : Visiting Distinguished Professor, IIT Indore, 2025
- : Doctor of Science (D.Sc.), *honoris causa* from Sai University, Chennai on 24<sup>th</sup> October 2025
- : **ANRF** (Anusandhan National Research Foundation) **Prime Minister Professor**, Government of India, 2025 (*He is one of the inaugural/first recipients*)

**B:** Fellow, TWAS (The World Academy of Sciences for the Advancement of Science in Developing Countries), Italy, 1998. (*When he was elected in 1998, "TWAS prize for Engineering Sciences" did NOT exist. Later, when the said prize was initiated in 2003, he was not eligible to contest for that which is allowed only before being elected as a Fellow as per TWAS rule.*)

- : Foreign Member, European Academy of Sciences and Arts, Austria, 2022.
- : Founding Fellow, Web Intelligence Academy (WIA), 2023

- : Life Fellow, Institute of Electrical and Electronics Engineers (L-FIEEE), USA, 2015
- : Fellow, Institute of Electrical and Electronics Engineers (FIEEE), USA, 1993
- : Fellow, International Association for Pattern Recognition (FIAPR), USA, 2002
- : Fellow, International Fuzzy Systems Association (FIFSA), USA, 2007
- : Fellow, International Rough Set Society (FIRSS), Poland, 2016
- : Fellow, Asia-Pacific Artificial Intelligence Association (AAIA), Hong Kong, 2021
- : Fellow, International Artificial Intelligence Industry Alliance (AIIA), Hong Kong, 2023

- : Fellow, Indian National Science Academy (FNA), 1993
- : Fellow, Indian Academy of Sciences (FASc), 1996
- : Fellow, National Academy of Sciences, India (FNASc), 1993
- : Fellow, Indian National Academy of Engineering (FNAE), 1995
- : Fellow, West Bengal Academy of Science and Technology (FAScT), 2000
- : Fellow, Institution of Engineers (FIE), India. 1994
- : Life Fellow, Institution of Electronics and Telecommunication Engineers (FIETE), India, 1997

**C:** ONRIFO (Office of Naval Research International Field Office, Government of USA) Fellowship in 2004.

- : INSA-JSPS (Government of Japan) Fellowship in 1996.
- : National Academy of Science (National Research Council) - NASA (Government of U.S.A.) Senior Research Associateship Award in 1989.
- : Fulbright Post-Doctoral Visiting Fellowship (Government of U.S.A) in 1986.
- : Medical Research Council (Government of U.K.) Post-Doctoral Award in 1981.
- : Commonwealth Scholarship (Government of U.K.) in 1979.

D: Best Production Award in the 7th World Book Fair, New Delhi, 1986 to his book - Fuzzy Mathematical Approach to Pattern Recognition, John Wiley and Sons (Halsted Press), N.Y., 1986. The book has also been **translated into Indonesian Bahasa and Chinese Languages.**

[https://lib-ft.unpak.ac.id/index.php?p=show\\_detail&id=45](https://lib-ft.unpak.ac.id/index.php?p=show_detail&id=45)

[https://library.jgu.ac.id/index.php?p=show\\_detail&id=4451&keywords=](https://library.jgu.ac.id/index.php?p=show_detail&id=4451&keywords=)

<https://www.tokopedia.com/maxisiahaan/fuzzy-pendekatan-matematik-untuk-pengenalan-pola-oleh-sankar-k-pal>

- : His book - Fuzzy Models for Pattern Recognition: Methods that Search for Structures in Data, IEEE Press, N.Y., 1992 was in the list of **IEEE Best Seller books till 1995.**

E: He is one of the *ten examples* out of 31000 Commonwealth Scholars whose stories of impact and leadership are featured in the Special anniversary edition of *Common Knowledge* (Issue # 17, November 2024): Celebrating the impact and legacy of Commonwealth Scholarships (UK) since 1960. See

<https://reader.experios.com/54578/5744/?page=1>

: **India's AI Revolution Spark: The Unstoppable Journey Begins** about Sankar K Pal - <https://youtu.be/x8mHVbw72UM?feature=shared>

: His research has **awfully influenced the contemporary world.** According to ISI Web of Science (Proc. World Congress on Engineering, vol.1, WCE-2009, July 2009, London), his paper (Pattern Recognition, 26, pp.1277-1294, 1993) is 16th most-cited article in the world using the word 'fuzzy'. As per Thomson Reuters Web of Science (IEEE-T-Cybernetics, 43, pp.1977-1989, 2013), his three papers (IEEE-T-TKDE, 16, pp.292-300, 2004, Pattern Recognition Letters, 26, pp.2509-2517, 2005, and IEEE-T-GSRS, 40, pp.2495-2501, 2002) ranked 17th, 23rd and 27th within top 31 impactful papers on Granular Computing. These are some examples.

: He has been featured within the **top 0.106920052%** with **C-score = 4.10705055** and **subject-wise world-wide rank of 230** in the domain of **Artificial Intelligence and Image Processing** in the 2020 list of top 2% (out of 2,15,114) scientists world-wide based on an independent study done by Stanford University scientists, and these indices remained almost so till 2024.

For methodology and data visit:

<https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3000918>.

: Honored by [ScholarGPS \(https://scholargps.com\)](https://scholargps.com) as a **“2022 Highly Ranked Scholar – Lifetime” in All Fields of Scholarly Endeavor** in recognition of his exceptional productivity, noteworthy impact, and quality of scholarly work in the top 0.05% of 30 million scholars worldwide. (Ranks: #6,768 [Overall \(All Fields\)](#), #1,549 [Physical Sciences and Mathematics](#), #9 [Soft computing](#), #31 [Pattern recognition](#), and #46 [Statistics](#)). These figures remained almost so till 2024.

*(World Ranking of his research by other Scientific bodies are mentioned under "Publication and Citation Index" in Item no.11)*

## 8. Editorial and other Professional Activities:

A: *Associate Editor*: IEEE Trans. on Pattern Analysis and Machine Intelligence (IEEE Press) (2002-2006), IEEE Trans. on Neural Networks (IEEE Press) (1994-1998; 2003-2006), IEEE Trans. on Fuzzy Systems (IEEE Press) (1993-1995), Pattern Recognition Letters (Elsevier) (1993-2011), Neurocomputing (Elsevier) (1995-2005), Int. J. Approximate Reasoning (Elsevier) (1992-1993), IET Image Processing (IEE Press) (2007-2019), Int. J. Pattern Recognition and Artificial Intelligence (World Scientific) (2003 to date), Information Sciences (Elsevier) (2000 to date), Fuzzy Sets and Systems (Elsevier) (2003 to date), LNCS Trans. on Rough Sets (Springer) (2003 to date), Journal of Data, Information and Management (Springer) (2018 to date), Engineering Applications of Artificial Intelligence (Elsevier) (2022 to date), Journal of Computational and Cognitive Engineering (Bon View Publishing Pte Ltd) (2023 to date), Applied Intelligence (Kluwer) (2002-2012), Fundamenta Informaticae (IOS Press) (2003-2019), Int. J. Computational Intelligence and Applications (World Scientific), Journal of Intelligent Information Systems (Springer) (2008-2012), The Journal Ingeniería y Ciencia, (published by Escuela de Ciencias y Humanidades and the Escuela de Ingeniería of Universidad EAFIT in Colombia) (2014-2015), and Proc. INSA-A (Indian National Science Academy-A).

: *Editor-in-Chief*: Int. J. Signal Processing, Image Processing and Pattern Recognition, SERSC, Korea (2008-2019).

: *Book Series Editor*: Frontiers in Artificial Intelligence and Applications (FAIA), IOS Press; Netherlands (2007 to date); Statistical Science and Interdisciplinary Research, World Scientific, Singapore (2008 to date).

: *Executive Advisory Editor*: IEEE Trans. on Fuzzy Systems (1996-2000), Int. J. Approximate Reasoning (Elsevier) (1994 to date), Int. J. Image and Graphics (World Scientific), Int. J. Computational Science and Engineering (Inderscience) (2011 to date), Int. J. Business Intelligence and Data Mining (Inderscience) (2017 to date), Int. J. Machine Intelligence and Sensory Signal Processing (Inderscience) (2016-2021), and Data-Centric Engineering (Cambridge Univ. Press) (2020 to date).

: *Guest Editor*: IEEE Computer, IEEE Systems, Man and Cyberns-A, Theoretical Computer Science: Theory of Natural Computing (Elsevier), Fundamenta Informaticae (IOS Press), Neurocomputing (Elsevier), Pattern Recognition Letters (Elsevier), Applied Intelligence, Information Sciences (Elsevier), Applied Soft Computing (Elsevier), IET Image processing (IEE Press), Natural Computing (Springer), Int. J. Engg. Intell. Syst., Proc. Indian National Science Academy, and J. Inst. Elect. Telecom. Engg. (India)

B: Founder and founding President, Indian National Academy of Engineering (INAE), Kolkata Chapter (2007-17).

: Founding President, Indian Society for Rough Sets (ISRS), 2010.

: Founding Executive Member and then Life Member, Indian Unit for Pattern Recognition and Artificial Intelligence (IUPRAI), 1984.

: Founding Executive Member and then Life Member, Indian Society for Fuzzy Mathematics and Information Processing (ISFUMIP), 1983.

: Founding Fellow, Web Intelligence Academy (WIA), 2023

## 9. Establishing a Center for Excellence in Soft Computing Research and Leading Projects for National Importance

A: Center for Excellence in Soft Computing Research:

The Department of Science & Technology (DST), Government of India has established under its IRHPA (Intensification of Research in High Priority Areas) scheme the **Center for Soft Computing Research: A National Facility** at ISI, Kolkata under his leadership. The center, having first of its kind in the country, plays a major role in the current and future IT perspective of the nation and provides a strong base for research and training, and collaborative work with Industry and other research organizations. It promotes soft computing research activity, through funding and monitoring, in institute like NITs and other less endowed institutes including those in North-East regions, of the country. It also provides a six-month postgraduate certificate course on soft computing. **In 2010, the Governing Council of ISI declared the Center as its Associate (Affiliated) Institute.**

(See Annexure A for details. See Annexure K(1) for the facility developed out of this.)

B: Principal Investigator of other Projects of National Importance: Some Examples

- (a) *"Handling Uncertainties for Machine Interpretation of Ill-defined Structures Present in Gray Level Images"* in the Machine Intelligence Unit, ISI, Kolkata, Sponsored by DEAL, DRDO, Dehradun. (duration August 1993 to October 1995)
- (b) *"A Neuro-fuzzy Image Recognition System: Methodology Development for Forensic Applications"* in the Machine Intelligence Unit, ISI, Kolkata, Sponsored by CSIR, New Delhi. (duration June 1993 to June 1997)
- (c) *"Cancer Management in Soft Computing Paradigm"* in the Machine Intelligence Unit, ISI, Kolkata, Sponsored by CSIR, New Delhi. (duration October 1997 to March 2001)
- (d) *"Knowledge-Based Connectionist Data Mining System: Design and Application"* in the Machine Intelligence Unit, ISI, Kolkata, Sponsored by CSIR, New Delhi. (June 2000 to March 2006)
- (e) *"Statistical, Structural and Soft Computing based techniques for Pattern Recognition: Theory, Algorithms, and applications to Bioinformatics"*, in Center for Soft Computing Research, ISI, Kolkata, Sponsored by INDO-BRAZIL Project, Coordinated by DST, New Delhi. (September 2010 to August 2013)

## 10. International Collaborations:

Formal collaboration and research projects with the following foreign universities

- a) Osaka Prefecture University, Osaka, coordinated by the Japan Society for the Promotion of Science (JSPS).
- b) INSEAD (Dept. of IT Management), Fontainebleau, France, coordinated through INSEAD Research Grant provided to ISI.
- c) Warsaw University, Poland, coordinated by the Polish State Committee for Scientific Research (KBN), Poland and Department of Science & Technology (DST), India.
- d) University of Naples Parthenope, Italy coordinated through Naples University Research

- Grant under ISI-Naples University joint research program.
- e) Hong Kong Polytechnic University, Hong Kong, coordinated by the Research Grants Council, Hong Kong.
  - f) Zhejiang University, China, coordinated by the Ministry of Science & Technology of the People's Republic of China and the Department of Science & Technology (DST), India.
  - g) NASA Johnson Space Center, Houston, through NRC-National Academy of Science Research Associateship Program (1990-94).
  - h) Computer Vision Lab, University of Maryland, College Park, MD, USA through Fulbright program.
  - i) US Naval Research Lab., Washington DC through ONRIFO program.
  - j) La Trobe University, Melbourne, Australia, coordinated by the Australian Research Council (ARC).
  - k) University of Sao Paulo, Brazil, coordinated through Indian National Sciences Academy and Brazilian Academy of Science.

*(For other collaborating institutes, viz, 48 foreign and 16 Indian, leading to joint publications, see Annexure F. For some examples of Europe-wide collaborative research, see Annexure I.)*

## 11. Teaching and Research Experience

More than forty-nine years' experience in research and teaching Pattern Recognition, Image Processing, Fuzzy Logic, Artificial Neural Networks, Soft Computing. Taught to M.Stat. and M.Tech.(CS) courses in ISI and Calcutta University, as well in Ph.D. programs abroad, e.g., Soft Computing and Data Mining in Trento University, Italy.

Research interests include Pattern Recognition and Machine Learning, Image Processing, Data Mining, Soft Computing, Fuzzy Sets and Uncertainty Analysis, Neural Nets, Genetic Algorithms, Rough Sets, Web Intelligence, Bioinformatics, Safety Analytics, Climate Analytics, Computing with Words, and Big Data.

*(See Annexure B for significant research contributions.)*

### **Ph.D. Theses Supervised and Post-doctorates & Scientists mentored:**

**PhDs (officially supervised):** 22 (10 awarded from ISI, 7 awarded from Jadavpur University, 2 awarded from Calcutta University, 1 awarded from IIT-Kharagpur, and 2 awarded from The Hong Kong Polytechnic University, Hong Kong).

*(See Annexure C(1) for details of PhD theses supervised)*

**PhDs (unofficially supervised):** 7 (See Annexure C(2) for Example List of Research Fellows Trained in India and Abroad)

**Post-doctorates mentored in India and Abroad:** Twenty-eight (28)

**Scientists/ Engineers Mentored in India and Abroad:** Twenty (20)

*(See Annexure C(2) for Example list of Post-docs and Scientists/Engineers Mentored)*

**Note:** Among the 22 PhDs that he has graduated so far, several are internationally known researchers and science leaders with awards & honors like, Padmashree, S.S.

Bhatnagar Prize, Infosys Prize, P.C. Mahalanobis National Award of MOSPI, Govt. of India, J.C. Bose National Fellow, Directors of premier Institutes like ISI and IIIT, President of IEEE Computational Intelligence Society, USA, Vice-President, Data Science at InMobi, San Mateo, CA, USA, Fellows of IEEE, TWAS, IAPR, IFSA, INSA and other National Academies. *Further, five of them and two of his post-docs, and he himself (eight together) are featured in the Stanford list of top 2% scientists worldwide in the domain of Artificial Intelligence and Image Processing.*

## Publications and Citation Index:

**21 Books** (Authored: 8, Edited Monograph: 13), 20 Edited Conference Proceedings, **506 Research papers** (301 in International Journals, 62 in Book Chapters and 143 in Conference Proceedings), and **2 US Patents**.

(See attached List of Publications for details.)

**Google Scholar** h-index = 86, i10-index = 294, i100-index = 76, g-index = 180, citation of the mostly cited single paper = **6070+** and total citations  $\approx$  **39,000** (as in Sept 2025)

(Google Scholar Link: <https://g.co/kgs/vZrsE9h>)

- According to 2020 Stanford list of top 2% scientists world-wide, he has been featured within the **top 0.106920052%** with **C-score = 4.10705055** and **subject-wise rank of 230** in the domain of **Artificial Intelligence and Image Processing**. For world-wide full list of top 2% scientists covering all disciplines, see: <http://shorturl.at/qHIJ4> (where he ranked #14374).
- He is ranked #14225 in World's top 2% Scientists **covering all disciplines** as per the standardized citation indicators, 2021, maintained by Elsevier. See <https://elsevier.digitalcommonsdata.com/data.../btchxktzyw/3>.
- He is ranked #418 within the Top 1,000 Scientists globally in the field of **Computer Science**, according to 2022 edition of World-wide Ranking of Top 1,000 Scientists released by Guide2Research (<https://www.guide2research.com/scientists/>) and Research.com ([research.com/scientists-rankings/computer-science](https://research.com/scientists-rankings/computer-science)).
- As per **AD Scientific Index 2024**, he is ranked #1 within his institute (ISI), #95 within India, #1585 in Asia, and #14996 in the world across all disciplines.
- Honored by **ScholarGPS** (<https://scholargps.com>) as a “**2022 Highly Ranked Scholar – Lifetime**” in **All Fields of Scholarly Endeavor** in recognition of his exceptional productivity, noteworthy impact, and quality of scholarly work in the top 0.05% of 30 million scholars worldwide. (Ranks: #6,768 **Overall (All Fields)**, #1,549 **Physical Sciences and Mathematics**, #9 **Soft computing**, #31 **Pattern recognition**, and #46 **Statistics**)

In similar ScholarGPS report of “**2024 Highly Ranked Scholars – Lifetime**”, these figures are (Ranks: #7,266 **Overall (All Fields)**, #1,634 **Physical Sciences and Mathematics**, #11 **Soft computing**, #33 **Pattern recognition**, and #48 **Statistics**), His ScholarGPS® ID: 41913333069533

(See Annexure D for some examples of quality-recognition of his work by other researchers.)

## US Foreign Patents Granted:

[D. Bhandari, C.A. Murthy and S.K. Pal, Optimization technique using evolutionary algorithms, US Patent # 8,700,548; Issued on April 15, 2014.](#)

<https://patents.google.com/patent/US8700548B2/en>

S.K. Pal and S. Meher, Rough Wavelet Granular Space and Classification of Multispectral Remote Sensing Image, Korea Patent # IN-800853-05-KR-NAT, Issued Patent (21 Jan 2015); China Patent # IN-800853-04-CN-NAT, Application Granted (27 Jan 2016); US Patent # IN-800853-03-US-NAT, Application Granted (6 Oct 2015), Patent No. US9152877.

<https://patents.google.com/patent/US9152877B2/en>

**Journal Special Issues Guest-Edited:** Sixteen (16)

*(See Annexure E for details.)*

## Books:

### *Authored Books:*

- i. S. K. Pal and D. Dutta Majumder, Fuzzy Mathematical Approach to Pattern Recognition, John Wiley & Sons (Halsted), N.Y., 1986.
- ii. S. K. Pal and S. Mitra, Neuro-Fuzzy Pattern Recognition: Methods in Soft Computing, John Wiley, N.Y., 1999.
- iii. S. K. Pal and Simon C.K. Shiu, Foundation of Soft Case-Based Reasoning, John Wiley, N.Y., 2004.
- iv. S. K. Pal and P. Mitra, Pattern Recognition Algorithms for Data Mining, Chapman & Hall CRC Press, Boca Raton, FL, 2004.
- v. S. Bandyopadhyay and S. K. Pal, Classification and Learning with Genetic Algorithms: Applications in Bioinformatics and Web Intelligence, Springer Verlag, Heidelberg, 2007.
- vi. P. Maji and S.K. Pal, Rough-Fuzzy Pattern Recognition: Application in Bioinformatics and Medical Imaging, John Wiley, N.Y., 2012.
- vii. S.K. Pal, S.S. Ray and A. Ganivada, Granular Neural Networks, Pattern Recognition and Bioinformatics, Springer, Heidelberg, 2017.
- viii. D.B. Chakraborty and S.K. Pal, Granular Video Computing: with Rough Sets, Deep Learning and in IoT, World Scientific, Singapore, 2021.

### *Edited Books:*

- ix. J. C. Bezdek and S. K. Pal (Eds.), Fuzzy Models for Pattern Recognition: Methods

that Search for Structures in Data, IEEE Press, N.Y., 1992.

- x. S. K. Pal and P. P. Wang (Eds.), Genetic Algorithms for Pattern Recognition, CRC Press, Boca Raton, Florida, 1996.
- xi. S. K. Pal and A. Skowron (Eds.), Rough Fuzzy Hybridization: A New Trend in Decision Making, Springer Verlag, Singapore, 1999.
- xii. S. K. Pal, A. Ghosh and M. K. Kundu (Eds.), Soft Computing for Image Processing, Physica Verlag, Heidelberg, 2000.
- xiii. S. K. Pal, T. S. Dillon and D. S. Yeung (Eds.), Soft Computing in Case Based Reasoning, Springer Verlag, London, 2001.
- xiv. S. K. Pal and A. Pal, (Eds.) Pattern Recognition: From Classical to Modern Approaches, World Scientific, Singapore, 2001.
- xv. D. Zhang and S. K. Pal (Eds.), Neural Networks and Systolic Array Design, World Scientific, Singapore, 2002.
- xvi. A. Ghosh and S. K. Pal (Eds.), Soft Computing Approach to Pattern Recognition and Image Processing, World Scientific, Singapore, 2002.
- xvii. S. K. Pal, L. Polkowski and A. Skowron (Eds.), Rough-Neural Computing: Techniques for Computing with Words, Springer Verlag, Heidelberg, 2003.
- xviii. S. K. Pal and J. F. Peters (Eds.), Rough-fuzzy Image Analysis: Foundations and Methodologies, Chapman & Hall/CRC, Boca Raton, Florida, 2010.
- xix. S. K. Pal, A. Petrosino and L. Maddalena (Eds.), Handbook in Soft Computing for Visual Surveillance, Chapman & Hall/ CRC Press, Boca Raton, Florida, 2012.
- xx. S. Misra and S. K. Pal (Eds.), Soft Computing Applications in Sensor Networks, Chapman & Hall/ CRC Press, Boca Raton, Florida, 2017.
- xxi. A. Pal and S. K. Pal, (Eds.) Pattern Recognition and Big Data, World Scientific, Singapore, 2017.

*(See List of Publications for details of books).*

## 12. Academic & Administrative Leadership and National/ International Contributions

: He has made pioneering and seminal contributions in the development and evolution of the discipline Data Science and Analytics starting from pattern recognition and fuzzy sets since March 1975, to image processing since 1979, machine learning and neural networks since 1987, soft computing and machine intelligence since 1992, data mining since 2000, granular computing since 2007, and deep learning since 2017. These contributions are characterized by Google Scholar **h-index of 86** with **total citations over 39,000** (as in August 2025). His most-cited single paper (viz, Pal and Pal, *Pattern Recognition*, 1993) is

**based on the research work entirely done in India** and it has **#6070+** citations which is *noteworthy*.

- : He has built an active research school since 1983 on Machine Intelligence and Learning which comprises the activity in the areas of Pattern Recognition, Image Processing, Soft Computing, Data Mining, Fuzzy Sets and Systems, Artificial Neural Networks, Genetic Algorithms etc. This school has been recognized as a **separate department, named Machine Intelligence Unit (MIU) of Indian Statistical Institute**, Kolkata in 1993. The school is now enjoying International and National recognition under his direction. As an independent evidence towards this, he together with his former six Ph.D. students, one post-doc student and two other members of MIU are featured in the recent Stanford list of top 2% scientists worldwide in the domain of Artificial Intelligence and Image Processing. **This demonstrates his visionary leadership.**
- : The DST, New Delhi has established in Indian Statistical Institute (ISI) under his leadership the **Center for Soft Computing Research (CSCR): A National Facility**. The center, which is first in the country, acts as a strong base for nationwide research and training in the said field with linkage to industries and premier institutes in India and abroad, with special provision for less endowed institutions. The Center has been declared in 2010 as an **Associate Institute of ISI** by its Governing Council.

*(For a glimpse of the facility/ infrastructure developed as well as some example outcome of the CSCR, see Annexure K(1). The same for MIU is shown in Annexure K(2).)*

- : He was the **first Director in the 75-year history** of the Indian Statistical Institute, after its inception in 1931, who is a Computer Scientist, not a Mathematician or a Statistician like his nine predecessors. This is indeed a very significant achievement that reflects the impact of his interdisciplinary research contributions comprising Computer Science and Statistics, as well as his eminence in leadership particularly to an Institute which is internationally known primarily for Statistics and Mathematics.
- : He is the first ex-employee of ISI being **elected to hold the honorable Chair of President of ISI** since its inception in 1931.
- : During his term as the Director of ISI (August 2005 - July 2010), he established the **third Centre of ISI at Chennai**, more than three decades after the second Centre was established at Bangalore, with focus on conducting more applied research. Establishing the **fourth Center of ISI in North-East region** of the country (founded in Tezpur) was an outcome of his vision document, and the creation of the center was approved during his tenure. Several new courses in the post graduate curriculum were also introduced across the centers of ISI.

In doing so, he was carrying out the **wish expressed by the honorable prime minister of India, Prof. Manmohan Singh**, in his speech on December 24, 2006, in the Inaugural Ceremony of the Platinum Jubilee of ISI, namely, that ISI should expand its activities to serve the nation in a better fashion in statistics, information technology (IT) and planning.

- : During the said inaugural ceremony on December 24, 2006, the prime minister Prof. Manmohan Singh declared 29<sup>th</sup> June, the birthday of Prof. Prasanta Chandra Mahalanobis, founder of ISI, as the **National Statistics Day** to be observed every year.

An **honorary D.Sc. degree** was conferred on Prof. Singh.

- : He established a full-fledged **International Statistical Education Centre (ISEC)** in ISI campus by enhancing the scope and presence of the existing programme, on the eve of its Diamond Jubilee, and providing it with a distinct identity in a separate campus with infrastructural facilities on international standard.
- : He was instrumental in **getting approval from the Cabinet (Government of India) of the IISc pay-scales** for ISI faculty. Before this, they had been getting the lower UGC pay-scales; thereby failing to attract good faculty.
- : Under his leadership (during January 1990 to March 1992, and February 1994 to June 1994) an active research group on fuzzy logic and uncertainty analysis was formed in the Software Technology Branch, **NASA Johnson Space Center, Houston, TX, U.S.A.**
- : He has delivered Keynote, Plenary or Invited talks and special courses in various National and International Conferences/Workshops and Institutes in India and abroad on an average of about 10 per year since 1994. The total number of such Keynote/Plenary talks is **about 130**, and the Invited talks is **over 200**.

His world-wide distinction made him travel to about **40 countries across six continents** as visiting scientists/ professors, collaborators, awardees, keynote/ plenary/ IEEE-distinguished speakers, expert-committee members, PhD-supervisors, Academy-Fellows etc. The count of such **foreign visits from 2003 to 2024**, for example, **has been 92 in 34 countries**. This includes the occasions of delivering **56** Keynote/ Plenary/ IEEE-distinguished/Named lectures and **63** Invited talks in **28** countries like USA, Canada, Brazil, Chili, Mexico, UK, Italy, Poland, Spain, France, Germany, Netherlands, Hungary, Russia, Australia, New Zealand, Algeria, Iran, Saudi Arabia, Qatar, China, Taiwan, Korea, Hong Kong, Macau, Indonesia, Thailand, and Bangladesh. The number of **foreign collaborating institutes** that led to joint publications/ books is **48**.

*(See Annexure F for collaborating institutes leading to joint publications. See Annexure G for some example academic visits abroad and talks delivered since 2003. See Annexure I for some examples of his Europe-wide sustained research activities)*

Besides, he **has many international activities** abroad contributing to society. These include: guiding research work leading to PhD degree; serving in various academic bodies and committees for evaluating e.g., research projects for Government funding, annual progress of research centers/ institutes, PhD theses, as well as in international committees for prestigious awardee selection, fellow-election, faculty selection/ promotion, and preparing new course curriculum, in Europe, Hong Kong, USA, Malayasia, Singapore, and Australia, among others.

- : His book - Fuzzy Models for Pattern Recognition: Methods that Search for Structures in Data, IEEE Press, N.Y., 1992 was in the list of **IEEE Best Seller books** till 1995.

His book - Fuzzy Mathematical Approach to Pattern Recognition, John Wiley and Sons (Halsted Press), N.Y., 1986, which is unique in its kind, has been translated into **Indonesian Bahasa and Chinese Languages**.

[https://lib-ft.unpak.ac.id/index.php?p=show\\_detail&id=45](https://lib-ft.unpak.ac.id/index.php?p=show_detail&id=45)

[https://library.jgu.ac.id/index.php?p=show\\_detail&id=4451&keywords=](https://library.jgu.ac.id/index.php?p=show_detail&id=4451&keywords=)

<https://www.tokopedia.com/maxisiahaan/fuzzy-pendekatan-matematik-untuk-pengenalan-pola-oleh-sankar-k-pal>

- : He has **graduated 22 PhD students**, so far, in India and abroad. All are internationally well placed in academia and industry. Many of whom are **internationally known leading scientists** with recognitions like Padmashree, S.S. Bhatnagar Awardee, Infosys Awardee, TWAS Prize Awardee, INAE Chair Professor, Fellows of IEEE, TWAS, IFSA, INSA and other National Academies, JC Bose National Fellow, Editor-in-Chief of IEEE Transactions, Vice-President of Multinational IT Company, Directors of Premier National Institutes like ISI and IIT, and are featured in Stanford list of top 2% scientists worldwide.
- : He is the scientist who **introduced the Soft Computing** concept and research in India.
- : International Conference on Pattern Recognition and Machine Intelligence (**PReMI**), the Proceedings of which are being published by Springer Verlag, Heidelberg, under its prestigious LNAI (Lecture Notes in Artificial Intelligence) Series, is his **brainchild**. Its nine editions, so far, were held in ISI, Kolkata (2005, 2007, 2013, 2017, 2021 & 2023), IIT-Delhi (2009), Asam Central University, Tezpur (2019), Higher School of Economics, Moscow, Russia (2011), and Warsaw University of Technology, Poland (2015). This biennial event primarily helps Indian researchers and students in the said areas to interact among themselves as well as with experts from India and abroad for furtherance of their research.
- : He is the **Third Padma Awardee** of ISI after Prof. P.C. Mahalanobis and Prof. C.R. Rao. His Padma Shri in 2013 came after 45 years since 1968 when Prof. P.C. Mahalanobis and Prof. C.R. Rao received Padma Bhishusan and Padma Bhusan respectively.
- : A one-day workshop on “**40 Years of Fuzzy Sets at Indian Statistical Institute**” was organized in honor of him at ISI, Kolkata on September 13, 2015, to celebrate his 65<sup>th</sup> birth anniversary.
- : Played a key role in India in **educating and mentoring** several scientists/engineers/researchers in industries, universities & research organizations for applying pattern recognition, image processing, soft computing and machine intelligence theories
- : Actively involved in conducting and participating in various **Outreach programs** of the country for educating students/ scholars/ teachers in remote places in India, particularly in **North-East regions of the country**, since 2000. This includes the visit to several schools in rural areas for inspiring the young students for science education and opting for science career.

*(See Annexure J for some of his Outreach academic activities performed.)*

In this spirit, his Center for soft computing research also provided fellowships to faculty and scholars from **less endowed institutions** of the country to work at the center for quality improvement.

- : Acted as the Chairman of several National Scientific Committees including the Information technology Academic Council (IT-AC), Govt. of West Bengal, and the Syllabus Committee for classes VI to XII, CLTP (**Computer Literacy Training Program**), West Bengal Board of Secondary Education, Govt. of West Bengal.

- : Served in various **National/ International high-power committees** for Awards, Honors, S & T Policy-making, University Vice-Chancellor selection, selecting the Director of National Institute of Technology (NIT), selecting the Chief Statistician of India, MOSPI, GoI, , Reviewing the overall performance of IIT and IISER, Project Evaluation, Planning and Program, and in Institutional Governing Councils, among others.

*(Annexure H lists some example committees that he has served in India and Abroad.)*

- : Contribution to **S&T Policymaking** in the country: Served in various National S&T Policymaking committees including the Big Data Initiative (2014-2015) and the Covid-19 India Supermodel Initiative (2020-2021) of the DST, Govt. of India.

*Annexure B(2)* describes two examples of his such contributions as a member of the Big Data Initiative, and Covid-19 India Supermodel Initiative of DST, Government of India. The Office Memorandum and the outcome that evolved out of these committees are furnished in *Annexure M*

- : Founder of the Kolkata Chapter of INAE (Indian National Academy of Engineering) in 2007, and its Founding President (July 2007 - Oct 2017).
- : Founding President of Indian Society for Rough Sets (2010 – 2015)
- : Founder and Founding Head of Machine Intelligence Unit, ISI (March 1993 – July 2005).
- : Founder of the Center for Soft Computing Research: A National Facility, ISI, in 2004, and its Founding PI (2004 - 2015).
- : **Director, Indian Statistical Institute (ISI)** for the term August 2005 – July 2010. As Director, he was the Head or Principal Executive Officer of both Administrative and Academic affairs of ISI which is an Institute of National Importance having ten centers/units located all over India, viz, Delhi, Bangalore, Chennai, Tezpur, Giridih, Hyderabad, Pune, Mumbai and Vadodara, with headquarters at Kolkata. Director oversees the functioning of all of them.
- : **Elected President, Indian Statistical Institute (ISI)** for the term 2022-2026. President holds the highest Chair of ISI Governing Council, and also confers the degrees/diplomas to students in annual convocation.

### 13. Other Relevant Information

- A. **Philanthropic Activity: Donations to Alma-maters and Instituting Medals/ Fellowships to benefit Science and Society:** Besides his academic and research contributions, Pal has instituted the following awards through donations to his alma-maters, starting from school education. These are aimed at nurturing the talent and scientific spirit as well as to help the students from less privileged community, which in turn benefits the society:
  - i) Instituted **two Merit-cum-Means Scholarships** (in his parents name) in 2013 for supporting two economically backward students of Classes IX and X every year in his alma-mater, *Ariadaha Kalachand High School*, Kolkata

700057, India. This facilitates them to complete their secondary school education for societal benefit.

- ii) Instituted the **Parul Bala Pal Gold Medal Award** (in his mother's name) at *Ramakrishna Mission Vivekananda Centenary College (RKM-VCC)*, Rahara, Kolkata 700118, India in 2023 for the Best Graduating B.Sc.(Hons) Student across all science disciplines. The purpose is to nurture bright science-minds for higher studies as well as for the service of mankind, the motto of RK Mission. (RKM-VCC is one of the best colleges in West Bengal. Its 2023 NIRF ranking is #8 out of 200 in India with CGPA of 3.8 out of 4 on a seven-point scale at A++ Grade by the National Assessment and Accreditation Council (NAAC)).
- iii) Instituted the **Sunity Kumar Pal Gold Medal Award** (in his father's name) at *Indian Statistical Institute* in 2003 for the best M.Tech.(CS) dissertation. This encourages and promotes research excellence which, in turn, serves the society better.
- iv) Besides, he has been donating frequently to the Student Assistance Fund of ***Imperial College of Science & Technology, London***, UK, another Alma-mater, to help students from the developing world who face hardship to complete their study.

B. **Patriotism:** NASA Johnson Space Center, Houston, TX, USA, desired to offer him a "Green card" in 1991 requesting to stay permanently in the USA when he was working there as a National Research Council (US National Academy of Sciences) Guest Investigator (Resident Research Associate). But he turned down the offer and returned back to serve his country forever.

#### 14. Named Lectures Delivered

- i: *Japanese Fuzzy Logic Companion Lectures* in 1988 and 1990 for the engineers and scientists of Japanese industries who want to apply fuzzy logic for commercial product.
- ii: 1993 *Vikram Sarabhai Lecture* in Electronics/Telecommunications/Informatics/Automation in the Physical Research Laboratory, Ahmedabad.
- iii: *Jawaharlal Nehru Fellowship Lecture* of Jawaharlal Nehru Memorial Fund, delivered at Electronics Niketan, Department of Electronics, Govt. of India, and at Allahabad University, Allahabad in 1994.
- iv: *Amal K. Roy Memorial Lecture* of the Institute of Electronics & Telecomm. Engineers (IETE), India, Kolkata Chapter, 1996.
- v: *Platinum Jubilee Lecture in Information Technology* of the Institute of Engineers (India), 1996.
- vi: 1997 *Ramlal Wadha Gold Medal Lecture* of the Institute of Electronics & Telecomm. Engineers (IETE), India.
- vii: *Ananta K. Sengupta Memorial Lecture*, Dept. of Applied Physics, Calcutta University, Calcutta, 1998.
- viii: *IEEE (USA) Distinguished Visitor Lectures* in 1998, 1999, 2003 and 2012 in fifteen IEEE Chapters of Australia, Singapore, China, Hong Kong, New Zealand, and Bangladesh.
- ix: *67<sup>th</sup> Annual General Meeting Special Lecture* of Indian Academy of Science, 2001.
- x: 2001 *S.H. Zaheer Medal Lecture* of Indian National Science Academy (INSA), delivered

- at the Department of Mathematics, Punjab University, Chandigarh.
- xi: 5<sup>th</sup> *Distinguished Information Technology (IT) Lecture*, Under the lecture series on “Current topics of interest in IR sector”, Ministry of Communication and Information Technology, Govt. of India, New Delhi, August 22, 2003.
  - xii: 1<sup>st</sup> “*Bengal Science Lecture*” (in IT & Bio-IT) under the National Program “*Year of Scientific Awareness 2004*”, Calcutta, organized by the Science & Technology Council and Department of Science & Technology, Govt. of West Bengal, India, Nov 24, 2004.
  - xiii: *Kolkata Kolon Talk* in S. N. Bose Center of Basic Science, November 5, 2004.
  - xiv: *Golden Jubilee Plenary Talk* at the CSIR-Central Mining Research Institute (CMRI), Dhanbad, Jharkhand, India in 2006.
  - xv: 1<sup>st</sup> *D.M. Bose Memorial Lecture* on its 121<sup>st</sup> Birth Anniversary, 26<sup>th</sup> November 2006, at the Bose Institute, Kolkata.
  - xvi: *Golden Jubilee Talk* at the ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, May 21, 2007.
  - xvii: *Zdzislaw Memorial Plenary Talk* in Warsaw, Poland on 29<sup>th</sup> June 2007 at the Int. Conference on Rough Sets and Emerging Intelligent Systems Paradigms (RSEISP), 2007.
  - xviii: *Prof. A.K. Chowdhury Memorial Talk* in Jadavpur University, Kolkata on January 6, 2008, under the 9<sup>th</sup> Int. Conference on Distributed Computing and Networking (ICDCN), 2008.
  - xix: *Bose Colloquium Lecture* at the S.N. Bose National Center for Basic Sciences, January 8, 2010.
  - xx: *P. C. Mahalanobis Memorial Lecture* of Indian Science News Association, delivered at Visva-Bharati, Shantiniketan, July 17, 2010.
  - xxi: *Zdzislaw Pawlak Memorial Plenary Talk* in Warsaw, Poland on 28<sup>th</sup> June 2010 at the 7<sup>th</sup> Int. Conference on Rough Sets and Current Trends in Computing (RSCTC), 2010.
  - xxii: *Golden Jubilee Distinguished Lecture* at Hong Kong Baptist University, Hong Kong, March 3, 2011
  - xxiii: *Prof. P.P. Chatterjee Memorial Lecture*, Department of Applied Mathematics, University of Calcutta, India, September 5, 2011
  - xxiv: *IEEE Distinguished Visitor Lectures* at Bangladesh University of Engineering & Technology (BUET), Dhaka, BRAC, Dhaka, and Rajshahi University of Engineering & Technology (RUET), Rajshahi in November 2012.
  - xxv: *5th Srinivasa Ramanujan Memorial Lecture* at the Netaji Subhas Open University, Kolkata on 7<sup>th</sup> March 2013.
  - xxvi: *Faraday Memorial Lecture* at the IEEE Hyderabad Section, Hyderabad, September 22, 2013.
  - xxvii: *4<sup>th</sup> Convocation Speech as Chief Guest* at the National Institute of Technology (NIT), Patna, September 28, 2014.
  - xxviii: *59<sup>th</sup> Convocation Speech as Chief Guest* at Jadavpur University, Kolkata, December 24, 2014.
  - xxix: *11<sup>th</sup> Convocation Speech as Chief Guest* at the Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT), Gandhinagar, January 17, 2015.
  - xxx: *National Science Day Lecture* at the CSIR-Central Glass and Ceramic Research Institute, Kolkata, February 25, 2015
  - xxxi: *2015 Prof. S.N. Mitra Award Lecture* of Indian National Academy of Engineering (INAE) at the Defence Institute of Advanced Technology (DIAT), Pune, December 10, 2015
  - xxxii: *64<sup>th</sup> Foundation Day Lecture*, CSIR-CEERI, Pilani, September 21, 2016
  - xxxiii: *Golden Jubilee Celebration Inaugural Lecture*, Electronics and Telecommunication Engineering Dept., Indian Institute of Engineering Science and Technology (IIEST), Shibpur, West Bengal, March 01, 2017
  - xxxiv: *2017 Jawaharlal Nehru Birth Centenary Lecture* of Indian National Science Academy

- (INSA) at Savitribai Phule Pune University, Pune, July 12, 2017
- xxxv: *National Science Day Lecture* of Indian National Academy of Engineering - Kolkata Chapter at Calcutta University, Salt Lake Campus, Kolkata, February 28, 2018
- xxxvi: *National Technology Day Talk* at DIT University, Dehradun on May 11, 2018.
- xxxvii: *Foundation Day Lecture*, IIT Patna, Patna, August 6, 2018.
- xxxviii: *Teachers' Day Lecture of the year 2018*, ICAR-Indian Agricultural Research Institute, New Delhi, September 5, 2018.
- xxxix: *14<sup>th</sup> Convocation Address as Chief Guest* at National Institute of Technology (NIT) Calicut, Kozhikode, Kerala, September 29, 2018.
- xl: *Prof. Meghnad Saha Memorial Lecture of the National Academy of Sciences, India*, Jharkhand Chapter, to commemorate the 125<sup>th</sup> Birth anniversary of its founder, CSIR-NML Auditorium, Jamshedpur, October 5, 2018.
- xli: *Prof. M. N. Saha Memorial Lecture of the National Academy of Sciences, India*, Varanasi Chapter, to commemorate the 125<sup>th</sup> Birth anniversary of its founder, Banaras Hindu University, Varanasi (BHU), March 29, 2019.
- xlii: *CSIR Foundation Day Lecture*, CSIR Madras Complex and CSIR-Structural Engineering Research Center, Chennai, September 27, 2019.
- xliii: *Special Public Lecture (Webinars)* as a part of Golden Jubilee Celebration of DST, GoI, organized by the NASI-Delhi Chapter and MHRD-Institution Innovation Council, Deen Dayal Upadhyaya College, University of Delhi, September 26, 2020.
- xliv: *Indian National Science Academy "Anniversary Lecture"*, 88<sup>th</sup> INSA Anniversary General Meeting, CSIR-National Institute of Oceanography, Visakhapatnam, December 14-16, 2022.
- xlv: *XX Convocation Address as Chief Guest*, Tezpur University, Tezpur, Assam, December 30, 2022.
- xlvi: *56<sup>th</sup> Lecture in the Visva Bharati Lecture Series*, Santiniketan, West Bengal, Feb 06, 2023.
- xlvii: *4<sup>th</sup> Convocation Address as Chief Guest*, Brainware University, Kolkata, West Bengal, February 24, 2023.
- xlviii: *30<sup>th</sup> Prasanta Chandra Mahalanobis Memorial Lecture*, 30<sup>th</sup> West Bengal State Science & Technology Congress, Dept of Science and Technology and Biotechnology, Govt. of West Bengal, organized at Science City, Kolkata, February 28, 2023.
- xlix: *INAE-Kolkata Chapter Science Day Lecture*, CSIR-Indian Institute of Chemical Biology, Kolkata, March 01, 2023.
- l: *Prof. P.C. Mahalanobis Memorial Lecture*, World Meteorological Day, India Meteorological Department (IMD), Govt. of India, Regional Meteorological Center, Calcutta, March 23, 2023.
- li: *Convocation Address as Chief Guest*, Ramkrishna Mission Vivekananda Centenary College, (An Autonomous College), Rahara, Kolkata 700118, Sept 29, 2023.
- lii: *INAE-Kolkata Chapter Engineers' Day Lecture*, Academy of Technology, Adisaptagram, Hooghly, West Bengal, September 15, 2024.
- liii: *85<sup>th</sup> Acharya J.C. Bose Memorial Lecture* at Bose Institute, Kolkata on its 108<sup>th</sup> Foundation Day, November 30, 2024.
- liv: *Indian National Science Academy Distinguished Lecture (IDL-2)*, 90<sup>th</sup> INSA Anniversary General Meeting, SRM Institute of Science & Technology, Kattankulathur, Chennai, December 9-10, 2024.
- lv: *Convocation Speech as Guest of Honor to receive Doctor of Science, D.Sc. (Honoris Causa) award* at Sai University, Chennai, October 24, 2025
- .....

- Annexure A:** Center for Soft Computing Research: A National Facility
- Annexure B(1):** Significant Research Contributions
- Annexure B(2):** Contribution to S and T Policies in the Country: Some Examples
- Annexure C(1):** List of PhD Theses Supervised
- Annexure C(2):** Example List of Postdocs Supervised, Research Fellows Trained and Scientists Mentored
- Annexure D:** Examples of Recognition by other Researchers in the Field
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- Annexure F:** Example Collaborating Institutes Leading Joint Publications (Papers, Books & Conference Proceedings)
- Annexure G:** Academic Visits Abroad (2003 onwards)
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- Annexure I:** Europe-wide Research Activities: Some Examples
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- Annexure K(1):** Facility/Infrastructure Developed and Outcome: Center for Soft Computing Research
- Annexure K(2):** Facility/ Infrastructure Developed: Machine Intelligence Unit
- Annexure K(3):** Facility/ Infrastructure Developed at ISI Kolkata, Delhi, Bangalore and Chennai during his tenure as Director ISI (August 2005 - July 2010)
- Annexure L:** Sanctioned Letters from Ministries for Some Externally Funded Projects
- Annexure M:** Big Data Initiative (2014) and Covid-19 India Supermodel Initiative (2020), DST, Govt. of India: Office Memorandum and Technical Report and Newspaper Links
- Annexure N: Complete List of Publications and Patents of Prof. Sankar K. Pal**

**Center for Soft Computing Research (CSCR): A National Facility**

(<https://www.isical.ac.in/~scc>)

IRHPA (Intensification of Research in High Priority Areas) is a complementary program to the SERC program of the DST, Government of India, with activities consisting of setting up of units/core groups around an eminent scientist and major National Research Facilities to nucleate research activities in these areas. The scheme has contributed to augmenting general R&D capabilities at academic institutions and national laboratories.

Under the said IRPHA scheme a *Center for Soft Computing Research: A National Facility* is set up at the Indian Statistical Institute (ISI), Kolkata, with Prof. Sankar K. Pal as the Principal Investigator (PI) and the Head, because of his outstanding contributions and achievements in the area of soft computing and machine intelligence.

The Center has been declared in 2010 as an **Associate Institute of ISI** by its Governing Council.

**Objectives:**

The center focuses mainly on basic research, as well as on manpower development and promoting soft computing research in other institutes in the country. The activities of the center include:

- a) conducting basic research in pattern recognition, machine learning, image and video analysis, computational theory of perception, computing with words, granular computing, cognitive vision, data mining, web intelligence, bioinformatics, fuzzy sets, rough sets, neural networks, support vector machines, evolutionary algorithms, particle swarm optimization, hybrid techniques etc.,
- b) demonstrating applications to some focused areas like social network analysis, video surveillance, biometrics, and remotely sensed image analysis apart from web mining, temporal data analysis, bioinformatics, and medical image analysis,
- c) supervising the work for Ph.D. and Master's degree theses, and mentoring Post-docs.
- d) developing manpower: providing a three-month value addition certificate course on machine intelligence and soft computing (entry through interview) for postgraduate degree holders in order to enable them to join CS/ IT related research or teaching institutes or industries,
- e) providing fellowships to faculty and scholars from less endowed institutions in the country, including North-East regions, to work at the center for quality improvement,
- f) imparting training to researchers/students from industry and academia including R&D labs; providing training to government officials; and offering regular short term advanced courses on upcoming research areas,
- g) supporting collaborative work, with travel allowances and local hospitality, to scientists/ researchers of national institutes, laboratories and universities e.g., IIT, Delhi; IIT, KGP; CDAC, Kolkata and NIT, Rourkela,

- h) nurturing and upgrading soft computing community and institutes like NITs & CDAC in the country by conducting collaborating projects, evaluating project proposals for funding them by DST through the Center and monitoring the progress,
- i) conducting a network project involving premier research institutes like IITs and IISc.
- j) organizing seminars/conferences/workshops/schools by eminent faculty from India and abroad,
- k) providing a forum of exchanging ideas or establishing a linkage among scientists of leading institutions and industry working in similar areas by inviting interested faculty/ research personnel.

***Collaboration with foreign Institutes:*** International collaboration with organizations like CIMPA, France, University of Palermo, Italy; University of Trento, Italy; INSEAD, France, and Meiji University, Japan; University of Sao Paulo, Brazil; and other Soft Computing Centers like The Berkeley Initiative in Soft Computing, and European Center for Soft Computing.

See **Annexure K(1)** for the Facility/Infrastructure developed out of this center CSCR at ISI Kolkata and some example outcome.

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**Significant Research Contributions**

**Pattern Recognition, Soft Granular Mining, Machine Intelligence and Data Science**

The nominee has made fundamental contributions to machine intelligence research by developing various modern and classical approaches. He pioneered the development of fuzzy set theory, and neuro-fuzzy, rough-fuzzy and granular computing, in general, and their applications in pattern recognition, image/video processing, machine learning, case-based reasoning, data mining, machine-mind development, and knowledge-based systems, in particular. His image processing research in 1970s is perhaps the first investigation (other investigator: A. Rosenfeld, UMD, College Park, USA) that brings out the root relation between the abstract concept of fuzzy sets and image processing tasks and the associated uncertainties/ambiguities.

The theories and methodologies formulated for pattern recognition and data mining allow human like (soft) decision by reducing the system uncertainty, while enhancing its performance, computational intelligence, speed, and flexible information processing ability. It is shown, both theoretically and experimentally, how the merits of fuzzy logic, artificial neural networks, genetic algorithms, rough sets and psychological facts can be integrated symbiotically to achieve these characteristics. Family of generic fuzzy neural networks, pioneered in early 1990s, by combining the human-like reasoning style of fuzzy systems with the learning and connectionist structure of neural networks not only provide enhanced learning and knowledge mining, but also can explain the network decision in natural language. These models, capable of accepting linguistic input, constitute the basic modules that laid the foundation of neuro-fuzzy computing and later, soft computing. It also provides a basic framework for today's Explainable AI.

Further, when a problem involves incomplete, uncertain and vague information, and differentiating the individual elements becomes difficult, it is often found convenient to consider granules to represent a structure of patterns evolved by performing operations on the individual patterns. Accordingly, his granular computing models with adaptive granulation have been effective in efficient and intelligent information processing in those situations that arise such as in bioinformatics, medical imaging, web intelligence, video surveillance, safety analytics, climate analytics, human-centered robotics, and machine-mind design.

The work is prominently significant when the pattern indeterminacy is due to inherent vagueness rather than randomness, and the data is heterogeneous and large.

These have laid the foundation of modern AI and led to synergistic technological developments in data science.

In the process, he has introduced various new tools, uncertainty measures, neural models and Z-number based indices. For example, image entropy (namely, global, local, and conditional) defined in mid 1980s uses new definitions of probabilistic entropy and non-probabilistic entropy based on exponential nature of information gain. Its properties include those of Shannon-entropy. This unique measure is widely used in image processing and computer vision. Generalized rough-fuzzy entropy (2009) quantifies the ambiguity due to both class overlapping and domain granularity. It is useful such as in identifying drug resistant miRNAs

for cancer, and detecting ill-defined white matter, gray matter and cerebrospinal fluid regions in brain MR images. Feature similarity based unsupervised dimensionality reduction algorithm (in early 2000s) is suitable for data sets, large in both size and dimension. Zstar-number (2015) based on perception granules quantifies the precision of semantics embedded in a sentence for machine perception encapsulation. Viewing a social relation as a string with various forces acting on it, a Tension measure for such a relation (2018) is defined based on a new concept of double bounded rough sets. This measure is useful for link prediction in online social networks. Granular deep learning architecture using AlexNet (2022) with spatio-temporal granules provides fast and accurate real time video tracking in traffic monitoring for safety. Similar is the case for the recently developed granulated interpretable CNN (Convolutional Neural Networks) GrI-CNN (2024) based on an end-to-end interpretable CNN architecture for classifying multispectral and hyperspectral remote sensing images. Here the model addresses the problem of interpretability of CNN architecture by using fuzzy and rough sets that make each architecture component functionally interpretable where the shape and size of granules evolve based on the user's needs. Using only the required weight parameters reduces the computation time.

The contribution is fundamental and impeccable. It is significant both from theoretical and applied points of view and has immense societal impact.

Details of the concepts and models developed with various real-life applications are mentioned with references as follows.

### ***The Concept and Models Developed***

Notable systems/ methodologies with theoretical analysis, developed by him, include: multi-valued recognition system (IEEE T-SMC, 7, 625-629, 1977; IEEE T-SMC, 22, 607-620, 1992); correlation between fuzzy sets (Fuzzy Sets and Systems, 17, 23-38, 1985); generalized set operators (IEEE T-SMC, 17, 840-847, 1987); bounds for membership functions (Inform. Sci., 65, 43-171, 1992); new entropy measures (IEEE T-PAMI, 4, 204-208, 1982; IEEE T-SMC, 21, 1260-1270, 1991); proving convergence under mislabeled training samples (IEEE T-SMC, 17, 1072-1077, 1987); generalized guard zone for unsupervised learning with proof of convergence (Pattern Recognition, 23, 325-335, 1990); probabilistic algorithm for active support vector learning (IEEE T-PAMI, 26, 413-418, 2004); fuzzy-MAT (Pattern Recognition Letters, 12, 585-590, 1991); fuzzy multilayer perceptron (IEEE T-NN, 3, 683-697, 1992); fuzzy self-organizing map (IEEE T-SMC, 26, 608-620, 1996); unsupervised feature selection using feature similarity (IEEE T-PAMI, 24, 301-312, 2002); granular network for unsupervised feature selection (Neural Networks, 48, 91-108, 2013); fuzzy-rough granular self-organizing map (Theoretical Computer Science, 466, 37-63, 2012; IEEE T-NNLS, 29, 1890-1906, 2016); granular flow graph (IEEE T-Cyberns., 47, 4096-4107, 2017); neighborhood rough filter and intuitionistic entropy (IEEE T-FS, 26, 2188-2200, 2018); video conceptualization and motion entropy (Inform. Sci., 543, 488-503, 2021); mixed category perception networks (IEEE T-NN, 6, 1091-1108, 1995; IEEE T-NN, 6, 1337-1354, 1995); unsupervised feature evaluation network (IEEE T-NN, 11, 366-376, 2000); Hough transform network (Electron. Letts., 35, 577-578, 1999); optimal stopping time for genetic algorithms (Fundamenta Informaticae, 35, 91-111, 1998); proving that GA-classifier approaches Bayes classifier under limiting conditions (J. Franklin Institute, 336, 387-422, 1999); variable-length chromosome genetic classifier (IEEE T-SMC-B, 30, 890-895, 2000); evolutionary-modular-rough-fuzzy knowledge based network (IEEE T-NN, 9, 1203-1216, 1998; IEEE T-KDE, 15, 14-25, 2003); granular case miner (IEEE T-KDE, 16, 292-300, 2004); rough case-based-reasoned granular mining (IEEE T-KDE, 18, 415-429, 2006);

density based multi-scale data condensation (IEEE T-PAMI, 24, 1-14, 2002); generalized rough-fuzzy c-means/medoids algorithm (IEEE T-SMC-B, 37, 1529-1540, 2007); generalized rough-fuzzy image entropy (IEEE T-SMC-B, 39, 117-128, 2009); nearest fragment operator for gene ordering (App. Intell., 26, 183-195, 2007); indices for web page ranking (IEEE T-KDE, 21, 21-34, 2009); stemmer via distribution based word segregation (IEEE T-SMC-B, 37, 350-360, 2007); fuzzy web surfer model (Proc. Int. Conf. Web Intelligence, 120-123, 2005); rough set theoretic spatio-temporal outlier detection (IEEE T-KDE, 26, 194-207, 2014); fuzzy granular social network model (Inform. Sci., 314, 100 -117, 2015; IEEE T-CSS, 5, 841-853, 2018); granular deep learning concept and interpretable models (Neural Comp. and Appl., 32, 16533-16548, 2020; IEEE T-ETCI, 6, 171-181, 2022; IEEE J-STAR, 16, 57-70, 2023; IEEE T-GRS, 62, 1-12, 2024); and Z-number approach, Zstar-number, and models based on computing with words (Theoretical Comp. Sci., 448, 2-14, 2013; Inform. Sci., 323, 143-178, 2015; Inform. Sci., 405, 227-258, 2017; IEEE T-CDS, 10, 726-737, 2018; IEEE T-ETCI, 4, 686-695, 2020; IEEE T-FS, 30, 2800-2812, 2022; IEEE T-ITS, 23, 24116-24125, 2022; Knowledge-Based Sys., 280, Article no. 110992, 2023).

### **Applications**

Their applications are demonstrated in **Speech recognition** (IEEE T-SMC, 7, 625-629, 1977; IEEE T-SMC, 8, 302-308, 1978); **Medical imaging** (IEEE T-PAMI, 5, 69-77, 1983; IEEE T-SMC, 16, 657-667, 1986; IEEE T-BME, 47, 934-940, 2000; IEEE T-KDE, 19, 859-872, 2007); **Space mission** (Inform. Sci., 72, 1-63, 1993; IEEE T-AP, 51, 862-871, 2003); **Remote sensing** (IEEE T-SMC-A, 26, 241-247, 1996; IEEE T-GRS, 39, 303-308, 2001; IEEE T-GRS, 40, 2495-2501, 2002; Patt. Recog., 45, 2690-2707, 2012; IEEE J-STAR, 16, 57-70, 2023; IEEE T-GRS, 62, 1-12, 2024); **Video tracking and surveillance** (IEEE T- Cyberns., 47, 4096-4107, 2017; IEEE T-FS, 26, 2188-2200, 2018; Inform. Sci., 543, 488-503, 2021; IEEE T-ETCI, 6, 171-181, 2022), **Bioinformatics** (IEEE T-KDE, 19, 859-872, 2007; IEEE T-SMC-B, 37, 742-749, 2007; IEEE T-BME, 56, 229-236, 2009; IEEE T-SMC-B, 40, 741-752, 2010; IEEE T-BME, 59, 1162-1168, 2012; Medical & Biological Engg. & Computing, 54, 701-710, 2016; IEEE T-NNLS, 29, 1890-1906, 2016; IEEE/ACM T-CBB, 15, 659-672, 2018; IEEE/ACM T-CBB, 18, 973—984, 2021); **Web intelligence** (IEEE T-KDE, 21, 21-34, 2009; Web Intell. and Agent Sys., 8, 181-202, 2010); **Context-granularization and machine-mind development** (Fundamenta Informaticae, 124, 197-229, 2013; Theoretical Comp. Sci., 448, 2-14, 2013; Natural Computing, 14, 603-635, 2015; Inform. Sci., 405, 227-258, 2017; IEEE T-CDS, 10, 726-737, 2018; IEEE T-ETCI, 4, 86-695, 2020); **Social network analysis** (Fundamenta Informaticae, 130, 317-342, 2014; Theoretical Comp. Sci., 551, 22-28, 2014; Inform. Sci., 316, 107-122, 2015; Patt. Recog. Lett., 67, 145-152, 2015; IEEE T-CSS, 5, 841-853, 2018); **Smart grid** (IEEE Syst, J., 12, 2353-2360, 2018; IEEE Syst, J., 12, 2645-2653, 2018; IEEE T-SC, 7, 211-220, 2022); **Safety analytics** (IEEE T-FS, 28, 131-2142, 2020; IEEE T-FS, 30, 297-309, 2022; IEEE T-ITS, 23, 24116-24125, 2022; Knowledge-Based Sys., 280, Article no. 110992, 2023); **Climate Analytics** (J. Data, Inform.& Management, 4, 167–183, 2022; Environ. Monitoring and Assessment, 194, Article no. 653, 2022; Environ. Monitoring and Assessment, 195, Article no. 223, 2023; J. Data, Inform. & Management, 6, 1-14, 2024); **Human Detection and Tracking in Human-Robot Coexisting Environments** (IEEE T-Instru Measure, 71, 1-12, Art no. 2520412, 2022; IEEE Sensors Lett., 7, 1-4, Art no. 6000504, 2023; IEEE T-Indus Inform, vol. 19, no. 9, pp. 9877-9886, Sep 2023).

The range of his unique interdisciplinary research in pattern recognition and machine intelligence has

- **augmented the definition of soft computing** by introducing rough sets as

another constituent; thereby enhancing significantly its basic computational intelligence characteristics, and hence the foundation for the conception and design of high Machine-IQ systems,

- led to the emergence of several modern disciplines such as *Rough-fuzzy CTP (Computational Theory of Perception)*, *Soft Case Based Reasoning*, and *Cognitive Machine-Mind Design*, involving fuzzy sets with other computational paradigms/ tasks,
  - added a new dimension to ***Natural Computation paradigm***, and
  - provided numerous powerful tools and theories for the **development of today's AI and data science & analytics**, among others.
- Because of outstanding contributions, the Department of Science & Technology, Govt. of India has established under his leadership the nation's first Soft Computing Research Center in ISI, Kolkata in 2004.
  - “**AI FOR ALL**”, the national strategy/ program for artificial intelligence as framed in 2018 by NITI Aayog, Govt. of India, is yet another example of such outcome of his research.

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**Contribution to S and T Policies in the Country: Some Examples**

Prof. Pal has served in many National Policy Making committees. These include:

(a) Member, Programme Development and Advisory Committee (PDAC) for Big Data Initiative, DST, Govt. of India, 2015. (Office Memorandum NO. BDID/01/04/2014, GOVT OF INDIA, MINISTRY OF SCIENCE & TECHNOLOGY, DEPARTMENT OF SCIENCE & TECHNOLOGY (BIG DATA INITIATIVES DIVISION), Date: 22.05.2014. (The Office Memorandum, dt. 22.05.2024, is given in **Annexure M**)

The objective of the committee is to guide, mentor and suggest in developing the strategy document for fostering and promoting Data Science, Technology, Research and Applications in the country, that includes Big Data and Analytics. (In some of the committee meetings, the nominee acted as the Chairman of the committee in the absence of the DST, Secretary). One may refer to the Technical Report, named, "DATA SCIENCE, TECHNOLOGY, RESEARCH & APPLICATIONS (dASTRA)" - Programme and Strategy Document, Department of Science and Technology, Ministry of Science & Technology, Govt. of India, 2015, which explains the strategic road map that evolved as an outcome of the initiative to benefit the overall development of the country. Some salient features of dASTRA are as follows:

dASTRA aims at addressing some of the data science core research issues, technology development, rapid roll out of applications and a connect to evolve possible solutions to some of the national developmental issues. The project is to be implemented in five years with an estimated cost of Rs 580 Cores. The major activities of the project will include (i) R&D PROMOTION through Expert Driven PI Research, Directed Research-Cluster Based Network Programs, International Collaborative Research Program, (ii) ESTABLISHMENT OF CENTRE OF EXCELLENCE FOR DATA SCIENCE, (iii) SKILL DEVELOPMENT-CAPACITY & TRAINING through Fellowship Based Internships, Short Term Training for Faculty, On-Line Programs, National Workshops & Conferences, Collaborative Interactive Conferences and Entrepreneur Development, (iv) INTERNATIONAL LINKAGES & COLLABORATIONS UN (R&D and Standards), Regional Associations/Collaborations, Bilateral & Multi-Lateral Exchange Programs, and (v) DATA SCIENCE LAB INFRASTRUCTURE DEVELOPMENT.

The Technical Report dASTRA has 226 pages with size of 90.3MB. Therefore, the first six pages and the Conclusion section are mentioned in **Annexure M** to provide a glimpse of the report for convenience.

(b) Member, "Covid-19 India National Supermodel" Initiative, SERB-DST, Govt. of India, 2020 (Office Memorandum No. DST/PCPM/Misc-02/ COVID-INS/2020, Government of India, Ministry of Science and Technology. Department of Science & Technology, (PCPM Division), dated, 27 May 2020. ((The Office Memorandum, dt. 27.05.2020, is shown in **Annexure M**)

In view of the COVID 19 epidemic with severe health impact leading to infections and death, Department of Science and Technology (DST) and Science and Engineering Research Board (SERB) together have launched a COVID-19 India National Supermodel initiative with the aim to aggregate successful evidence-based mathematical and statistical forecasting

models, and create a Supermodel to include best predictive analytics for robust forecasting of infectious disease spread which could be used by the policymakers in India and around the world to curb the epidemic. It has been decided to constitute a consultative committee to work closely with DST and SERB, and the coordinators of this initiative and provide critical inputs on technical aggregation, guidance and final delivery of a robust Supermodel.

Coronavirus disease of 2019 (COVID-19) has unleashed an epidemic with severe health impact leading to infections and death, and even after many months of the discovery of the SARS-CoV-2 virus, which causes the disease, the world is still grappling with the pandemic. While the Government is keeping a close watch on infectivity and mortality, it is imperative to bring in a robust forecasting model for predicting the spread and enhancing disease surveillance. Notably, numerous mathematical models Covid-rc forecasting and surveillance, funded by DST-SERB and other agencies, are being worked out by investigators.

'COVID-19 India National Supermodel initiative aggregated successful evidence-based mathematical and statistical forecasting models, and created a Supermodel to include best predictive analytics for robust forecasting of infectious disease spread and could be used by the policymakers in India and around the world to curb the epidemic.

As part of this initiative, JNCASR and IISc, Bangalore took a coordinating role to connect and work with all Covid-19 modeling projects and programs in the country, in order to develop a set of benchmarks to assess various models and to finally deliver COVID-19 India National Supermodel.

Report of the committee was presented to Rajya Sabha. Relevant 23 Newspaper Links on this are detailed in **Annexure M**. "India Today" is one such news media whose report on 18 October, 2020 is in the following link:

IndiaToday	18-10-2020	<a href="https://www.indiatoday.in/india/story/india-reached-coronavirus-peak-in-late-september-crisis-likely-to-end-by-february-end-govt-appointed-panel-1732845-2020-10-18">https://www.indiatoday.in/india/story/india-reached-coronavirus-peak-in-late-september-crisis-likely-to-end-by-february-end-govt-appointed-panel-1732845-2020-10-18</a>
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Other such policy-making committees are:

(c) Member, Technical Advisory Group, Grand Challenge India (GCI) - Immunization Data: Innovating for Action (IDIA) program, under the joint venture of Biotechnology Industry Research Assistance Council (BIRAC), DBT, Govt. of India, and Bill & Melinda Gates Foundation (BMGF), USA, 2019-2023.

(d) Member, Technical Advisory Group (TAG), Biotechnology Industry Research Assistance Council (BIRAC), DBT, Govt. of India, 2018 to date.

**Annexure H** shows some other committees where he served in India and abroad.

**Annexure C(1)**

**List of PhD Theses *Officially* Supervised in India and Abroad**

***India:***

<b>Sr. No.</b>	<b>Name</b>	<b>PhD Thesis Title</b>	<b>Institute/University/ Year Awarded</b>
1.	Nikhil R. Pal	On Image Segmentation Measures and Object Extraction	Indian Statistical Institute, Calcutta, 1991
2.	Ashish Ghosh	On Image Segmentation Using Neural Networks and Fuzzy Sets	Indian Statistical Institute, Calcutta, 1993
3.	Deba Prasad Mandal	A Multivalued Approach for Uncertainty Management in Pattern Recognition Problems Using Fuzzy Sets	Indian Statistical Institute, Calcutta, 1993
4.	Sushmita Mitra	Neuro-fuzzy Models for Classification and Rule Generation	Indian Statistical Institute, Calcutta, 1995
5.	Jayanta Basak	Connectionist Models for Certain Tasks Related to Object Recognition	Indian Statistical Institute, Calcutta, 1995
6.	Sanghamitra Bandyopadhyay	Pattern Classification Using Genetic Algorithm	Indian Statistical Institute, Calcutta, 1998
7.	Rajat K. De	On Feature Selection, Classification and Rule Generation Using Fuzzy Sets and Neural Networks	Indian Statistical Institute, Calcutta, 2000
8.	Sitabhra Sinha	Chaos, Control and Synchronization in Excitatory-Inhibitory Neural Network Models	Indian Statistical Institute, Calcutta, 2000
9.	Pabitra Mitra	Certain Pattern Recognition Tasks for Data Mining Problems	Indian Statistical Institute, Calcutta, 2003
10.	Susmita Ghosh (nee De)	Genetic Algorithms: Some New Operators and Applications to Connectionist Object Extraction.	Jadavpur University, Calcutta, 2004
11.	B. Uma Shankar	On Segmentation Techniques on Remotely Sensed Images	Jadavpur University, Calcutta, 2006
12.	Shubhra Sankar Ray	New Computational Methods for Gene Analysis from Microarray Data	Jadavpur University, Calcutta, 2008

13.	B. Laxmi Narayan	Web Surfer Models: Preprocessing, Page Ranking and Quantitative Evaluation	Indian Statistical Institute, Calcutta, 2009
14.	Debashis Sen	Soft Computing Based Hybrid Techniques for Image Processing	Jadavpur University, Calcutta, 2011
15.	Dinabandhu Bhandari	On Convergence and Stopping Criteria of Genetic Algorithms with Elitist Models	Jadavpur University, Calcutta, 2012
16.	Debarati Bhunia Chakraborty	Rough Sets and Granular Computing in Video Processing	Jadavpur University, Calcutta, 2017
17.	Suman Kundu	Granular Model for Social Networks: Target Set Selection and Fuzzy-rough Community Detection	Jadavpur University, Calcutta, 2017
18.	Romi Banerjee	Machine-Mind Design for Natural Language Comprehension	University of Calcutta, Calcutta, 2019
19.	Jayanta Kumar Pal	Pattern Recognition Techniques In Analyzing miRNA Expressions In Cancer	University of Calcutta, Calcutta, 2021
20.	Anima Pramanik	Learning Algorithms for Event Detection from Traffic Surveillance Videos	Indian Institute of Technology (IIT), Kharagpur, 2024

**Abroad:**

21.	Li Yan	Soft Computing Techniques for Case Knowledge Extraction in CBR System Development	Hong Kong Polytechnique University, Hong Kong, 2006
22.	Ben Niu	Statistical Pattern Recognition: Locality Preserving Embeddings and Ensemble of Rules	Hong Kong Polytechnique University, Hong Kong, 2008

All of them are well placed in academia and industry. Many of whom are internationally known leading scientists with recognitions like Fellows of IEEE, TWAS, IAPR, IFSA, INSA, INAE, Padmashree, S.S. Bhatnagar Prize awardee, Infosys prize awardee, P.C. Mahalanobis National Award of MOSPI, Govt. of India, JC Bose National fellow, President of IEEE Computational Intelligence Society, USA, Vice-President, Data Science at InMobi, San Mateo, CA, USA, and Directors of premier national institutes like ISI and IIIT.

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**Example List of Postdoctoral Scholars Trained in India and Abroad**

1. Dr. Mohua Banerjee, IIT Kanpur
2. Dr. S.N. Sarbadhikari, Int. Inst. Heath Management, New Delhi
3. Dr. Mala Mitra, CSIR\_CEERI, Pilani
4. Dr. Alok K Deb, IIT Kharagpur
5. Dr. Sankha Deb, IIT Kharagpur
6. Dr. Haider Banka, ISM-IIT Dhanbad
7. Dr. Subhra Sankar Ray, ISI Kolkata
8. Dr. Kuntal Ghosh, ISI Kolkata
9. Dr. Pradipta Maji, ISI Kolkata
10. Dr. Sujata Ghosh, ISI Chennai
11. Dr. Saroj Kumar Meher, ISI Bangalore
12. Dr. Debashis Sen, IIT Kharagpur
13. Dr. Rajarshi Pal, IDRBT, Hyderabad
14. Dr. Syeda Darakshan Jabeen, BITS Mesra
15. Dr. Minakshi Banerjee, RCC Institute of Information Technology, Kolkata
16. Dr. Parthapratim De
17. Dr. Mohd Abdul Hai Zahid
18. Dr. Debarati Chakraborty, University of Hull, UK
19. Dr. Romi Banerjee, IIT Jodhpur
20. Dr. Pritam Paral, IEST, Shibpur, Kolkata \
21. Dr. Arun Kumar, BITS Pilani, Goa Campus
22. Dr. Chandrani Chatterjee, ISRO SAC, Ahmedabad
23. Dr. Debashree Dutta (ongoing)
24. Dr. Anima Pramanik (ongoing)
25. Dr. Saikat Biswas (ongoing)
26. Dr. Sayani Adak (ongoing)
27. Dr. A.H. El-Baz, Damietta University, New Damietta City, Egypt
28. Dr. Simon CK Shiu, Hong Kong Poly University, Hong Kong

**Example List of Research Fellows Trained in India and Abroad**

1. \*Amita Pathak, ISI Calcutta
2. \*Basabi Chakraborty, ISI Calcutta
3. \*C.A. Murthy, ISI Calcutta
4. Malay K. Kundu, ISI Calcutta
5. \*Sambhunath Biswas, ISI Calcutta
6. Swati Choudhury, ISI Calcutta
7. Atanu Bhattacharyya, Vidyasagar College
8. \*Amitava Roy, VEC, Kolkata
9. Suman Mitra, ISI Kolkata
10. \*Suman Saha, ISI Kolkata
11. \*Avatharam Ganivada, ISI Kolkata
12. Suchismita Das, ISI Kolkata

13. Debasmita Bhowmik, Calcutta University
14. Ashish Garg, IIT Kharagpur
15. Souvik Das, IIT Kharagpur
16. Ritwik Bhaduri, ISI Kolkata
17. Shreya Biswas, Jadavpur University
  
18. Q. Zhou, H, Hong Kong Poly University, Hong Kong
19. C. Wong, Hong Kong Poly University, Hong Kong
20. A. Albanese Naples university, Naples, Italy
21. A. Ferone, Naples university, Naples, Italy
22. M.R. Azimi Sadjadi, Imperial College, London, UK
23. N.M. Nasrabadi, Imperial College, London, UK
24. F. Deravi, Imperial College, London, UK
25. S.A. Kwabwe, Imperial College, London, UK
26. M. Guha, Imperial College, London, UK

(\* Their PhD theses work also supervised without being the Official Guide)

#### **Example List of Scientists/ Scientific Leaders Mentored in India and Abroad:**

1. Prof. Nikhil R Pal, FNA, FIEEEE. FTWAS, ISI, Kolkata (Former PhD student, mentored for better research career in national and international level)
2. Prof. Sushmita Mitra, FNA, FIEEEE. FTWAS, ISI Kolkata (Former PhD student, mentored for better research career in national and international level)
3. Prof. Sanghamitra Banerjee, FNA, FIEEEE. FTWAS, ISI Kolkata (Former PhD student, mentored for better research career in national and international level)
4. Prof. C.A. Murthy, FNASc, FNAE, ISI Kolkata (Colleague mentored for better research career in national and international level)
5. Prof. Ashish Ghosh, FNASc, IIIT Bhubaneswar (Former PhD student, mentored for better research career in national and international level)
6. Prof. Jayanta Basak, FNAE (Former PhD student, mentored for better research career in national and international level)
7. Prof. Debatosh Guha, FNA, FIEEEE, Calcutta University (Faculty of his Alma Mater, mentored for better research career in national and international level)
8. Prof. Pabitra Mitra, FAScT, IIT Kharagpur (Former PhD student, mentored for better research career in national and international level)
9. Prof. Pradipta Maji, FNASc, ISI, Kolkata (Former Post-doctoral student, mentored for better research career in national and international level)
10. Prof. Bhargab B. Bhattacharya, FNAE, FNASc, FIEEEE (Colleague at ISI, mentored for better research career in national and international level)
11. Prof. Sivaji Chakravorti, FNA, Jadavpur University (mentored for better research career in national and international level)
12. Prof. Ayanendranath Basu, FNASc, ISI (Colleague at ISI (mentored for better research career)
13. Prof. Ujjwal Maulik, FIEEEE, FNAE, Jadavpur University (mentored for better research career)
14. Prof. Partha Pratim Chakraborty, FNA, IIT Kharagpur (mentored for better research career)
15. Prof. Santanu Chowdhury, FNAE, FNASc, IIT Delhi (mentored for better research career)

16. Prof. Subhasis Chaudhuri, FNA, FIEEEE, IIT Bombay (mentored for better research career)
17. Prof Sudip Misra, FNAE, FNASc, FIEEEE, IIT Kharagpur (mentored for better research career)
18. Prof. J. Maiti, IIT Kharagpur (mentored for better research career)
19. Prof. Dilip Pratihar, FNAE, IIT Kharagpur (mentored for better research career)
20. Dr. Amitava Roy, VEC, Kolkata (mentored in rough sets and pattern recognition)
21. Prof. Dhruva Bhattacharyya, Assam Central University, Tezpur (mentored for better research career)
22. Prof. Amlan Chakraborty, Calcutta University (mentored for better research career)
23. Prof Saurav Das, IIT Indore (mentored for better research career)
24. Prof. M. Tanveer, IIT Indore (mentored for better research career)
25. Dr. Romi Banerjee, IIT, Jodhpur (mentored for better research career in national and international level)
26. Prof. Siddhartha Bhattacharyya, Christ University, Bangalore (mentored for better research career)
27. Dr. Debasish Majumder, CDAC-Kolkata (mentored in image processing for better research career)
28. Prof. Ajith Abraham, Bennett University (Times group), Noida (mentored in soft computing for better research career)
29. Dr. Madhushree Chakrabarty, Bangur Institute of Neurosciences, Kolkata (mentored in image processing for better research career)
  
30. Dr. Kalyanmoy Gupta, US Naval Research Lab, Washington, DC, USA (Mentored in case-based reasoning, rough sets and knowledge discovery)
31. Mr. Lui Wang, NASA JSC, Houston, USA (Mentored in fuzzy logic in pattern recognition and image processing)
32. Mr. Albert Leigh, NASA JSC, Houston, USA (Mentored in fuzzy logic in pattern recognition and image processing)
33. Prof. Soumitra Dutta, INSEASD, Fontainebleau, France (Mentored in web intelligence and IT management)
34. Prof. Alfredo Petrosino, Naples University, Naples, Italy (Mentored in soft computing, data mining and knowledge discovery)
35. Prof. Farzin Deravi, University of Kent, UK (Mentored in image processing)
36. Prof. David Zhang, FIEEEE, Hong Kong Poly University, Hong Kong (Mentored in artificial neural networks and machine learning)
37. Prof. Daniel S. Yeung, FIEEEE, Hong Kong Poly University, Hong Kong (Mentored in artificial neural networks and case-based reasoning)
38. Prof. Y.Y. Tan, FIEEEE, Hong Kong Baptist University, Hong Kong (Mentored in artificial neural networks and case-based reasoning)
39. Anirban Lahiri, Director, Technology, Arndit Ltd., Saint Ives, Cambridgeshire UK (mentored in AI and Data science research)

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## Annexure D

### Examples of Recognition by other Researchers in the Field

- Various authors have explained in their books the significance of the contribution of his work. Some of them devoted an entire section in their books whereas some others described his algorithms as examples. These include:

**Section 5.2** (pp. 177-182) of the book Fuzzy Tech. In Patt. Recog., Wiley, N.Y., 1982 by A. Kandel, (ii) **Example 3.8** (pp. 71-72) of the book Adaptive Patt. Recog. and Neural Nets., Addison-Wesley, N.Y., 1989 by Y.H. Pao, (iii) **Section 3.8.3** (pp. 147-150) of the book Adaptive Fuzzy Systems, Academic Press, N.Y., 1994 by T. Terano et. al., (iv) **Section 7.2** (pp. 180-190) of the book Using Fuzzy Logic: Towards Intelligent Systems, Prentice Hall, N.Y., 1994 by J. Yan et. al., (v) **Examples 13.5** (pp. 371-374) & **13.6** (pp. 375-377) of the book Fuzzy Sets and Fuzzy Logic : Theory and Applications, Prentice Hall, N. J., 1995 by G.J. Klir and B. Yuan, (vi) **Equation 7.3** (pp. 270, Chapter 7) of the book Computational Intelligence P.C. Tools, Academic Press, Boston, 1996 by R. Eberhart et al., (vii) **Section** on Image Processing (pp. 430-437) and Syntactic Recognition (pp. 437-444) with **Examples 12.9, 12.10 & 12.11** of the book Fuzzy Logic with Engineering Applications, McGraw Hill, N.Y., 1997 by Timothy J. Ross, (viii) **Sections 5.5A** (p. 581) and **5.7A** (pp. 627-628) of the book Fuzzy Models and Algorithms for Pattern Recognition and Image Processing, Kluwer Academic, Boston, 1999 by J.C. Bezdek et al., (ix) **Sections 10.5, 10.6 & 10.6.1** (pp. 213-217) of the book Image Processing: Principles and Applications, Wiley, N.J., 2005 by T. Acharya and A.K. Ray, and (x) **Sections 15.5** (p. 662), **15.5.2** (p. 666 & p. 669), and **15.6.1** (p. 673) of the book Neural Networks: A Classroom Approach, Tata McGraw-Hill, New Delhi, 2006 by S. Kumar.

which have been **devoted entirely** to describing some of his algorithms/ definitions, and their significance.

- His **two papers** [IEEE Trans. Syst., Man and Cyberns., SMC-7, pp. 625-629, 1977; In Fuzzy Sets: Theory and Applications to Policy Analysis and Information Systems (eds. P.P. Wang and S.K. Chang), pp. 223-230, 1980] appeared in the then list of key 65 references in fuzzy pattern recognition (Kandel, Fuzzy Tech. in Patt. Recog., Wiley, 1982, p. 211), and **seven papers** [J. Inst. Electron. and Telecom. Engrs., 23, pp. 113-120, 1977; IEEE Trans. Syst., Man and Cyberns., SMC-7, pp. 625-629, 1977; IEEE Trans. Syst., Man and Cyberns., SMC-8, pp. 302-308, 1978; Int. J. of Syst. Sci. 9, pp. 873-886, 1978; Int. J. of Syst. Sci. 9, pp. 887-897, 1978; IEEE Trans. Pattern Anal. Machine Intell., PAMI-5, pp. 69-77, 1983; IEEE Trans. Syst., Man and Cyberns., SMC-13, pp. 94-100, 1983] appeared in

the then list of 1000 important references on fuzzy set theory and applications (Kandel, Fuzzy Math. Tech. with Applications, Addison Wesley, 1986, pp. 248, 253, 254).

- Bezdek et al. have made the following **two comments** in pages 550 and 668 of their book Fuzzy Models and Algorithms for Pattern Recognition and Image Processing, Kluwer, Boston, 1999, that
  - ``The **earliest paper** on image enhancement with fuzzy sets is due to Pal and King [IEEE Trans. Syst. Man and Cyberns., vol. 11, no. 7, pp. 494-501, 1981]", and
  - ``The **first work** on fuzzy edge detection was apparently Pal and King [IEEE Trans. Pattern Anal. Machine Intell., vol. 5, no. 1, pp. 69-77, 1983]".
- His paper IEEE Trans. Neural Nets, NN-3, pp. 683-697, 1992 has received the **1994 Outstanding Paper Award** from the IEEE Neural Networks Council, U.S.A.
- His three papers Journal of Biosciences, vol. 32, no. 5, 1019-1025, 2007; IEEE Trans. Biomedical Engineering, vol. 56, no. 2, pp. 229-236, 2009; and IEEE Trans. Biomedical Engineering, vol. 59, no. 4, pp. 1162-1168, 2012 are included as **Curated Papers in Saccharomyces Genome Database**. ([Saccharomyces Genome Database](#), [Saccharomyces Genome Database](#), [Saccharomyces Genome Database](#) )

A detailed review of his book (1986) is provided by M. Roubens in ACM Computing Reviews, June 1987, pp. 308-309. This book received **Best Production Award** in the 7th World Book Fair, New Delhi, 1986, and **has been translated into Indonesian Bahasa and Chinese Language**.

[https://lib-ft.unpak.ac.id/index.php?p=show\\_detail&id=45](https://lib-ft.unpak.ac.id/index.php?p=show_detail&id=45)

[https://library.jgu.ac.id/index.php?p=show\\_detail&id=4451&keywords=](https://library.jgu.ac.id/index.php?p=show_detail&id=4451&keywords=)

<https://www.tokopedia.com/maxisiahaan/fuzzy-pendekatan-matematik-untuk-pengenalan-pola-oleh-sankar-k-pal>

- The format of his book (1992) has **set the standards** (according to four IEEE reviewers) for future reprint books. The book had been in the list of **IEEE best sellers** for consecutive four years. In the Foreword of this book Prof. L. A. Zadeh, founder of fuzzy set theory, mentioned that **S. K. Pal first applied** fuzzy sets to the speech recognition problem in 1977. Subsequently, Bezdek and Pal have been major contributors to both the theory and applications of fuzzy models in image processing and pattern recognition. The following comments are made on the book by different reviewers:
  - `..... one of the best written concise discussions of fuzzy set theory and its applications to pattern recognition that I have ever seen.'- Frederick E. Petry, Tulane University
  - `The whole book is excellent and timely.'-George J. Klir, State University of New York at Binghamton
- In the Forewords of his book Pattern Recognition Algorithms for Data Mining (2004), following comments are made by three founders:
  - `The importance of the book is hard to exaggerate. It is a treatise that is an exemplar of authority, deep insights, encyclopedic coverage and high expository skill. ... Its authors, Professors S.K. Pal and P. Mitra are foremost authorities in pattern recognition, data mining and related fields.' - Lotfi A. Zadeh (founder of Fuzzy Set theory), University of California, Berkeley.

- 'The book presents an unbeatable combination of theory and practice and gives a comprehensive view on methods and tools in modern KDD.' - Zdzislaw Pawlak (founder of Rough Set theory), Polish Academy of Sciences, Warsaw.
- 'This volume provides a very useful, thorough exposition of the many facets of this application from several perspectives. ... I am pleased to recommend it as a valuable addition to the books in this field.' - Laveen N. Kanal (K.S. Fu Awardee in Pattern Recognition), University of Maryland, College Park.
- According to Science Citation Index (SCI), USA, his **three papers** (Patt. Recog., 26, pp. 1277-1294, 1993; IEEE Trans. Neural Networks, 3, pp. 683-697, 1992; and IEEE Trans. Neural Networks, 6, pp. 51-63, 1995) **ranked 2nd, 3rd, and 15th** respectively in the list of top-cited papers in Engineering Sciences from India during 1992-2001.
- Table below shows **largest citation** of his paper (Pal and Pal, Patt. Recog., 26, pp. 1277-1294, 1993) among the other most referenced OBIA (Object Based Image Analysis) papers. (vide, ISPRS J. Photogrammetry and Remote Sensing, vol. 65, pp. 2-16, 2010).

Citations of the most referenced OBIA relevant papers in ISI and Google Scholar. Per year calculation excludes the year of publication to avoid a bias in the publication order within the year of publication, and ends in 2008.

	ISI	Per year	Google scholar	Per year
OBIA specific				
Benz et al. (2004)	150	<b>37.5</b>	220	55.0
Burnett and Blaschke (2003)	63	<b>12.6</b>	101	20.1
Pesaresi and Benediktsson (2001)	86	<b>12.3</b>	92	13.1
Câmara et al. (1996)	49	<b>4.1</b>	331	27.3
Baatz and Schäpe (2000)	-	-	294	36.3
Blaschke and Strobl (2001)	-	-	72	10.2
For comparison				
Haralick and Shapiro (1985)	720	<b>30.6</b>	1104	48.0
Pal and Pal (1993)	777	<b>51.8</b>	1187	79.1

- According to *ISI Web of Science* (vide, Jose M. Merogo and Anna M. Gil-Lafuente, An Overview of Fuzzy Research in the ISI Web of Knowledge Proc. of the World Congress on Engineering 2009, vol. 1, WCE 2009, July 1-3, 2009, London, UK), : <https://www.researchgate.net/publication/44259957>
  - his paper (Pal and Pal, Patt. Recog., 26, pp. 1277-1294, 1993) is the **16th most cited** article in the world that uses the word 'fuzzy', and
  - he is the **10th topmost world leading expert** publishing largest no. of articles with the word 'fuzzy'.
- According to *Thomson Reuters's Web of Science* (vide, J.T. Yao, V. Vasilakos and W. Pedrycz, Granular Computing: Perspectives and Challenges, IEEE Trans, Cybernetics, 43, pp. 1977-1989, 2013), DOI: 10.1109/TSMCC.2012.2236648
  - his three papers (Pal and Mitra, IEEE Trans. TKDE, 16, pp. 292-300, 2004; Pal et al, Pattern Recog. Lett., 26, pp. 2509-2517, 2005; and Pal and Mitra, IEEE Trans. GSRS, 40, pp.2495-2501, 2002) ranked **17th, 23rd and 27th** in the list of top 31 papers which contributed to the h-index of 30 of "Granular Computing".
- According to Exaly (<https://exaly.com/author/8761149/sankar-k-pal/rankings>), he is the **3rd most cited author** of "*Pattern Recognition Letters*" in 2004.

- **He is one of the ten examples out of 31000 Commonwealth Scholars** whose stories of impact and leadership are featured in the Special anniversary edition of *Common Knowledge* (Issue # 17, November 2024): Celebrating the impact and legacy of Commonwealth Scholarships (UK) since 1960. See <https://reader.experios.com/54578/5744/?page=1>
- **Google Scholar Citation Indices** of his publications: *h-index* = 86, *i10-index* = 294, *i100-index* = 76, *g-index* = 180, *citation of the mostly cited single paper* = 6070+, and *total citations more than 39,000* (as in Sept 2025)
- **India's AI Revolution Spark: The Unstoppable Journey Begins about Sankar K Pal** - <https://youtu.be/x8mHVbw72UM?feature=shared>
- Impact of the contribution is recognized in India/ abroad not only by the Academies, Scientific/ Professional bodies and Foundations, but also by the **Industrial forum, like FICCI** (Federation of Indian Chambers of Commerce & Industry).
- PhDs that he has graduated, so far, in India and abroad: several of whom are **internationally known researchers and science leaders** with recognitions like Padmashree, S.S. Bhatnagar Awardee, Infosys Awardee, PCM National Awardee of MOSPI, GoI, INAE Chair Professor, Fellows of IEEE, TWAS, IFSA, INSA and other National Academies, Editor-in-Chief of IEEE Transactions, and Director of Premier Institute.
- He has been featured within the **top 0.106920052%** with **C-score = 4.10705055** and **subject-wise world-wide rank of 230** in the domain of **Artificial Intelligence and Image Processing** in the recent (2020) list of top 2% scientists world-wide based on an independent study done by **Stanford University** scientists. For methodology and data visit: <https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3000918>. For world-wide full list of top 2% scientists, see: <http://shorturl.at/qHIJ4> (He is in Serial no.14374). For the list of Indian scientists see: <https://docs.google.com/.../1mMongq947bS3KcMhsDpf.../edit...> Further, his six graduated-PhDs and one post-doc are also included in that list.
- He is ranked #14225 in World's top 2% Scientists **covering all disciplines** as per the standardized citation indicators, 2021, maintained by Elsevier. See <https://elsevier.digitalcommonsdata.com/data.../btchxktzyw/3>.
- He is ranked #418 within the Top 1,000 Scientists globally in the field of **Computer Science**, according to 2022 edition of World-wide Ranking of Top 1,000 Scientists released by Guide2Research (<https://www.guide2research.com/scientists/>) and Research.com ([research.com/scientists-rankings/computer-science](https://research.com/scientists-rankings/computer-science)).
- As per **AD Scientific Index 2024**, he is ranked #1 within his institute (ISI), #95 within India, #1585 in Asia, and #14996 in the world across all disciplines.

**All these demonstrate his visionary leadership and the impact of his research contributions.**



## Annexure E

### List of Journal Special Issues Guest-Edited: Examples

- S.K. Pal and Pradip K. Srimani, Special Issue on Neurocomputing: Motivation, Models and Hybridization, *IEEE Computer*, vol. 29, no. 3, 1996.
- S.K. Pal, Special Issue on Neural Networks, *J. Inst. Electron. and Telecom. Engrs.*, vol. 42, no. 4 & 5, 1996.
- S.K. Pal and Andrzej Skowron, Special Issue on Soft Computing, *Fundamenta Informaticae*, vol. 37, nos. 1-2, 1999.
- S.K. Pal, Witold Pedrycz, Andrzej Skowron and Roman Swiniarski, Special Issue on Rough-neuro Computing, *Neurocomputing*, vol. 36, nos. 1-4, 2001.
- Sanghamitra Bandyopadhyay, Ujjwal Maulik and S.K. Pal, Special Issue on Evolutionary Computation in Engineering Science, *J. Inst. Electron. and Telecom. Engrs.*, vol. 48, no. 5, 2002.
- S.K. Pal and Andrzej Skowron, Special Issue on Rough Sets, Pattern Recognition and Data Mining, *Pattern Recognition Letters*, vol. 24, no. 6, 2003.
- S.K. Pal and Ashish Ghosh, Special Issue on Soft Computing Data Mining, *Information Sciences*, vol. 163, nos. 1-3, 2004.
- Tharam S. Dillon, Simon C.K. Shiu and S.K. Pal, Special Issue on Soft Case Based Reasoning, *Applied Intelligence*, vol. 21, no. 3, 2004.
- S.K. Pal, Hung Son Nguyen and Andrzej Skowron, Special Issue on Rough sets and Fuzzy sets in Natural Computing, *Theoretical Computer Science - C*, vol. 412, no. 42, 2011.
- Zhihua Cui, Sheela Ramanna, James F. Peters and S. K. Pal, Special issue on Cognitive informatics and Computational Intelligence: Theories and Methods, *Fundamenta Informaticae*, vol 123, pp. i-iv, 2013.
- S.K. Pal, and Saroj K. Meher, Special issue on Granular Soft Computing for Pattern Recognition and Mining, *Applied Soft Computing*, vol. 13, no.9, 2013.
- Alfredo Petrosino and S.K. Pal, Special Issue on Decision Making in Human and Machine Vision, *IEEE Trans. Systems, Man and Cyberns.: Systems*, vol, 44, no. 5, 2014.
- Chris Cornelis, Hung Son Nguyen, S.K. Pal, Andrzej Skowron and Wei-Zhi Wu, Special Issue on Rough Sets and Fuzzy Sets, *Fundamenta Informaticae*, vol. 142, nos. 1-4, December 2015.

- S.K. Pal, Saroj Meher and Andrzej Skowron, Special Issue on Granular Mining and Knowledge Discovery, *Pattern Recognition Letters*, vol. 67, part 2, pp. 109-112, 2015.
- S.K. Pal and B. Uma Shankar, Special Issue on Machine Learning in Image Processing, *IET Image Processing*, vol. 9, no. 11, November 2015
- Pradipta Maji, S.K. Pal and Andrzej Skowron, Special Issue on Pattern Recognition and Mining, *Natural Computing* (Springer), vol. 15, no. 3, 2016

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## Annexure F

### **Example Collaborating Institutes Leading to Joint Publications (Papers, Books, Journal Special Issues & Conf. Proceedings) (List is not exhaustive)**

#### ***India:***

IIT Kharagpur  
IIT Delhi  
IIT Jodhpur  
IISc Bangalore  
IIT Guwahati  
Academy of Scientific and Industrial Research, CSIR-CSIO, Chandigarh  
Central University, Hyderabad  
Indian Statistical Institute, Bangalore Center, Bangalore  
University College of Science and Technology, Calcutta University, Kolkata  
Jadavpur University, Kolkata  
CDAC-Kolkata  
RCC Institute of Information Technology, Kolkata  
Netaji Subhas Institute of Technology, New Delhi  
National Institute of Technology Karnataka Surathkal, Mangalore  
Indian Institute of Information Technology and Management-Kerala, Trivandrum  
Indian Institute of Management, Ranchi  
Tezpur Central University, Tezpur  
Bangur Institute of Neuroscience, Kolkata  
Kerala University of Digital Sciences Innovation and Technology (Digital  
University Kerala) Thiruvananthapuram  
Bennett University (The Times Group), Greater Noida

#### ***Abroad:***

NASA Johnson Space Center, Houston, TX, USA  
US Naval Research Lab, Washington, DC, USA  
University of Maryland, College Park, USA  
University of Pensacola, Florida, USA  
Duke University, Durham, North Carolina, USA  
Colorado State University, Fort Collins, Colorado, USA  
University of California, Santa Barbara, USA  
Cyber Technologies Laboratory of Son Corporation, San Jose, USA  
Fordham University, New York, USA  
Florida Institute for Human and Machine Cognition, Florida  
Washington University in St Louis, St. Louis, USA  
Pennsylvania State University, Pennsylvania, USA  
University of Michigan, Dearborn, USA

Florida International University, Miami, USA  
Machine Intelligence Research Lab, Auburn, Washington, USA  
University of Manitoba, Winnipeg, Canada  
University of Alberta, Alberta, Canada

Imperial College, London, UK  
Leicester Polytechnique, Leicester, UK  
University of Bradford, UK  
Cambridge University, UK  
INSEAD, Boulevard de Constance, Fontainebleau, Cedex, France  
Institut De Mathematiques De Marseille, France  
University of Naples Parthenope, Naples, Italy  
National Research Council, Institute for High Performance Computing and  
Networking, CNR, Naples, Italy  
University of Siena, Siena, Italy  
University of Palermo, Sicily, Italy  
University of Calabria, Italy  
Institute of Mathematics, Warsaw University, Warsaw, Banacha, Poland  
Warsaw University of Technology, Warsaw, Poland  
HSE University, Moscow

Hong Kong Polytechnic University, Kowloon, Hong Kong  
Hong Kong University of Science and Technology, Hong Kong  
Baptist University of Hong Kong, Hong Kong  
University of Macau, Macau  
Tsinghua University, Beijing, China  
Beijing Normal University, Zhuhai, China

Yonsei University, Seoul, South Korea  
Sungshin University, South Korea  
Maebashi Institute of Technology, Japan  
University of Nagasaki, Nagasaki, Japan  
National Central University, Taiwan  
University of Tasmania, Australia  
La Trobe University, Melbourne, Australia

Damietta University, New Damietta City, Egypt  
Echahid Cheikh Larbi Tebessi University, Tebessa, Algeria  
Bahria University, Islamabad, Pakistan  
University Ibn Tofail, Kenitra, Morocco

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**Academic Visits Abroad (2003 onwards): An Example**

(Total 92 visits to 34 countries across six continents since 2003)

**2003**

- **Australia & New Zealand:** To deliver a series of IEEE Distinguished Lectures under the IEEE Distinguished Visitor Program at Brisbane, Sydney and Melbourne (Australia), and Christchurch and Auckland (New Zealand), July 21-31, 2003.
- **Italy:** To deliver a Keynote talk at the 5th International Workshop on Fuzzy Logic and Applications (WILF 2003), Istituto Italiano Studi Filosofici, Palazzo Serra di Cassano, Naples, October 9-11, 2003.
- **China:** To attend the TWAS meeting at Beijing, and to attend the Int. Conference on RSFDGrC'03 at Chong Qing as a Keynote Speaker, October 16-24, 2003.
- **USA:** Attended the Second International BISC Workshop (FLINT-CIBI03) as an Invited speaker and a Panellist, UC Berkeley, Dec 15-18, 2003. Also visited the Center for Automation Research, University of Maryland, College Park, MD during Dec 19-22, 2003 and the US Naval research Lab, Washington DC, during Dec 22-24, 2003 for invited talks.

**2004**

- **China:** To deliver a Keynote speech at the 2nd International Conference on Active Media Technology (AMT-04), Chongqing, China, May 29-31, 2004.
- **Poland:** To deliver a Plenary talk at the MSRAS-2004, Plock and two invited Talks at Warsaw University, June 7-9, 2004.
- **USA:** To conduct research as an ONRIFO Visiting Fellow for two months in the Information Technology Division, US Naval Research Lab. Washington, DC, and establish collaboration with them in the area of Case Based Reasoning and Soft Data Mining during 21 June - 20 August 2004. In addition to this, delivered talks at
  - a) LNK Corporation, Maryland on July 5, 2004,
  - b) University of Pennsylvania Medical Center, Philadelphia, PA on July 26, 2004,
  - c) Center for Automation Research, University of Maryland, College Park on July 30, 2004,
  - d) Computer Science and Engineering Department, Michigan State University, East Lansing on August 6, 2004,
  - e) Computer Science Department, Georgia Institute of Technology, Atlanta on August 10, 2004, and
  - f) Electronics Warfare Division, Naval Research Lab, Washington, DC on August 18, 2004.
- **China:** a) Visited the Institute of Computing Technology, Chinese Academy of Sciences, Beijing, on September 22, 2004, and b) Attended the IEEE World Internet Consortium as the Director of the Indian WIC Center and chaired two sessions in the conference, September 20-24, 2004.
- **Italy:** Series of invited talks on Pattern Recognition and Machine Intelligence at the University of Trento, Trento, October 24-30, 2004.

**2005**

- **Egypt:** Attended the 16th TWAS General meeting in Alexandria, Egypt, November 29 – December 02, 2005.

## 2006

- **China:** Delivered a) a Keynote speech in the Forum on Theory of Granular Computing from Rough Set Perspective in Nanchang, 20-22 July 2006, b) a Keynote Speech in the 1st International Conference on Rough Sets and Knowledge Technology (RSKT 2006) in Chongqing, 24-26 July 2006, and c) an Invited talk at Tsinghua University, Beijing, July 27, 2006.
- **China:** Delivered an Invited talk at the WICI International Workshop on Web Intelligence (WI) meet Brain Informatics (BI) (WImBI), Beijing, December 15-16, 2006.

## 2007

- **Thailand:** Delivered a Keynote talk at the Asia Modelling Symposium (AMS 2007) held at Prince of Songkla University, Phuket, Thailand, March 27-30, 2007.
- **Italy:** Delivered a) a Keynote talk at the 6th Int. Workshop on Data Analysis in Astronomy, Erice, Italy, and b) a series of talks at the University of Naples, Italy during April 15-22, 2007.
- **Korea:** Delivered a Keynote talk at the Int. Conf on Multimedia and Ubiquitous Computing, 2007 at Korean Bible University, Seoul, Korea, April 25-28, 2007.
- **Mexico:** Attended the IFSA World Congress, Cancun, Mexico during June 18-21, 2007 for receiving the IFSA Fellowship Award and Chairing a session.
- **Poland:** Delivered Z. Pawlak Memorial Plenary Talk at the Int. Conf. on Rough Sets and Emerging Intelligent Systems Paradigms (RSEISP'07) at Warsaw University of Technology, Warsaw, Poland, June 27-30, 2007.
- **China:** Delivered a Plenary talk at the 3rd WSEAS International Conference on Data Mining and Intelligent Information (DMIP'07), Beijing Jiaotong University, Beijing, September 15-17, 2007.
- **Thailand:** Invited talk and discussion with the faculty of Computer Science, Statistics and Mathematics, Mahidol University, Bangkok, Thailand, Oct 31, 2007.
- **Italy:** a) Attended the TWAS Meeting, Trieste, Italy, and b) Visited the University of Naples, Italy for delivering a Guest Lecture, during November 12-18, 2007.

## 2008

- **China:** Keynote talk at the 3rd International conference on rough Sets and Knowledge Technology (RSKT-2008), Southwest Jiaotong University, Chengdu, China, May 17-19, 2008.
- **Canada:** For the following purposes:
  - a) Attended the 7th International Symposium on Methodologies for Intelligent Systems, York University, Canada, May 20-23, 2008 as a speaker,
  - b) Invited talk at Brock University, Canada, May 22, 2008, and
  - c) Visited the University of Manitoba, Canada, May 23-27, 2008.
- **Brazil:** Attended the INSA-Brazil Academy of Science Collaborative Workshop as a member of the Indian delegation team, Rio de Janeiro, Brazil, June 23-26, 2008, and also visited the Federal University of Rio de Janeiro for an Invited talk.
- **France:** Invited talk at INSEAD, Fontainebleau, France, June 27-30, 2008.
- **China:** Plenary talk at the 2008 IEEE conference on Granular Computing, Hangzhou, China, August 25-28, 2008.
- **Mexico:** Attended the TWAS meeting at the Mexico City, Mexico, November 8-13, 2008.

- **China:** Keynote talk at the 2008 International Symposium on Signal Processing, Image Processing and Pattern Recognition (SIP 2008), Hainan Island, China, December 13-15, 2008.

## 2009

- **Italy:** Attended the ISI - EU project meeting at Trento, Italy, and delivered a series of talks at the University of Trento, Italy, February 4-10, 2009.
- **Netherlands:** Visited Virje University and IOS Press, Amsterdam, Netherlands for meetings, June 2-6, 2009.
- **Italy:** a) Delivered the Keynote talk at the International Workshop on Fuzzy Logic and Applications (WILF'09) at the University of Palermo, Italy, and b) Visited the University of Naples & University of Milano, Italy for delivering a series of lectures under ISI-Naples Univ. collaborative programme, during June 7-23, 2009.
- **USA:** Visited the Computer Vision Lab, University of Maryland, College Park, USA for research collaboration, and delivered talks, August 18-31, 2009.
- **Italy:** Delivered an Invited talk at the International Conference for Digital Libraries and the Semantic Web (ICSD 2009) at the University of Trento, Italy, September 8-12, 2009.
- **South Africa:** Attended the TWAS General Meeting, Durban, South Africa, October 20 - 23, 2009.
- **China:** Delivered a Keynote talk at the 3rd Chinese Conference on Pattern Recognition (CCPR 2009) at Nanjing University of Science, Nanjing, China, November 3 - 6, 2009.

## 2010

- **Italy:** Collaborative research under the formal agreement between ISI & University of Naples, Italy during April 22 - May 18, 2010. Besides delivered
  - a) a series of talks at Naples University, Italy, and
  - b) an Invited talk at the University of Salerno, Italy.
- **Poland:** Delivered
  - a) a Keynote talk at 4th International KES Symposium on Agents and Multi-Agent systems - Technologies & Applications, Gdynia, Poland, June 23-26, 2010,
  - b) a Keynote talk at 7th International Conference on Rough Sets & Current Trends in Computing, RSCTC 2010, Warsaw, June 28-30, 2010, and
  - c) Performed collaborative research work with the Institute of Mathematics, University of Warsaw, Poland.
- **China:** Delivered a Keynote talk in the 'Cognitive Science and Information Science' section at the 7th International Conference on Cognitive Science (ICCS 2010) at China National Convention Center (CNCC) in Beijing, China, August 18 - 20, 2010.
- **China:** Delivered
  - a) a Keynote talk at 5th International Conference on Rough Sets and Knowledge Technology (RSKT 2010), Beijing, China, and
  - b) a Keynote talk at 10th China Conference on Rough Set and Soft Computing (CRSSC2010) at Chong Qing University of Posts and Telecommunications, Chong Qing, China, during October 11 - 15, 2010
- **Taiwan:** Delivered a Keynote talk at the 2nd International Symposium on Aware Computing (ISAC 2010) at Tainan, Taiwan, October 30 - November 3, 2010.
- **Brazil:** Delivered
  - a) an Invited talk at 15th Iberoamerican Congress on Pattern Recognition (CIARP-10), Univ. of Sao Paulo, Sao Paulo,

- b) an Invited talk at Federal University-ABC, Sao Paulo, Brazil, and
- c) Performed collaborative work at the University of Sao Paulo under Indo-Brazil project, during November 8 - 14, 2010.

## 2011

- **Hong Kong:** Delivered the Golden Jubilee Distinguished Lecture at Hong Kong Baptist University, Dept. of Computer Science and other collaborative work, February 28-March 9, 2011.
- **Indonesia:** Delivered the Keynote talk at the International Conference on Data Engineering and Internet Technology (DEIT 2011), Bali, Indonesia, March 14 - 17, 2011.
- **Italy:** Delivered a Keynote talk at 7th International Workshop on Data Analysis in Astronomy (DAA2011), Erice, Italy, and visit to University of Naples, Italy in connection with the collaborative research under the formal agreement with ISI, during April 11-19, 2011.
- **USA:** Invited talk at the World Conference on Soft Computing, San Francisco State University, San Francisco, USA. Also visited the University of Maryland, College Park, USA for a talk, during May 23 - June 3, 2011.
- **Iran:** Keynote talk at 2011 Symposium on Artificial Intelligence and Signal Processing (AISP2011), Sharif University, Tehran, Iran, June 14 - 17, 2011.
- **Russia:** Attending the conference PReMI-11, Moscow as its General Chair, June 25-30, 2011.
- **Italy:** For the following purposes:
  - a) Collaborative research at the University of Naples, Italy under the formal agreement with ISI,
  - b) Attending the TWAS General Meeting, Trieste, Italy, and
  - c) Delivering an invited talk at the University of Padova, Italy, during September 13-27, 2011.

## 2012

- **Indonesia:** Keynote talk at the 3rd International Conference on Soft Computing, Intelligent System and Information Technology (ICSIIT), Bali, Indonesia, May 23-27, 2012.
- **Saudi Arabia:** Invited talk at the International Workshop on Three Approaches to Data Mining: Test Theory, Rough Sets and Logical Analysis of Data, King Abdullah University of Science and Technology (KAUST), Jeddah, Saudi Arabia, June 8-12, 2012.
- **Korea:** Keynote talk at the 4th International Conference on Advanced Communication and Networking (ACN 2012), Jeju, Korea, August 29-31, 2012.
- **China:** Attending the TWAS General Meeting at Tianjin, China, September 17-21, 2012.
- **USA:** a) Collaborative work with the Radiology Dept., University of Pennsylvania, Philadelphia, USA, and b) Invited talk at the ECE Dept., University of IOWA, USA, Oct 2-12, 2012.
- **Bangladesh:** IEEE Distinguished Visitor Talks during November 5 - 8, 2012 at
  - a) Bangladesh University of Engineering & Technology, Dhaka,
  - b) BRAC University, Dhaka, and
  - c) Rajshahi University of Engineering & Technology, Rajshahi.
- **Spain:** Invited talks at 2012 Int. Falls School in Natural Computing (FSNC 2012), Tarragona, Spain, November 19-23, 2012.

- **Macau:** Invited talk at the International Conference on Active Media Technology 2012 (AMT-12), Macau, December 3 - 7, 2012.

### 2013

- **USA:** Collaborative work at the a) University of Pennsylvania, Philadelphia, USA, and b) University of Maryland, College Park, USA, during May 9 - 21, 2013.
- **Italy:** Keynote talk at the 23rd Italian Workshop on Neural Networks, Vietri, Salerno, Italy, and Collaborative research at the University of Naples, Italy under the formal agreement with ISI, during May 22-28, 2013.
- **Italy:** Invited talk at the International Conf. on Image Analysis and Processing (ICIAP), Naples, Italy, Sept 10-13, 2013.
- **Argentina:** Attending the TWAS General Meeting at Buenos Aires, Argentina, Sept. 30 - Oct. 5, 2013.

### 2014

- **Bangladesh:** IEEE Distinguished Visitor Talk, American International University, Dhaka, Bangladesh, May 26, 2014.
- **Hong Kong:** Invited talk at the Computer Science Department, Hong Kong Baptist University, Hong Kong, June 12, 2014.
- **China:** Invited talk at the United International College of Hong Kong Baptist University, Zhuhai, China, June 16, 2014.
- **Bangladesh:** Keynote talk at the a) 3rd International Conference on Informatics, Electronics & Vision (ICIEV), 2014, Dhaka, Bangladesh, and b) 9th International Forum on Strategic Technology (IFOST 2014), Cox's Bazar, Chittagong, Chittagong University of Science & Technology, Bangladesh, during May 22-26, 2014.
- **Oman:** Attended the 25th TWAS General Meeting at Al Bandar Hotel, Muscat, Sultanate of Oman, October 26-29, 2014.

### 2015

- **Poland and France:** a) Plenary Talk at the 6th International Conference on Pattern Recognition and Machine Intelligence (PReMI'15), Warsaw University of Technology, Warsaw, Poland, and b) Visit at the Telecom Paris Tech, Paris, France, during June 24 – Jul 7, 2015.
- **Hungary:** Invited talk at the Szechenyi Istvan University, Gyor, Hungary, November 13-16, 2015.
- **Austria:** Attended the 13th General Conference and 26th TWAS General Meeting at Austrian Academy of Science, Vienna, Austria, November 17 – 21, 2015.
- **Germany:** Invited Talks at the  
a) Universitat Paderborn, November 22-25, 2015, and  
b) German Workshop on Computational Intelligence, Dortmund, Nov 26-27, 2015.
- **China:** Keynote Talk at the 2015 Annual International WICI Workshop at Beijing University of Technology, China and for collaborative research work, December 25 - 28, 2015.

### 2016

- **Spain:** Series of Invited Talks at the 2nd International Winter School on Big Data (BigDat 2016) at University of Deusto, Bilbao, Spain, February 7 – 11, 2016.

- **Bangladesh:** Keynote talk at the 5th International Conference on Informatics, Electronics & Vision (ICIEV'16), University of Dhaka, Dhaka, Bangladesh, May 11-15, 2016.
- **UK:** Visit during June 7-18, 2016 for the following purposes:
  - a) Visiting some departments of Imperial College, London, June 7 -10, 2016,
  - b) Meetings at Data Mining Services, Ltd., Windsor, June 13 - 15, 2016, and
  - c) Invited talk at Santander Bank, London, June 17, 2016.
- **Chile:** IRSS Fellow Lecture, International Joint Conference on Rough Sets (IJCRS 2016) at Universidad de Chile, Santiago, Chile, October 05-13, 2016.
- **Rwanda:** Attended the 27th TWAS General meeting at Kigali, Rwanda, November 12 - 17, 2016
- **Algeria:** Keynote talk at the 1st Mediterranean Conference on Pattern Recognition and Artificial Intelligence (MedPRAI 2016), Tebessi University, Tebessa, Algeria, November 20-24, 2016.

## 2017

- **Bangladesh:** Keynote talks at the a) International Conference on Imaging, Vision and Pattern Recognition (icIVPR2017), University of Dhaka, Dhaka, February 13-14, 2017, and b) International Conference on Electrical, Computer and Communication Engineering (ECCE-2017) at Chittagong University of Engineering & Technology (CUET), Cox Bazar Bangladesh, February 16-18, 2017.
- **Australia:**
  - a) Plenary address at the Workshop on Big Data Analysis, La Trobe University, Melbourne, March 13-15, 2017, and
  - b) Invited talk in the Computer Science and Information Technology Dept., La Trobe University, Melbourne, Australia, March 16, 2017.
- **Hong Kong:** Distinguished Lecture and academic discussion with researchers at Hong Kong Baptist University, Hong Kong, May 15, 2017.
- **China:** Distinguished Lecture at Guangdong University of Technology, Guangzhou, China, May 17, 2017.
- **Poland:** Keynote talk at the International Joint Conference on Rough Sets, IJCRS 2017, University of Warmia and Mazury, Olsztyn, Poland and Collaborative Research work, July 3 – 07, 2017.
- **Italy:** a) Invited Talks and Collaborative Research work at the Dept. of Science and Technology, University of Naples, Parthenope, Naples, Nov 19-23, 2017, and b) Invited talk at the University of Genoa, Italy, November 24, 2017.

## 2018

- **China:** Collaborative discussion meetings at the Qingdao Forum on Science & Technology, and 2nd Qingdao International Academician Conference, Qingdao, China, August 16-18, 2018.

## 2019

- **UK:** Series of invited talk(s) at 5th International School on Big Data (BigDat 2019), University of Cambridge, U.K., January 7-11, 2019.
- **Thailand:** Keynote talk at the International Conference on Information, System and Convergence Applications (ICISCA), Bangkok, Thailand, January 23-25, 2019.

- **China:** Keynote speech at the Int. Conf. on Smart Grid Technology and Data Processing: Smart Urban Resource and its Breakthrough in Technology and Management, Suzhou, China, 28 Feb – 1 Mar. 2019.
- **USA:** a) Collaborative research work at the Center for Automation Research, Dept. of Electrical and Computer Engineering, University of Maryland, College Park, MD during April 28 to May 03, 2019, and b) Invited talk in the Department of Electrical and Computer Engineering, University of Illinois, Urbana-Champaign (UIUC), IL, USA on May 7, 2019.
- **China:** Invited talk at the 3rd Qingdao International Academicians Conference, Qingdao, China, May 28 - 31, 2019.

### 2023

- **USA:** Collaborative research work with Knexus Research Corporation, 174 Waterfront Street, Suite 310, National Harbour, Maryland, MD 20745, USA, during May 31 to June 9, 2023, and delivered an Invited talk on June 01, 2023.
- **UK:** Collaborative research work with Arndit Ltd., St. John's Innovation Center, Cowley Road, Cambridge CB4 0WS and the Department of Engineering, University of Cambridge during July 30 to August 27, 2023.
- **Bangladesh:** Keynote talk at the 6th Int. Conf. on Electrical Information and Communication Technology (EICT-2023), Khulna University of Engineering & Technology (KUET), Bangladesh, December 7 -10, 2023.

### 2024

- **Thailand:** Keynote talk at the 8th Int. Conf. on Artificial Intelligence, Automation and Control Technologies (AIACT 2024), Phuket, Thailand, February 29 - March 2, 2024.
- **Qatar:** Invited talk at the Texas A & M University at Qatar, Doha, March 23 - 26, 2024.
- **Russia:** Keynote talk at Data Fusion Conference 2024 (Nation-wide top-level event on AI & Data Science), Moscow, Russia, April 17 and 18, 2024.

### 2025

- **USA:** Collaborative research work in biomedical engineering with Johns Hopkins University (JHU), Baltimore, MD, USA during July 11-19, 2025. Paid visits to different centers/units of JHU including a) Carnegie Center for Surgical Innovation, b) Ding Research Lab and Cancer Research Facilities, and c) Medical Image Computing and analysis Lab in the medical campus of JHU.
- **China:** Keynote Talk at Symposium on AI, Southwest University, Chongqing, October 19-20, 2025

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## Annexure H

### Examples of Committees Served in India and Abroad (list is not exhaustive)

#### *India:*

- Chairman, Recruitment and Assessment of Scientists, Defence Research and Development Organization (DRDO), Govt. of India.
- Chairman, Project Review and Steering Group (PRSG) for the project “Development of Isolating Tools for Steganographic Images”, CDAC, MIT, Govt. of India.
- Chairman, Project Review and Steering Group (PRSG) for the project “Setting up of National Resource Center on steganography”, CDAC, MIT, Govt. of India.
- Chairman, Information Technology (IT) Academic Council, Govt. of West Bengal.
- Chairman, Syllabus Committee for classes VI to XII, CLTP (Computer Literacy Training Program), West Bengal Board of Secondary Education (WBBSE), Govt. of West Bengal.
  
- Member, Search Committee for selecting the Chairman, Chief Statistician of India, and four members of the Statistical Commission, Ministry of Statistics and Program Implementation (MOSPI), Govt. of India.
- Member, Selection Committee for Vice-Chancellor, Central South Bihar University, Bihar.
- Member, Selection Committee for Director, National Institute of Technology (NIT), Calicut, Kerala.
- Member, Selection Committee for Deputy Director, IIT Kharagpur
- Member, Search cum Selection Committee for selecting the First Vice-Chancellor of Presidency University, Kolkata, 2010.
  
- Member, Governing Council, Indian Association for Cultivation of Science (IACS), Kolkata.
- Member, Board of Governing Body, Indian Institute of Science Education and Research (IISER) Kolkata.
- Member, Board of Governors, DM-IIIT, Jabalpur.
- Member, First Governing Council, Presidency University, Kolkata.
- Member, Governing Board, Birla Industrial and Technological Museum (BITM), Kolkata.
- Member, Research Advisory Council, Central Scientific Instrument Organization, CSIR-CSIO, Chandigarh.
- Member, Governing Council, National Academy of Sciences, India (NASI), 2017-2018.
- Member, Governing Council, Indian National Academy of Engineering (INAE), 2007-2008.
- Member, Governing Council, Indian Science Congress Association (ISCA), 2023-24.
  
- Member, Govt. Appointed Review Committee for overall performance of IIT Kharagpur, 2011.
- Member, Govt. Appointed Review Committee for subject-wise performance of IISER Kolkata, 2011.
- Member, Programme Development and Advisory Committee (PDAC) for **Big Data Initiative**, DST, Ministry of Science & Technology, Govt. of India, 2014-2015 (OM date: 22, 05, 2014).
- Member, Technical Advisory Group (TAG), Biotechnology Industry Research Assistance Council (BIRAC), DBT, Govt. of India, 2018 to date.
- Member, Technical Advisory Group, Grand Challenge India (GCI) - Immunization Data: Innovating for Action (IDIA) program, under the joint venture of Biotechnology Industry

- Research Assistance Council (BIRAC), DBT, Govt. of India, and Bill & Melinda Gates Foundation (BMGF), USA, 2019-2023.
- Member, **Covid-19 India National Supermodel** Committee, SERB-DST, Govt. of India. 2020 to 2021 (OM date: 27. 05. 2020).
  - Member, Advisory Committee, Shanti Swarup Bhatnagar Prize (Engineering Sciences), CSIR, New Delhi, Govt. of India. (11 times since 1993)
  - Member, Advisory Committee, CSIR Young Scientist Award, CSIR, New Delhi (5 times).
  - Member, Advisory Committee, Swarnajayanthi Fellowship, Dept. of Science and Technology (DST), New Delhi, Govt. of India.
  - Member, Empowered Committee for implementation of Awards and Fellowships for outstanding and meritorious research work in Statistics, Ministry of Statistics and Program Implementation, Govt. of India.
  - Chairman, Sectional Committee, Indian National Academy of Engineering (INAE), New Delhi.
  - Member, Sectional Committee (Engineering Sciences), Indian National Science Academy (INSA), New Delhi. (Sectional Committee 4: 01.01.1998 to 31.12.2000 and 01.01.2011 to 31.12.2011; Sectional Committee 5: 01.01.2012 to 31.12.2013)
  - Member, Sectional Committee (Engineering and Technology), Indian Academy of Sciences (IASc.), Bangalore.
  - Sectional President, Physical Sciences, National Academy of Sciences, India (NASI), Prayagraj, 2009.
  - Member, Fellowship Scrutiny Committee, National Academy of Sciences (NASI), Prayagraj. (2 different periods of time)
  - Member, Platinum Jubilee Young Scientist Award Selection Committee, National Academy of Sciences (NASI), Prayagraj. (2 different periods of time)
  - Advisor, National Academy of Sciences, India (NASI), Kolkata Chapter, Feb 2019 to date
  - Member, INSA-INSPIRE Faculty selection committee, Govt. of India.
  - Member, Advisory Committee, Fund for Improvement of Science & Technology Infrastructure in Universities, and other Higher Educational Institutions (FIST), DST, New Delhi, Govt. of India.
  - Member, Project Advisory Committee (PAC), Electrical, Electronics and Computer Engineering, DST, New Delhi, Govt. of India.
  - Member, Engineering Sciences Research Committee (ESRC), CSIR, New Delhi.
  - Member, Steering Committee, Research Projects, DOE, New Delhi, Govt. of India.
  - Member, Project Review Committee (PRC), Bharat Heavy Electricals Ltd. (BHEL), Hyderabad.
  - Member, Governing Council of Delhi University, New Delhi.
  - Member, Expert Committee of Post Graduate Courses, Indira Gandhi National Open University (IGNOU), New Delhi.
  - Member, Academic Committee, Indian Institute of Information Technology (IIIT), Allahabad.
  - Member, Promotional Assessment Committee (PAC), Indian Institute of Science, IISc, Bangalore. (12 consecutive years since 2006)
  - Member, ITBT Task Force, Govt. of West Bengal.
  - Member, Science and Technology Council, Govt. of West Bengal.
  - Member, IT Cell, Maulana Abul Kalam Azad University of Technology (erstwhile West Bengal University of Technology), West Bengal
  - Member, Faculty Recruitment/Promotional Committee in different Institutes such as IIT Delhi, IIT Kharagpur, IIT Roorkee, Visva-Bharati University, Santiniketan, Benaras

Hindu University, Veer Surendra Sai University of Technology, Sambalpur, Jadavpur University, Calcutta University, Tezpur Central University, Manipur Central University, SRM University, Chennai, and SRM University, Amaravati.

- Vice President, Indian Science News Association, Calcutta, 2007
- Member, Board of Governors (BOG), Adamas Institute of Technology, Barasat, West Bengal, 2011
- Member, Advisory Committee, Bennett University (Times of India Group), Greater Noida, Uttar Pradesh, 2023
- Member, Governing Board, Brainware University, Barasat, West Bengal, May 2025 to May 2028
  
- Chairman of all important committees of ISI nationwide as its Director during 2005-2010, and as Prof-In-Charge of the then Physical and Earth Sciences Division of ISI during 1988-1990.
- Charman, Ph.D./D.Sc. Committee, Indian Statistical Institute, Kolkata.
- Chairman, M.Tech. Syllabus Committee, Indian Statistical Institute, Kolkata.
- Chairman, Intellectual Property Rights (IPR) Committee, Indian Statistical Institute, Kolkata.
- Convener, Policy Planning and Evaluation Committee (PPEC), Indian Statistical Institute, Kolkata.
- Member, 4<sup>th</sup> Pay Scale Review Committee implementation for Faculty, Indian Statistical Institute, Kolkata.
- Member, Review Committee for the Protection of Research Risk to Human, Indian Statistical Institute, Kolkata.

***Abroad:***

- Director, Web Intelligence Consortium (WIC) India Center. 2003
- Vice-President, International Artificial Intelligence Industry Alliance, 2023
  
- Member, Project Evaluation Committee, NASA, USA, 1990-92, and 1994
- Member, IEEE Fellow Selection Committee, Neural Networks Council, USA, 1994
- Member, Advisory Board, IEEE (USA) Distinguished Visitor Program for Asia Pacific Region, 1999
- Member, Project Evaluation Committee, Hong Kong Research Council, Hong Kong since 2003
- PhD Co-Supervisor (with Dr. Simon CK Shiu), Hong Kong Polytechnique University, Hong Kong, 2003 (PhD Students: Mr. Niu Ben and Ms. Yan Li)
- Member, Foreign Expert, M. Phil. Thesis Evaluation Committee, Hong Kong Polytechnique University, Hong Kong, 2002.
- Member, External Expert Panel for Post Graduate IT Management Course, Hong Kong Baptist University, Hong Kong, 2004
- PhD Thesis Foreign Examiner, University of Naples, Italy, 2010 (PhD student: Ms. Alessia Albanese)
- Member, Advisory Board, International Rough Set Society, 2011
- Member, Expert Committee to evaluate the “Centre for New Methods in Computational Diagnostics and Personalized Therapy (SANO)” as a part of The International Research Agenda Program PLUS, Poland, 2022

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### Europe-Wide Research Activities: Some Examples

- **Conducted PhD and Post-doctoral research** in Electrical Engineering Department, Imperial College of Science and Technology, University of London, UK during September 1979 - May 1983. with Commonwealth Scholarship, UK, and Medical Research Council Post-Doctoral Fellowship UK. He pioneered the development of “fuzzy set theoretic image processing” research with his PhD Advisor/ Mentor Dr. Robert A. King. Since a gray tone image possesses some ambiguity within the pixels due to the possible multivalued levels of brightness, its regions, boundaries, edges, skeletons, relations etc. are ill-defined and do not lend themselves to precise definition. His research introduces some basic models and tasks, like gray image definition, image enhancement, edge detection, primitive extraction, image ambiguity measures (entropy and index of fuzziness), and image thresholding/segmentation in the notion of fuzzy set theory. Here one avoids committing oneself to a specific segmentation (i.e., either 0 or 1 of pixel-membership) and allows the segments to be fuzzy subsets (i.e., continuum pixel membership in  $[0,1]$ ) of the image. See for example, *Electron. Letters*, 1980; *IEEE-SMC*, 1981, 1983; *IEEE-PAMI*, 1982, 1983; and *Pattern Recognition Letters*, 1983. Images were collected from Philips Research Lab, Redhill, Surrey (in the form of paper tape), and Institute of Sick Children, London (X-ray plates of hand and wrist). These basic models and definitions developed have laid the foundation (building blocks) of fuzzy/soft computing-based image processing and vision research. His work is perhaps the first investigation that brings out the root relation between the abstract concept of fuzzy sets and image processing tasks.
- **Established sustained and extensive research collaborations** with many other European institutions and centers where he held numerous visiting positions. Many articles, books, journal special issues, theses, and conference proceedings were published out of these collaborations. For example, in Warsaw University, Poland, his collaboration (1997-2017) began under INDO-POLISH joint Government program, with Prof. Andrzej Skowron, Institute of Mathematics, Warsaw University and Prof. Zdzisław Pawlak (Father of Rough Sets), Warsaw Technical University. Notably, the “Rough-Fuzzy “computing paradigm was conceptualized during his first visit there in 1997 (Pal and Skowron book, Springer, 1999). This collaboration, particularly with Professor Pawlak (the creator of rough sets) and Prof. Skowron’s research group, has been instrumental in earning several of his team’s achievements and laurels at Indian Statistical Institute (ISI), Kolkata in the said area including the establishment of the world class Center for Soft Computing Research, funded by the Department of Science & Technology, Govt. of India. The research initiated by the said cooperation, including their joint projects, and continued by himself and his team for years at ISI, Kolkata have laid the foundation for, and led to, numerous modern technologies and important real-world applications of these hybrid methodologies in AI and data science.

Similarly, in Naples University Parthenope, Italy, his collaboration (2004-2020) started with Prof. Alfredo Petrosino, Applied Mathematics Department, under a joint agreement between two Institutes to utilize his expertise in soft computing and data mining in strengthening a research group there. The concept of “Kernel Set“ of rough outlier sets for spatio-temporal outlier detection is an example outcome (*IEEE-TKDE*, 2014), among others, which has wider applications in data science and analytics. Collaboration in INSEAD, France (2001-13) was in the area of web intelligence with

Prof. Soumitra Dutta, (the then) Dean, School of IT Management. INSEAD provided a grant to ISI-Kolkata to support his PhD students. Interesting concepts concerning, e.g., web surfer model (IEEE-TKDE, 2005) and dispersion index for pattern classification (Pattern Recognition, 2012) resulted.

- **Total Articles Published** under collaboration (with UK, Italy, Poland and France): **28** (Journal: 19, Conference: 5, Book Chapter: 4)
- **Books Published: 3** (i) S.K. Pal, A. Petrosino and L. Maddalena (Eds.), Handbook in Soft Computing for Visual Surveillance, Chapman & Hall/ CRC Press, Boca Raton, Florida, 2012; ii) S.K. Pal, L. Polkowski and A. Skowron (Eds.), Rough-Neural Computing: Techniques for Computing with Words, Springer, Heidelberg, 2003; iii) S.K. Pal and A. Skowron (Eds.), Rough Fuzzy Hybridization: A New Trend in Decision Making, Springer, 1999)
- **Journal Special Issues Guest-Edited: 8** (i) P. Maji, S.K. Pal, and A. Skowron, "Pattern Recognition and Mining", Natural Computing, vol. 15, no. 3, 2016; ii) S.K. Pal, S. Meher and A. Skowron, "Granular Mining and Knowledge Discovery", Pattern Recognition Letters, vol. 67, part 2, pp. 109-112, 2015; iii) C. Cornelis, H.S. Nguyen, S.K. Pal, A. Skowron and W.Z. Wu, "Rough Sets and Fuzzy Sets", Fundamenta Informaticae, vol. 142, nos. 1-4, December 2015; iv) A. Petrosino and S.K. Pal, "Decision Making in Human and Machine Vision", IEEE T-SMC: Systems, vol. 44, no. 5, 2014; v) H.S. Nguyen, S.K. Pal and A. Skowron, "Rough sets and Fuzzy sets in Natural Computing", Theoretical Computer Science - C, vol. 412, no. 42, 2011.; vi) S.K. Pal and A. Skowron, "Rough Sets, Pattern Recognition and Data Mining", Pattern Recognition Letters, vol. 24, 2003; vii) S.K. Pal, W. Pedrycz, A. Skowron and R. Swiniarski, "Rough-neuro Computing", Neurocomputing, vol. 36, nos. 1-4, 2001; viii) S.K. Pal and A. Skowron, "Soft Computing", Fundamenta Informaticae, vol. 37, nos. 1-2, 1999.)
- **Conferences Jointly Organized & Proceedings: 4** (i) M. Kryszkiewicz, S. Bandyopadhyay, H. Rybinski and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (6th Int. Conf, PReMI 2015, Proceedings, Warsaw, Poland), LNCS, vol. 9124, Springer, Heidelberg, 2015; ii) S.O. Kuznetsov, D.P. Mandal, M.K. Kundu and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (4th Int. Conf. on PReMI 2011, Proceedings, Moscow, Russia), LNCS, vol. 6744, Springer, Berlin, 2011; iii) V. Gesu, S.K. Pal and A. Petrosino (Eds), Fuzzy Logic and Applications (8th Int. Workshop on Fuzzy Logic and Appls., Proceedings, Palermo, Sicily, Italy), LNAI, vol. 5571, Springer, Berlin, 2009; iv) D. Slezak, S.K. Pal et al, (Eds.), Signal Processing, Image Processing and Pattern Recognition (2009 Int. Conf. on Signal Processing, Image Processing and Pattern Recognition, SIP 2009 Proceedings), Communications in Computer and Information Science, vol. 61, Springer, Berlin, 2010.)
- **Visiting Fellowship:** With his active initiative many of his PhDs and post-docs were/ are in Europe for joint training and academic visits with Commonwealth Scholarship, Humboldt and DAAD Fellowship, or some other programs.
- **Some Example Named/ Keynote Lectures Delivered** in Europe since 2003:

1. Keynote talk at the 5th Int. Workshop on Fuzzy Logic and Applications (WILF 2003), Istituto Italiano Studi Filosofici, Palazzo Serra di Cassano, Naples, **Italy**, October 9-11, 2003.
2. Plenary talk at the MSRAS-2004, Plock, **Poland** and two invited Talks at Warsaw University, **Poland**, June 7-9, 2004.
3. Series of invited talks on Pattern Recognition and Machine Intelligence at the University of Trento, Trento, **Italy**, October 24-30, 2004.
4. Keynote talk at the 6th Int. Workshop on Data Analysis in Astronomy, Erice, **Italy**, April 15-18, 2007.
5. A series of invited talks at the University of Naples, **Italy**, April 19-22, 2007.
6. Attended the TWAS Meeting, Trieste, **Italy**, and delivered a Guest Lecture at the University of Naples, **Italy**, November 12-18, 2007.
7. *Zdzislaw Memorial Plenary Talk* at the Int. Conference on Rough Sets and Emerging Intelligent Systems Paradigms (RSEISP), Warsaw, **Poland**, June 29, 2007.
8. Invited talk at INSEAD, Fontainebleau, **France**, June 27-30, 2008.
9. A series of invited talks (under a ISI - EU project) at the University of Trento, **Italy**, February 4-10, 2009
10. Keynote talk at the Int. Workshop on Fuzzy Logic and Applications (WILF'09), University of Palermo, **Italy**, June 9-12, 2009.
11. A series of lectures at the University of Naples, **Italy**, under ISI-Naples Univ. collaborative program, during June 13-20, 2009
12. Invited talk at the University of Milano, **Italy**, June 21-22, 2009.
13. Invited talk at the Int. Conference for Digital Libraries and the Semantic Web (ICSD 2009), University of Trento, **Italy**, September 8-12, 2009.
14. *Zdzislaw Pawlak Memorial Plenary Talk* at the 7<sup>th</sup> Int. Conference on Rough Sets and Current Trends in Computing (RSCTC), Warsaw, **Poland**, June 28, 2010.
15. Keynote talk at 4th Int. KES Symposium on Agents and Multi-Agent systems - Technologies & Applications, Gdynia, **Poland**, June 23-26, 2010.
16. Keynote talk at 7th Int. Conference on Rough Sets & Current Trends in Computing, RSCTC 2010, Warsaw, **Poland**, June 28-30, 2010.
17. Keynote talk at 7th Int. Workshop on Data Analysis in Astronomy (DAA2011), Erice, **Italy**, 11-15, 2011.
18. Talk at 4th Int. Conference on Pattern Recognition and Machine Intelligence (PReMI-11), Moscow, **Russia**, as its General Chair, June 25-30, 2011
19. Invited talk at the University of Padova, **Italy**, September 23-24, 2011.
20. Invited talks at 2012 Int. Falls School in Natural Computing (FSNC 2012), Tarragona, **Spain**, November 19-23, 2012.
21. Keynote talk at the 23rd Italian Workshop on Neural Networks, Vietri, Salerno, **Italy**, May 22-25, 2013.
22. Invited talk at the Int. Conf. on Image Analysis and Processing (ICIAP), Naples, **Italy**, Sept 10-13, 2013.
23. Plenary Talk at the 6th Int. Conference on Pattern Recognition and Machine Intelligence (PReMI'15), Warsaw University of Technology, Warsaw, **Poland**, June 2015.
24. Invited talk at the Szechenyi Istvan University, Gyor, **Hungary**, November 13-16, 2015.
25. Invited Talks at the Universitat Paderborn, **Germany**, November 22-25, 2015.

26. Invited Talk at German Workshop on Computational Intelligence, Dortmund, **Germany**, Nov 26-27, 2015.
27. Series of Invited Talks at the 2nd Int. Winter School on Big Data (BigDat 2016) at University of Deusto, Bilbao, **Spain**, February 7–11, 2016.
28. Talks at Data Mining Services, Ltd., Windsor, **U.K.**, under a collaborative meeting, June 13 - 15, 2016.
29. Invited talk at Santander Bank, London, **U.K.**, June 17, 2016.
30. Keynote talk at the Int. Joint Conference on Rough Sets, IJCRS 2017, University of Warmia and Mazury, Olsztyn, **Poland**, July 3-7, 2017.
31. Invited talks at the Dept. of Science and Technology, University of Naples, Parthenope, Naples, **Italy**, Nov 19-22, 2017.
32. Invited talk at the University of Genoa, **Italy**, November 23-24, 2017.
33. Series of invited talk(s) at 5th Int. School on Big Data (BigDat 2019), University of Cambridge, **U.K.**, January 7-11, 2019.
34. Collaborative research work jointly with Arndit Ltd., St. John's Innovation Center, Cowley Road, Cambridge CB4 OWS, **U.K.**, and the Department of Engineering, University of Cambridge, **U.K.** during July 30 to August 27, 2023.
35. Keynote speaker at Data Fusion Conference 2024 (Nation-wide top-level event on AI & Data Science), Moscow, **Russia**, April 17 and 18, 2024.

- **Other Activities:**

- Editorial Board Member of several journals like Pattern Recognition Letters, Information Sciences, Fuzzy Sets and Systems, Neurocomputing, Int. J. Approximate Reasoning, and Fundamenta Informaticae which are published by **Netherlands based** publishing companies such as **Elsevier and IOS Press**.
- Book Series Editor: Frontiers in Artificial Intelligence and Applications, IOS Press, **Netherlands** based publishing house.
- Editor of eleven LNCS/ LNAI publications from Springer Heidelberg, **Germany**
- Author of six books by Springer, Berlin or Heidelberg, **Germany**
  
- PhD Thesis Foreign Examiner, University of Naples, Parthenope, Italy, 2010 (PhD student: Ms. Alessia Albanese)
- Member, Expert Committee to evaluate the “Centre for New Methods in Computational Diagnostics and Personalized Therapy (SANO)” as a part of The International Research Agenda Program PLUS, Poland, 2022.

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### Outreach Academic Activities: Some Examples

Prof. Pal has been involved in contributing to various Science Outreach Programs in India since 2001. These are mentioned, with dates & topics and his role, as follows:

#### A. Outreach programs organized and attended for undergraduate and post-graduate students at North-East Regions of India

1. One Week Workshop on Recent Advances in Engineering Science and Technology. NIT Sikkim, Ravangla, South Sikkim, March 1-5, 2020 (jointly organized by NIT Sikkim and the INAE Kolkata Chapter when Prof. SK Pal was its President)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural, Keynote and Valedictory speeches
2. ISI-MZU School on "Soft Computing Techniques: theory and Applications", Department of Mathematics & Computer Science, Mizoram University, Aizawl, March 20-24, 2017.  
Role of SK Pal: Organizing and delivering the Inaugural and Keynote speeches
3. NORTH-EAST-ISI-ADBU summer school on "Soft Computing Paradigm and Machine Intelligence Techniques", Department of Computer Science and Information Technology, Assam Don Bosco University, Airport Road, Azara, Guwahati, July 07-11, 2016. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
4. Winter School on "Soft Computing Methodologies in Bioinformatics", Department of Agricultural Statistics, Assam Agricultural University, Jorhat, Assam, December 04-08, 2015. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
5. ISI-NIT Silchar Spring School on "Computational Biology: Tools and Techniques", Department of Computer Science and Engineering, National Institute of Technology, Silchar, Assam, March 20 – 24, 2015. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
6. ISI-SU Autumn School on "Machine Intelligence and Applications", Sikkim University, Gangtok, Sikkim, September 22– 26, 2014. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Keynote and valedictory speeches
7. ISI-TU Winter School on "Pattern Recognition and Image Processing", Tripura University, Agartala, Tripura, March 25-29, 2014. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to

Inaugural and Keynote speeches

8. Workshop on Contemporary and Future Perspectives of Bio-Engineering in Medical Science and Technology, NIT-Agartala, Tripura, July 9, 2013.  
Role of SK Pal: Delivering a distinguished lecture to students
9. International Conference on Rough Sets, Fuzzy Sets and Soft Computing (ICRFSC-13), Tripura University, Agartala, Jan 17-19, 2013.  
Role of SK Pal: Delivering a few lectures in the course, in addition to a Keynote speech
10. ISI-MZU School on "Soft Computing and Applications", in collaboration with Mizoram University (MZU), Aizawl, November 5-9, 2012. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural, Keynote and Valedictory speeches
11. ISI-NEHU Winter School on "Soft Computing, Pattern Recognition and Image Processing", North-Eastern Hill University, Shillong, Meghalaya, October 20 – 24, 2011. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
12. ISI-TU Assam Winter School on "Soft Computing", Tezpur University, Assam, December 20-23, 2011. (Organized by Machine Intelligence Unit, ISI whose founder is Prof. SK Pal.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
13. ISI-DST Nagaland Winter School on "Bioinformatics", DST, Nagaland, Kohima, March 8-12, 2010. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was the Director of ISI.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
14. ISI-SMIT Winter School on "Image Processing and Machine Vision", SMIT, Majitar, Rangpo, Sikkim, March 9-13, 2009. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was the Director of ISI.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
15. ISI-MU Winter School on "Data Mining and Computational Biology", Imphal, Manipur, January 28-February 01, 2008. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was the Director of ISI.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Keynote speech
16. ISI-AU Winter School on "Image Processing and Analysis", Assam University, Silchar, January 18-22, 2007. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was the Director of ISI.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches

17. ISI-TU Winter School on "Pattern Recognition and Machine Intelligence", Tripura University, Agartala, January 17-21, 2006. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was the Director of ISI.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
18. Workshop on "Multimedia Systems & Communication", Dept. of CS & IT, Tripura University, Agartala, January 06, 2006  
Role of SK Pal: Invited speaker
19. ISI-NERIST Winter School on "Soft Computing, Data Mining and Bioinformatics", Nirjuli, Arunachal Pradesh, February 14-18, 2005. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was its founding head.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Keynote and Valedictory speeches
20. ISI Spring School on Data Mining and Bioinformatics: Recent Trends, SMIT, Majitar, Rangpo, Sikkim, March 22-26, 2004. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was its founding head.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural, Keynote and Valedictory speeches
21. ISI Autumn School on "Pattern Recognition and Data Mining with Applications to Web & Biological data", North Eastern Hill University, Shillong, September 23-27, 2003. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was its founding head.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural and Keynote speeches
22. ISI Winter School on "Soft Computing, Pattern Recognition, Image Processing and Data Mining", Aizawl, Mizoram, November 20-22, 2001. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was its founding head.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural, Keynote and Valedictory speeches
23. ISI Spring School on "Soft Computing, Image Processing and Data Mining", Gauhati University, Guwahati, March 12-16, 2001. (Organized by Machine Intelligence Unit, ISI when Prof. SK Pal was its founding head.)  
Role of SK Pal: Organizing and delivering a Series of lectures in the course, in addition to Inaugural, Keynote and Valedictory speeches

**B. Outreach activities for popularizing machine intelligence, data mining and related research to school & college students**

24. Engineers' Day celebration organized by INAE Kolkata chapter at the Academy of Technology, Adisaptagram, Hooghly District, West Bengal, September 15, 2024  
Role of SK Pal: Chief Guest and delivering the keynote talk to undergraduate college students on "Machine Intelligence: Why, How and What Should".
25. "AI based activities" under the banner of CSIR's JIGYASA (a flagship programme of CSIR, GoI, on student-scientist connect) for school and college students, Organized by

CSIR-Central Electrochemical Research Institute, Karaikudi, Tamil Nadu, August 30, 2023

Role of SK Pal: Chief Guest and delivering a talk to a group of selected school and college students on “Machine Intelligence: Why and How”.

26. AICTE-Distinguished Chair Professorial Lecture series at Bombay College of Pharmacy, Mumbai, The Indian Pharmaceutical Association-Maharashtra State Branch, January 8, 22, and 29, 2022

Role of SK Pal: Delivering a series of invited talks (online) in three days as AICTE Distinguished Chair Professor on “Soft Computing, Machine Intelligence and Data Mining”.

27. Tathva'19: Students' Annual Techno-management Fest, National Institute of Technology, Calicut, India, October 19, 2019

Role of SK Pal: Delivering a Tathva lecture to students on “Pattern Recognition, Machine Intelligence to Data Science: Evolution and Challenges - A journey over 45 years”.

28. IEEE Student Section, Surathkal, Karnataka, February 21, 2014

Role of SK Pal: Delivering an invited lecture to undergraduate and postgraduate students on “A, B, C of Big-Data & Relevance of Soft Computing”.

29. Prof. Ram Meghe College of Engineering & Management, Badnera, Amaravati, Maharashtra, January 20, 2014

Role of SK Pal: Delivering a few invited talks to undergraduate students on “Soft Computing, Machine Intelligence and Granular Data Mining: An Overview”.

30. ST. Thomas' College of Engineering. and Technology, Kolkata, October 09, 2013.

Role of SK Pal: Delivering an invited lecture to college students on “Soft Computing, Machine Intelligence and Granular Data Mining: An Overview”.

31. Kumaraguru College of Technology, Coimbatore, Tamil Nadu, December 10, 2011.

Role of SK Pal: Delivering an invited lecture on “Fuzzy Logic” to students and faculty in connection with Faculty Development Program on “Introduction to Machine Learning – Theory and Applications”,

32. Summer Camp of School Students under INSPIRE Internship Program of DST, Govt. of India at Visva-Bharati, Santiniketan, West Bengal, August 10, 2009.

Role of SK Pal: Addressing the school students on the topic “Pattern Recognition and Machine Intelligence: Why and How”.

33. Aditya Institute of Technology and Management, K. Kotturu, Tekkali, Srikakulam District, Andhra Pradesh, [June 27, 2009](#).

Role of SK Pal: Delivering an invited talk to undergraduate students on “Classification Methods for Data Mining: Tasks, Issues & Challenges”.

34. GR Govindarajulu School of Applied Computer Technology, PSGR Krishnammal College for women, Coimbatore, Tamil Nadu, June 25, 2009

Role of SK Pal: Delivering the Keynote talk on “Research Methods and Research Directions in Computer Science and Engineering” in a Symposium.

35. MVGR College of Engineering, Vizianagaram, Andhra Pradesh, May 18, 2009

Role of SK Pal: Delivering the Inaugural Speech and Keynote talk on Machine Learning in a FDP program.

36. Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya (SCSVMV University), Enathur, Kanchipuram, Tamil Nadu, September 30, 2008

Role of SK Pal: Delivering a seminar talk on Web Information Systems and Technologies to students and research scholars

37. Mepco Schlenk Engineering College, Sivakasi, Tamil Nadu, December 13, 2007.

Role of SK Pal: Delivering invited talks to students on “Machine Intelligence, Computational Theory of Perception and Rough-fuzzy Computing”

38. Durgapur Institute of Advanced Technology and Management, Durgapur, West Bengal, May 28, 2007.

Role of SK Pal: Delivering an invited talk on “Data mining and Machine Intelligence”.

39. New Arts, Commerce and Science College, Ahmednagar, Maharashtra, January 28 and 29, 2007.

Role of SK Pal: Delivering invited talks on “Fuzzy Mathematics and its Applications”

40. St Margarets (or St Edmund's) School, Shillong, Oct 18, 2004.

Role of SK Pal: Delivering an invited talk to higher secondary school students on “Pattern Recognition: An Introduction”.

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**Facility/ Infrastructure Developed and Outcome at ISI Kolkata: Center for Soft Computing Research**

*Facility/Infrastructure Developed and Outcome at  
Center for Soft Computing Research (CSCR)*

(An Associate Institution of ISI)

<https://www.isical.ac.in/~scc>

Location: 1<sup>st</sup> Floor, R.A. Fisher Bhavan, Indian Statistical Institute, Kolkata 700 108

Area: 1045 (12.86m x 81.26m) Sq meter

Funded by: Department of Science and Technology, Govt. of India till January 2016.

Fund sanctioned by DST: Rs. 6,38,56000.00

Inaugurated by: Prof. M.G.K. Menon, FRS on 25<sup>th</sup> October 2005

**Founder and Principal Investigator: Prof. Sankar Kumar Pal**

• **No. of Labs: 5**

Major Lab Equipment as in October 2024:

- i) Desktops: 40
- ii) Laptops: 03
- iii) Colour Printer: 02
- iv) Black and White Printer: 10
- v) Scanner: 02
- vi) GPU Server: 01
- vii) UPS: 01
- viii) Wifi Modem: 03
- ix) Projector Machine: 02
- x) Network Switch: 09
- xi) Projector Screen: 01
- xii) Xerox Machine: 01
- xiii) Photocopier Machine: 01
- xiv) White Board: 08

- Meeting Room/ Library: 01
- Conference Room: 01
- Visitor's Room: 01
- Office: 01
- Faculty Room: 06
- Research Associate Room: 03
- Trainee rooms
- Other office and computer rooms

## Research Areas:

- Deep Learning
- Data Science and Machine Learning,
- Automated Pollution Prediction and Rainfall Prediction
- Cognitive Science, Cybernetics,
- Information processing in plants and small animals,
- Computational Biology,
- Psychophysics,
- Graph Manipulation Algorithms,
- Information Technology for Accessibility and Health Care Applications,
- Granular Mining,
- Granular Deep Learning,
- Uncertainty Modelling, Explainable AI,
- Computational Theory of Perception,
- Rough Sets, Z-numbers, Safety Analytics,
- Pollution and Climate Analytics, Video Analytics,
- Human Detection and Tracking in Human-Robot Coexisting Environments,
- Remote Sensing, and Soft Computing Technology.
- Bioinformatics,
- Computational Biology,
- Neural Networks,
- Soft Computing

## Research Outcome so far:

No. of Publications (as per CSCR Website)

Books: 26 (Authored: 05, Edited – 21)

Book Chapters – 35

Journal Papers – 219

Conference Papers – 117

Patents – 03

## List of Manpower Trained:

**Ph.D:** 18 (Awarded – 16, Submitted – 2)

**Scholars received PhD degrees:** Shubhra Sankar Ray, JU (2008-09), Minakshi Banerjee CU (2008-09), Debasish Sen JU (2011-12). Dinabandhu Bhandari, JU (2012-13), Aninda Halder, JU (2013-14), Moumita Roy, JU (2014-15), Avatharam Ganivada, CU (2015-16), Debarati Chakraborty, JU (2016-17), Suman Kundu JU (2017-18), Alok Datta, JU (2017-18), Bhaskar Dey, CU (2017-18), Romi Banerjee, CU (2019-20), Jayanta Pal, CU, (2021-22), Anjan Chowdhury, ISI (2024-25), Shibsankar Roy, CU (2025-26), Joginder Singh, ISI (2024-25), Keerthi S. Chandra, ISI (2024-25),

(For details of PhD theses, see <https://www.isical.ac.in/~scc>)

**Post-docs: 25**

Alok K Deb	Sankha Deb	Mohd Abdul Hai Zahid
Haider Banka	Kuntal Ghosh	Pradipta Maji
Sujata Ghosh	Saroj Kumar Meher	Debashis Sen
Rajarshi Pal	Syeda Darakshan Jabeen	Minakshi Banerjee
Parthapratin De	Saurabh Das	A.H. El-Baz
Debarati Chakraborty	Satabdi Ghosh	Romi Banerjee
Pritam Paral	D. Arun Kumar	Chandrani Chatterjee
Debashree Dutta	Anima Pramanik	Saikat Biswas
Sayani Adak		

Master's level dissertations: 61

IASC summer trainees and other bachelor's level projects: 119

Other trainees: 53

**Visiting Professor: 1****Current Research Staff strength:**

- Associated/ Deputed faculty: 4
- Post-Doc: 4
- Research Fellow and Project linked person: 7

**External funded projects carried out: (Apart from Center for Soft Computing Research Fund)**

Sl. No.	Name of the Project	Principal Investigator	Funded by	Tenure & Grant
1.	J.C Bose Fellowship	Prof. Sankar K. Pal	DST, New Delhi	2006-2018 Fellowship Rs.25,000/month up to Sep 20215 and Research Gran Rs. 15,00,000/ year up to Sept 2018
2.	Indo-Brazil Collaborative Project	Prof. Sankar K. Pal	DST, New Delhi	2010-2013 Rs. 16,92,680/
3.	INAE Chair Professor	Prof. Sankar K. Pal	INAE	2013-2014
4.	Erasmus Mundus External Co-operation (EMECW)	Prof. Ashish Ghosh	European Commission	2014-2016
5.	DST INSPIRE Faculty Award	Dr. Saurabh Das	DST, New Delhi	2015-2018 Rs. 47,10,773/
6.	DAE Raja Ramanna Fellowship	Prof. Sankar K. Pal	DAE, Govt of India	2015-2018 Rs. 30,89,493/
7.	NaVIC GAGAN Utilization Programme, SAC, ISRO	Dr. Saurabh Das	ISRO	2016-2018 Rs. 20,00,000/

8.	Understanding vision from filling in and visual illusion perspectives with the help of computational modeling	Dr. Kuntal Ghosh	DST (CSRI)	2017-2021 Rs. 16,84,000/
9.	INSA Distinguished Professor	Prof. Sankar K. Pal	INSA	2018-2020 Rs.27,00,000/
10.	Development of computer vision based 3D Indian sign languages recognition to assist differently abled	PI: Sandipa Ray Mentor: Dr. Kuntal Ghosh	WOS-B, DST, Govt. of India	2017-2021 Rs.9,85,500/
11.	Influence of socio-economic status in the relationship between central obesity and cognitive development of school children of Kolkata, India and the changes in serum leptin and insulin resistance in different grades of central obesity	PI: Dr. Satabdi Ghosh Mentor: Dr. Kuntal Ghosh	NPDF Scheme, SERB, Govt. of India	2018-2020 Rs.16,50,000/
12	Networking on Data Science and Machine Learning under DST-ICPS Programme	Prof. Ashish Ghosh	DST-ICPS Programme	2019-2023 Rs.81,95,000/
13.	Coordination of Cluster Projects under Data Science Research	Prof. Ashish Ghosh	DST ICPS Programme	2019-2023 Rs.40,60,000/
14.	National Science Chair	Prof. Sankar K. Pal	SERB, DST, GOI	2020-till date Rs. 1,34,00,000/
16.	Towards development of assistive technology for Indian sign language: cognitive analysis and application development	PI: Sandipa Ray Mentor: Dr. Kuntal Ghosh	WOS-B, DST, Govt. of India	2021-till date Rs. 17,71,000/
17.	Unearthing the heterogeneity in virulence using both ICMR COVID-19 testing data and other primary data	Dr. Kuntal Ghosh	ICMR	2022-2024 Rs.15,35,020/
18.	Center for Distributed Deep Learning Framework for Classification	Prof. Ashish Ghosh	INDO-US Science & Technology USSTF)	2021-2023 Rs. 13,72,913/
19.	Understanding the Impact of 'Invasive' and 'Non-Invasive' Stimuli on Cognitive Intelligence of	Dr. Kuntal Ghosh	DST, GoI (WISE KIRAN)	2023-till date Rs.13,72,913/

	Adult Zebrafish			
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**Note:** PhDs produced, so far, from the CSCR have been serving national academic Institutes, national labs or multi-national industries such as IIT, IIIT, NIT, ISI, Hyderabad Central University, Assam University, RCC Institute of Information Technology, Hull University, UK, IBM, Jio Platform Limited, Reliance Industries, and Yahoo! Santa Clara, California, USA.

## Pictorial Glimpses of CSCR



CSCR entrance



PI Room

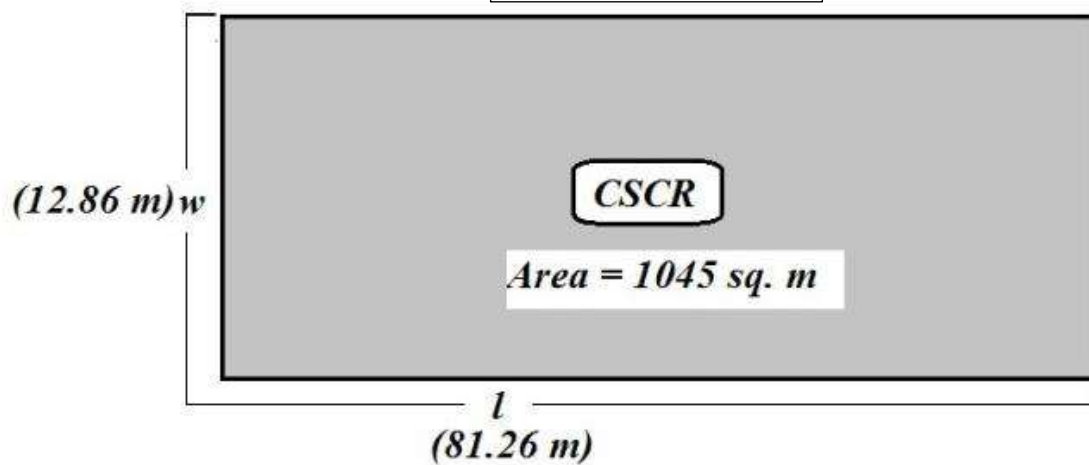


CSCR Meeting Room/ Library



Research Scholars' Lab

Total Area of CSCR



## Pictorial Glimpses of CSCR - 2



Faculties' Rooms



Corridor and Notice Boards



Office Room



Lecture Room

PI (S.K Pal)'s Room



Facility/ Infrastructure Developed at ISI Kolkata: Machine Intelligence Unit

Machine Intelligence Unit (MIU)

Founded on March 30, 1993

Location: 3rd and 4<sup>th</sup> floors, Platinum Jubilee Bhawan, ISI Kolkata

Founder: Prof. Sankar K. Pal

<https://www.isical.ac.in/~miu>

Pictorial Glimpses of MIU



MIU entrance



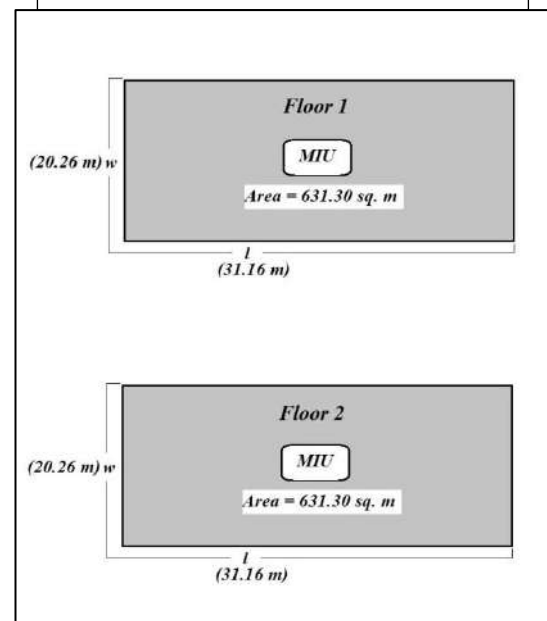
Corridor



Research Scholars' Lab

- MIU is internationally reoputed. It has produced many scientists with laurels like FNA, FASc, FNASc, FNAE, FIEEE, FTWAS, SS Bhatnagar award, Padma Shri, ISI Director, and IIIT Director.
- Current Faculty Strength: 10

Total Area of MIU 1262.6 Sq meter



For other details about MIU, see <https://www.isical.ac.in/~miu>

**Facility/ Infrastructure Developed at ISI Kolkata, Delhi, Bangalore and Chennai during his tenure as Director ISI (August 2005 - July 2010)**

**A. ISI, Kolkata**



Platinum Jubilee Academic Building at ISI Kolkata, Inaugurated by PM, Dr. Manmohan Singh on 24.12.,2024. Fund sanctioned for this as well as construction completed during his directorship.

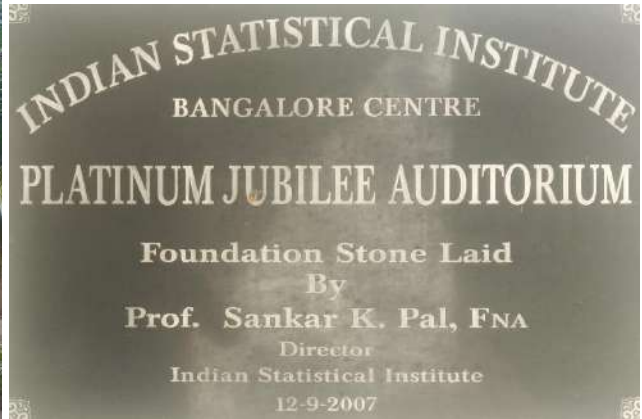


Platinum Jubilee Underpass between 203 BT Road and 202 BT Road of ISI, Kolkata. Fund sanctioned for this as well as construction completed during his directorship.



CD Deshmukh Bhawan at ISI, 202, BT Road, Kolkata. Fund sanctioned for this as well as a part construction made during his directorship.

## B. ISI, Bangalore



Platinum Jubilee Auditorium at ISI, Bangalore. Inaugurated by Sri Pranab Mukherjee, Chairman, ISI Council on 19.09.2009. Fund sanctioned for this as well as construction completed during his directorship.



Guest House at ISI, Bangalore. Construction completed during his tenure as Director, but the fund was sanctioned before.



Research Scholar Hostel at ISI, Bangalore. Fund sanctioned for this as well as a part construction made during his directorship.



B., Math Hostel at ISI, Bangalore. Fund sanctioned for this as well as a part construction made during his directorship.

### C. ISI, Delhi



Platinum Jubilee Hostel at ISI, Delhi. Fund sanctioned for this as well as construction completed during his directorship.

### D. ISI. Chennai



Creation of the ISI Chennai Centre during his directorship. The centre was inaugurated on 26 July 2008 by Shri Pranab Mukherjee, Chairman, ISI Council, in the presence of other dignitaries.

Sanctioned Letters from Ministries for Some Externally Funded Projects

NO. IR/S3/ENC-01/2002  
Government of India  
Department of Science and Technology,  
(Vigyan Aur Prodyogiki Vibhag)

Technology Bhavan,  
New Mehrauli Road,  
New Delhi - 110016.  
Dated 12<sup>th</sup> April, 2004.

ORDER

SUB: Financial Assistance under SERC (IRPHA Scheme) for the research project entitled "Establishment of a Center for Soft Computing Research at the Indian Statistical Institute, (ISI) Kolkata" from Prof. Sankar K. Pal, Professor & Head, Machine Intelligence Unit, Indian Statistical Institute (ISI), Kolkata- release of first instalment of grant.

Sanction of the President is conveyed for sanctioning the research project entitled "Establishment of a Center for Soft Computing Research at the Indian Statistical Institute (ISI), Kolkata" from Prof. Sankar K. Pal, Professor & Head, Machine Intelligence Unit, Indian Statistical Institute (ISI), Kolkata, at a total cost of Rs. 2,58,80,000/- (Rupees Two Crores fifty eight Lakhs eighty thousand only) for a duration of 36 months and also to release of Rs. 1,25,00,000/- (Rupees One Crore twenty five lakhs only) being the first instalment of grant-in-aid under the SERC (IRPHA) for implementation of the said research project. The details of expenditure for which the total allocation of Rs. 2,58,80,000/- for period of 36 months approved is given in Annexure-"A".

2. The sanction of the grant is subject to the conditions as detailed in attached Annexure-"B" and also available at DST website [www.serc-dst.org](http://www.serc-dst.org).
3. On the basis of the terms & conditions given in Annexure-"B", action is being taken for the drawl of the sanctioned amount as the first instalment of the grant during 2004-2005.
4. The amount of Rs. 1,25,00,000/- (Rupees One Crore twenty five lakhs only) being the first instalment of the grant will be drawn by the Drawing & Disbursing officer of the Deptt. of Science & Technology from the Pay & Accounts Office of DST and will be disbursed to the Director, Indian Statistical Institute, B.T. Road, Kolkata-700108 by means of payee A/C Demand Draft.
5. The grantee institution will furnish to the DST, Utilization Certificate and an Audited Statement of Accounts pertaining to the grant immediately after the end of each financial year. Progress report will be sent every six months.

Shyam Sunder Kohli  
12/4/04

6. Positions of project staff is co terminus with the duration of the project and that DST would have no liability to meet these manpower costs beyond the duration of the project.

7. The institution will maintain separate audited accounts for the project. It is found expedient to keep a part or whole of the grant in bank account earning interest. The interest earned should be reported to the DST. The interest thus earned will be treated as a credit to the institution to be adjusted towards further instalment of the grant.

8. The expenditure will be debited as under:

Demand No. 80-DST

3425 Other Scientific Research (Major Head)

60 Others (Sub Major Head)

60,200 Assistance to other Scientific Bodies (Minor Head)

25 Research & development support.

25.01 Grants-in-aid for R&D Support.

25.01.31 Grant-in-aid for the year 2004-2005 (Plan)

(This amount is being released from (SERC) IRHPA Programme)

9. As Per Rule 150(1) of GFR the accounts of Grantee Institution shall be open to inspection by the sanctioning authority/ audit whenever the institute is called upon to do so.

10. The sanction has been issued under the powers delegated to the Ministry/Department and with the concurrence of IFD vide their Sanction No 100/IFD/91/2004-2005 dated 12<sup>th</sup> April, 2004.

*Shyam Sunder Kohli*  
(S.S. Kohli)  
Scientist-D

To

The Pay & Accounts Officer  
Deptt. Of Science & Technology  
New Delhi

Copy forwarded for information and necessary action to:

1. The Director of Audit (CW & M-II), AGCR Bldg, New Delhi

2. Cash Section, DST (with two spare copies)

3. Sanction folder. 4. IFD, DST

5. The Director, Indian Statistical Institute; B.T. Road, Kolkata-700108.

6. Prof. Sankar K. Pal, Head Machine Intelligence Unit, Indian Statistical Institute,  
B.T. Road, Kolkata-700108.

*Shyam Sunder Kohli*  
(S.S. Kohli)  
Scientist-D

No. IR/S3/ENC-01/2002  
Government of India  
Ministry of Science & Technology  
Department of Science & Technology

Technology Bhavan  
New Mehrauli Road  
New Delhi - 110016

Dated: 19<sup>th</sup> October 2010

**ORDER**

**Subject: -** Finance Assistance under SERC (Engg. Sciences) for the research project entitled "**Establishment of a Center for Soft Computing Research**" implemented by Prof. Sankar K. Pal, Indian Statistical Institute, 203, B.T. Road, Kolkata-708108 - regarding extension, revision of project cost and release of next installment of the grant.

In continuation of this Department's sanction order of even number dated 12-04-2004 on the subject mentioned above, sanction of the President is hereby accorded to the additional amount of Rs.3,63,96,000/- (Rupees Three crores sixty-three lakhs ninety-six thousand only) for extension of the project duration for **two years nine months i.e. till 31-07-2013** and upward revision of the total cost of the project from Rs.2,74,60,000/- (Rupees Two crores seventy-four lakhs sixty thousand only) to Rs.6,28,56,000/- (Rupees Six crores twenty-eight lakhs fifty-six thousand only) and also support of three new satellite projects. The details of the additional (with breakup) budget of Rs.3,63,96,000/- is as follows :-

(figures are Rs. in Lacs)

SL No.	Budget Head	Center it self	IIT-Delhi	IIT- KGP	Tezpur Univ.	Total
1	Salary of Scientist/ Assistant Prof./ Fellowship/ Honorarium of Scholars/Visitors	150	0.00	5.40	2.88	158.28
2	Travel and related expenses including for MAC meeting	15.00	0.45	0.90	0.75	17.10
3	Permanent Equipment	80.00 *	7.00	0.53	3.85	91.38
4	Library support (books and journals)	5.00	0.00	0.00	0.00	5.00
5	Contingency/ Consumables	15.00	0.45	0.90	0.90	17.25
6	Workshops/ Conferences/ Seminars/School	15.00	0.00	0.00	0.00	15.00
7	Conducting Certificate Courses and related issues like lab/smart classroom preparation	15.00	0.00	0.00	0.00	15.00
8	Annual maintenance	15.00	0.00	0.00	0.00	15.00
	<b>Sub-total</b>	<b>310.00</b>	<b>7.90</b>	<b>7.73</b>	<b>8.38</b>	<b>334.01</b>
	Institutional Overhead	25.00	1.78	1.67	1.50	29.95
	<b>Total</b>	<b>335.00</b>	<b>9.68</b>	<b>9.40</b>	<b>9.88</b>	<b>363.96</b>

*Sujam Saha Kalita*  
Sc-F / 19-10-2010

Contd...2...

No. IR/S3/ENC-01/2002  
Science & Engineering Research Board  
(SERB)

Technology Bhavan  
New Mehrauli Road  
New Delhi - 110016  
Dated: 23<sup>rd</sup> August 2013

**ORDER**

**Subject:-** Finance Assistance under SERB for the research project entitled "Establishment of a Center for Soft Computing Research" implemented by Prof. Sankar K. Pal, Indian Statistical Institute, 203, B.T. Road, Kolkata-708108 – regarding extension and release of next instalment of the grant..

In continuation of our sanction order of even number dated 12-04-2004 on the subject mentioned above, SERB hereby sanctions no cost extension of the project duration until 31-01-2016 and for release of an amount of Rs.1,00,00,000/- (Rupees One Crore only) to the Director, Indian Statistical Institute, 203 B.T. Road, Kolkata-700108 (W.B.) being the next installment of the grant for 2013-2014 for the implementation of the above mentioned research project. Carry forward of Rs.6,60,409/- (Rupees Six Lakh sixty thousand four hundred nine only) from the financial year 2012-13 to be spent during the financial year 2013-14 is also approved.

2. Other terms and conditions of the grant will remain unchanged for the project.
3. As per rule 211(1) of GFR the accounts of Grantee Institution shall be open to inspection by sanctioning authority / audit whenever the Institution is called upon to do so.
4. It is certified that the provisions of 212 of GFR relating to Utilization Certificate for the funds released under the research project has been satisfied and Utilization Certificate is enclosed herewith.
5. The amount of Rs.1,00,00,000/- (Rupees One Crore only) will be drawn by the Drawing and Disbursing Officer, SERB and will be disbursed to the Director, Indian Statistical Institute, 203 B.T. Road, Kolkata-700108 (W.B.) by means of A/C payee Cheque.
6. The above release is made under "Grant-in-aid General" (46.01.31).
7. This sanction is issued with the approval of competent authority under delegated powers and vide sanction number SERB/F/3246/2013-14 dated 22-08-2013.

*Skyam Sundar Kohli*  
(S S Kohli)  
Scientist-'F'

To,  
The Pay & Accounts Officer,  
Science and Engineering Research Board (SERB), New Delhi.

Copy forwarded for information and necessary action to:-

1. Drawing and Disbursing Officer, Science and Engineering Research Board (SERB), Technology Bhavan, New Mehrauli Road, New Delhi-110016 (2 copies).
2. Prof. Sankar K Pal,  
Indian Statistical Institute,  
203, B.T. Road, Kolkata-708108,  
West Bengal.
3. The Director,  
Indian Statistical Institute,  
203, B.T. Road, Kolkata-708108,  
West Bengal.
5. SERB Secretariat 6. File copy.

*Skyam Sundar Kohli*  
(S.S. Kohli)



**Dr. RAJIV SHARMA**  
**ADVISOR**  
**INTERNATIONAL COOPERATION**  
**Tel. Fax: 26967357**  
**Fax: 26862418**  
**Email: [rajivdst@nic.in](mailto:rajivdst@nic.in)**  
**[rajivdst@hotmail.com](mailto:rajivdst@hotmail.com)**

D.O. No. INT/BRAZIL/IT-P/05/2010

भारत सरकार  
विज्ञान और प्रौद्योगिकी मंत्रालय,  
विज्ञान और प्रौद्योगिकी विभाग,  
टेक्नोलॉजी भवन, महेराजी मार्ग,  
नई दिल्ली-110016

GOVERNMENT OF INDIA  
MINISTRY OF SCIENCE AND TECHNOLOGY,  
DEPARTMENT OF SCIENCE AND TECHNOLOGY,  
TECHNOLOGY BHAVAN, NEW MEHRAULI ROAD,  
NEW DELHI-110 016

Dated August 12, 2010

**Sub: India-Brazil S&T Cooperation-Computational Technique Mega Project-project entitled "Statistical, Structural and soft computing based Techniques for Pattern recognition: Theory, Algorithms and Applications to Bioinformatics.**

Dear Prof. Pal,

I am pleased to inform you that your above mentioned project under India-Brazil Science Council has been approved at a total budget of Rs. 51,59,000/- for 3 year's duration. Necessary Sanction order for release of 1<sup>st</sup> year's installment of grant-in-aid of Rs. 19,90,120/- is being issued separately. The breakup of the budget approved for the said project is attached.

With best regards,

Yours Sincerely

(Dr. RAJIV SHARMA)  
Scientist 'G'12/08/10

Prof. Sankar Kumar Pal,  
J C Bose National Fellow  
Machine Intelligence Unit,  
Indian Statistical Institute,  
203, Barrackpore Trunk Road,  
Kolkata-700 108  
Fax 033-2578 3357/2578 8699

# Agreement for Educational and Scientific Cooperation

between

College of Engineering, Osaka Prefecture University,  
Sakai, Japan

and

Indian Statistical Institute, Calcutta,  
India

College of Engineering, Osaka Prefecture University, Sakai, Japan and Indian Statistical Institute, Calcutta, India agree to cooperate in the areas of education and scientific research for promoting fruitful academic cooperation between the two institutions.

1. Both the institutions agree to promote the following types of activities in the chosen fields of mutual understanding:
  - i : Exchange of students for study, training and research;
  - ii : Exchange of information on education, science and technology;
  - iii : Exchange of members of the institutions for scientific research, lectures and discussion;
  - iv : Joint scientific works.
2. Realization of the academic tasks given above shall be based on the close communication and discussion between the institutions.
3. Both the institutions understand that the implementation of this agreement and the financial arrangements concerned shall be negotiated and will depend on the availability of funds.
4. This agreement is written in Japanese and English, and will go into effect from the date of signing by the representatives of both of the institutions. Initially, this collaboration is valid for five years, but it could be extended if both institutes agree. This agreement can be amended by mutual consent.



Prof. Tsutomu Minami  
Dean, College of Engineering  
Osaka Prefecture University

Date: Feb. 21, 1997



Prof. S. B. Rao  
Director  
Indian Statistical Institute

Date: 20 December 1996

DIRECTOR  
INDIAN STATISTICAL INSTITUTE  
203, BARRACKPORE TRUNK ROAD  
CALCUTTA-700 035

# INDIAN STATISTICAL INSTITUTE

Professor S. B. Rao  
DIRECTOR



200 BARRACKPORE TRUNK ROAD  
CALCUTTA 700 036, INDIA

Telegram : STATISTICA, CALCUTTA 700 036  
Telephone : 650-8040, 650-8035 (4 lines)  
650-8025, 657-7004 (4 lines)

FAX : 91-33-6500080

e-mail : director @ istat.ernet.in

No. D. O. 7 3186

20 December 1996

Professor Tsutomu Minami  
Dean  
College of Engineering  
Osaka Prefecture University  
1-1 Gakuen-cho, Sakai, Osaka 593  
JAPAN.

Dear Professor Minami,

This has reference to the letter of Professor S.K. Pal written to Professor H. Tanaka dated November 20, 1996 and subsequently the reply of Professor Tanaka to Professor Pal dated December 03, 1996 regarding an academic collaboration between Indian Statistical Institute and the College of Engineering, Osaka Prefecture University, Japan.

Please find enclosed two copies of the agreement for the said collaboration duly signed by me. (As mentioned in the aforesaid letter of Professor Pal to Professor Tanaka, this agreement is subject to the approval of the Academic Council as well as the Council of our Institute). Please sign on them and send one copy back to me.

With regards,

Yours sincerely,

(S. B. Rao)



**G PADMANABHAM**  
**PRINCIPAL SCIENTIFIC OFFICER**  
**INTERNATIONAL DIVISION**  
**TEL: 6962819 EXT. 489**  
**FAX: 6862418/6863847**

भारत सरकार  
विज्ञान और प्रौद्योगिकी मंत्रालय  
विज्ञान और प्रौद्योगिकी विभाग  
टेक्नोलॉजी भवन, नया महरौली मार्ग, नई दिल्ली-110016  
GOVERNMENT OF INDIA  
MINISTRY OF SCIENCE & TECHNOLOGY  
Department of Science & Technology  
Technology Bhavan, New Mehrauli Road, New Delhi-110016

DO No..INT/POL/POC96-98/P-25/96

Date 6.11.96

**Dear Professor Pal,**

We are happy to inform you that the Indo-Polish joint project "Reasoning under uncertainty about complex objects/rough set theory & fuzzy set theory" has been included for implementation under the Indo-Polish Programme of Cooperation (POC) for 1996-98. Dr MK Chakraborty, Calcutta University is the principal investigator and yourself is the co-investigator from the Indian side and Prof A Skowron is the Principal investigator from the Polish side. A copy of the POC document is enclosed for your information, where in your project is listed at s.no. 25. Total number of mutually agreed exchanges are indicated there in. The terms and conditions are also clearly indicated in the POC document that sending side shall provide round-trip air ticket and the receiving side shall provide the expenditure on local hospitality. Kindly send your administrative approval and visit proposal through Prof Chakraborty, Principal investigator of the project. Kindly send your visit proposal as per the enclosed format.

With kind regards,

Sincerely yours,

*G. Padmanabham*  
(G Padmanabham)

**Professor SK Pal,**  
Machine Intelligence Unit,  
Indian Statistical Institute,  
203, BT Road,  
**Calcutta - 700 035**



REGISTERED

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH  
EXTRAMURAL RESEARCH DIVISION  
CSIR COMPLEX, PUSA, NEW DELHI - 110 012

No. 22(0346)/02/EMR-II  
From : Head, Human Resources Development Group

Dated : 28.3.02

To  
✓  
PROF SANKAR K PAL  
MACHINE INTELLIGENCE UNIT  
INDIAN STATISTICAL INST  
KOLKATA 700035 W B

Subject : Grants-in-aid for your scheme entitled : KNOWLEDGE-BASED CONNECTIONIST DATA MINING SYSTEM : DESIGN AND APPLICATIONS

Sir,

I am directed to refer to your proposal for sanction of CSIR Scheme titled above and to convey the approval of DG CSIR as per the details given below.

I	Duration of the Scheme (from the date of Commencement)	36 Months
II	Staff	3-RA/SRF/JRF
III	Contingency (per annum in Rs)	80,000
IV	Equipment (lumpsum in Rs)	1,45,000
V	Scientist Allowance (for Emeritus Scientist only)	

- The above sanction is subject to review of periodical progress of the project by expert committee.
- DG CSIR has also approved the release of the following grants for the period 01/04/2002 to 31/03/2003

No	Grants	Amount (in Rs)
I	Staff	2,88,000
II	Contingency	80,000
III	Equipment	1,45,000
IV	Scientist Allowance	
Total :		5,13,000

- Sanction of grants is subject to strict compliance of the terms and conditions enclosed or as may be modified from time to time. Please go through the instructions carefully with regard to subsequent release of grants and your obligations under this sanction. The cheque for the I<sup>st</sup> installment is being sent to the concerned authority of your institution along with a copy of this letter.

The expenditure is debitable to budget head P81102.

Yours faithfully,

SECTION OFFICER (EMR-II)

Encl : As above

Copy to :-

Indian Statistical Instt,  
Kolkata-700035.

- Registrar/~~Principal~~ alongwith a cheque No. \_\_\_\_\_ dated \_\_\_\_\_ for Rs \_\_\_\_\_ representing first year's grant for the above scheme. The utilisation of grant is subject to compliance of para-1 of the terms and conditions stated overleaf.
- Sr F&AO(EMR) alongwith FVC for first year's grant

Cheque will be sent separately

PTO

**Contents:**

- 1. Big Data Initiative (2014), DST, Govt. of India**
  - **Office Memorandum**
  - **First 6 pages and the Conclusion page of the 226-page Technical Report Generated**
  
- 2. Covid-19 India Supermodel Initiative (2020), DST, Govt. of India**
  - **Office Memorandum**
  - **23 Leading Newspaper Links of the Report submitted to Rajya Sabha**

**No.BDID/01/04/2014**  
**GOVT OF INDIA**  
**MINISTRY OF SCIENCE & TECHNOLOGY**  
**DEPARTMENT OF SCIENCE & TECHNOLOGY**  
**(BIG DATA INITIATIVES DIVISION)**

.....

Technology Bhavan,  
New Mehrauli Road  
New Delhi-110016.  
Date: 22.05.2014

**OFFICE MEMORANDUM**

**Subject: Constitution of Programme Development Advisory Committee (PDAC) Big Data Initiatives – Reg.**

DST constituted a Programme Development Advisory Committee (PDAC) to advise Big Data Initiatives programme development and for positioning on broad scientific principles.

2. The composition of PDAC
  - (a) Prof Sankar Pal, ISI, Kolkata
  - (b) Prof Santanu Chaudhury, IITDelhi
  - (c) Prof S Bapiraju, Central University of Hyderabad, Hyderabad
  - (d) Prof Ramesh Hariharan, Adjunct Professor, IISc, Bangalore
  - (e) Dr Raghavendra Singh, IBM Research, New Delhi
  - (f) Dr Gautam Shroff, TCS Innovation Lab, New Delhi
  - (g) Prof Vijay Chandru, IIACD, Bangalore
  
3. The broad Terms of Reference (ToR) of the Committee
  - a) The tenure of the Committee will be for a one year.
  - b) The Committee shall advise and suggest the Programme Development, shaping and positioning.
  - c) Non-official members will be entitled for reimbursement of TA/DA, local travel, accommodation charges and honorarium of Rs.1500/- per day of the meetings as per eligibility, entitlement and GOI norms.
  - d) PDAC can co-opt additional members on specific requirement basis with the approval of Competent Authority.



(K R Murali Mohan)  
Head, Big Data Initiative Division

To

1. Prof Sankar Pal, ISI, Kolkata
2. Prof Shantanu Choudhury, IITDelhi
3. Prof Bappi Raju, Central University of Hyderabad, Hyderabad
4. Prof Ramesh Hariharan, Adjunct Professor, IISc, Bangalore
5. Dr Raghavendra Singh, IBM Research
6. Dr Gautam Shroff, TCS Innovation Lab
7. Prof Vijay Chandru, IIACD, Bangalore
8. PPS to Secretary, DST
9. PPS to JS&FA, DST
10. File



(K R Murali Mohan)  
Head, Big Data Initiative Division

**DATA SCIENCE, TECHNOLOGY,  
RESEARCH & APPLICATIONS (dASTRA)**

**PROGRAMME AND STRATEGY DOCUMENT**



**DEPARTMENT OF SCIENCE & TECHNOLOGY,  
Ministry of Science & Technology, Government of India**

**2015**

## **EXECUTIVE SUMMARY**

*A new discipline 'Data Science' is emerging and is a fusion of Statistics, Mathematics, Computer Science and domain areas. Some of the S&T challenges that researchers across the globe and as well as in India facing are related to data deluge in general and in particular pertaining to Astrophysics, Materials Science, Earth & atmospheric observations, Energy, Fundamental Science, Computational Biology, Bioinformatics & Medicine, Engineering & Technology, GIS and Remote Sensing, Cognitive science, Statistical data, Social media, Commerce and Trade. These challenges require development of advanced algorithms, visualization techniques, data streaming methodologies and analytics. The overall constraints that research community facing are*

- *The IT Challenge: Storage and computational power*
- *The computer science : Algorithm design, visualization, scalability (Machine Learning, network & Graph analysis, streaming of data and text mining), distributed data, architectures, data dimension reduction and implementation*
- *The mathematical science: Statistics, Optimization, uncertainty quantification, model development (statistical, Ab Initio, simulation) analysis and systems theory*
- *The multi-disciplinary approach: Contextual problem solving*

*In a broader perspective, Big Data Analytics (BDA), is one of the technological outcomes of 'Data Science'. In the research context, so called analytics over Big Data is playing a leading role. Analytics cover a wide family of problems mainly arising in the context of Database, Data Warehousing and Data Mining research. Analytics research is intended to develop complex procedures running over large-scale, enormous in-size data repositories with the objective of extracting useful knowledge hidden in such repositories. One of the most significant application scenarios where Big Data arise is, without doubt, scientific computing. Here, scientists and researchers produce huge amounts of data per-day via experiments. But extracting useful knowledge for decision making purposes from these massive, large-scale data repositories is almost impossible for actual DBMS-inspired analysis tools. From a methodological point of view, there are also research challenges. A new methodology is required for transforming Big Data stored in heterogeneous and different-in-nature data sources into a structured, hence well-interpretable format for target data analytics. As a consequence, data-driven approaches, can replace the traditional hypothesis-driven research.*

*We believe that this will require enhancements to the state-of-the-art in a variety of disciplines such as computer vision, pattern recognition, Natural Language Processing (NLP) and fusion of classifiers. We will make a case for the viability of this plan and step through a case study in machine learning techniques for combining classifiers. We believe that the development of such technologies is also likely to have significant broader societal impact through applications development.*

*DST initiated a country wide consultative process To assess the R&D perspective of Data Science, Technology development, Research, gaps identification and applications development,*

*To evolve methods and structures to connect National developmental issues with academics and Industry, Assess the present status of the Big Data Analytics in terms of market size, different players providing services across sectors/ functions, opportunities, SWOT analysis, policy framework (if any), present skill levels available etc, Market landscape survey to assess the future opportunities and demand for skill levels in next 10 years, Gap analysis in terms of skills levels and policy framework, Evolve a strategic Road Map and micro level action plan clearly defining roles of various stakeholders - Govt., Industry, Academia, Industry Associations and others with clear timelines and outcome for the next 10 years.*

*Based on the consultations, Data Science, Technology, Research and Applications (dASTRA) programme was evolved which aims at addressing some of the data science core research issues, technology development, rapid roll out of applications and a connect to evolve possible solutions to some of the national developmental issues. The project is to be implemented in five years with an estimated cost of Rs 580 Cores. The major activities of the project will include (i) **R&D PROMOTION** through Expert Driven PI Research, Directed Research-Cluster Based Network Programs, International Collaborative Research Program,(ii) **ESTABLISHMENT OF CENTRE OF EXCELLENCE FOR DATA SCIENCE**, (iii) **SKILL DEVELOPMENT - CAPACITY & TRAINING** through Fellowship Based Internships, Short Term Training for Faculty, On-Line Programs, National Workshops & Conferences, Collaborative Interactive Conferences and Entrepreneur Development (iv) **INTERNATIONAL LINKAGES & COLLABORATIONS UN (R&D and Standards)**, Regional Associations/Collaborations, Bilateral & Multi Lateral Exchange Programs, and (v) **DATA SCIENCE LAB INFRASTRUCTURE DEVELOPMENT.***

**PROGRAMME DEVELOPMENT AND ADVISORY COMMITTEE  
(PDAC) MEMBERS**

Department of Science & technology constituted a PDAC to guide, mentor and suggest in developing the strategy document for fostering and promoting Data Science, Technology, Research and Applications in the country, that includes Big Data and Analytics, the following are the external members of the PDAC.

1. Prof Sankar K Pal,  
Distinguished Scientist and Former Director ISI, Kolkata
2. Prof Santanu Choudhary  
Professor, IITDelhi
3. Prof Bapiraju Professor,  
Central University of Hyderabad. Hyderabad
4. Prof Ramesh Hariharan  
Adjunct Professor, IISc, Bangalore
5. Dr Raghavendra Singh  
IBM Research, New Delhi
6. Dr Gautam Shroff  
TCS Innovation Labs, New Delhi
7. Prof Vijay Chandru  
Adjunct Professor, ICTS, Banaglore
8. Prof S Pyne  
Professor, CR Rao Advanced Institute of Mathematics, Statistics and Computer Science,  
Hyderabad
9. Shri Avnish Sabharwal  
Accenture India (Pvt.) Limited, Bangalore

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## CONCLUSIONS

Scientific progress is a result of relentless academic research endeavour. The scientific community has been focused for a while now on the growing challenges of Data Science in a number of disciplines. This immense repository of past/current academic knowledge is increasing at an exponential rate, and handily qualifies as Big Data in terms of volume, variety and velocity of growth. The estimation of the veracity of this data also presents challenges. As the amount of knowledge in an academic field grows, a quick assessment of the state-of-the-art in any sub-field becomes that much harder. One way of enabling the acceleration of the process of discovery, is to significantly enhance current search capabilities to support deep scientific queries. This includes:

- Improving the efficiency and depth of search by enabling segmentation and recognition of all the components of a traditional academic research including graphs, tables, and diagrams.
- Developing tools to integrate various sources of information on any topic, not just from the textual content but often from parallel channels such as video, speech, and the web, in order to gain comprehensive understanding on the topic, and most importantly.
- Making unapparent connections between methods, features, data, constraints, and parameters across the spectrum of reported scientific data using advanced data mining approaches.

Keeping in view the fast growth of Business Analytics in future across the various applications, it is imperative to chalk out a strategic Road Map in this direction to reap the benefits towards the overall development of the country.

The present study, through a combination of primary and secondary research has established the need of urgent initiative on part of DST to (i) strengthen the dASTRA Ecosystem of the country, (ii) take steps to nurture the same so as to leverage the unique advantageous position of the country's human resource in not only in the scientific research and development but in the business and industry also.

The project is to be implemented in five years and the cost has been estimated to be around Rs. 580 Cores. The major activities of the project will include (i) R&D PROMOTION through Expert Driven PI Research, Directed Research - Cluster Based Network Programs, International Collaborative Research Program,(ii) ESTABLISHMENT OF CENTRE OF EXCELLENCE ON DATA SCIENCE, (iii) SKILL DEVELOPMENT - CAPACITY & TRAINING through Fellowship Based UG/PG and Ph D, Short Term Training for Faculty, On-Line Programs, National Workshops & Conferences, Collaborative Interactive Conferences, Entrepreneur Development, (iv) INTERNATIONAL LINKAGES & COLLABORATIONS through UN (R&D and Standards), Regional Associations/Collaborations, Bilateral & Multi Lateral Exchange Programs, and (v) DATA SCIENCE LAB INFRASTRUCTURE DEVELOPMENT.

No. DST/PCPM/Misc-02/COVID-INS/2020  
 Government of India  
 Ministry of Science and Technology  
 Department of Science & Technology  
 (PCPM Division)

Technology Bhavan  
 New Delhi-110016  
 Dated: 27.05.2020

**OFFICE MEMORANDUM**

**Sub.: Project on “COVID-19 India National Supermodel”**

Coronavirus disease of 2019 (COVID-19) has unleashed an epidemic with severe health impact leading to infections and death, and even after many months of the discovery of the SARS-CoV-2 virus, which causes the disease, the world is still grappling with the pandemic. While the Government is keeping a close watch on infectivity and mortality, it is imperative to bring in a robust forecasting model for predicting the spread and enhancing disease surveillance. Notably, numerous mathematical models Covid-19 forecasting and surveillance, funded by DST-SERB and other agencies, are being worked out by investigators.

**COVID-19 India National Supermodel** initiative will aggregate successful evidence-based mathematical and statistical forecasting models, and create a Supermodel to include best predictive analytics for robust forecasting of infectious disease spread and could be used by the policymakers in India and around the world to curb the epidemic.

As part of this initiative, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) and IISc, Bangalore will take a coordinating role to connect and work with all Covid-19 modeling projects and programs in the country, in order to develop a set of benchmarks to assess various models and to finally deliver **COVID-19 India National Supermodel**. Coordination team will consult and work as appropriate with the research groups active in modeling, various software developers and reputed companies to ensure delivery of a suitable user interface and software.

A detailed note of **COVID-19 India National Supermodel** initiative is enclosed as Annex-I.

Following consultative committee is set up to work closely with DST and SERB, and coordinators of this initiative to provide critical inputs on technical aggregation, guidance and final delivery of a robust Supermodel.

1	Prof M Vidyasagar, IIT Hyderabad	Chairman
2	Prof M Agarwal, IIT Kanpur	Member
3	Prof Arup Bose, ISI Kolkata	Member
4	Prof B Bagchi, IISc Bangalore	Member
5	Prof S K Pal, ISI Kolkata	Member
6	Dr Gagandeep Kang, Executive Director, THSTI, Faridabad	Member

7	Dr Manoj Murhekar, Director, National Institute of Epidemiology, Chennai	Member
8	Dr D T Mourya, Director, National Institute of Virology, Pune	Member
9	Maj. Gen. Madhuri Kanitkar, Head Quarters (Northern Command), Udhampur	Member
10	Dr. Shailja Vaidya-Gupta, Sr Adviser, O/o PSA	Member

Additional members can be co-opted with the approval of the Chairman.

An integrated national Supermodel on COVID-19 may be ready by end of June 2020, which may be subjected to further continuous improvements.

The efforts on the **COVID-19 India National Supermodel** initiative will be monitored by Science & Engineering Research Board (DST-SERB).

This issues with the approval of Secretary, DST.



(Rabindra K Panigrahy)  
Scientist-D

Tel. 26590441  
Email: rabindra.p@gov.in

To:-

1. Prof M Vidyasagar, FRS, Distinguished Professor, Electrical Engineering, Room: C-112, Academic Block C, Indian Institute of Technology Hyderabad, Kandi-502285, Sangareddy, Telangana
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5. Prof S K Pal, Distinguished Scientist and former, Director, Indian Statistical Institute, 203, BT Road, Kolkata – 700108
6. Prof (Ms) Gagandeep Kang, Executive Director, Translational Health Science and Technology Institute (THSTI), NCR Biotech Science Cluster, 3rd Milestone, Faridabad – Gurgaon Expressway, Faridabad, Haryana 121001
7. Dr Manoj Murhekar, Director (National Institute of Epidemiology, Chennai) (mmurhekar@gmail.com)
8. Dr D T Mourya, Director (National Institute of Virology, Pune)
9. Maj. Gen Madhuri Kanitkar, AVSM, VSM, M.G. (Medical), Head Quarters (Northern Command), Udhampur, 182101, J&K.
10. Dr. Shailja Vaidya-Gupta, Sr Adviser, O/o Principal Scientific Adviser to Govt. of India, New Delhi

Copy to:-

1. Secretary, SERB
2. PPS to Secretary, DST

Newspaper Links on COVID-19 India Supermodel Initiative Report

Name of Newspaper	Date	Links
TheWeek	18-10-2020	<a href="https://www.theweek.in/wire-updates/national/2020/10/18/del35-virus-govt-panel-iit.html">https://www.theweek.in/wire-updates/national/2020/10/18/del35-virus-govt-panel-iit.html</a>
TheHindu	18-10-2020	<a href="https://www.thehindu.com/sci-tech/health/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/article32886373.ece">https://www.thehindu.com/sci-tech/health/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/article32886373.ece</a>
Express Healthcare	18-10-2020	<a href="https://www.expresshealthcare.in/amp/covid19-updates/minimal-active-symptomatic-infections-by-feb-end-if-all-safety-protocols-followed-covid-19-india-national-supermodel-committee/425348/">https://www.expresshealthcare.in/amp/covid19-updates/minimal-active-symptomatic-infections-by-feb-end-if-all-safety-protocols-followed-covid-19-india-national-supermodel-committee/425348/</a>
Hindustan Times	19-10-2020	<a href="https://www.hindustantimes.com/india-news/covid-could-be-under-control-by-feb-panel/story-dXTj1CeDnHsKxcEAHTAbcO.html">https://www.hindustantimes.com/india-news/covid-could-be-under-control-by-feb-panel/story-dXTj1CeDnHsKxcEAHTAbcO.html</a>
TheHindu	18-10-2020	<a href="https://www.thehindu.com/news/national/coronavirus-india-october-18-2020-live-updates/article32885122.ece">https://www.thehindu.com/news/national/coronavirus-india-october-18-2020-live-updates/article32885122.ece</a>
Indian Express	21-10-2020	<a href="https://indianexpress.com/article/explained/coronavirus-india-surge-winters-elections-government-panel-6781860/">https://indianexpress.com/article/explained/coronavirus-india-surge-winters-elections-government-panel-6781860/</a>
Financial Express	18-10-2020	<a href="https://www.financialexpress.com/lifestyle/health/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/2108467/">https://www.financialexpress.com/lifestyle/health/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/2108467/</a>
LiveMint	18-10-2020	<a href="https://www.livemint.com/news/india/covid-pandemic-has-peaked-in-india-can-be-controlled-by-end-of-feb-2021-govt-appointed-panel-11603011260870.html">https://www.livemint.com/news/india/covid-pandemic-has-peaked-in-india-can-be-controlled-by-end-of-feb-2021-govt-appointed-panel-11603011260870.html</a>
Hindustan Times	18-10-2020	<a href="https://www.hindustantimes.com/india-news/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/story-VPbCk5XYJq2F1r1h5h4zLP.html">https://www.hindustantimes.com/india-news/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/story-VPbCk5XYJq2F1r1h5h4zLP.html</a>
ET HealthWorld	18-10-2020	<a href="https://health.economictimes.indiatimes.com/news/industry/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/78732535">https://health.economictimes.indiatimes.com/news/industry/no-fresh-lockdowns-recommended-at-local-level-government-appointed-panel-on-covid-19/78732535</a>
Business Today	18-10-2020	<a href="https://www.businesstoday.in/current/economy-politics/no-fresh-lockdowns-recommended-at-local-level-govt-panel-on-covid19/story/419303.html">https://www.businesstoday.in/current/economy-politics/no-fresh-lockdowns-recommended-at-local-level-govt-panel-on-covid19/story/419303.html</a>
Bloomberg Quint	19-10-2020	<a href="https://www.bloombergquint.com/business/covid-19-active-cases-have-peaked-in-india-says-government-panel">https://www.bloombergquint.com/business/covid-19-active-cases-have-peaked-in-india-says-government-panel</a>
DNAIndia	19-10-2020	<a href="https://www.dnaindia.com/india/report-no-fresh-covid-19-lockdowns-recommended-at-local-level-government-appointed-panel-2850804">https://www.dnaindia.com/india/report-no-fresh-covid-19-lockdowns-recommended-at-local-level-government-appointed-panel-2850804</a>
GulfTimes	19-10-2020	<a href="https://www.gulf-times.com/story/675685/Covid-can-be-controlled-by-Feb-says-govt-panel">https://www.gulf-times.com/story/675685/Covid-can-be-controlled-by-Feb-says-govt-panel</a>
IndiaToday	18-10-2020	<a href="https://www.indiatoday.in/india/story/india-reached-coronavirus-peak-in-late-september-crisis-likely-to-end-by-february-end-govt-appointed-panel-1732845-2020-10-18">https://www.indiatoday.in/india/story/india-reached-coronavirus-peak-in-late-september-crisis-likely-to-end-by-february-end-govt-appointed-panel-1732845-2020-10-18</a>
IndiaTv	18-10-2020	<a href="https://www.indiatvnews.com/news/india/coronavirus-peak-in-india-over-can-be-controlled-by-february-2021-says-govt-appointed-panel-vidyasagar-657984">https://www.indiatvnews.com/news/india/coronavirus-peak-in-india-over-can-be-controlled-by-february-2021-says-govt-appointed-panel-vidyasagar-657984</a>
SirfNews	18-10-2020	<a href="https://www.sirfnews.com/india-past-covid-19-peak-says-government-panel/">https://www.sirfnews.com/india-past-covid-19-peak-says-government-panel/</a>
Asian Age	19-10-2020	<a href="https://www.asianage.com/india/all-india/191020/india-may-beat-covid-by-end-of-february-panel.html">https://www.asianage.com/india/all-india/191020/india-may-beat-covid-by-end-of-february-panel.html</a>

RFI	20-10-2020	<a href="https://www.rfi.fr/en/international/20201020-india-s-covid-19-crisis-under-control-by-early-2021-says-expert-committee">https://www.rfi.fr/en/international/20201020-india-s-covid-19-crisis-under-control-by-early-2021-says-expert-committee</a>
The North Line	18-10-2020	<a href="http://www.thenorthlines.com/covid-has-peaked-in-india-now-on-decline-govt-panel/">http://www.thenorthlines.com/covid-has-peaked-in-india-now-on-decline-govt-panel/</a>
Zee News	18-10-2020	<a href="https://zeenews.india.com/india/indias-covid-19-cases-peaked-in-september-crisis-can-be-controlled-by-february-govt-panel-2318422.html?UTM_SRC=breakingnews">https://zeenews.india.com/india/indias-covid-19-cases-peaked-in-september-crisis-can-be-controlled-by-february-govt-panel-2318422.html?UTM_SRC=breakingnews</a>
Business Standard	18-10-2020	<a href="https://www.business-standard.com/article/current-affairs/no-fresh-lockdown-recommended-at-local-level-to-curb-covid-19-govt-panel-120101800508_1.html">https://www.business-standard.com/article/current-affairs/no-fresh-lockdown-recommended-at-local-level-to-curb-covid-19-govt-panel-120101800508_1.html</a>
BBC	19.10.20	<a href="https://www.bbc.com/news/world-asia-india-54596707">https://www.bbc.com/news/world-asia-india-54596707</a>

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**List of Publications of Dr. Sankar K. Pal**

**List of 21 Books, 20 Conference Proceedings, 506 Research Papers (including 301 in International Journals, 62 in Edited Books, 143 in Conference Proceedings), and 3 US Patents.**

**a) Articles Published in Journals**

1. D. Dutta Majumder, A.K. Datta and S.K. Pal, "Computer Recognition of Telugu Vowel sounds", *J. Comp. Soc. India*, vol. 7, no. 1, pp. 14-20, 1976.
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  143. A. Pramanik, K. Venkatagiri, S. Sarkar and S.K. Pal, "Deep Network-based Slow Feature Analysis for Human Fall Detection", *Proc. 2022 International Conference on Computational Modelling, Simulation and Optimization (ICCMSO)*, Asian Institute of Technology

## d) Books

### *Authored Books:*

1. S.K. Pal and D. Dutta Majumder, *Fuzzy Mathematical Approach to Pattern Recognition*, John Wiley & Sons (Halsted), N.Y., 1986.  
ISBN: 0-470-27463-8, Pages: 280  
Foreword by: Prof. Lotfi A. Zadeh, University of California, Berkeley.  
Contents: Introduction, Fuzzy Subsets and Properties, Classificatory Analysis, Preprocessing, Feature Selection and Primitive Extraction, Speech Recognition, Adaptive Classification, Fuzzy Grammars and Syntactic Recognition  
A detailed review of the book is provided by M. Roubens in *ACM Computing Reviews*, June 1987, pp. 308-309.  
The book received Best Production Award in the 7th World Book Fair, New Delhi, 1986.  
The book has been translated into Indonesian Bhasa and Chinese Languages.  
(<https://www.tokopedia.com/maxisiahaan/fuzzy-pendekatan-matematik-untuk-pengenalan-pola-oleh-sankar-k-pal>)
2. S.K. Pal and S. Mitra, *Neuro-Fuzzy Pattern Recognition: Methods in Soft Computing*, John Wiley, N.Y., 1999.  
ISBN: 0-471-34844-9, Pages: 408  
Foreword by: Prof. Lotfi A. Zadeh, University of California, Berkeley.  
Contents: Introduction, Fuzzy Logic and Neural Networks : Models, Integration, and Soft Computing, Pattern Classification, Other Applications of Fuzzy MLP, Self-Organization, Pixel Classification, and Object Extraction, Feature Evaluation, Rule Generation and Inferencing, Using Knowledge-Based Networks and Fuzzy Sets, Rough-Fuzzy Knowledge-Based Networks.  
Critical reviews of the book are provided by-
  - i) Prof. Radim Belohlavek in *Int. J. General Systems*, 30(3), 411-413, May 2001 (<https://doi.org/10.1080/03081070108960714>) and
  - ii) Prof. Scott Dick in *IIE Transactions*, 34(6), 585-587, 2002 (<https://doi.org/10.1080/07408170208936921>)
3. S.K. Pal and Simon C.K. Shiu, *Foundation of Soft Case-Based Reasoning*, John Wiley, N.Y., 2004.  
ISBN: 0-471-08635-5, Pages: 324  
Foreword by: Prof. Lotfi A. Zadeh, University of California, Berkeley.  
Contents: Introduction, Case Representation and Indexing, Case Selection and Retrieval, Case Adaption, Case-Base Maintenance, Applications, Fuzzy Logic, Artificial Neural Networks, Genetic Algorithms, Rough Sets.
4. S.K. Pal and P. Mitra, *Pattern Recognition Algorithms for Data Mining*, Chapman & Hall

CRC Press, Boca Raton, FL, 2004.

ISBN: 1-58488-457-6, Pages: 280

Foreword by: Prof. Lotfi A. Zadeh, University of California, Berkeley, Prof. Z. Pawlak, Polish Academy of Sciences, Warsaw, and Prof. Laveen N. Kanal, University of Maryland, College Park.

Contents: Introduction, Multiscale Data Condensation, Unsupervised Feature Selection, Active Learning Using Support Vector Machine, Rough-fuzzy Case Generation, Rough-Fuzzy Clustering, Rough Self-Organizing Map, Classification, Rule Generation and Evaluation using Modular Rough-fuzzy MLP, Role of Soft-Computing Tools in KDD, Data Sets Used in Experiments.

5. S. Bandyopadhyay and S.K. Pal, *Classification and Learning with Genetic Algorithms: Applications in Bioinformatics and Web Intelligence*, Springer Verlag, Heidelberg, 2007.

ISBN: 978-3-540-49606-9, Pages: 326

Contents: Introduction, Genetic Algorithms, Supervised Classification Using Genetic Algorithms, Theoretical Analysis of the GA-Classifier, Variable String Lengths in GA-Classifier, Chromosome Differentiation in VGA-Classifier, Multi-objective VGA-Classifier and Quantitative Indices, Genetic Algorithms in Clustering, Genetic Learning in Bioinformatics, Genetic Algorithms and Web Intelligence, Appendices, References, Index.

The book is unique in the sense of describing how a search technique, the genetic algorithm, can be used for pattern classification mainly through approximating decision boundaries, and it demonstrates the effectiveness of the genetic classifiers vis-a-vis several widely used classifiers, including neural networks. It provides a balanced mixture of theories, algorithms and applications, and in particular results from the bioinformatics and Web intelligence domains.

The book has been critically reviewed and lauded in the IAPR newsletter, 30(4), page 12, 2008 (<http://www.iapr.org/docs/newsletter-2008-04.pdf>).

6. P. Maji and S.K. Pal, *Rough-Fuzzy Pattern Recognition: Application in Bioinformatics and Medical Imaging*, Wiley-IEEE, N.Y., 2012.

ISBN: 978-1-1180-0440-1, Pages: 312

Foreword by: Prof. Andrzej Skowron, University of Warsaw, Poland

Contents: Introduction, Rough-Fuzzy Hybridization and Granular Computing, Rough-Fuzzy Clustering: Generalized c-Means Algorithm, Rough-Fuzzy Granulation and Pattern Classification, Fuzzy-Rough Feature Selection using f-Information Measures, Rough Fuzzy c-Medoids and Amino Acid Sequence Analysis, Clustering Functionally Similar Genes from Microarray Data, Selection of Discriminative Genes from Microarray Data, Segmentation of Brain Magnetic Resonance Images, References, Index.

Emphasizing applications in bioinformatics and medical image processing, this text offers a clear framework that enables readers to take advantage of the latest rough-fuzzy computing techniques to build working pattern recognition models. The authors explain step by step how to integrate rough sets with fuzzy sets in order to best manage the uncertainties in mining large data sets. Chapters are logically organized according to the major phases of pattern recognition systems development, making it easier to master such tasks as classification, clustering, and feature selection. Numerous examples and case studies help readers better understand how pattern recognition models are developed and used in practice.

7. S.K. Pal, S.S. Ray and A. Ganivada, Granular Neural Networks, Pattern Recognition and Bioinformatics, Springer, Heidelberg, 2017.

ISBN: 978-3-319-57115-7, Pages: 227

Contents: Introduction to Granular Computing, Pattern recognition and Data Mining, Classification using Fuzzy Rough Granular Neural Networks, Clustering Using Fuzzy Rough Granular Self-organizing Map, Fuzzy Rough Granular Neural Network and Unsupervised Feature Selection, Granular Neighborhood Function for Self-organizing Map: Clustering and Gene Selection, Gene Function Analysis, RNA Secondary Structure Prediction: Soft Computing Perspective, Appendix, Index.

This book provides a uniform framework describing how fuzzy rough granular neural network technologies can be formulated and used in building efficient pattern recognition and mining models. Formation of granules in the notion of both fuzzy and rough sets is stated. Judicious integration in forming fuzzy-rough information granules based on lower approximate regions enables the network in determining the exactness in class shape as well as handling the uncertainties arising from overlapping regions; resulting in efficient and speedy learning with enhanced performance. Layered network and self-organizing analysis maps, which have a strong promise to Big data, are considered as basic modules.

The book is structured according to the major phases of a pattern recognition system (e.g., classification, clustering, and feature selection) with a balanced mixture of theory, algorithm and application. It covers the latest findings as well as directions for future research. Special emphasis is given to bioinformatics applications. The volume is recommended for both students and practitioners working in computer science, electrical engineering, data science, system design, pattern recognition, image analysis, neural computing, social network analysis, big data analytics, computational biology and soft computing.

8. D.B. Chakraborty and S.K. Pal, Granular Video Computing: with Rough Sets, Deep Learning and in IoT, World Scientific, Singapore, 2021.

ISBN: 978-981-122-711-0 (hardcover); 978-981-122-713-4 (e-book), pages: 256

Contents: Introduction: Video Processing, Granular Computing, Rough Sets, Deep Learning and IoT; Partial Supervised Tracking; Unsupervised Tracking; Unsupervised Occlusion Handling; Trustability Measures of Tracking Algorithms; Object Recognition and Deep Learning; Video Conceptualization; Index

This volume links the abstract concept of granular computing with object tracking and video analysis and their implementation in deep learning and the Internet of Things. It describes how different uncertainties, involved in the task of video processing, could be handled in rough set theoretic granular computing frameworks. Issues in video computing, such as object tracking from videos in constrained situations, occlusion/overlapping handling, measuring of the reliability of tracking methods, object recognition and linguistic interpretation in video scenes, and event prediction from videos, are the addressed in this volume. Methods to address the afore mentioned issues by reducing data dependency, as well as several unsupervised (without manual interaction/ labeled data/ prior information) methods are also described in this work. Rough-set approximation, and decision-making with rough rule-base are the two key features used in the book to deal with the incomplete knowledge-base, due to the unsupervised environments. Different aspects of rough sets (such as neighborhood rough sets, rough flow graph, adaptive rough rule-base) and granular computing (unequal granules, spatio-temporal granules, motion granules, and granulated deep learning) are explored based on the

requirements of different problems along with their demonstration in real-time environments.

This book provides a balanced mixture between theory, algorithms and applications and shows the future scopes of the theories described in different applications. It may be used both as a textbook and reference book for graduate students and researchers in computer science, electrical engineering, system science, data science, and information technology, and is recommended for both students and practitioners working in computer vision, machine learning, video analytics, image analytics, artificial intelligence, system design, rough set theory, granular computing, and soft computing.

***Edited Books:***

9. J.C. Bezdek and S.K. Pal (Eds.), *Fuzzy Models for Pattern Recognition: Methods that Search for Structures in Data*, IEEE Press, N.Y., 1992.

ISBN: 0-7803-0422-5, Pages: 539

Foreword by: Prof. Lotfi A. Zadeh, University of California, Berkeley.

Contents: Introduction, Cluster Analysis, Classifier Design and Feature Analysis, Image Processing and Machine Vision, Fuzzy Logic, Neural Networks and Learning in Pattern Recognition

This book consists of 50 pages of original material (written by the authors) and 51 seminal papers (most of them are IEEE publications) reprinted from journals.

The book was in the list of IEEE Best Seller books till 1995.

10. S.K. Pal and P.P. Wang (Eds.), *Genetic Algorithms for Pattern Recognition*, CRC Press, Boca Raton, Florida, 1996.

ISBN: 0-8493-9467-8, Pages: 320

This book is unique of its kind and consists of 13 articles, written by leading scientists over the world, demonstrating how the effectiveness of Genetic Algorithms can be exploited for solving some existing problems of pattern recognition and for designing efficient systems.

11. S.K. Pal and A. Skowron (Eds.), *Rough Fuzzy Hybridization: A New Trend in Decision Making*, Springer Verlag, Singapore, 1999.

ISBN: 981-4021-00-8, Pages: 454

This is the first book on integrating rough sets and fuzzy sets for developing efficient decision making system with real life applications. It has 20 articles written by leading experts over the world.

12. S.K. Pal, A. Ghosh and M.K. Kundu (Eds.), *Soft Computing for Image Processing*, Physica Verlag, (Springer), Heidelberg, 2000.

ISBN: 3-7908-1268-4, Pages: 590

Foreword by: Prof. A. Rosenfeld, University of Maryland, College Park.

The volume provides a collection of 21 articles, written by leading experts all over the world, containing new material and describing, in a unified way with extensive real life

applications, the merits and significance of performing different image processing/analysis tasks in soft computing paradigm.

13. S.K. Pal, T.S. Dillon and D.S. Yeung (Eds.), *Soft Computing in Case Based Reasoning*, Springer Verlag, London, 2001.

ISBN: 1-85233-262-X, Pages: 372

Foreword by: Prof. H.J. Zimmenmann, Aachen, Germany.

The book, which is unique of its kind, describes how various soft computing tools can be applied to design and develop methodologies and systems with case based reasoning (CBR) for real life decision-making or recognition problems. It comprises 15 contributions from experts from all over the world.

14. S.K. Pal, A. Pal (Eds.), *Pattern Recognition: From Classical to Modern Approaches*, World Scientific, Singapore, 2001.

ISBN: 981-02-4684-6, Pages: 612

Foreword by: Prof. L. N. Kanal, University of Maryland, College Park.

The volume provides a collection of 21 articles, written by leading experts all over the world, describing the evolution and recent development of various pattern recognition methodologies with significant applications including data mining and knowledge discovery.

15. D. Zhang and S.K. Pal (Eds.), *Neural Networks and Systolic Array Design*, World Scientific, Singapore, 2002.

ISBN: 981-02-4840-7, Pages: 405

The volume, containing 16 chapters, describes in a unified way, the basic concepts, theories and characteristic features of integrating different facets of Neural Networks (NNs) and Systolic Arrays (SAs), as well as presents recent developments and significant applications. The articles, written by experts from all over the world, demonstrate the various ways this integration can be made to efficiently design methodologies, algorithms and architectures, and also implementations, for NN applications.

16. A. Ghosh and S.K. Pal (Eds.), *Soft Computing Approach to Pattern Recognition and Image Processing*, World Scientific, Singapore, 2002.

ISBN: 981-238-251-8, Pages: 372

This volume provides a collection of sixteen articles containing review and new material. In a unified way, they describe the recent development of theories and methodologies in pattern recognition, image processing and vision using fuzzy logic, artificial neural networks, genetic algorithms, rough sets and wavelets with significant real life applications. The book details the theory of granular computing and the role of a rough-neuro approach as a way of computing with words and designing intelligent recognition systems. It also demonstrates applications of the soft computing paradigm to case based reasoning, data mining and bio-informatics with a scope for future research.

17. S.K. Pal, L. Polkowski and A. Skowron (Eds.), *Rough-Neural Computing: Techniques for Computing with Words*, Springer Verlag, Heidelberg, 2004.

ISBN: 3-540-43059-8, Pages: 734

Foreword by: Prof. Zdzistaw Pawlak, University of Information Technology and Management, Warsaw, Poland, and Prof. Lotfi A. Zadeh, University of California, Berkeley.

Exploring the potential and strength of neural networks, rough sets, and rough-fuzzy hybridization, this book is devoted to rough-neural computing, which is also related to the novel aspect of computing with words. It has 29 articles contributed by experts from all over the world and provides foundational and methodological issues as well as applications in various fields.

18. S.K. Pal and J.F. Peters (Eds.), *Rough Fuzzy Image Analysis: Foundations and Methodologies*, Chapman & Hall/CRC, Boca Raton, Florida, 2010.

ISBN: 978-1-4398-0329-5, Pages: 266

This is the first book under the series of Mathematical and Computational Imaging Sciences of Chapman & Hall/CRC. Emphasizing the utility of fuzzy, near and rough sets in image analysis, the volume having twelve chapters introduces the fundamentals and applications in the state of the art of rough-fuzzy image analysis. The volume is unique in the sense that it presents a new approach to image analysis using near sets and tolerance spaces; provides a complete implementation of near sets and offers the NEAR system for download on <http://wren.ece.umanitoba.ca/>; and covers an array of applications, particularly in medical imaging involving breast cancer diagnosis, laryngeal pathology diagnosis, and brain MR segmentation.

19. S.K. Pal, A. Petrosino and L. Maddalena, *Handbook in Soft Computing for Visual Surveillance*, Chapman & Hall/ CRC Press, Boca Raton, Florida, 2012.

ISBN: 978-1439856840, Pages: 342

Information on integrating soft computing techniques into video surveillance is widely scattered among conference papers, journal articles, and books. Bringing this research together in one source, *Handbook on Soft Computing for Video Surveillance* illustrates the application of soft computing techniques to different tasks in video surveillance. Worldwide experts in the field present novel solutions to video surveillance problems and discuss future trends.

After an introduction to video surveillance systems and soft computing tools, the book gives examples of neural network-based approaches for solving video surveillance tasks and describes summarization techniques for content identification. Covering a broad spectrum of video surveillance topics, the remaining chapters explain how soft computing techniques are used to detect moving objects, track objects, and classify and recognize target objects. The book also explores advanced surveillance systems under development.

Incorporating both existing and new ideas, this handbook unifies the basic concepts, theories, algorithms, and applications of soft computing. It demonstrates why and how soft computing methodologies can be used in various video surveillance problems.

20. S. Misra and S.K. Pal (Eds.), *Soft Computing Applications in Sensor Networks*, Chapman & Hall/ CRC Press, Boca Raton, Florida, 2017.

ISBN: 13: 978-1-4822-9875-8, Pages: 284

The book provides research describing soft computing approaches in sensor networking, while investigating the novel solutions and discussing future trends in this field. With eleven

chapters containing tutorials and new material, mostly written by prominent academicians, researchers and practitioners, the volume describes basic concepts, theory and algorithms that demonstrate why and how soft computing techniques can be used for sensor networking in different disciplines. Different case studies and applications topics considered include: smart node model for wireless sensor networks (WSNs), protocols for WSN routing, fault-tolerant routing in WSNs, optimal cluster head positioning in heterogeneous sensor networks, ubiquitous context aware services, energy-aware wireless body area networks in health care delivery, and the definition of various network entropy measures. After a brief tutorial-style introduction, each chapter provides a comprehensive description of the developments in its respective area.

21. A. Pal and S.K. Pal (Eds.), *Pattern Recognition and Big Data*, World Scientific, Singapore, 2017

ISBN: 978-98-1314-4545, Pages: 856

Containing twenty six contributions by experts from all over the world, this book presents both research and review material describing the evolution and recent developments of various pattern recognition methodologies, ranging from statistical, linguistic, fuzzy-set-theoretic, neural, evolutionary computing and rough-set-theoretic to hybrid soft computing, with significant real-life applications.

The volume provides state-of-the-art of classical and modern approaches to pattern recognition and mining, with extensive real life applications. It describes efficient soft and robust machine learning algorithms and granular computing techniques for data mining and knowledge discovery, and the issues associated with handling Big Data. Application domains considered include bioinformatics, cognitive machines (or machine mind developments), biometrics, computer vision, the e-nose, remote sensing and social network analysis.

#### **e) Edited Conference Proceedings**

1. N. Zhong, J. Bradshaw, S.K. Pal, D. Talia, J. Liu, and N. Cerrone (Eds.), *Intelligent Agent Technology (Proc. 2004 IEEE/WIC/ACM International Conference, September 20-24, 2004, Beijing, China)*, IEEE Computer Society, Los Alamitos, California, USA, 2004.
2. N. Zhong, S.K. Pal, Y.Y. Tang and J. Liu(Eds.), *Wavelet Analysis and its Applications and Active Media Technology (Proc. International Computer Congress, May 28-30, 2004, Logistical Engineering University, P R China)*, World Scientific Pub Co Inc. 2004.
3. S.K. Pal, S. Bandhyopadhyay, and S.N. Biswas (Eds.), *Pattern Recognition and Machine Intelligence (Proc. 1st International Conference on Pattern Recognition and Machine Intelligence (PReMI'05)*, December 20-22, 2005, Kolkata, India), *Lecture Notes in Computer Science*, Vol. 3776, Springer-Verlag, Berlin, 2005.
4. A. Ghosh, R.K. De and S.K. Pal (Eds.), *Pattern Recognition and Machine Intelligence (Proc. 2nd International Conference on Pattern Recognition and Machine Intelligence (PReMI'07)*, December 18-22, 2007, Kolkata, India), *Lecture Notes in Computer Science*, Vol. 4815, Springer-Verlag, Berlin, 2007.
5. V.D. Gesù, S.K. Pal and A. Petrosino (Eds.), *Fuzzy Logic and Applications (Proc. 8th International Workshop on Fuzzy Logic and Applications, (WILF 2009)*, June 9-12, 2009, Palermo, Italy), *Lecture Notes in Artificial Intelligence*, Vol. 5571, Springer-Verlag, Berlin, 2009.
6. S. Chaudhury, S. Mitra, C.A. Murthy, P.S. Sastry and S.K. Pal (Eds.), *Pattern*

- Recognition and Machine Intelligence (*Proc. 3rd International Conference on Pattern Recognition and Machine Intelligence (PReMI'09)*, December 16-20, Indian Institute of Technology, New Delhi, India, 2009), Lecture Notes in Computer Science, Vol. 5909, Springer, 2009.
7. D. Slezak, S.K. Pal, B.-H. Kang, J. Gu, H. Kuroda, T-h. Kim (Eds.), Signal Processing, Image Processing and Pattern Recognition (*Proc. Int. Conf. on Signal Processing, Image Processing and Pattern Recognition (SIP 2009)*, December 10-12, Jeju Island, Korea, 2009), Communications in Computer and Information Science, Vol. 61, Springer, 2010.
  8. S.K. Pal, W.I. Groskey, N. Pissinou, T.K. Shih and D. Slezak (Eds.), Signal Processing and Multimedia (*Proc. Int. Conf. on Signal Processing, Image Processing and Pattern Recognition (SIP 2010)*, December 10-12, Jeju Island, Korea, 2010), Communications in Computer and Information Science, Vol. 123, Springer, 2010.
  9. S.O. Kuznetsov, D.P. Mandal, M.K. Kundu and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (*Proc. 4th International Conference on Pattern Recognition and Machine Intelligence (PReMI'11)*, June 27 - July 1, Higher School of Economics, Moscow, Russia, 2011), Lecture Notes in Computer Science, Vol. 6744, Springer, 2011.
  10. M.K. Kundu, S. Mitra, D. Mazumdar and S.K. Pal (Eds.), Perception and Machine Intelligence (*Proc. 1st Indo-Japan Conference (PerMin 2012)*, January 12-13, Kolkata, India, 2012), Lecture Notes in Computer Science, Vol. 7143, Springer-Verlag, Berlin, 2012.
  11. P. Maji, A. Ghosh, M. Narasimha Murty, K. Ghosh and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (*Proc. 5th International Conference on Pattern Recognition and Machine Intelligence (PReMI'13)*, December 10-14, 2013, Kolkata, India), Lecture Notes in Computer Science, Vol. 8251, Springer-Verlag, Berlin, 2013.
  12. S.M. Thampi, A. Abraham, S.K. Pal and J.M.C. Rodriguez, (Eds.), Recent Advances in Intelligent Informatics (*Proc. 2nd International Symposium on Intelligent Informatics (ISI'13)*, August 23-24, Mysore, India, 2013), Advances in Intelligent Systems and Computing, Vol. 235, Springer, Berlin, 2014.
  13. M.K. Kundu, S. Chaudhury, S. Mitra, D. Mazumder and S.K. Pal (Eds.), Perception and Machine Intelligence, (*Proc. 2nd International Conference on Perception and Machine Intelligence Indo-Japan Conference (PerMin 2012)*, February 26-27, 2015, Kolkata, India), ACM-ICPS, Vol. 0982, ACM, N.Y., 2015
  14. M. Kryszkiewicz, S. Bandyopadhyay, H. Rybinski and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (*Proc. 6th International Conference on Pattern Recognition and Machine Intelligence (PReMI'15)*, June 30 - July 3, 2015, Warsaw, Poland), Lecture Notes in Computer Science, Vol. 9124, Springer-Verlag, Berlin, 2015.
  15. B. Uma Shankar, K. Ghosh, D.P. Mandal, S.S. Ray, D. Zhang and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (*Proc. 7th International Conference on Pattern Recognition and Machine Intelligence (PReMI'17)*, December 5-8, 2017, Kolkata, India), Lecture Notes in Computer Science, Vol. 10597, Springer-Verlag, Berlin, 2017.
  16. M. E.Y El Kettani, C Djeddi, I Siddiqi, Y Hannad and S.K. Pal Eds.), [Proceedings of the 2nd Mediterranean Conference on Pattern Recognition and Artificial Intelligence](#) (MedPRAI-2018), March 27-28, 2018, Rabat, Morocco, ACM, N.Y., 2018
  17. S. Bhattacharyya, S.K. Pal, I. Pan and A. Das (Eds.), Recent Trends in Signal and Image processing (*Proc. ISSIP 2018*, November 21-22, 2018, Kolkata, India), Advances in

Intelligent Systems and Computing, Vol. 922, Springer, Singapore, 2019.

18. B. Deka, P. Maji, S. Mitra, D.K. Bhattacharyya, P.K. Bora and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (*Proc. 8th International Conference on Pattern Recognition and Machine Intelligence (PReMI'19)*), December 17-20, 2019, Tezpur, India), Lecture Notes in Computer Science, Vol. 11941 and Vol. 11942, Springer-Verlag, Berlin, 2019.
19. A. Ghosh, Irwin King, M. Bhattacharyya, S.S. Ray and S.K. Pal (Eds.), Pattern Recognition and Machine Intelligence (*Proc. 9th International Conference on Pattern Recognition and Machine Intelligence (PReMI'21)*), December 15-18, 2021, Kolkata, India), Lecture Notes in Computer Science, Vol. 13102, Springer-Verlag, Berlin, 2024.
20. S.K. Pal, S. Thampi and A. Abraham (Eds.), Intelligent Informatics, (*Proc. 8th International Symposium on Intelligent Informatics (ISI 2023)*), December 18–20, 2023, Bangalore, India), Smart Innovation, Systems and Technologies, vol. 389, Springer, Berlin, 2024.

#### **f) U.S. Patents**

1. “Optimization Technique Using Evolutionary Algorithms”, US Patent # 8,700,548; Issued on April 14, 2014. (Co-inventors: D. Bhandari and C.A. Murthy).  
<http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetacgi%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=%22Pal,+Sankar%22.INNM.&OS=IN/>  
<https://patents.google.com/patent/US8700548B2/en>
  2. "Rough Wavelet Granular Space and Classification of Multispectral Remote Sensing Image", Korea Patent # IN-800853-05-KR-NAT, Issued Patent (21 Jan 2015); China Patent # IN-800853-04-CN-NAT, Application Granted (27 Jan 2016); US Patent # IN-800853-03-US-NAT, Application Granted (6 Oct 2015), Patent No. US9152877 (Co-inventor: S. Meher) <https://patents.google.com/patent/US9152877B2/en>
  3. “Fuzzy Medial Axis Transformation Skeletonizing, Pattern Recognition, Compression and Animation” NASA Case Number MSC-21997, US Patent Application # EF872607565US (Co-inventor: L. Wang).
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