

BIO-DATA (with 10 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:** *National Science Chair*, SERB-DST, Govt. of India
President, Indian Statistical Institute
Emeritus Professor, Indian Statistical Institute
AICTE Distinguished Chair Professor
(Former Director and Distinguished Scientist,
Indian Statistical Institute)
4. **Address:**

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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: Jawaharlal Nehru Fellow, Machine Intelligence Unit, Indian Statistical Institute, Calcutta from September 1993 to August 1995.
- xiv: **Distinguished Scientist** and Head, Machine Intelligence Unit, Indian Statistical Institute, Calcutta from July 1998 to July 2005.
- xv: 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).
- xvi: Visiting Scientist, Department of Computer Science and Computer Engineering, La Trobe University, Melbourne, Australia during June and July 2002 (on leave from ISI).
- xvii: Visiting Scientist, Information Technology Division, US Naval Research Lab., Washington DC, USA, from June to August 2004 (on leave from ISI).
- xviii: Principal Investigator, Center for Soft Computing Research, ISI, Kolkata from October 2005 to September 2015.
- xix: **Director** and Distinguished Scientist, Indian Statistical Institute from August 2005 to July 2010.
- xx: Visiting Professor, Department of Applied Science, University of Naples Parthenope, Naples, Italy during April and May 2010 (on leave from ISI).
- xxi: 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).
- xxii: Distinguished Scientist and Former Director, Indian Statistical Institute from August 2010 to September 2015.
- xxiii: INAE (Indian National Academy of Engineering) Chair Professor from April 2013 to March 2015.
- xxiv: Raja Ramanna Fellow, Dept. of Atomic Energy, Govt. of India from October 2015 to

September 2018.

- xxv: Emeritus Professor, Indian Statistical Institute, Kolkata from September 2018 to date.
- xxvi: **INSA (Indian National Science Academy) Distinguished Professor** from October 2018 to August 2020.
- xxvii: Scholar-in-Residence, IIT Jodhpur (to mentor AI and Data Science research) from May 2019 to date
- xxviii: **National Science Chair**, SERB-DST, Govt. of India from August 2020 to date.
- xxix: AICTE (All India Council for Technical Education) Distinguished Chair Professor from September 2021 to date.
- xxx: **President**, Indian Statistical Institute from September 2022 to date.
- xxxi: Vice-President, International Artificial Intelligence Industry Alliance (AIIA), Hong Kong from 2023 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, July 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
- : 5th Distinguished Information Technology (IT) Lecture, Ministry of Communication and Information Technology, Government of India, New Delhi, 2003
- : 1st Bengal Science Lecture in IT and Bio-IT under the National Program “*Year of Scientific Awareness 2004*”, Calcutta, organized by the Science & Technology Council, Department of Science & Technology, Government of West Bengal, India
- : **Director**, Indian Statistical Institute for the term 2005-2010 (*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*),
- : Distinguished 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*)
- : **National Science Chair**, SERB-DST, Government of India, 2020
- : 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
- : 14th **President**, Indian Statistical Institute from Sept 2022 to date (*He is the first Ex-employee of ISI being elected to hold this honorable Chair after its inception in 1931*)
- : 30th 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, February 28, 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 Fellow under Engineering & Technology (in INSA Fellow Category), 2024

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 prize was initiated in 2003, he was not eligible to contest for that which is allowed only before 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.
: 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://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 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% (of 2,15,114) scientists world-wide based on an independent study done by **Stanford University** scientists, and remained almost so till 2024.

For methodology and data visit:

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

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.)

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 Torbe 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 Officially Supervised and Post-doctorates mentored:

PhDs: 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, and).

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

Post-doctorates mentored: Twenty-three (23)

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, **500 Research papers** (295 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 = 85, i10-index = 282, i100-index = 76, g-index = 180, citation of the mostly cited single paper = **5900** and total citations \approx **37,000+** (as in June 2024)

- 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).

- 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.

(See *Annexure D* for some examples of quality recognitions 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 14, 2014.](#)

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).

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 85 and total citations** more than **37,000**, with citations of most-cited single paper equal to **5900** (as in June 2024). His most-cited single paper (viz, Pal and Pal, *Pattern Recognition*, 1993) is based on the research work entirely done in India, and its citation #5900 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: 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.
- : 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 29th 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 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. Total number of Keynote/Plenary talks is **about 125**, and the Invited talks is **over 200**. The number of countries **visited as an academic visitor is 44**. The number of **foreign collaborating institutes** that led to joint publications/ books is **48**.

(See Annexure F for collaborating institutes leading to joint publications, and Annexure G for some example academic visits abroad and talks delivered since 2003.)

Besides, he **has many international activities** abroad contributing to the 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://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 IIIT, 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 (**PRMI**), 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), 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 Bhishuan 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 65th 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 examples of 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, 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.

(For some example committees served in India and Abroad, see Annexure H)

- : 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 2022-2024. 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: *67th 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: *5th Distinguished Information Technology (IT) Lecture*, Ministry of Communication and Information Technology, Govt. of India, New Delhi, 2003.
- xii: *1st Bengal Science Lecture in IT and Bio-IT* under the National Program “*Year of Scientific Awareness 2004*”, Calcutta, organized by the Science & Technology Council, Department of Science & Technology, Govt. of West Bengal, India.
- xiii: *Kolkata Kolon Talk* in S. N. Bose Center of Basic Science in 2004.
- xiv: *Golden Jubilee Plenary Talk* at the CSIR-Central Mining Research Institute (CMRI), Dhanbad, India in 2006.
- xv: *1st D.M. Bose Memorial Lecture* on his 121st Birth Anniversary, 26th November 2006, at the Bose Institute, Kolkata.
- xvi: *Golden Jubilee Talk* at the ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata on 21st May 2007.
- xvii: *Zdzislaw Memorial Plenary Talk* in Warsaw, Poland on 29th 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 9th 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 28th June 2010 at the 7th 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 7th March 2013.
- xxvi: *Faraday Memorial Lecture* at the IEEE Hyderabad Section, Hyderabad, September 22, 2013.
- xxvii: *4th Convocation Speech* at the National Institute of Technology (NIT), Patna, September 28, 2014.
- xxviii: *59th Convocation Speech* at Jadavpur University, Kolkata, December 24, 2014.
- xxix: *11th Convocation Speech* 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: *64th 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 (IEST), Shibpur, March 01, 2017
- xxxiv: *2017 Jawaharlal Nehru Birth Centenary Lecture* of Indian National Science Academy (INSA) at Savitribai Phule Pune University, 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, August 6, 2018.
- xxxviii: *Teachers' Day Lecture of the year 2018*, ICAR-Indian Agricultural Research Institute, New Delhi, September 5, 2018.
- xxxix: *14th Convocation Address*, 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 125th 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 125th 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, Sept 26, 2020.
- xliv: *Indian National Science Academy "Anniversary Lecture"*, 88th INSA Anniversary General Meeting, CSIR-National Institute of Oceanography, Visakhapatnam, December 14-16, 2022.
- xlv: *XX Convocation Address*, Tezpur University, Tezpur, Assam, December 30, 2022.
- xlvi: *56th Lecture in the Visva Bharati Lecture Series*, Santiniketan, West Bengal, Feb 06, 2023.
- xlvii: *4th Convocation Address*, Brainware University, Kolkata, West Bengal, February 24, 2023.
- xlviii: *30th Prasanta Chandra Mahalanobis Memorial Lecture*, 30th 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, 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, West Bengal, Sept 15, 2024.*

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Annexure A: Center for Soft Computing Research: A National Facility

Annexure B: Significant Research Contributions

Annexure C: List of PhD Theses Supervised

Annexure D: Examples of Recognition by other Researchers in the Field

Annexure E: List of Journal Special Issues Guest-Edited: Examples

Annexure F: Collaborating Institutes Leading to Joint Publications (Papers, Books & Conference Proceedings)

Annexure G: Academic Visits Abroad (2003 onwards)

Annexure H: Examples of Committees Served in India and Abroad

Annexure I: Europe-wide Research Activities: Some Examples

Annexure J: Outreach Academic Activities: Some Examples

Center for Soft Computing Research: 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 augment 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.

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 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 processing, machine learning, data mining, machine mind development, and knowledge-based systems, in particular. His image processing research in 1970s is perhaps the first investigation (other pioneer being 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.

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 of 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 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 precisiation 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. The measure is useful for link prediction in online social networks. Granular deep learning architecture using AlexNet (2022) provides fast and accurate real time video tracking in traffic monitoring for safety.

The contribution is fundamental and seminal. 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 (Patt. Recog. Letts., 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 models (Neural Comp. and Appl., 32, 16533-16548, 2020; IEEE T-ETCI, 6, 171-181, 2022; IEEE J-STAR, 16, 57-70, 2023); and Z-number approach and 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 Sysys., 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 Sysys., 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 Sysys., 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-IM, 71, 1-12, Art no. 2520412, 2022; IEEE Sensors Lett., 7, 1-4, Art no. 6000504, 2023; IEEE T-II, vol. 19, no. 9, pp. 9877-9886, Sep 2023.

The aforesaid 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.

- “**AI FOR ALL**”, the national strategy/ program for artificial intelligence as framed in 2018 by NITI Aayog, Govt. of India, is an example outcome of impact of the said research.
 - 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.
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Annexure C

List of PhD Theses Officially Supervised in India and Abroad

India:

Sr. No.	Name	PhD Thesis Title	Institute/University/ Year Awarded
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.

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://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	37.5	220	55.0
Burnett and Blaschke (2003)	63	12.6	101	20.1
Pesaresi and Benediktsson (2001)	86	12.3	92	13.1
Câmara et al. (1996)	49	4.1	331	27.3
Baatz and Schäpe (2000)	–	–	294	36.3
Blaschke and Strobl (2001)	–	–	72	10.2
For comparison				
Haralick and Shapiro (1985)	720	30.6	1104	48.0
Pal and Pal (1993)	777	51.8	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.
- **Google Scholar Citation Indices** of his publications: *h-index = 85, i10-index = 282, i100-index = 76, g-index = 180, citation of the mostly cited single paper = 5900, and total citations more than 37,000* (as in June 2024)
- 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).
- He has graduated 22 PhD students, 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/.../1mMonq947bS3KcMhsDpf.../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).
- 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

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

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

Academic Visits Abroad (2003 onwards)

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 (ICSIT), 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.

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.

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).
- Member, Governing Council, Indian National Academy of Engineering (INAE).
- 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, 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.
- Member, Covid-19 India National Supermodel Committee, SERB-DST, Govt. of India.

- 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.
- Member, Sectional Committee (Engineering and Technology), Indian Academy of Sciences (IASc.), Bangalore.
- Sectional President, Physical Sciences, National Academy of Sciences, India (NASI), Prayagraj.
- Member, Fellowship Scrutiny Committee, National Academy of Sciences (NASI), Prayagraj.

- 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, Advisory Committee, Bennett University (Times of India Group), Greater Noida, Uttar Pradesh, 2023
- 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.

- 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, 4th 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 7th 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

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. 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
19. 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
20. 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
21. 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
22. 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

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

23. **"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".
24. 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".
25. 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".
26. 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”.

27. 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”.

28. 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”,

29. Aditya Institute of Technology and Management, K. Kotturu, Tekkali, Srikakulam District, Andhra Pradesh, 26 June, 2009.

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

30. 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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