**UNIVERSITY OF CALCUTTA : ACADEMIC PROFILE OF FACULTY**

Dr. Saurabh Pal
Associate Professor, Instrumentation Engineering Section
Department of Applied Physics

► **Date of joining in the University:** 21.12.2012

► **Qualification:** M.Tech, PhD (Tech)
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► **Google scholar link:** https://scholar.google.co.in/citations?user=ilDM0uMAAAAJ&hl=en
► **ORCiD:** 0000-0002-5139-6573

► **Research Interest :**
  ➢ Biomedical signal and image processing and analysis
  ➢ Computer aided diagnosis and health monitoring
  ➢ Development of assistive diagnosis technology

► **Education:**

| College/ University | Degree | Year | Class |
|---|---|---|---|
| University of Calcutta | Ph. D. (Tech.) | 2013 | – |
| University of Calcutta | M. Tech. (Instrumentation and Control Engineering) | 2006 | First |
| University of Calcutta | B. Tech. (Instrumentation Engineering) | 2000 | First |
| University of Calcutta | B. Sc. (Physics Hons.) | 1997 | First |

► **Subjects undertaken:**

*Undergraduate level: B.Tech in Instrumentation Engineering*
1. Sensors and Transducers
2. Digital Signal Processing
3. Sensor and Transducer Laboratory
4. Industrial Instrumentation Laboratory
5. Digital Signal Processing Laboratory

*Post Graduate Level: M.Tech in Instrumentation and Control Engineering*
1. Computational Methods
2. Advanced Digital Signal Processing
3. Biomedical Measurements and Instrumentation
4. Biomedical Signal Processing and Analysis

### ► PhD Guidance as Supervisor / Joint Supervisor:

**Degree awarded:**

1. Dr Uday Maji, Associate Professor and HOD, Dept of AEIE, Haldia Institute of Technology, Haldia India
Title of thesis: Characterization and Classification of Cardiac Episodes using Data Adaptive Techniques
(Role: Principal Supervisor)

2. Dr. Deboleena Sadhukhan, Postdoctoral Researcher, Institut Langevin, France
Title of thesis: Compression and Analysis of Cardiac Signals
(Role: Joint supervisor)

**Thesis submitted:**

1. Samik Chakraborty, Assistant Professor, Heritage Institute of Technology, Kolkata, India
Title of thesis: Studies on multimodal biometric analysis for personalized authentication
(Role: Principal Supervisor)

**PhD candidates successfully completed pre-submission seminar and defense:**

1. Sangita Das
Title of thesis: "Assistive Technologies for Automated Cardiac Abnormalities Detection".
Role: Joint Supervisor

2. Surita Sarkar
Title of thesis: Studies on signal alternative methodologies for characterization of obstructive lung diseases
Role: Principal Supervisor

3. Sandipan Dhar
Title of thesis: Biosignal Acquisition, compression, encryption and classification
Role: Joint Supervisor

4. Moumita Sahoo, Assistant Professor, HIT Haldia, WB
Title of thesis: Studies on OCT and Fundus images towards automatic detection of retinal abnormalities using machine learning techniques
Role: Principal Supervisor

**PhD registered candidates**

1. Kausik Das, University research Fellow
Title of thesis: Alternative Methodologies for Assessment of Pain using Autonomic Parameters
Role: Supervisor

### ► Involvement in Seminar / Conference / Workshop (other than paper presentation):

- Member, organizing committee, International Conference in Control, Instrumentation, Energy Communication(CIEC14), Kolkata, India 2014 (proceedings published in IEEExplore)
- Organizing Secretary, International Conference in Control,

Instrumentation, Energy Communication(CIEC16), Kolkata, India 2016 (proceedings published in IEEExplore)

- Session Chair, International conference on Advancement of Computer Communication and Electrical Technology (ACCET 2016) , organized by Murshidabad College of Engineering and Technology, Berhampore, India, 2016
- Resource person, Refresher course on "Advances in Instrumentation and Automation: Role of ICT" at Jadavpur University, 2018
- Resource person, Workshop on 'Electrophysiological & Neuroimaging Studies including Mathematical Modelling', organized by, CPEPA, University of Calcutta, 2018
- TPC member in International Conference ISMS 2019 at Tripura University, India, 2019
- Resource person in Faculty Development Program in Artificial Intelligence and Machine Learning in Healthcare, organized by Department of Bioengineering and Electronics & Communication Engineering, BIT, Mesra, India, 2020
- Resource person, 5 Days National Workshop on Machine Learning and Artificial Intelligence organized by Department of IT, Tripura University, 2020
- Resource person, seminar on 'Biomedical signal processing based on artificial intelligence-2022', organized by Department of Electronics and Communication Engineering, Future Institute of Engineering and Management, Kolkata, 2022

## ▶ Research Outcome / Publication:

[Patent: 01(under process), Journals: 30; Books/ Book Chapters: 06; Conference: 25]

### Patent:
Indian patent on "A non-obstructive detection device for detecting COPD from Singles lead Electrocardiogram signals" (application no. 01931013009). (Published)

### Research publications in International Journals:

1. Automatic identification of Asthma from ECG Derived Respiration using Complete Ensemble Empirical Mode Decomposition with Adaptive Noise and Principal Component Analysis, S. Sarkar, S. Bhattacharjee, P.S. Bhattacharyya, M.Mitra, S.Pal, accepted for publication in 'Biomedical Signal Processing and Control', 2022

2. A Multi-Layer Stacked Ensemble Classifier Model for Improved Classification Accuracy of Maculopathy Gradation, M Sahoo, S Ghorai, S Pal, M Mitra, accepted for publication in 'Displays', 2022

3. Effortless detection of premature ventricular contraction using computerized analysis of photoplethysmography signal, S Dhar, A Chakraborty, D Sadhukhan, S Pal, M Mitra, 'Sādhanā' 47 (1), 1-11, 2022

4. EEG Based Automated Detection of Six Different Eye Movement Conditions for Implementation in Personal Assistive Application, A Paul, A Chakraborty, D Sadhukhan, S Pal, M Mitra, 'Wireless Personal Communications', 1-22, 2022

5. Automatic detection of obstructive and restrictive lung disease from features extracted from

ECG and ECG derived respiration signals, S Sarkar, P Bhattacharyya, M Mitra, S Pal, 'Biomedical Signal Processing and Control', 102791, 2021

**6.** Alternative Method For Pain Assessment Using EMG And GSR, K Sen, S Pal, 'Journal of Mechanics in Medicine and Biology', 2150039, 2021

**7.** Acoustic Feature Based Unsupervised Approach of Heart Sound Event Detection, S. Das, S. Pal, M.Mitra, accepted for publication in 'Computers in Biology and Medicine', 2020

**8.** PPG-Based Automated Estimation of Blood Pressure Using Patient-Specific Neural Network Modeling, A Chakraborty, D Sadhukhan, S Pal, M Mitra, 'Journal of Mechanics in Medicine and Biology' 20 (06), 2020

**9.** Automated myocardial infarction identification based on interbeat variability analysis of the photoplethysmographic data, A Chakraborty, D Sadhukhan, S Pal, M Mitra, 'Biomedical Signal Processing and Control' 57, 101747, 2020

**10.** Geometric retrieval algorithm-based ear biometry with occluded images, S Chakraborty, M Mitra, S Pal, 'International Journal of Biometrics' 12 (3), 247-268, 2020

**11.** A Novel Approach towards Non-obstructive Detection and Classification of COPD using ECG Derived Respiration, S. Sarkar, P. Bhattacharyya, M.Mitra, S. Pal, 'Australasian Physical & Engineering Sciences in Medicine' 42 (4), 1011-1024 2019

**12.** Automated screening of myocardial infarction based on statistical analysis of photoplethysmographic data, Deboleena Sadhukhan, Sandipan Dhar, Saurabh Pal, Madhuchhanda Mitra, 'IEEE Transactions on Instrumentation and Measurement', vol 69, issue 6, pg 2881-2890, 2019

**13.** Adaptive Band Limit Estimation based PPG data compression for portable home monitors, D Sadhukhan, S Pal, M Mitra, 'Measurement' 134,pg. 153-165, 2019

**14.** Automated Identification of Myocardial Infarction Using Harmonic Phase Distribution Pattern of ECG Data , D. Sadhukhan, S. Pal, M.Mitra, 'IEEE Transactions on Instrumentation and Measurement', vol 67, issue 10, pg 2303 – 2313, 2018

**15.** An efficient data compression and encryption technique for PPG signal, M.Mitra, S. Dhar, S.K. Mukhopadhyay, S. Pal, 'Measurement', Vol- 116, pg. 533-542, 2018

**16.** Automatic Segmentation of Accumulated Fluid inside the Retinal Layers from Optical Coherence Tomography Images, Moumita Sahoo, Saurabh Pal, MadhuchhandaMitra, 'Measurement' ,Vol 101, pg 138 – 144, 2017

**17.** Automated Real-Time Processing of Single Lead ECG for Simultaneous Heart Rate and Respiratory Rate Monitoring, Dishanamarata Dutta, Reshmi Das, Saurabh Pal, 'Journal of Medical Devices', Vol 11, issue 2, 2017

**18.** Arduino-based noise robust online heart-rate detection, Sangita Das, Saurabh Pal, Madhuchhanda Mitra, 'Journal of Medical Engineering and Technology', Vol 41, issue 3, pg 170 – 178, 2017

19. Differentiation of COPD from Normal Population using ECG Derived Respiration: a Pilot Observation, S.Sarkar, S.Bhattacherjee, P.Bhattacharyya, S.Pal, 'The Pulmo-Face', vol. XVI (1), pp. 12-18, 2016.

20. "Biometric Analysis using Fused Feature Set from Side Face Texture and Electrocardiogram", S. Chakraborty, M. Mitra, S. Pal, 'IET Science, Measurement and Technology', 2016

21. Significance of Exhaled Breath Test in Clinical Diagnosis – A Special Focus on the Detection of Diabetes Mellitus, S. Das, S. Pal, M.Mitra, 'Journal of Medical and Biological Engineering', 2015.

22. Imposed Target based Modification of Taguchi Method for Feature Optimisation with Application in Arrhythmia Beat Detection, U. Maji, M. Mitrta, S. Pal, 'Expert Systems with Applications', 2016.

23. Study of atrial activities for abnormality detection by phase rectified signal averaging technique, U. Maji, S. Pal & M. Mitra, 'Journal of Medical Engineering & Technology', vol. 39, issue 5, pp. 291-302, 2015

24. Characterizing Atrial Fibrillation in Empirical Mode Decomposition Domain, S. Pal, U. Maji, M. Mitra, 'Journal of Medical and Biological Engineering', 2015.

25. Electrocardiogram data compression using adaptive bit encoding of the discrete Fourier transforms coefficients, D. Sadhukhan, S. Pal, M. Mitra, 'IET Science, Measurement and Technology', Volume:9, Issue: 7 pg. 866 -874 , 2015.

26. Empirical Mode Decomposition based ECG enhancement and QRS Detection, Saurabh Pal, Madhuchhanda Mitra, 'Computers in Biology and Medicine', Vol. 42, issue 1, pg. 83-92, January, 2012.

27. Increasing the accuracy of ECG based biometric analysis by data modelling, Saurabh Pal, Madhuchhanda Mitra, 'Measurement', vol 45, issue 7, 2012.

28. "Detection of Cardiac Arrhythmic Beats by Logical Classifier using Binary Coding", Saurabh Pal, Madhuchhanda Mitra, International Journal of Science, Measurement and Technology (IET publication) vol 6, issue 6, pg 449 – 455, 2012.

29. Detection of ECG characteristic points using Multiresolution Wavelet Analysis based Selective Coefficient Method, Saurabh Pal, Madhuchhanda Mitra, 'Measurement',Vol. 43, Pg. 255-261 2010.

30. A hybrid wavelet and time plane based method for QT interval measurement in ECG signals, S. Majumder, S. Pal, S. Dhar, A. Sinha, A. Roy, 'Journal of Biomedical Science and Engineering', vol 2, no 4, Pg. 280-286, 2009

Articles published as book chapter, reports etc:

1. Chapter titled MRI, CT, and PETSCAN: Engineer's Perspective in the book *Cancer Diagnostics and Therapeutics- Current Trends, Challenges, and Future Perspectives*, Springer, 2022 (jointly with Dr Subhankar Ghosh, Professor, Department of Physics, St Xavier's College, Kolkata)

**2.** Chapter titled **SmartCovSens: A Multimodal Approach for Detection of COVID-19** in the book *Healthcare Informatics for Fighting COVID-19 and Future Epidemics*, Springer Chem, 2022 (Jointly with Prof Bipan Tudu, Jadavpur University and others)

**3.** Chapter titled **ECG Monitoring: Present Status and Future Trend** in the book *Encyclopedia of Biomedical Engineering*, Elsevier Science., 2019

**4.** Chapter titled **Trends of ECG Analysis and Diagnosis** in the book *Handbook of Research on Trends in the Diagnosis and Treatment of Chronic Conditions*, IGI Global Publishers, ISBN13: 9781466688285, 2015 (jointly with Prof S. Majumder, Dept of IT, Tripura University)

**5.** Chapter titled **ECG-Based Biometrics** in the book *Handbook of Research on Securing Cloud-Based Databases with Biometric Applications*, IGI Global Publishers, ISBN13: 9781466665590, 2014.

**6.** Chapter titled **ECG Data Analysis** in *Intelligent Medical Technologies and Biomedical Engineering: Tools and Applications*, ISBN 978-1-61520-977-4 IGI Global Publishers, 2010. (jointly with Prof S. Majumder, Dept of IT, Tripura University)


## Research publications in International Conferences:

**1.** A Chatterjee, S Pal, M Mitra, "PTT Based Portable Cuffless Systolic Blood Pressure Estimation", 2020 IEEE Calcutta Conference (CALCON), 142-146, 2020

**2.** Kaushik Sen, Saurabh Pal, "Estimation of pain from normalized energy of IMFs of EMG signal", ICMICA, NIT Kurukshetra, 2020

**3.** P. Das, J. Bhattacharya, K. sen, S. Pal, "Assessment of Pain using Optimized Feature Set from Corrugator EMG", IEEE Applied Signal Processing Conference (ASPCON), 2020

**4.** Ananda Chatterjee, Madhuchhanda Mitra, Saurabh Pal, Cuffless Systolic Blood Pressure Estimation Using Photoplethysmography Signal, International Conference on Computing, Power and Communication Technologies (GUCON), pg 424 – 427, 2019

**5.** Rohan Mandal, Uday Maji, Saurabh Pal, Detection of Human Activity for Ambient Assisted Living: A SVM Based Approach, International Conference on Innovation in Modern Science and Technology, pg 394 – 403, 2019

**6.** D Sadhukhan, S Pal, M Mitra , PPG Noise Reduction based on Adaptive Frequency Suppression using Discrete Fourier Transform for Portable Home Monitoring Applications, 15th IEEE India Council International Conference (INDICON), pg 1 – 6, 2018

**7.** Moumita Sahoo, Saurabh Pal, Madhuchhanda Mitra , A Novel Optic Disc and Blood Vessel Detection Algorithm, IEEE Applied Signal Processing Conference (ASPCON), pg 74 – 78, 2018

**8.** D Sadhukhan, S Pal, M Mitra, "Automated ECG analysis using Fourier harmonic phase", IEEE Region 10 Symposium (TENSYMP), pg 1-5,2017

Updated on 31<sup>st</sup> August, 2022

9. U Maji, S Mondal, A Biswas, I Barman and S Pal, "Characterizing Cardiac Arrhythmia by Optimized Window Length based PRSA Technique", CIEC16, Kolkata, 2016.

10. S. Chakraborty, S. Pal, "Photoplethysmogram signal based Biometric Recognition using Linear Discriminant Classifier" CIEC16, Kolkata, 2016.

11. Uday Maji, Saurabh Pal and Swanirbhar Majumder, "Estimation of Arrhythmia Episode using Variational Mode Decomposition Technique", IEEE International Instrumentation and Measurement Conference I2MTC-2015, pp.767-771.

12. U Maji, M Mitra and S Pal, "Detection and Characterisation of QRS complex in VMD Domain", Michael Faraday IET International Summit, pp. 586-589, 2015.

13. S. Sarkar, S Bhattacherjee, S. Pal, "Extraction of Respiration Signal from ECG for Respiratory Rate Estimation", MFIIS-2015, IET-Kolkata Local Network, 2015, pp 336 – 340

14. U Maji, M Mitra, S Pal, "Differentiating Normal Sinus Rhythm and Atrial Fibrillation in ECG Signal: A Phase Rectified Signal Averaging Based Approach", International Conference on Control, Instrumentation, Energy & Communication, pp.176-180, 2014.

15. U Maji, S Pal, "Detection of Atrial Flutter using PRSA", International Conference on Electronics, Communication and Instrumentation (ICECI), pp.1-4, Jan-2014.

16. U Maji, M Mitra, S Pal, "Automatic Detection of Atrial Fibrillation using Empirical Mode Decomposition and statistical Approach", CIMTA 2013, Elsevier, Procedia Technology, pg. 45 – 52.

17. Saurabh Pal, Madhuchhanda Mitra, "ECG based Biometric Authentication-a Novel Data Modelling Approach" proceedings of the International Conference on Image Information Processing (ICIIP 2011) held at Jaypee University of Info. Tech., HP, India, pp. 1-4, 2011.

18. Saurabh Pal, Samiul Alam, Madhuchhanda Mitra, "Binary Coding of Arrhythmic Beats for Generation of Simplified Classification Rule" International Conference on Communications and Industrial Applications (ICCIA 2011) 2011.pp.1-3.

19. Saurabh Pal, MadhuchhandaMitra, "An Adaptive Method for Elimination of Power Line Interference in ECG Signals using EMD", International Conference on Biomedical Engineering and Assistive Technologies (BEATS 2010)", NIT Jalandhar, Punjab, 2010.

20. S. Pal, M. Mitra, "QRS complex detection using Empirical Mode Decomposition based windowing Technique" SPCOM 2010, IISc. Bangalore, pg. 1-5,2010.

21. S. Majumder, S. Pal, P. K. Dutta, and A. K. Ray, "Wavelet and Empirical Mode Decomposition Based QT Interval Analysis of ECG Signal", 2nd IEEE International Conference on Intelligent Human Computer interaction, (IHCI 2010), pg 247-254,2010.

22. Saurabh Pal, Madhuchhanda Mitra, "Design of a Form Factor Based Expert System for Detection of Myocardial Infarction Using Supervised Classification Technique" ,Proceedings of International Conference on Advances in Computing, Control and Telecommunication Technologies'2009(ACT 2009), pg. 398-400

23.Saurabh Pal, Madhuchhanda Mitra, "ECG Feature Extraction by Multiresolution Wavelet Analysis based Selective Coefficient Method", 13th International Conference on Biomedical Engg(ICBME 2008), National University of Singapore, Singapore, pg 590-593, 2008.

24. S. Majumder, S. Pal and P.K. Dutta, "A Comparative Study for Disease Identification from Heart Auscultation using FFT, Cepstrum and DCT Correlation Coefficients", in the 13th International Conference on Biomedical Engg(ICBME 2008), National University of Singapore, Singapore pg. 754-757, 2008.

25. M. Mitra, S. Pal and S. Majumder "ECG Signal Processing for Analysis of Abnormalities based on QT Interval-A Novel Approach" International Conference on Modelling and Simulation 2007(MS'07), AMSE, Kolkata, pg. 216-218, 2007.


▶ **Reviewer in International Journals (Selected)**

 1. Measurement (Elsevier Science)
 2. IEEE Transactions on Instrumentation & Measurement
 3. IEEE Journal of Biomedical and Health Informatics
 4. Computers in Biology and Medicine (Elsevier Science)
 5. Biomedical Signal Processing & Control (Elsevier Science)