Tutorial Session on

"Role of Signal Processing, IoT and Deep Learning in AI-Enabled Power Quality Monitoring and Power-line Inspection: Concepts, Methods, Results and Future Directions"

by

Dr. M. Sabarimalai Manikandan

Indian Institute of Technology Palakkad, Kerala, India

Email: msm@iitpkd.ac.in (https://iitpkd.ac.in/people/msm)

The smart grid paradigm has become to be promising solutions with integration of recent advancements in sensing, computing and wireless communication technologies, which can improve efficiency, effectiveness, reliability, security, stability, scalability and sustainability of the both decentralized and centralized power grids. Smart building energy management and automation can generate a huge amount of data measurements from smart meters, sensors and devices. Recent advancements in signal processing, internet of things (IoT), deep-learning Networks and edge computing technologies can provide promising sustainable smart grid solutions to remotely monitor, measure and control energy flows in real time and automatically regulate to changes in energy supply and demand accordingly and enable end-to-end node based energy monitoring, control and management solutions based on the power quality. The IoT enabled power grid monitoring is an intelligent solution to monitor the centralized and decentralized power grids in real time from the point of power generation to consumption. Although the design of IoT framework is well established conceptually with recent advancements in wireless radios and computing technologies, there are many practical implementation challenges that need to be addressed in the design and development of AI powered Internet of Smart Grid Things (AI-IoSGT). In order to prevent power outages and electricity fluctuation/interruption and ensure high reliability of electricity supply and good power quality to the customers, regular inspection of the power-line or transmission line components, including the insulators, poles, cross arms, top caps and faults related to the missing top caps, broken insulators, collapsed poles, cracks in poles and cross arms, broken power lines, woodpecker damage on poles, trees lying across and against power lines, and rot damage on cross arms that may lead to various power quality problems such as the any voltage fluctuation, short or long voltage waveform variations (sag, swell, interruption), transients, inter- and intra-harmonics and failure of supply due to various causes. This tutorial covers the concepts, techniques and architectures which can be used for development of AI-enabled PQ monitoring and power-line inspection systems.

This talk presents key concepts of analog and digital compressed sensing (CS) techniques for IoT enabled PQ sensing and control nodes, and design considerations for selecting best sensing matrix which plays major role in reducing hardware complexity and can also enable direct measurement of essential parameters (features) for detecting or predicting PQ events in compressed sensing domain. The signal analysis and deep learning architectures will be presented by directly estimating essential parameters from limited CS measurements and for development of low-latency CS based deep learning architectures for directly performing PQ event detection, classification and prediction from a limited number of CS measurements without original signal reconstruction. It will cover the fundamental concepts of compressed sensing for enabling data encryption and low latency, and deep learning networks (DLNs) for PQ data analytics. This will also cover different pre-processing approaches for reducing size of DLN model.

- Compressed Sensing: Concepts, Architectures and Reconstruction Techniques
- Signal Decomposition Techniques for PQ Disturbance Classification
- Lightweight Deep Learning Methods for PQ Data Analytics
- Internet of Smart Grid Things (IoSGT) Architecture with Event-Triggered IoT Protocols
- Unmanned Aerial Vehicle Assisted AI-Powered Powerline Inspection and Monitoring Architecture

M. SABARIMALAI MANIKANDAN (Senior Member, IEEE) received the B.E. degree in Electronic and Communication Engineering, the M.E. degree in Microwave and Optical Engineering, and the Ph.D. degree in Cardiovascular Signal Processing from Indian Institute of Technology Guwahati.

Academic and Industry Experiences: He is currently an Associate Professor at Electrical Engineering, IIT Palakkad. He was an Assistant Professor at Indian Institute of Technology Bhubaneswar and Amrita Vishwa Vidyapeetham University, India. He was a Chief Engineer with the Advanced Technology Group, Samsung India Electronic Pvt., Ltd., Noida, India.

Research Focus: Design and development of Energy-Efficient AI-powered Health Sensing and Monitoring Systems, Drone Detection and See-Through Wall Human Sensing, Human-Machine Interactions and Voice-Enabled Technologies, and Sound Based Surveillance Systems. He has published more than 110 research papers in reputed journals and conference proceedings. He has patents in the applications of audio processing and health monitoring (one United States Patent granted) and five filed patents (India). He has delivered more than 70 technical talks in both national and international workshops and conferences.

Professional Activities: Dr. M. S. Manikandan was a recipient of the 2012 Outstanding Performance Award and also Employee of the Month during his tenure at Samsung India Electronic Pvt., Ltd. and received 2019 CVET Most Cited Article Award at the Biomedical Engineering Society (BME) conference, Philadelphia, USA and 2019 IET Healthcare Technology Letters Premium Award. He is currently the Chair of Cardio–Respiratory (CR) Subgroup of IEEE Standards P1752.2 and Vice Chair of Working Group of IEEE Standards P2520.3.1 (Standard for Machine Olfaction Devices and Systems) and Member of Working Group of IEEE P1924.1 (Energy Efficient Communication Hardware (COM/GreenICT-SC/EECH)) with main contribution of Recommendation of Sensor and Data Acquisition Techniques. He serves as Associate Editor of IEEE Access, Healthcare Technology Letters, IET Generation, Transmission & Distribution, PLOS Digital Health and Frontiers in Signal Processing (Biomedical Signal Processing) and Academic Editor and Guest Editor of Journal of Healthcare Engineering. He serves as the reviewer for reputed journals including the IEEE, ACM, IET, Springer, Elsevier, PLOS ONE, and Taylor and Francis.