INTELLIGENT SENSORS AND SENSOR NETWORKS

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MOTIVATION

- Internet of Things is an emerging field that is poised to change our lives, personally and professionally.
- It is estimated that by 2022, there will be more than 50 billion connected devices communicating through the Internet.
- Connected coffee makers, vehicles, smart power meters, sensors attached to cattle, or connected machines in a production plant, are examples of IoT realizations.
- Sensor technology is a key part, as well as a tangible realization, of IoT.

MOTIVATION

- Wireless sensor networks are distributed systems, in which autonomous devices or Motes, observe what could be complex environments to collect data such as temperature, humidity, motion, and sound) or, even medical data (such as heart rate, blood oxygen level and pulse rate).
- The data is collected through a network, fused/aggregated, routed and transported to control/analytics/ and decision-making applications
- Sensor networks are an enabler for a broad range of applications in different sectors such as agriculture, healthcare, manufacturing, mining, smart cities, etc.

MOTIVATION

- Sensors provide insightful and quite often critical data; and through communication they build intelligence, and as such they can advise and assist the users about optimal ways to put them to use.
- While the world of IoT is emerging, the need for inexpensive, fast, low power and intelligent device management, signal processing, and security emerge as critical requirements. Such requirements introduce challenges on the overall system design, deployment and management, due to the intrinsic resource limitations constraints of the IoT.

COURSE DESCRIPTION

In this course, the students will learn WSN theory and technology such as routing and security as well as will gain hands-on skills and practical knowledge in WSN.

- The course introduces diverse fundamental concepts encountered in designing and analyzing intelligent sensors and sensor networks (mobile and stationary), with emphases on mission critical applications.
- The course will cover theoretical models, and design principles;
- It will explore how AI and ML are used to tackle complex issues pertinent to the design and operation of large-scale SN.
- Will explore latest developments and open research issues in wireless sensor network algorithms, protocols, architectures, and applications.

LEARNING OBJECTIVES

The objective of this course is to make the students

- ✓Understand the basic WSN technology and supporting protocols,
- ✓Understand the different sensor network stack in terms of layers and their role, operations and challenges,
- ✓Understand and appreciate sensor fusion and data aggregation techniques as means for achieving accurate sensing and efficient data capture and transport,
- ✓Learn the different layers of the sensor network stack in terms of their role, operations and challenges,

LEARNING OBJECTIVES

- Learn how AI and M/L techniques are useful in addressing critical design and operation SN issues.
- Learn how Graph Signal Processing is emerging as a new domain of signal processing for analyzing the dynamics and topology of large scale sensor networks.
- Learn key routing protocols for sensor networks
- Understand the importance of sensor localization and synchronization and learn techniques for achieving location-aware synchronous sensor networks
- Appreciate how sensors are typically capable of wireless communication, but at the same time are significantly constrained in terms of the amount of available resources such as energy, storage and computation.

LEARNING OBJECTIVES

- The students will learn how such constraints make the design and operation of sensor networks considerably different from contemporary wireless networks. They will learn the importance of resource conscious protocols and management techniques.
- Lean advanced emerging sensor network security paradigms such as lightweight cryptography, and Blockchain.

TOPICS COVERED

- Sensors and Sensor Networks: what and why.
- Abstraction: Sensor level, network level, Middleware
- Localization
- Synchronization
- Routing and Transport
- Energy management and Energy-Aware Signal processing
- Data fusion and Integration
- Distributed Signal Processing
- Graph Signal Processing
- Topological and Management Issues
- Sensor Mobility Considerations
- Network-Level fault-tolerance and Network Survivability

AI AND SN

AI is in the center of SN:

- Sensing is an input to perception, pattern recognition and decision making. In other words sensing is intelligence enablement!
- However, the process of sensing in a network setup revolves around making smart decisions
- in power management, routing, security, analytics, task allocation, mobility and mobilization, etc.

LEARNING RESOURCES

- This course will be offered as an asynchronous teaching offering. I will post the course notes and lectures video recording on the course LEARN website.
- Once a Teaching Assistant is assigned, his/her information will be published.
- Supplementary material such as scientific articles and technical reports will be posted on the course website on LEARN in synchrony with the topics covered.
- The OMNET++ simulation environment or similar environment, and the MATLAB S/W will be used to help the students practice the course topics.

RECOMMENDED READING MATERIAL:

- ✓Anna Hac, "Wireless Sensor Network Designs," John Wiley & Sons, December 2003, 391 pages.
- ✓Edgar H. Callaway, Jr. and Edgar H. Callaway, "Wireless Sensor Networks: Architectures and Protocols," CRC Press, August 2003, 352 pages.
- ✓Victor Lesser, Charles L. Ortiz, and Milind Tambe, "Distributed Sensor Networks: A Multiagent Perspective," Kluwer, October 2003, 367 pages.
- ✓Shad Roundy, Paul Kenneth Wright, and Jan M. Rabaey, "Energy Scavenging for Wireless Sensor Networks: With Special Focus on Vibrations," Kluwer, January 2004, 212 pages.

RECOMMENDED READING MATERIAL:

- ✓Jose A. Gutierrez, Edgar H. Callaway, Raymond Barrett, "IEEE 802.15.4 Low-Rate Wireless Personal Area Networks: Enabling Wireless Sensor Networks," IEEE, April 2003.
- ✓Feng Zhao, and Leonidas J. Guibas (Eds), " Information Processing in Sensor Networks," Proceedings of Second International Workshop, IPSN 2003, Palo Alto, Ca, Usa, April 22-23, 2003, (Lecture Notes in Computer Science, 2634), Springer Verlag, 676 pages.

MARKING SCHEME

Assessment	Percentage of Final Grade
4 Assignments : 1) NW Stack, Communication model, Routing. 2) Localization and Synchronization. Sensor Fusion and Aggregation. 3) Compressive Sensing. Graph Signal Processing. 4) Security, Bigdata and Blockchain	35%
Project	25%
Final Examination	40%