Smart Cities and Smart Homes – Part II

Dr. Sudip Misra
Associate Professor
Department of Computer Science and Engineering
IIT KHARAGPUR
Email: smisra@sit.iitkgp.ernet.in
Website: http://cse.iitkgp.ac.in/~smisra/

Data Fusion

✓ Enormous volume of data is produced periodically in a smart city environment.

✓ Challenges include making the available/ incoming large data volume precise and accurate.

✓ Quality of data precision and accuracy affects the quality of decision making in IoT-enabled smart cities.

✓ Data fusion enables optimum utilization of massive data gathered from multiple sources, and across multiple platforms.

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

Multi-sensor Data Fusion

- ✓ Combines information from multiple sensor sources.
- ✓ Enhances the ability of decision making systems to include a multitude of variables prior to arriving at a decision.
- ✓ Inferences drawn from multiple sensor type data is qualitatively superior to single sensor type data.
- ✓ Information fusion generated from multiple heterogeneous sensors provides for better understanding of the operational surroundings.

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

Challenges

Imperfection	Inaccurate or uncertain WSN sensor data
Ambiguity	Outliers, missing data
Conflicts	Same sensor type reports different data for the same location.
Alignment	Arises when sensor data frames are converted to a singular frame prior to transmission
Trivial features	Processing of trivial data features may bring down the accuracy of the whole system

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES
NPTEL

Data Fusion Opportunities in IoT

- ✓ Collective data is rich in information and generates better intelligence compared to data from single sources.

- ✓ Optimal amalgamation of data.

- ✓ Enhancing the collective information content obtained from multiple low-power, low-precision sensors.

- ✓ Enables hiding of critical data sources and semantics (useful in military applications, medical cases, etc.).

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES
NPTEL

Stages of Data Fusion

Decision level	Feature level	Pixel level	Signal level
• Ensemble of decisions	• Fusion of information prior to decision making	• Fusion of information at the imaging device level itself	• Fusion of information at the sensor node/ within the local network itself.

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

Mathematical Methods of Data Fusion

Probability based
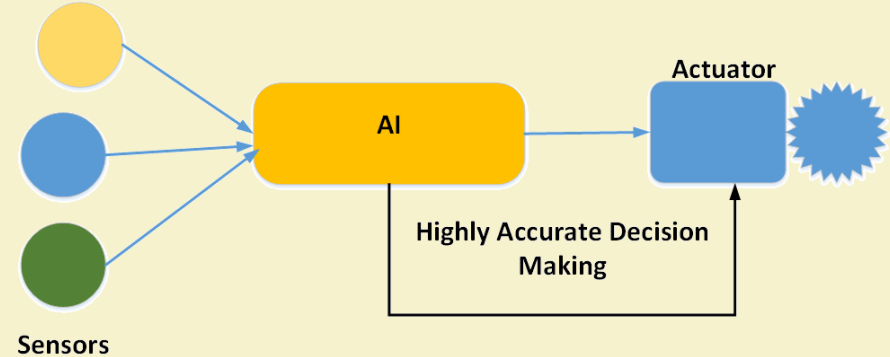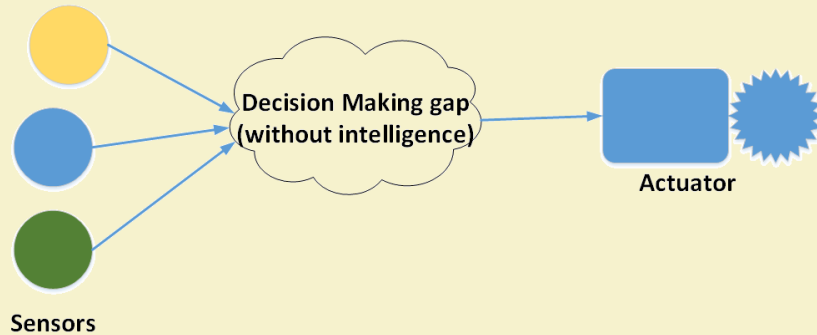
- Bayesian analysis, Statistics, Recursive methods

AI based

- ANN, Machine Learning, CNN

Theory of Evidence based

- Belief functions, Transferable belief models

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

AI in IoT Decision Making

Source: Alam, Furqan, et al. "Data Fusion and IoT for Smart Ubiquitous Environments: A Survey." *IEEE Access* (2017).

Data Fusion for Autonomous Vehicles

Smart Parking

✓ Shortens parking search time of drivers.

✓ Reduces traffic congestion.

✓ Reduces pollution by keeping unnecessarily lingering vehicles off the roads.

✓ Reduces fuel consumption and costs.

✓ Increases urban mobility.

✓ Shorter parking search time results in more parked time, and hence, more revenue.

Source: Lin, Trista, Hervé Rivano, and Frédéric Le Mouël. "A Survey of Smart Parking Solutions." *IEEE Transactions on Intelligent Transportation Systems* (2017).

IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES
NPTEL

Functional Layers in Smart parking

Information Collection

System Deployment

Service Dissemination

Source: Lin, Trista, Hervé Rivano, and Frédéric Le Mouël. "A Survey of Smart Parking Solutions." *IEEE Transactions on Intelligent Transportation Systems* (2017).

Smart Parking: Information Collection

Sensors

Parking Meters

Sensor Networks

Crowd sensing

Source: Lin, Trista, Hervé Rivano, and Frédéric Le Mouël. "A Survey of Smart Parking Solutions." *IEEE Transactions on Intelligent Transportation Systems* (2017).

IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES

NPTEL

Smart Parking: System Deployment

Software System

Information Management

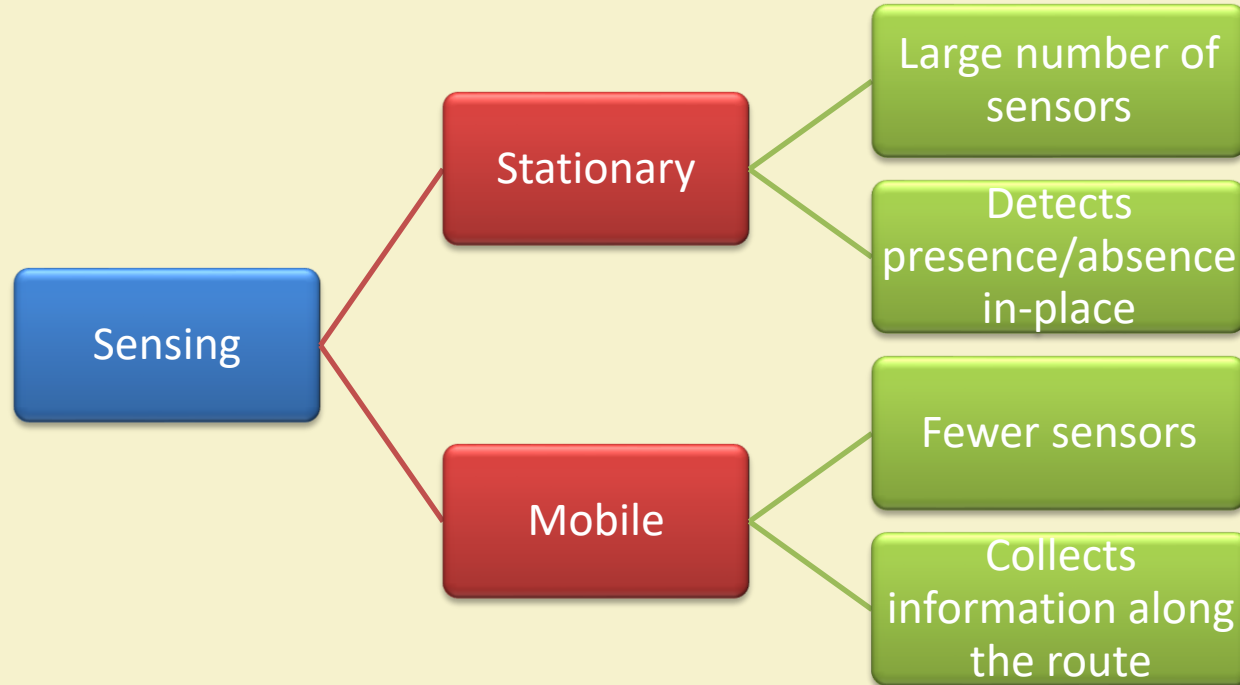E-parking

Guidance

Data Analytics

Source: Lin, Trista, Hervé Rivano, and Frédéric Le Mouël. "A Survey of Smart Parking Solutions." *IEEE Transactions on Intelligent Transportation Systems* (2017).

Smart Parking: Service Dissemination

- Dynamic Pricing
- Strategies
- Infrastructure-based information
- Infrastructure-free information
- Parking Choice
- Vehicular Activities

Source: Lin, Trista, Hervé Rivano, and Frédéric Le Mouël. "A Survey of Smart Parking Solutions." *IEEE Transactions on Intelligent Transportation Systems* (2017).

IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES

Information Sensing in Smart Parking

Source: Lin, Trista, Hervé Rivano, and Frédéric Le Mouël. "A Survey of Smart Parking Solutions." *IEEE Transactions on Intelligent Transportation Systems* (2017).

Energy Management in Smart Cities

✓ Energy efficient solutions

- Lightweight protocols

- Scheduling optimization

- Predictive models for energy consumption

- Cloud-based approach

- Low-power transceivers

- Cognitive management framework

Source: Ejaz, Waleed, et al. "Efficient Energy Management for Internet of Things in Smart Cities." IEEE Communications Magazine, 2017

Energy Management in Smart Cities

✓ Energy harvesting solutions

- Ambient energy harvesting
  - RF sources
  - Wind
  - Sun
  - Heat
  - Vibration

Source: Ejaz, Waleed, et al. "Efficient Energy Management for Internet of Things in Smart Cities." IEEE Communications Magazine, 2017

Energy Management in Smart Cities

✓ Energy harvesting solutions

  ▪ Dedicated energy harvesting

    ▪ Energy sources intentionally deployed near IoT sources.

    ▪ Amount of energy harvested depends upon:

      1. Sensitivity of the harvesting circuit
      2. Distance between the device and source
      3. Environment

Source: Ejaz, Waleed, et al. "Efficient Energy Management for Internet of Things in Smart Cities." IEEE Communications Magazine, 2017

Thank You!!

IIT KHARAGPUR

NPTEL ONLINE
CERTIFICATION COURSES