Wireless Multimedia Sensor Networks: Challenges and Opportunities

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Position Statements

- Collaborative Multimedia (Multi-modal) Sensing is the way to go!

- Pervasive Computing and Social Informatics is the future!
We live in a physical world, which we need to understand, serve, and control.
Opportunistic Clouds of Multi-modal Wireless Access Devices, Heterogeneous Access Networks, Services and Applications
Wireless Sensor Networks (WSN)

**Computation**
Sensory Data: A/D conversion, Compression, Filtering, Aggregation, Analysis

**Communication (Wireless)**
Broadcast sensory data, Dissemination, Routing

**Control (Sensing / Actuation)**
Sensing the physical world: temperature, humidity, pressure, light, velocity, sound, image

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Static WSNs

Traditional WSN architecture
Mobile WSNs
WSNs with mobile relays

Emerging Trends in Sensors
Multimedia WSNs

- Multimedia sensors (with image, audio/video streaming)
  - Application-specific devices
    - Surveillance cameras, stereo-cameras
  - Multimedia sensing platforms
    - Off-the-shelf products
    - Custom platforms

Emerging Trends in Sensing Applications
Smartphones and participatory sensing

- **Smartphones as sensing platforms**
  - Abundance of sensors
    - Acceleration, location, sound, video, orientation
  - Rich in processing and storage resources
    - Enabling computational-intensive applications
  - Several wireless technologies
    - WiFi, Bluetooth, long range cellular radio

- **Participatory, persuasive, social sensing applications**
  - Users involved in sensing campaigns
    - Traffic/accident monitoring, well being, pollution control
    - Incentives for participation
Multimedia and Heterogeneous WSNs
Putting everything together

- A wide variety of sensing devices
- Each device best suited for a specific task
- Exploit heterogeneity for collaborative sensing
Advantages of Collaborative Sensing
Energy conservation and sensing accuracy

- **Multi-scale** and triggered sensing
  - Low-power low-accuracy sensor can be used
  - Higher accuracy (power-hungry) sensors can be exploited only when necessary
    - Tradeoff between accuracy and energy consumption

- **Different sensing modalities**
  - Better characterization of the environment
    - Data fusion
  - Higher efficiency
    - Less bandwidth and energy usage

Premise: Sensors Everywhere

- Ultra light, ultra power, embeddable wireless devices networked everywhere (Internet of things)

- Sensors will be all pervasive, from clothing to coffee mugs to building structures

- Wireless and ubiquitous connectivity taken for granted

- Cognitive networks based overlay architectures

- Content rich (multi-modal) sensor applications

- Information deluge (e.g., recording every event in life)
Broader Impacts

- Societal Grand Challenges (National & Global)
  - Security and Safety (before, during and after events)
  - Healthcare (health risks, wellbeing and care)
  - Energy & Sustainability (monitoring and mitigation)
  - Extreme Events Management (disasters, forest-fires, ...)

- Citizen Science
  - Smart phones w/ burgeoning capabilities and sensors
  - Deep penetration of mobile devices and networking

- How to handle pervasive computing at scale?
Energy and Sustainability

- Smart appliances, buildings, power grid
  - Net-zero energy buildings
  - Minimize peak system usage
  - No cascading failures
  - Climate control
Smart Health Care

- Infusion pump
- Operating room of future
  - Patient records at every point of care
  - 24/7 monitoring and treatment
  - Assisted Technology for everyone
  - Smart prosthetics
- Embedded medical devices

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Wireless Multimedia Sensor Networks: New Challenges

- How to handle higher data rates (video/audio streaming)?
  - Innovative energy-saving architectures, algorithms, and protocols

- How to exploit higher spatio-temporal data correlation?
  - In-network: Fusion, estimation, detection, filtering, gathering, ...

- How to provide higher information assurance?
  - Accuracy, reliability, fault-tolerance, resiliency, security, robustness, ...

- How to deal with emerging security and privacy threats?
  - Virus spreading, e.g., Cabir for wireless cell phone networks
Research Opportunities

Uncertainty Management

- How to deal with (or tame) inherent Uncertainty?
  - sensing, wireless communications, mobility, topology control, coverage, routing, bandwidth and battery power, ...
  - distributed collaboration and coordination, aggregation (fusion), processing, decision making, duty cycling, ...

- Context Resolution and Situation-Awareness
  - How to unambiguously capture contexts from multi-modal sources despite noisy and incomplete information?

- Supporting QoS and QoI (quality of information)
  - How to improve information accuracy, reliability, latency? How to measure sensing quality in presence of uncertainty?
Socio-Pervasive World

Environment Sensing / Smart Environments

Disaster / Emergency Response

Situation Awareness: Humans as sensors feed multi-modal data streams

Pervasive Computing

People-Centric Sensing

Social

Informatics

Smart Hearth Care

Personal Sensing

Public Sensing

Social Sensing

ECG
Blood pressure
SpO2 ESR
Accelerometer

Evaluate
Sense
Intervene
Identify
Assess
Recap: Position Statements

- Collaborative Multimedia (Multi-modal) Sensing is the way to go!
- Pervasive Computing and Social Informatics is the future!