Autonomous Adaptive Sensing for Energy-Efficient IoT Applications

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Internet of Things

**Challenges:**

- The *scale* in terms of the number of units.
- The *constraints* in terms of resources: energy, memory, computation.
- The *nonstationary* and *heterogeneous* environments of things.
Internet of Things

**Challenges:**

The scale in terms of the number of units.

The constraints in terms of resources: energy, memory, computation.

The nonstationary and heterogeneous environments of things.

**Opportunities:**

Many applications only need to provide an overall picture of a situation.

Nodes can do energy harvesting.

The cloud can support nodes with computation.

There is much data to learn from.
IKTPLUSS: ART — Autonomous Resource-Constrained Things

• Phase 1
  • March to December 2017
  • 500 000.- NOK
  • Academic Workshop
  • Postdoc in Statistics
  • Search for Industry Partners

• Phase 2
  • ca. 4 years
  • 4 M NOK / year

• IES + IIK + IMF

• PhD in Statistical Learning for Autonomous Resource-Constrained Sensors
  • NTNU PhD position on enabling technologies
IoT - A Discipline?
1. Use IoT infrastructure to deliver data into AI processes.
2. Use AI to optimize the IoT infrastructure.
3. Use IoT to execute and distribute AI.
IoT - A Discipline?
Strategies

• **Adaptive** sensing: Only sense what is interesting
• **Autonomous** sensing: Without human intervention
Dependability vs. Constraints

• **Dependable:** Do not introduce single-point-of-failures, operate in isolation
• **Constrained:** Work on constrained nodes
Should you compute locally?

Energy
- How much energy should I use?
- How much energy do I have?
- How much energy will I harvest?

Sensing
- Which radio should I use?
- When will connectivity be great again?
- How should I send my data?

Network
- Should I store this?
- What should I send first?
- How much storage for what?

Storage
- How often should I measure?
- How many measurements should I take?
- How valuable is my next sample?

Security
- In which environment am I?
- Can I trust my peers?
- Is this a normal situation?

Context
- Where am I?
- What do I need to know about my environment?
- When will my environment change?
Autonomous Sensor Test Bed
Autonomous Adaptive Sensing

- Let sensors benefit from big data and machine learning
- Let sensors learn from each other
- All parameters in sensing applications are subject to learning
- Learning = autonomous optimization
LoRaWAN Gateway

**Upstream:**
- Sensor data
- Battery voltage
- Solar current
- Sensing mode

**Downstream:**
- Sensing mode update

- Server Backend
- TTN
- Weather Forecast
Energy Consumption Estimation

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- Sleep
- Post-sleep
- Wait
- Pre-send
- Post-send
- Send
- Pre-sleep

Power over time (t)