Developing Signal Processing Applications for the Internet of Things

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Agenda

- IoT and its components
- Developing and deploying algorithms for Edge Nodes
- Connecting to Aggregation services
- Conclusion
- Q&A
Internet of Things
Internet of Things

- Sensors & Actuators
  - Consumer
  - Industrial
  - Healthcare
  - Transportation
  - Infrastructure

- Internet
  - Application Integration
  - Data Collection
  - Analytics
  - Visualization
  - Security
Technologies Enabling IoT

- Low-cost low-power sensors and actuators
  - Data validation and clean-up
  - Smart control techniques
- Ubiquitous connectivity
  - Wired / wireless communication
- Data aggregation and analysis
  - “Big data”
Components of IoT

**Data Aggregator**
- Online analytics
- Visualization and reporting

**Edge Nodes**
- Local embedded algorithms
- Data reduction

**Exploratory Analysis**
- Historical analytics
- Algorithm development

**Communication**
- Deploy analytics to aggregator

**Connectivity**
- Deploy algorithm to device
Types of Edge nodes

- Classification based on Node types
  - Intelligent Nodes
  - Dumb nodes
Intelligent Node

- Capable of making local decisions
- May have node level aggregation
- May have local analytics capabilities
Developing signal processing algorithms

- Access to data
  - Android sensors
Developing signal processing algorithms

- Algorithm development

```
for k=1:max
    x = fft(dat)
    y = 20*log1
```

Andriod Fall Detection

This model runs at a rate of 10 Hz. The algorithm detects a fall if there is an acceleration change or jerk of more than 15 m/s3. Once a fall is detected a picture is taken and Lat, Lon of the location along with the acceleration during fall are overlayed on the image.
Developing signal processing algorithms

- Deployment of algorithm as an Android App
  - Android Support package

Detected a Fall at: 12.94, 77.69
Acceleration during fall: 27 m/s²
Machine learning for activity detection

Machine learning is ubiquitous. From medical diagnosis, speech, and handwriting recognition to automated...
Types of Edge nodes

- Classification based on Node types
  - Intelligent Nodes
  - Dumb nodes
Dumb Node

- Nodes act only as sensors
- Low frequency of update
- No local aggregation
Architecture

Weather Station

Arduino

Data pushed every minute

Internet

Data aggregator (ThingSpeak)

MATLAB
Connecting to Data Aggregator

MathWorks Weather Station, West Garage, Natick, MA 01760, USA

Tags: MathWorks Weather Station

Field 5 Chart

WeatherStation

Field 6 Chart

WeatherStation

Channel Location

Map data ©2015 Google, INEGI. Terms of Use
Thingspeak connectivity

- Write to a thingspeak channel from MATLAB

```matlab
% Read the 3 acceleration values from analog inputs and update them on
% Thingspeak
fieldName = 'field1';
Acceleration_X = readVoltage(ObjArduino, 'A3');
response = webwrite(thingSpeakWriteURL,'api_key',writeApiKey,fieldName,Acceleration_X);
```

- Read from a thingspeak channel from MATLAB

```matlab
% fetch last 8000 minutes of data
[d,t,ci] = thingSpeakFetch(12397,'NumPoints',8000);
% field 4 is temperature in deg F
tempF = d(:,4);
```

- Write to a thingspeak channel from a embedded hardware

![Arduino diagram](image)
Exploratory Analysis

- Historical analytics
- Algorithm development
Exploratory Analysis
Available Online On File Exchange

Analyzing Weather Data from an Arduino-based weather station
by MathWorks Internet of Things Team
17 Jul 2014 (Updated 02 Feb 2015)

Analyze data from a weather station connected to ThingSpeak

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File Information

Description: This example illustrates how to analyze data from a weather station connected to ThingSpeak.com. The data is visualized and analyzed in MATLAB. The example shows how to visualize wind speed and direction, calculate and plot dew point, and verify pressure trends. It also demonstrates some techniques to remove outlier data and fill in missing data.

This example requires the user to first install the MATLAB Support for ThingSpeak which is available here:
http://www.mathworks.com/matlabcentral/fileexchange/48714

For more information on IoT and acquiring sensor data from ThingSpeak, see the following resource page:
http://www.mathworks.com/thingspeak

Conclusion

**Data Aggregator**
- Online analytics
- Visualization and reporting

**Edge Nodes**
- Local embedded algorithms
- Data reduction

**Exploratory Analysis**
- Historical analytics
- Algorithm development

**Deployment**
- Deploy algorithm to device
- Deploy analytics to aggregator

**Communication**

**Connectivity**
Q & A
Thank you!