Fast algorithm prototyping with MATLAB for smart IoT systems

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Motivation

- 20-50 billion devices becoming connected in a few years
- We can expect a lot of data
- IoT systems, including edge devices, must become smarter and autonomous to handle some of that data -> machine learning on the edge
Challenges in Building IoT Systems with Analytics

1. How can engineers develop predictive models without being data scientists?

2. How can engineers migrate algorithms to run on the smart device or gateway?

3. How can engineers with no cloud programming skills quickly prototype an IoT system?

4. How can solution architects integrate engineering analytics into existing cloud/IT infrastructure?

Data Aggregation & Analytics

Deploy algorithms to nodes/devices

Deploy analytics to server/cloud

Communications Network

Smart Connected Devices

Algorithm Development

Sensor Analytics
IoT Challenge #1: Developing Predictive Models

1. How can engineers develop predictive models without being data scientists?
Example: Human Activity Recognition and Classification

Supervised Machine Learning

Dataset courtesy of:
Davide Anguita, Alessandro Ghio, Luca Oneto, Xavier Parra and Jorge L. Reyes-Ortiz.
Human Activity Recognition on Smartphones using a Multiclass Hardware-Friendly Support Vector Machine.
International Workshop of Ambient Assisted Living (IWAAL 2012), Vitoria-Gasteiz, Spain, Dec 2012
http://archive.ics.uci.edu/ml/datasets/Human+Activity+Recognition+Using+Smartphones

1. How can engineers develop predictive models without being data scientists?
Supervised Machine Learning Workflow

**Train:** Iterate until you find the best model

**Predict:** Use trained model make predictions from new input data

1. How can engineers develop predictive models without being data scientists?
IoT Challenge #2: Migrating Algorithms to Run on a Smart Device

2. How can engineers migrate algorithms to run on the smart device or gateway?
Code Generation removes the gap between algorithm development and implementation

2. How can engineers migrate algorithms to run on the smart device or gateway?
Processor-Optimized Code For

- ARM Cortex-M
- ARM Cortex-R
- ARM Cortex-A
- ST Nucleo Board
- ST Discovery Board
- Intel Curie
- TI microprocessors
- Mobile devices
  - iOS and Android
- Prototyping Hardware
  - Raspberry Pi, BeagleBone Black, Arduino
- Nvidia GPU’s

https://www.mathworks.com/hardware-support.html?q=&fq=product:EC&page=1
3. How can engineers with no cloud programming skills quickly prototype an IoT system?

IoT Challenge #3: Prototyping IoT Systems

Data Aggregation & Analytics

Deploy analytics to server/cloud

Communications Network

Deploy algorithms to nodes/devices

Algorithm Development

Sensor Analytics

Smart Connected Devices

Deploy to server/cloud

ThingSpeak™
What Is ThingSpeak?

**Web Site For People**

- MathWorks web service hosted on AWS
- Lets you collect, analyze and act on data from “things”
- It has MATLAB for IoT Analytics
- It’s free to get started

**Web Service for Devices**

```json
{
  "channel": {
    "id": 38629,
    "name": "Car Counter",
    "description": "Counting number of cars passing a reference line in 15 sec interval",
    "latitude": "42.28",
    "longitude": "-71.95",
    "fields": ["Number of Westbound Cars", "Number of Eastbound Cars"],
    "created": "2016-05-19T10:36:23Z",
    "last_entry_id": 1477221
  },
  "feeds": [
    {
      "created": "2016-05-19T10:36:20Z",
      "entry_id": 1477220,
      "fields": ["18.000000", "8.000000"
    },
    {
      "created": "2016-05-19T10:36:19Z",
      "entry_id": 1477219,
      "fields": ["18.000000", "14.000000"
    }
  ]
}
```

3. How can engineers with no cloud programming skills quickly prototype an IoT system?
IoT Challenge #4: Integrating Engineering Analytics into the Cloud

1. Algorithm Development
2. Sensor Analytics
3. Data Aggregation & Analytics
4. Deploy analytics to server/cloud
5. Deploy algorithms to nodes/devices
6. Smart Connected Devices
7. Algorithm Development
8. Sensor Analytics

4. How can solution architects integrate engineering analytics into existing cloud/IT infrastructure?
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Integrating MATLAB with Third Party IoT Cloud Platforms

4. How can solution architects integrate engineering analytics into existing cloud/IT infrastructure?
Summary

1. Use high-level functions and apps to develop AI
   - Enable quicker algorithm/model development
2. Automatically generate code for edge
   - Avoid double-implementation: reduce cost and avoid errors in recoding
   - Power your devices with AI
3. Prototype cloud analytics with ThingSpeak
   - Avoid cloud-architecting, use the same code as on desktop
4. Integrate with existing cloud systems using MATLAB Production Server
   - Avoid recoding, call MATLAB-functions as a service
Close the gaps
Unify workflows
Reduce time-to-market
What next?

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Thank You