Environmental Sensing at the Edge: Waggle and the Array of Things

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Collaborators: Charlie Catlett, Rajesh Sankaran, Rob Jacob, and Nicola Ferrier
Big Sensor Science

Big, Expensive, Precise, Sparse

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What if environmental sensor systems could be massively parallel?

What if sensors supported edge computing?
**Waggle**: An Open Platform for *Intelligent* Sensors
Exploiting Three areas of Disruptive Technology + “Deep Space Probe” design

- **Machine Learning**
  - Computer Vision

- **Novel Sensors**
  - Nano / MEMS

- **Edge Computing**
  - GPU / Smartphones

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Powerful, Resilient & Hackable

Multiple boot media (μSD / eMMC)

4-core ARM

4 + 4-core ARM

8-core GPU

Node Control & Communications

In-Situ / Edge Processing

Relays

Heartbeat Monitors

Reset pins

Current Sensors

Real time clock & Internal sensors

“Deep Space Probe” Design

Linux Development Environment

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The Array of Things

Charlie Catlett, Pete Beckman, Rob Jacob, Nicola Ferrier, Mike Papka, Rajesh Sankaran, et. al.
Urban Challenges are Neighborhood-Specific

But many city challenges are hyper-local, and to diagnose and address them requires much better measurement strategies.

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AoT Nodes are going up in Chicago
Chemical Sensors

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Physical Sensors
Computer Vision Research: Tracking Pedestrians

Detected pedestrians are captured by green bounding boxes.

Tracking Experiment
Blue bounding box represents the pedestrian and red dot represents the centroid. The edge processor can send the centroid coordinates.

Research by (* using INRIA public dataset):
- Zeeshan Nadir (Purdue University)
- Ethan Trokie (Northwestern University)
- Nicola J. Ferrier (Argonne National Lab)
Example of flood/pond water

Process 50 frames:

Extract the mode frame. Notice it captures all the reflections and stationary objects.

Legend:
White Portion – Water
Black Portion - Non-water

Automated water/non-water segmentation

Ground Truth (human)

Computer Vision Research: Water Detection

Research by:
- Zeeshan Nadir (Purdue University)
- **Ethan Trokie** (Northwestern University)
- Nicola J. Ferrier (Argonne National Lab)
Detection uses OpenCV HOG descriptor and linear SVM. Detection size (window size) is (64, 128). The detector is written in Python and for 640x480 image, performs about 3 images/sec on current Waggle Edge processor.

Research by:
1. Yongho Kim (Purdue University)
2. Nicola J. Ferrier (Argonne National Lab)
Computer Vision Research: Vegetation Growth

Original

Single Mean Model

Mixture Model

Research by:
• Renee Zha (Northwestern University)
• Zeeshaan Nadir (Purdue University)
• Cristina Negri (Argonne National Lab)
Pete Beckman: Argonne National Laboratory

Work with David Lary, Udallas
Measure pollen in Chattanooga
Imagine Programmable Infrastructure

Examples from discussions with smart people about cities:

• Interesting Stops
• Diesel Truck Stops
• Bike Helmets
• Wildlife & QoL
• Audio quality of life
• Traffic Crowds
• Street water
• Collisions
• Pedestrian Misses
• Baby Strollers

All based on parallel computing & deep learning, advanced system software

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Next Steps:
Edge Processing and Deep Learning With Feedback

Inference

Parallel Computing

Reduced, Compressed data

New classifiers (code)

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Hardware for Edge Computing is Rapidly Changing

NVIDIA Jetson TX2 example:
- “AI at the edge”
- 256 Pascal cores
- ½ TF SP FLOPS

Edge Processing common:
- Drones
- Car collision detection system
- Camera systems
Questions?

http://www.wa8.gl

http://arrayofthings.github.io

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