Physically Grounded AI: Interacting with the Physical World

Dieter Fox
University of Washington
Department of Computer Science & Engineering

What do I mean by that?

- AI-system that acts in the real world or at least interprets sensor data collected in the physical world
- We’re going to see many of these ...
  - Robots (home, street, air, battlefield)
  - Smart devices
  - Smart houses

"Since its birth in 1956, the AI dream has been to build systems that exhibit broad-spectrum competence and intelligence. STAIR revisits this dream, and seeks to integrate onto a single robot platform tools drawn from all areas of AI including learning, vision, navigation, manipulation, planning, and speech/NLP."

-Andrew Ng talk abstract
Vehicles competing in the Urban Challenge will have to think like human drivers and continually make split-second decisions to avoid moving vehicles, including robotic vehicles without drivers, and operate safely on the course.

-Dr. Norman Whitaker, Urban Challenge Program Manager

Wearable sensors and sensors in environment provide information about person’s state

State includes
- Physical location
- Physical activity (walking, running, driving, …)
- Physical goals
- Higher level activities (conversation, stand in line, shopping, watching a movie, …)
**Activity Recognition**

- Goal: Estimate a person’s state
- Basis for huge number of applications:
  - Healthcare
  - Long-term health monitoring
  - Guidance
  - Diaries
  - …

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**Predict Goal and Path**

[Liao-Fox-Kautz: AAAI-04]

[Diagram: Predicted goal and path]

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**Application: Opportunity Knocks**

[Patterson-Liao: Ubicomp-04]

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**Detect User Errors**

[Diagram: Detecting user errors]
Application: Opportunity Knocks

RFID Tags for In-Home Activity Recognition

[Patterson-Fox-Kautz-Philipose: ISWC-05]
[Philipose-Fishkin-etAl: Pervasive-04]

Tracking Breakfast Activities

Sample Output

Relational model performs smoothing over object hierarchy
**Wearable Multi-Sensor Unit**

- **Records 4 hours of audio, images (1/sec), GPS, and sensor data (accelerometer, barometric pressure, light intensity, gyroscope, magnetometer)**

**Soldier Activity Recognition**

- **Automatic generation of mission summaries**
  - Motion type (linger, walk, run, drive, ...)
  - Environment (inside, outside building)
  - Location and building
  - Events (marked via keyword)

**Some Observations**

- **AI systems connected to the physical world**
  - Comprised many AI problems
  - Great tools to drive AI research
  - Will have huge impact

- **Bottom up approach to AI**

- **Robotics and UbiComp communities build many gadgets, AI is needed to make them smart**

- **(So far?) key problems seem to be in state estimation, not control / decision making**

**Data**

- **Collecting data will be easy / cheap**
- **Making sense of it is the hard part**

- **Wearable sensors**
  - **Indexing** the data is key problem
  - Vision and speech are crucial but can't do all of it
  - Need to combine all sources of information

- **Use the Web!**
**Inference and Learning**

- **Machine learning** is crucial for these systems
- **Graphical models** as core components
- Large collection of models that are loosely coupled
- Issues:
  - Where do states come from?
  - Labeled data is hard to get
  - Use the Web?

**Decision Making**

- **POMDPs:** overkill for most applications
  - Good state estimation can make decision making easier
  - System needs to be aware of its uncertainty and know when it's lost (also wrt to user state)
  - Interesting connection to user interfaces
  - Maybe we need complex AI planning once systems are capable enough