

Physically Grounded AI: Interacting with the Physical World

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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

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Indoor Robots: STAIR

- "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

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Opening Doors



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Going Outdoors: Urban Challenge

- “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

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Going Outdoors: Urban Challenge

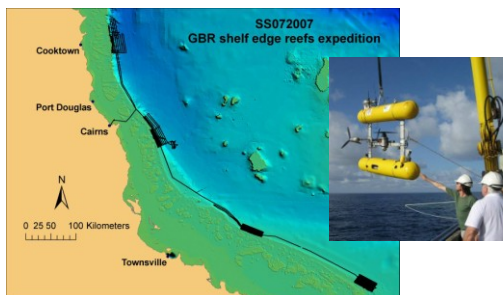


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Going Underwater



Stefan Williams, USyd

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Smart Devices / Environments

- 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, ...)

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Activity Recognition

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

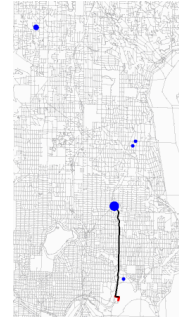
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Predict Goal and Path

[Liao-Fox-Kautz: AAAI-04]



- Predicted goal
- Predicted path

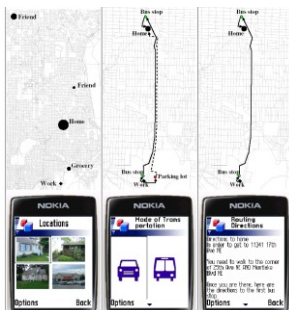
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Application: Opportunity Knocks

[Patterson-Liao-etAl: Ubicomp-04]



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Detect User Errors



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Application: Opportunity Knocks

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RFID Tags for In-Home Activity Recognition

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

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Tracking Breakfast Activities

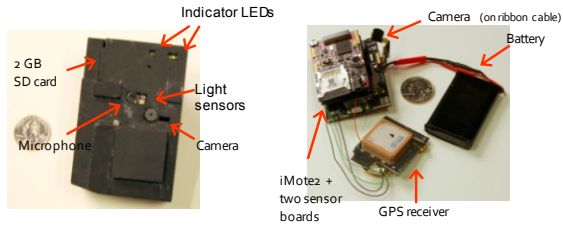
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Sample Output

Relational model performs smoothing over object hierarchy

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Wearable Multi-Sensor Unit



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

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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)



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Some Observations

- AI systems connected to the physical world
 - encompass 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

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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!

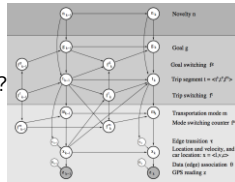
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Inference and Learning

- 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?



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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

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