Robotics, sensors and advanced manufacturing

MnDRIVE
Minnesota's Discovery, Research, and InnoVation Economy

Minnesota Power Systems Conference November 4-6, 2014
My Brush with Electric Energy Education and Research

Honorary Member of UMN ECE Electric Energy Group

Research on mitigation of radar interference from wind turbines

Dodge City, KS, NEXRAD (KDDC)
MnDRIVE Initiatives

A landmark partnership between the University and the state of Minnesota

Robotics, Sensors and Advanced Manufacturing

Global Food Ventures

Advancing Industry, Conserving Our Environment

Discoveries and Treatments for Brain Conditions
MnDRIVE – Robotics, Sensors and Advanced Manufacturing (RSAM)

- **Vision**: Establish the University of Minnesota as a leading center of education, research, and innovation in the technologies and applications of robotics, intelligent systems, and manufacturing.
  - Build on University’s existing strengths
  - Strengthen and expand partnerships with Minnesota industry in core and application technologies
  - Strengthen and expand cross-disciplinary collaborations across the University on emerging applications
  - Exploit the robotics platform and manufacturing as an effective tool for early education in design, innovation, and attraction of students to STEM fields
Why Robotics

• **Worldwide in 2011**
  - **Industrial robot** sales were up 38% from 2010; 166,000 robots sold of which 34% for the automotive sector.
  - **Service robot** sales were up 9% from 2010; 16,408 units of which 32% for the defense sector.
  - Market worth $18.39 billion, expected to reach $46.18 billion by 2017.
  - **Personal and domestic** sales up 15% over 2010; 2.5 million units, $636 million in sales, mostly toys and robot vacuums.
    (data from International Federation of Robotics and marketsandmarkets.com)

• **Kiva** was acquired for **$780M** by Amazon for automated warehousing

• **Google** acquired eight robotics companies in 2012

• **Robotics** = Sensing, Automation, and Intelligence
Why Sensors and Manufacturing

- Sensors connect the physical world with automation and machine intelligence (e.g. necessary for the smart grid)
  - Strong sensor work at the University and Minnesota industry
- The “maker movement,” and re-emergence of domestic manufacturing innovations
- Federal initiative on manufacturing through the National Network for Manufacturing Innovation (NNMI)
  - America Makes: National Additive Manufacturing Innovation (Youngstown, OH)
  - Digital Manufacturing and Design Innovation (Chicago, IL)
  - Lightweight & Modern Metals Manufacturing Innovation (Detroit, MI)
  - Next Generation Power Electronics Innovation (Raleigh, NC)
- Minnesota’s advanced manufacturing strengths
RSAM: Industrial Impact

Strengthening partnerships with Minnesota operations
# Unmanned Systems

## Potential Applications

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[www.auvsi.org](http://www.auvsi.org)
Activities 2014

- Core laboratory development
- Expansion of industrial partnerships
- Recruitment of six new faculty
- Research seed funding (exploratory grants)
- Technology transition (entrepreneurship grants)
- Educational outreach to schools and community (MnDRIVE RSAM Scholars)
  - Minnesota has the largest FIRST Robotics teams per campita in the US.
U of M Project Examples

• Outreach
• Medical robotics, and 3D printing
• General robotics and localization
• Uninhabited land/water/air systems
  – Environmental monitoring
  – Precision agriculture
K-12 Outreach

Tech camps, special events, collaborations with schools

• CSE Expo and summer camp
Robotics in CSE, Kowalewski

- Surgical robotics – hard to soft (catheter) tools
Orthosis – NSF Center for Compact and Efficient Fluid Power

Foot orthosis

Because of its superior power to weight ratio, fluid power is ideal for applications like orthosis where space and weight are at a premium.
Additive Manufacturing – 3D Printing
Medical Device Research and Design

**Airway Model**
Simulate tissues by printing in multiple materials with different durometers in one print.

**Mouth**
Flexible materials options allow for more realistic models.

**Heart**
Multiple material options
Robotics in CSE, Roumeliotis

Human-humanoid coordinated object manipulation

Vision-aided inertial navigation w/o GPS
Robotics in CSE, Papanikolopoulos

Scout

Tumbler

Loper
Robotics in CSE, Isler

Environmental monitoring, and active localization
Robotics in CSE, Mohan

- Flywheel energy storage for mobile robots
PRECISION AGRICULTURE

• 2 year transdisciplinary grant through MnDRIVE to “close the loop” around agriculture

• Research economic tradeoffs and advocate for policies to enable UAS use in agriculture

• Teamed up with the University of Minnesota, Morris Campus.

• Case Study: Mitigate Soybean Aphid infestation

Fig 1. Precision agriculture: Affordably "closing-the-loop" for Minnesota farmers
Apple Orchard Surveys

The vehicle and sensors

Image segmentation
How do we find where we are indoors? Vision-aided Inertial Navigation

- Robust & efficient fusion of inertial measurements w/ camera observations [UMN-patented technology initially developed for NASA]

Advantages

- **Efficiency**
  - Low cost/power/weight sensors
  - Adjustable processing cost

- **Versatility**
  - Same device for humans & robots
  - No prior maps required

Navigating through Walter Library using a Samsung S4 cell

Mapping Walter Library’s 4th floor using an aerial robot and a cell
Precision Agriculture

Vision-based Surveying of Apple Orchards with an Autonomous Aerial Vehicle

Pravakar Roy, Nikolaos Stefas, Pratap Tokekar and Volkan Isler

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Thank you!