# AME 3623:
# Embedded Real-Time Systems

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# What is an Embedded System?

# What is an Embedded System?

- Computing system with a non-standard interface (often no keyboard or screen)
- Often involved in sensing and control (and may not even talk to a human)
- Typically a custom system for a very specific application

# What is an Embedded System? (cont)

- Limited processing capabilities:
  – Can be extremely small
  – Can require a small amount of power
- Can have significant real-time constraints
  – Act on inputs very quickly
  – Generate high-frequency outputs
- Often a higher expectation of reliability

# Examples of Embedded Systems

# Robotics

Mark Tilden

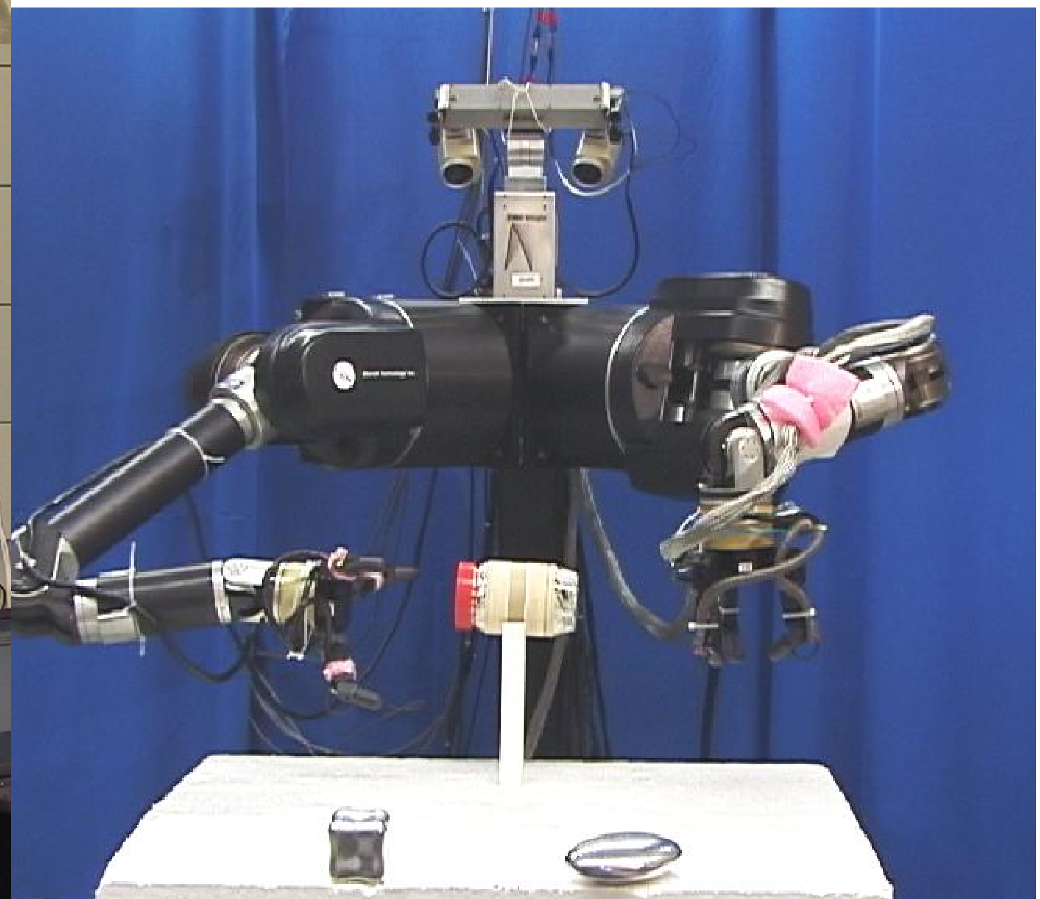
Los Alamos National Labs and Wowwee

picture from *Robosapiens*

# Humanoid Robotics

NASA/JSC Robonaut

UMass Torso



# Real-Time Robotic Control

# Dual-Limb Coordination

# Personal Satellite Assistants

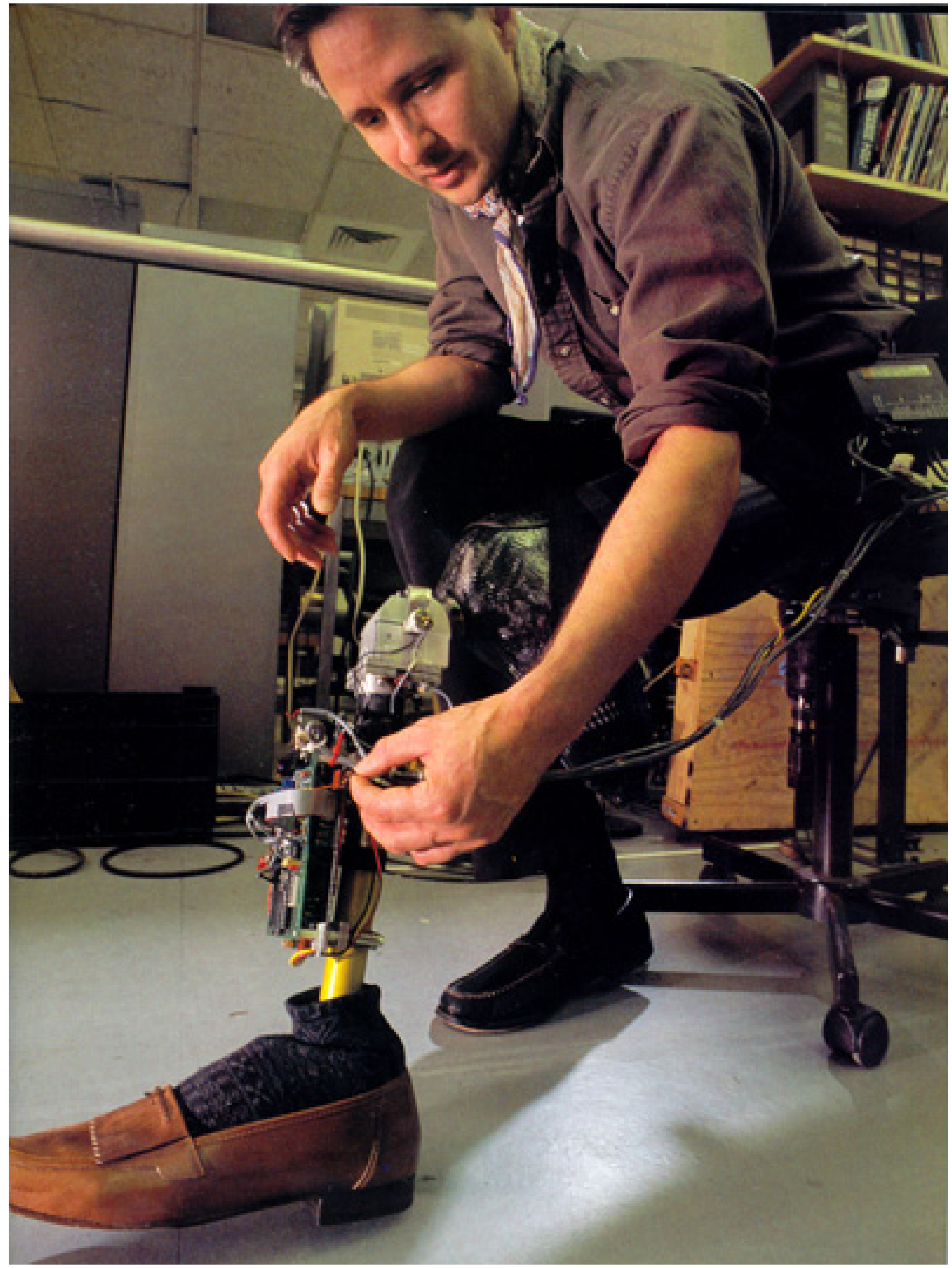
NASA Ames
Research Center

picture from
*Robosapiens*

# Intelligent Prosthetics

Hugh Herr
MIT Leg Lab

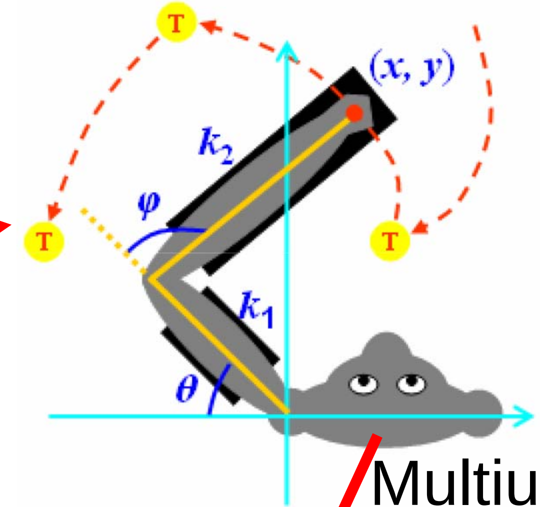
picture from
*Robosapiens*



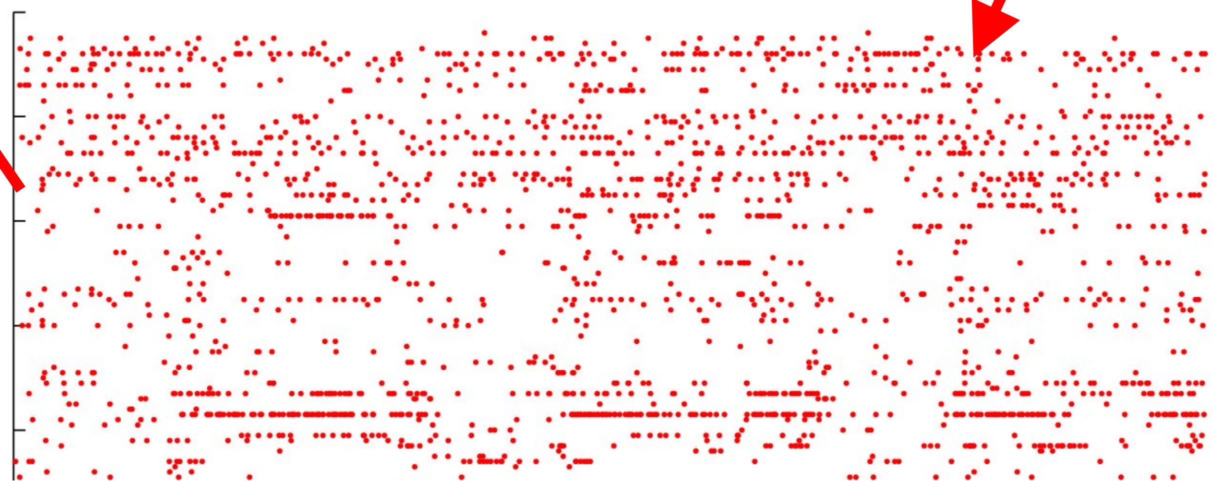
# Brain-Machine Interfaces

Estimate of intended movement

Command prosthetic arm




Multiunit recording



Predictive model

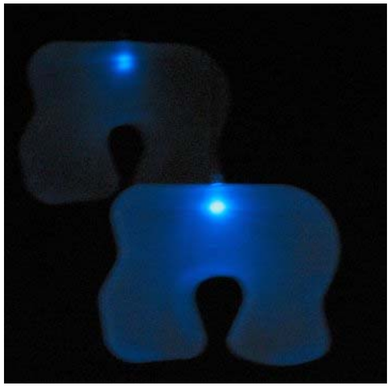
In collaboration with Nicholas G. Hatsopoulos and Lee E. Miller

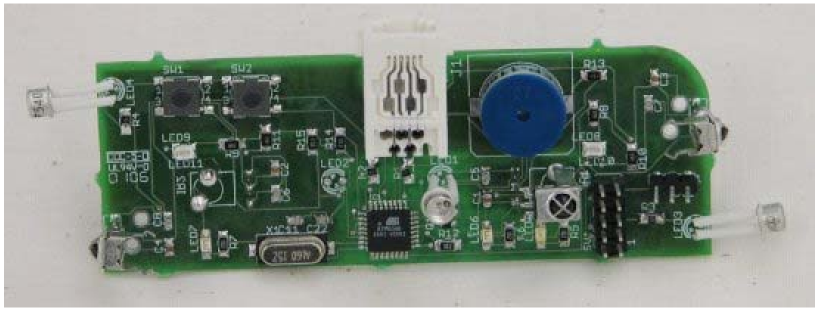
# Real-Time Activity Recognition for Assistive Robotics

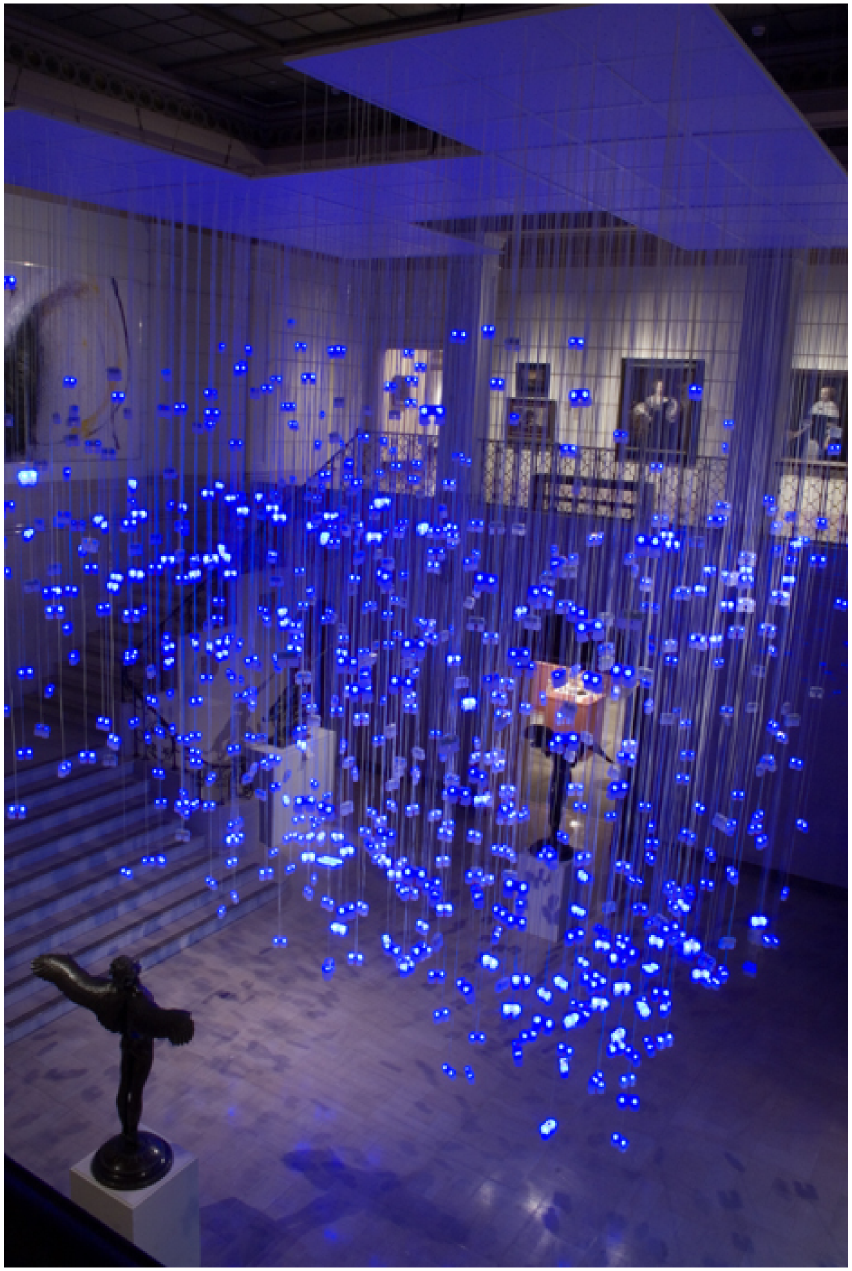
OU Crawling Assistant
(Kolobe, Fagg, Miller, Southerland)

# Sensor Networks

1000 sensor nodes







# Embedded Systems Challenges

# Embedded Systems Challenges

- Sensing the environment:
  - Sensors are typically far from ideal (noise, nonlinearities, etc.)
  - Sensors/subsystems can fail
  - Hard to get a 'complete' view of the environment
- Affecting the environment through "actuators"
  - Application can require fast, precise responses

# Embedded Systems Challenges (cont)

- Testing/debugging can be very difficult:
  - Hard to identify and replicate all possible situations
  - Often involves the interaction of many different components
  - Often no standard user interface
  - Limited on-board resources with which to record system state

- Competing requirements of cost, complexity, design time, size, power…

# Embedded Systems Challenges (cont)

- Lack of reliability can be a killer ….. literally

# My Assumptions About You

- Circuits and sensors class (or equivalent):
  - Boolean logic and circuits (AND/OR/NOT gates)
  - Analog circuits (in particular, resistive-capacitive circuits)
- Some background in programming
  - We will be using C for all projects
- Everyone has a functional laptop that can be used for the projects

# Course Goals

By the end of this course, you will be able to:

- design and implement embedded circuits involving microcontrollers, sensors and actuators,
- use code and circuit design tools,
- design, program and debug embedded sensing and control software,
- work in collaborative teams to solve system design and implementation challenges, and
- communicate in both oral and written forms with team members.

# Sources of Information

- Primary readings: web pages and book sections (posted on D2L & linked in the schedule)
- Pencasts: recorded audio & writing
- Other textbooks:
  - Optional reference material listed on the class website
- Class web page: www.cs.ou.edu/~fagg/classes/ame3623
- Desire2Learn: learn.ou.edu

You are responsible for making sure that you have access to all of these resources


HOW TO
SURVIVE
A ROBOT
UPRISING
TIPS ON DEFENDING YOURSELF
AGAINST THE COMING REBELLION
Daniel H. Wilson

# “Flipped” Class Structure

We will be experimenting some with a new class structure this semester:

- Some lecture material will be presented as pencasts. You are responsible for viewing these **before** our class time. (this is your homework)
- In class, we will address any questions that you have about the pencasts, expand on the material and do in-class exercises (some of which will be graded)

# Class Schedule

www.cs.ou.edu/~fagg/classes/ame3623/schedule.html

- Lecture plans
- Required reading and pencast viewing

# Channels of Communication

- Lecture
- Class email list: time-critical messages to the class
- Desire2Learn announcements
- Desire2Learn discussion group: you may post questions (and answers)
- Private email or office hours for non-public questions/discussions

# Grading

- Components of your grade:
  - Midterm exam: 10%
  - Final exam: 20%
  - In-class exercises: 25%
  - Four projects: 40%
  - In-class participation: 5%

- Grades will be posted on the Desire2Learn

- Final grades boundaries will be selected based on the overall class distribution

# Exams

- Closed book/closed notes
  - Exception: you are allowed 1 page of your own notes

- Assigned seating

- No electronic devices

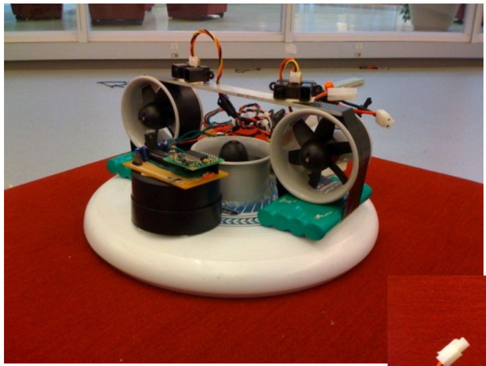
- Grading questions must be addressed before the returned exams leave the classroom

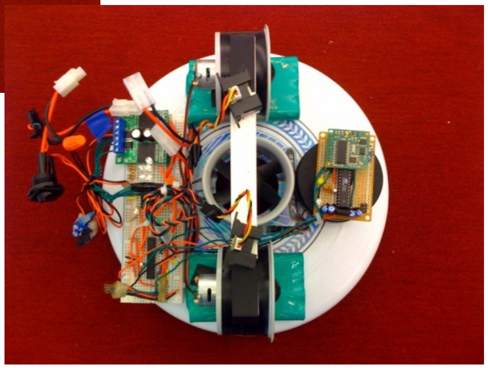
# In-Class Exercises

- Mixture of individual and paired work
- Some will be graded

# Group Projects

- Four group projects will focus on sensor processing and design of robot control circuits





- Project Topics:
  - Digital and Analog I/O
  - Intra-processor communication
  - Motor control
  - Finite-state machines and microcontrollers

# Project Grading

Group grades are a function of:

- Code correctness and readability
- Documentation
- Demonstration and presentation

Individual grades:

- Group grade scaled by your personal contribution, plus
- Personal contribution (must have 2 significant contributions over the course of the semester)

# Group Projects (cont)

- Lab space: Felgar Hall 300
- Groups will be of size 2-3 and will be assigned
- Be ready to demonstrate project by the due date
- Projects require more than a day to complete
- Project reports in **pdf or postscript** format
- Code handed in through your group's "subversion" tree
- Projects may be late (but I do not recommend this): 0-24 hrs: 10% penalty; 24-48 hrs: 20% penalty; 48+ hrs: 100% penalty

# Classroom Conduct

- Ask plenty of questions
- Contribute to the discussions

- No: cell phone use (including texting)
- No: laptop use (except for classroom exercises)

- More details in the syllabus

# Proper Academic Conduct

Projects:

- All work must be that of your group: no looking at, discussing or copying solutions from other groups or from the net
- General discussion is (again) OK

Secure your data

# Next Time

- Analog circuits review
- Review readings and pencasts: see the schedule page