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)

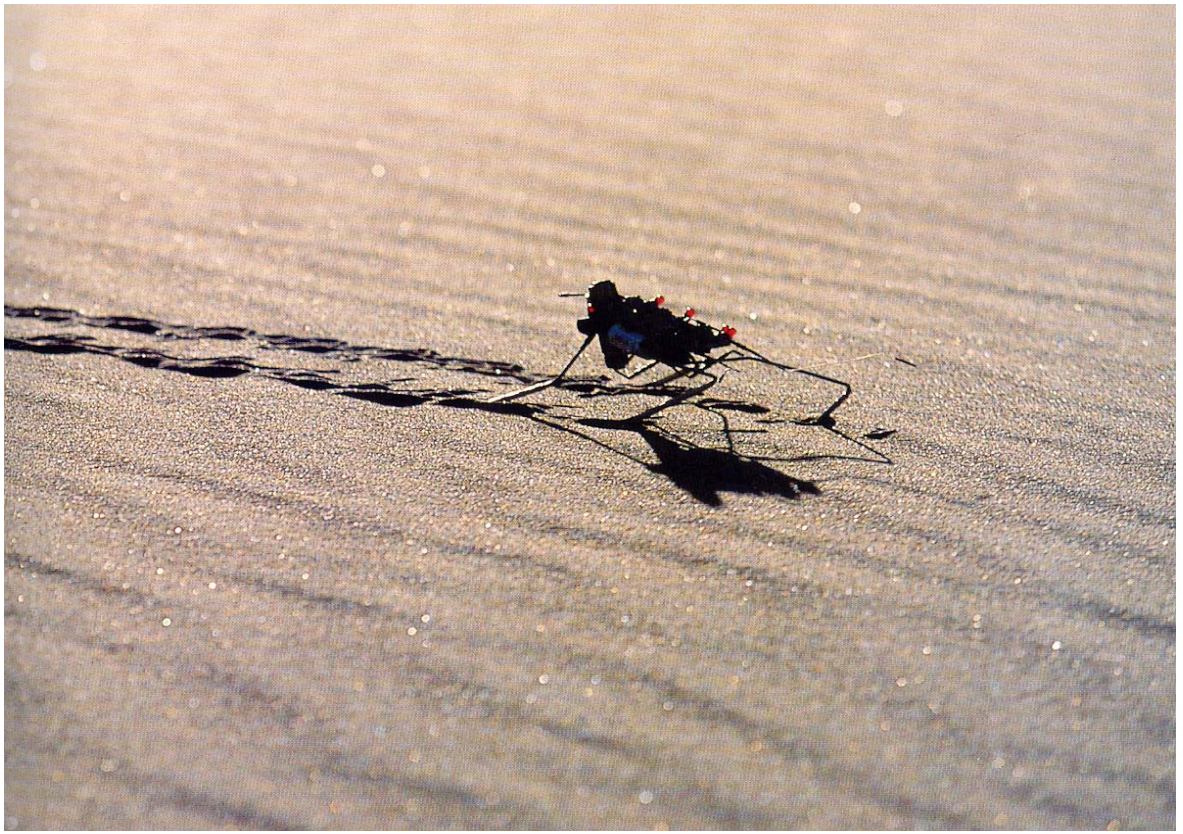
- Limited processing capabilities:
  - Can be extremely small
  - Can require a small amount of power
- Can have significant real-time constraints
  - Act on inputs very quickly
  - Generate high-frequency outputs
- Often a higher expectation of reliability

Examples of Embedded Systems

Robotics

Mark Tilden

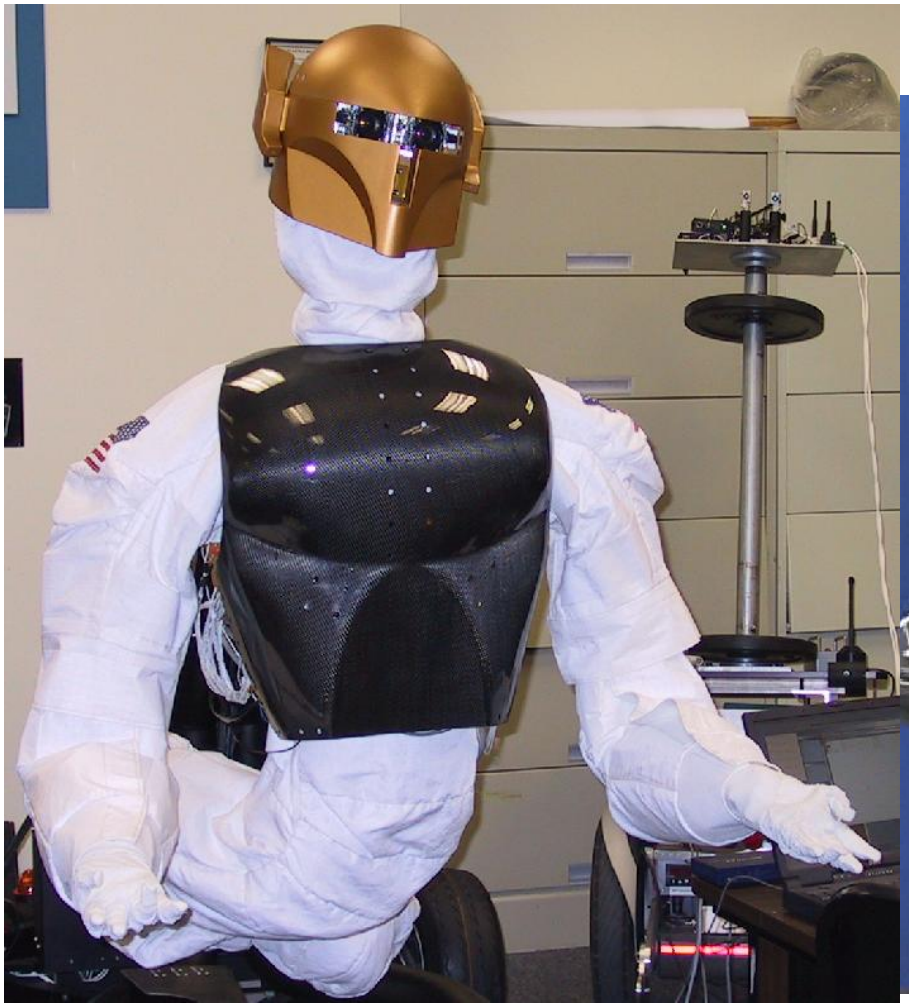
Los Alamos National Labs and Wowwee



picture from *Robosapiens*

Humanoid Robotics

NASA/JSC Robonaut



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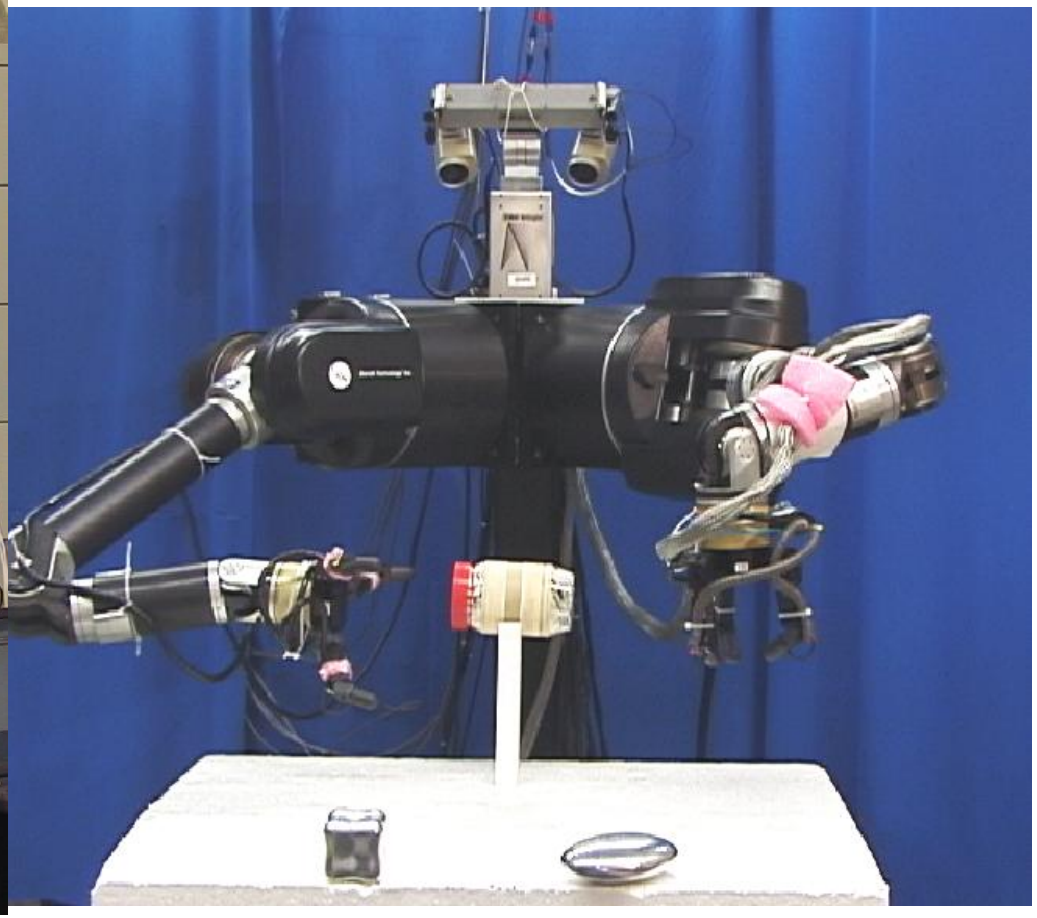


Real-Time Robotic Control

Dual-Limb Coordination

Personal Satellite Assistants

NASA Ames Research Center

picture from *Robosapiens*

Wearable Computing

Intelligent Prosthetics

Hugh Herr
MIT Leg Lab

picture from
Robosapiens

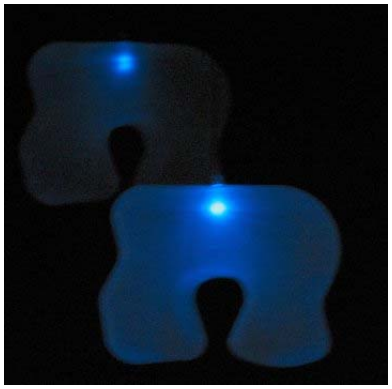

Autonomous Flying Vehicle
USC Robotics

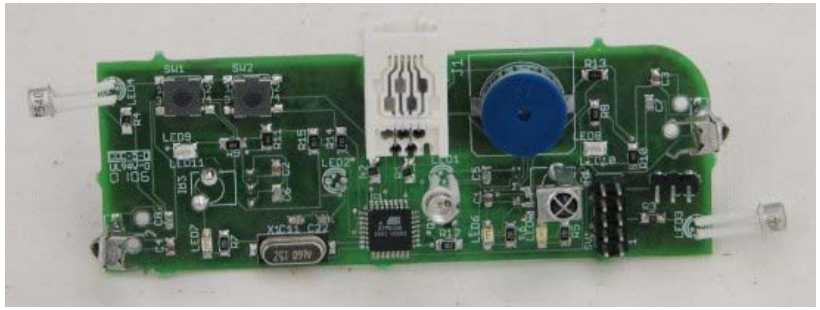
RC Heli Example

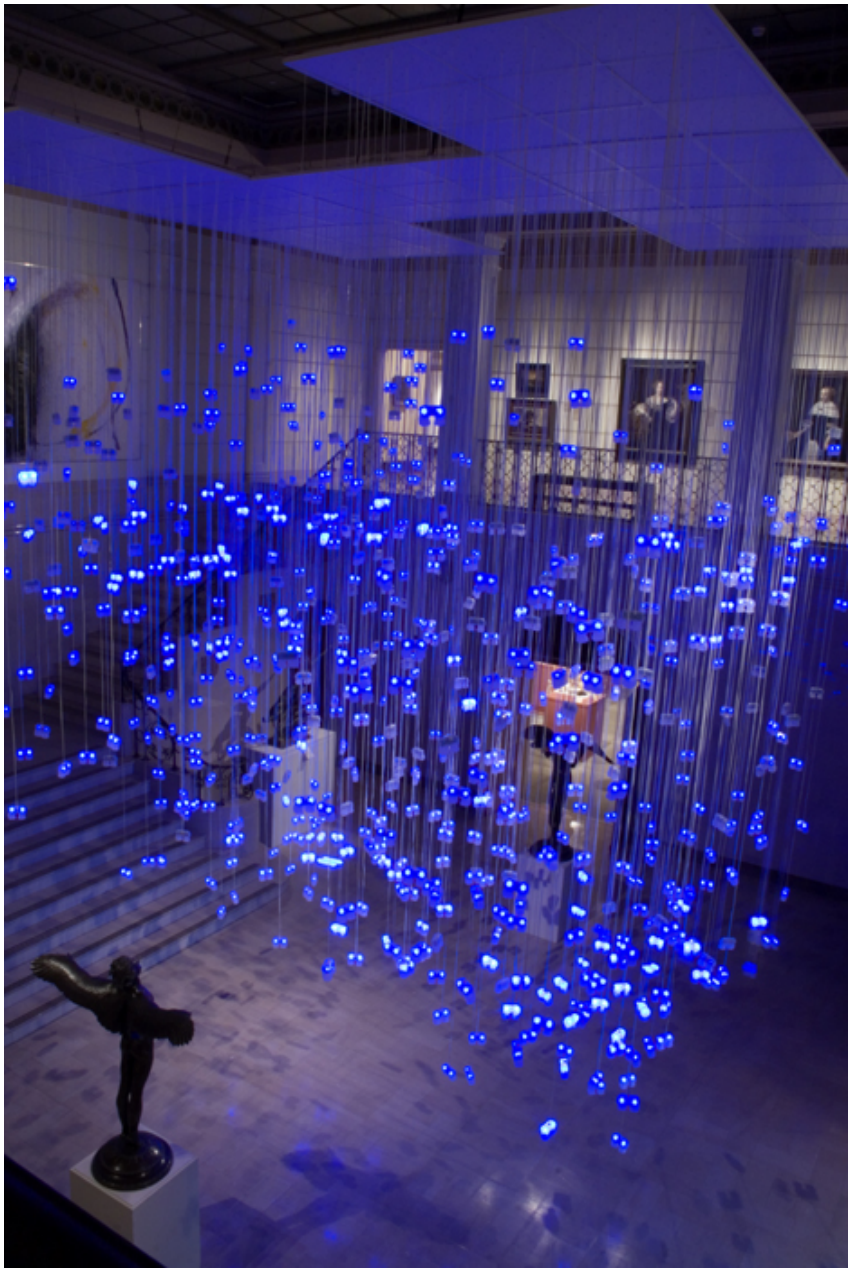
RC Heli Example II

Sensor Networks

1000 sensor nodes







Embedded Systems Challenges

Embedded Systems Challenges

- Sensing the environment:
  - Sensors are typically far from ideal (noise, nonlinearities, etc.)
  - Sensors 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): basic analog circuits
- Some background in programming
  - We will be using C for all four projects
- Everyone has a laptop that can be used for the projects

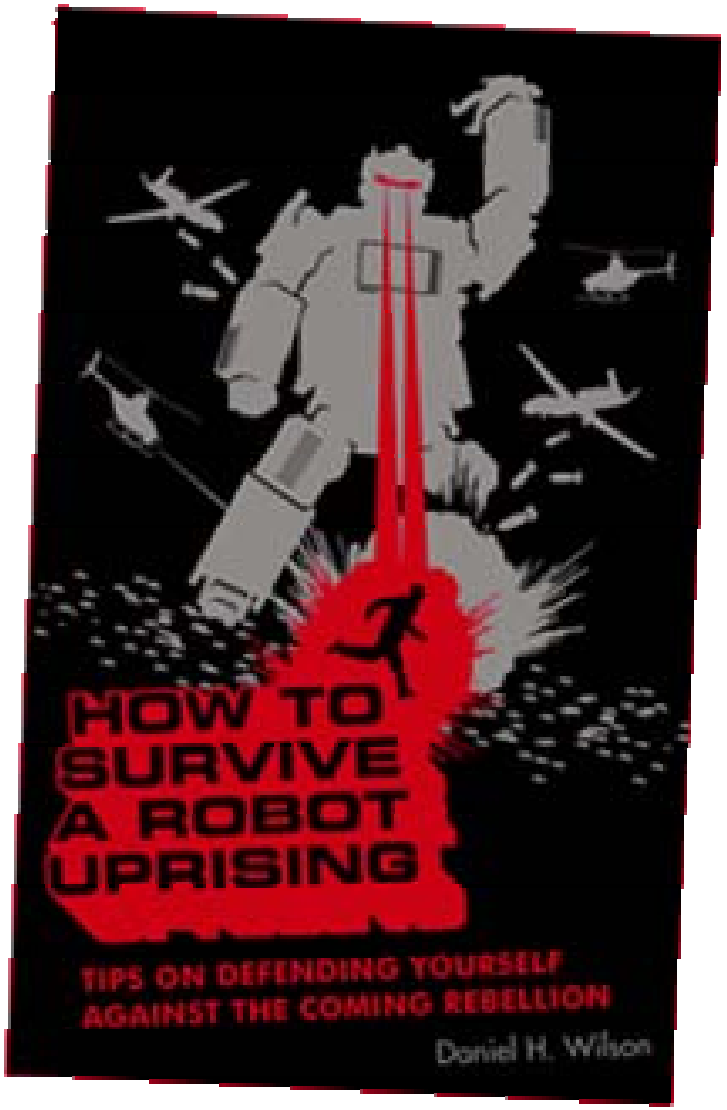
Course Goals

- Gain an understanding of:
  - Basics of computer architecture
  - Theory of embedded system design
  - Practical issues in embedded system implementation
- Gain hands-on experience with embedded systems
- Learn communication and team-oriented skills within and outside of your field

Sources of Information

- Textbooks:
  - Designing Embedded Hardware, John Catsoulis, O'Reilly, 2005, **2nd Edition**, ISBN: 0-596-00755-8
  - **(optional)** Embedded C Programming and the Atmel AVR, Richard H. Barnett, Sarah Cox, Larry O'Cull (2006), **2nd Edition**, Thomson/Delmar Learning, ISBN: 1418039594
- Class web page: www.cs.ou.edu/~fagg/classes/ame3623_s08/
- 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

Class Schedule

www.cs.ou.edu/~fagg/classes/ame3623_s08/schedule.html

- Lecture plans
- Required reading

As changes are made, they will be posted here

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%
  - Five homework assignments and several pop quizzes: 30%
  - Four projects: 35%
  - 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

Homework Assignments

- Individual work
- Hand-in:
  - Through the digital dropbox of Desire2Learn or hardcopy
  - By 5:00 on the due date (no exceptions)
- Grading questions must be addressed within one week of being returned

Group Projects

- Four group projects will focus on sensor processing and design of robot control circuits
  - Control of an X-UFO

- Project Topics:
  - Inter-processor communication
  - Finite-state machines and microcontrollers
  - Sensor interface and processing

Group Projects (cont)

- Groups will be of size ~4 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
- Projects may be late (but I do not recommend this):
  - 0-24 hrs: 10% penalty
  - 24-48 hrs: 20% penalty
  - 48+ hrs: 100% penalty

Laboratory Details

- Location: FH 100/101
- Times: the TAs and I will hold our office hours in the lab
  - Once projects are assigned, we will have the lab open for ~20-24 hrs/week
- Laboratory policies are discussed in the syllabus

Classroom Conduct

- Ask plenty of questions
- Contribute to the discussions

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

Academic Conduct/Misconduct

Homework assignments:

- All work must be your own: no looking at or copying solutions from other students or from the net
- General discussion is OK (e.g., the fundamental skills that we are learning)

- When in doubt: ask

Academic Conduct/Misconduct

Projects:

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

Secure your data

Next Time

- Analog circuits review
- Readings: Designing Embedded Hardware (DEH)
  - pp. 65-86 (through RC circuits)
  - pp. 90-93 (Diodes)