CS [45]163: Embedded Systems

Andrew H. Fagg

Symbiotic Computing Laboratory

School of Computer Science

University of Oklahoma

Teaching Assistant:

Di Wang

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)

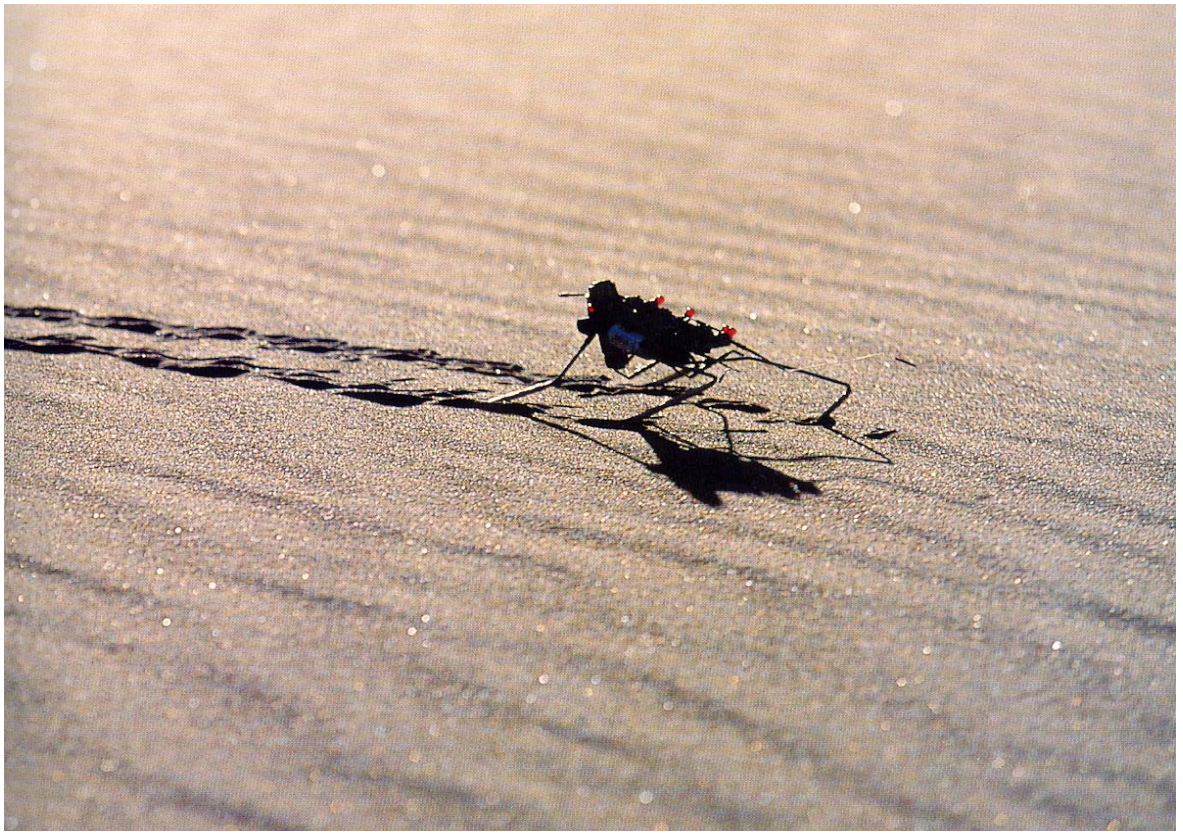
- Limited processing capabilities:
  - Can be extremely small
  - Can require a small amount of power
- Can have significant real-time constraints
  - Act on inputs very quickly
  - Generate high-frequency outputs
- Often a higher expectation of reliability

Examples of Embedded Systems

Robotics

Mark Tilden

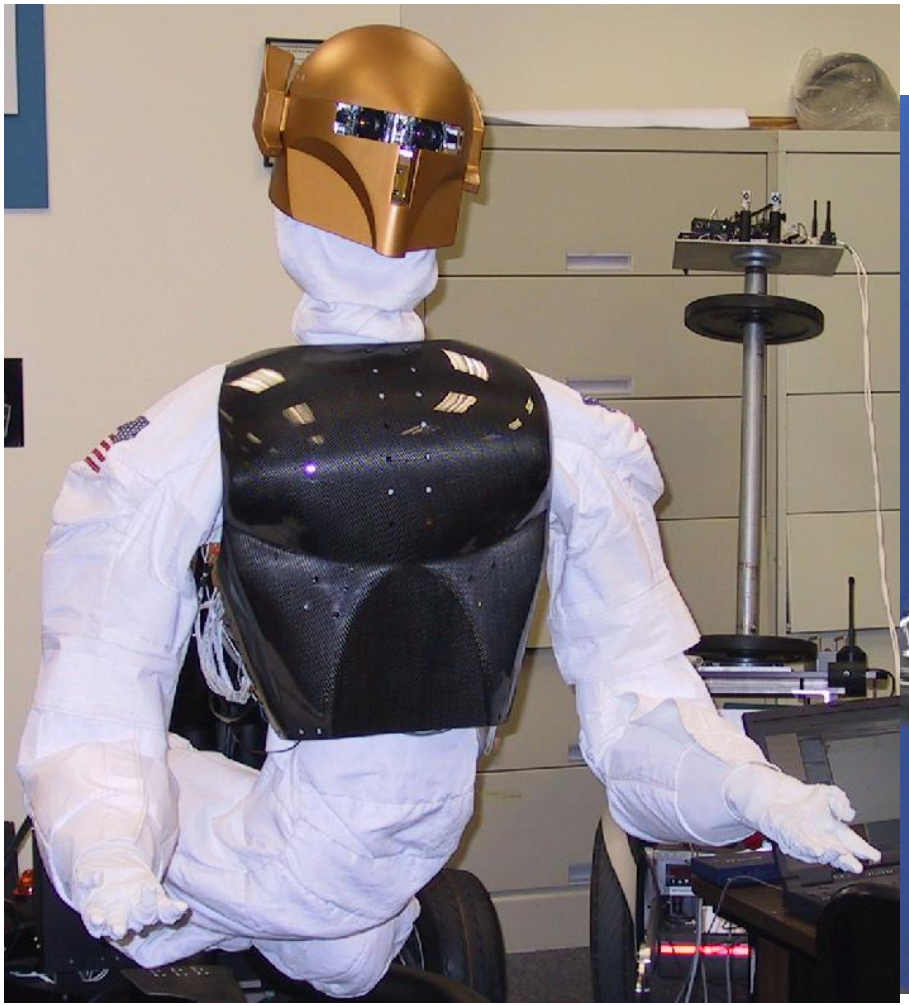
Los Alamos National Labs and Wowwee



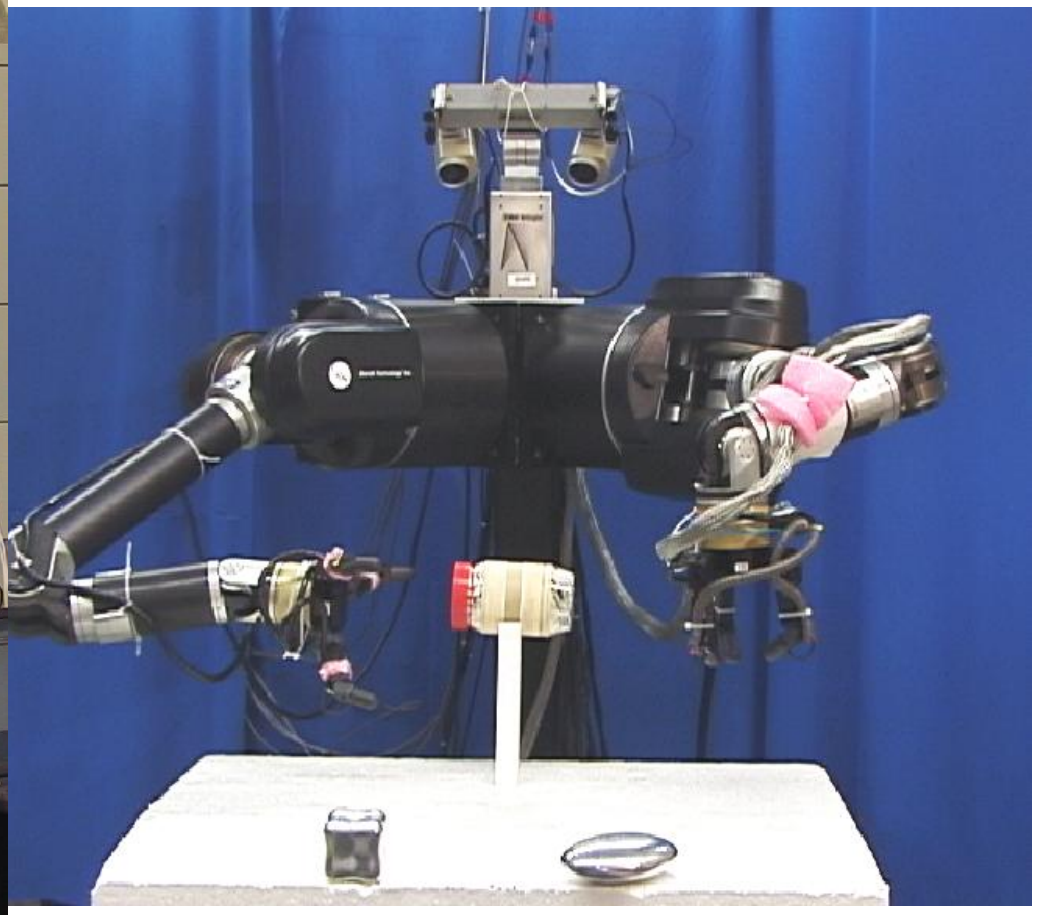
picture from *Robosapiens*

Humanoid Robotics

NASA/JSC Robonaut



UMass Torso



Dual-Limb Coordination

Personal Satellite Assistants

NASA Ames
Research Center

picture from
Robosapiens

Wearable Computing

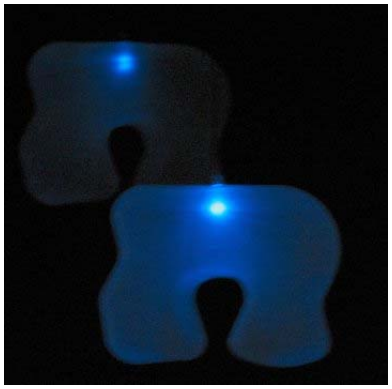
Intelligent Prosthetics

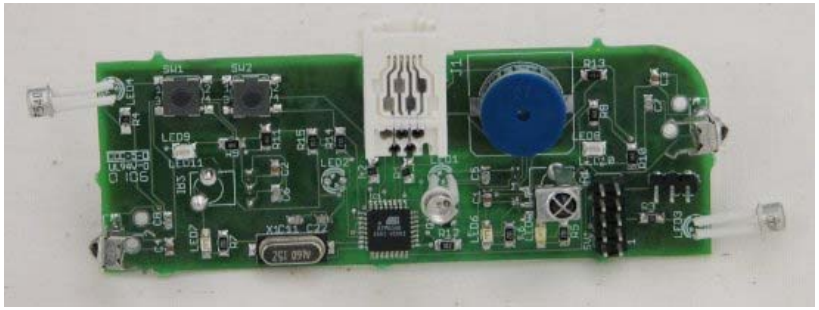
Hugh Herr
MIT Leg Lab

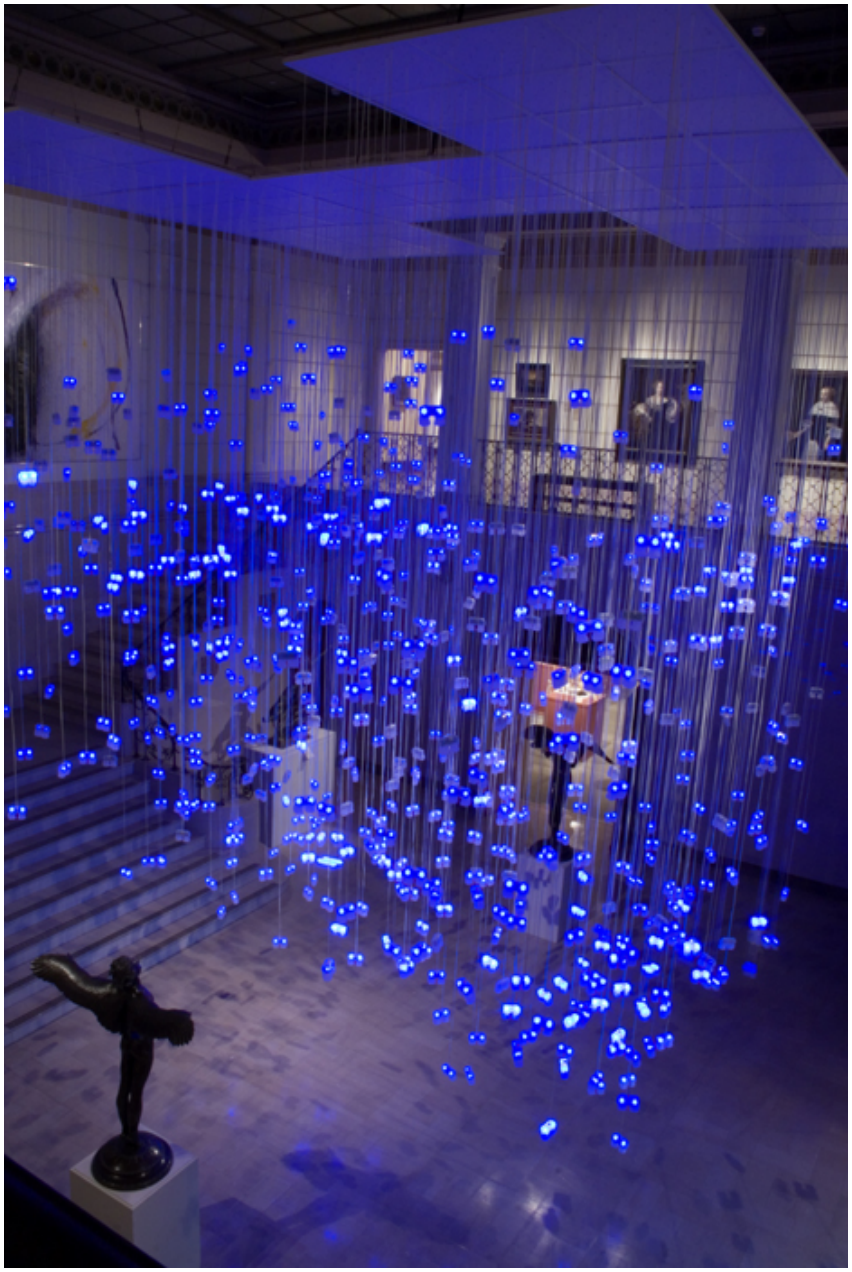
picture from
Robosapiens

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

- Background in: Computer Organization, Operating Systems and Linear Algebra
- Programming in C
- Everyone has a laptop that can be used for the projects
- Ability to “jump into” technical documentation

Course Goals

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

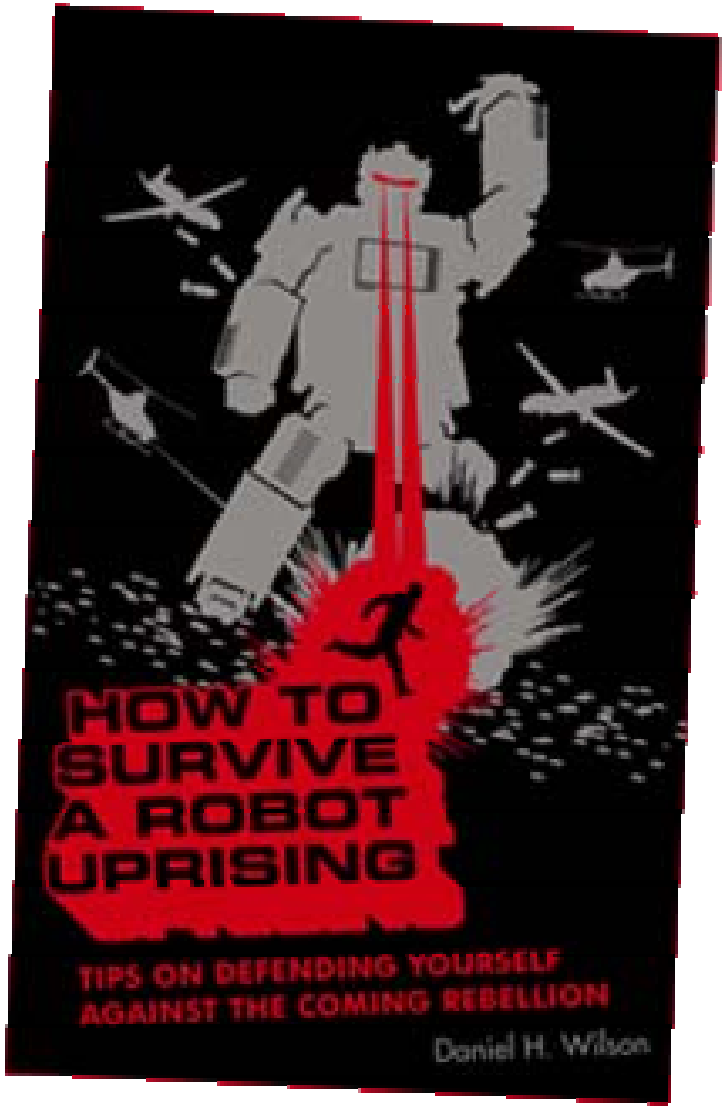
- understand, analyze, design, implement and debug hardware and software systems consisting of an embedded processor, an electronic interface, and a physical system,
- employ analytical skills and design tools at the intersection of engineering, computer science and mathematics, and
- practice effective organizational and communication skills in interdisciplinary teams.

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
  - Also reading the Atmel Mega 8 specification (downloadable)
- Class web page: www.cs.ou.edu/~fagg/classes/embedded_systems/
- Desire2Learn: learn.ou.edu

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

(available at the Engineering Library)



Class Schedule

www.cs.ou.edu/~fagg/classes/embedded_systems/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:
  - Final exam: 20%
  - Four homework assignments: 20%
  - Five project milestones: 50%
  - In-class participation: 10%

- Grades will be posted on the Desire2Learn

Final Exam

- 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

Five robot soccer milestones:

1. Obstacle avoidance and real-time visual tracking
2. Compass and visual-based navigation
3. Positioning robot for dribbling and shooting; global visual tracking of robots and ball
4. Shooting and global navigation
5. Playing full game

Project components

Technical components include:

- Analog interfaces and sensors
- Serial communication (RS232 and I2C)
- Computer vision
- Wireless communication (Zigbee)
- Robot motion control
- High-level control

Group Projects

- Groups will be of size 3-4
- 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:
  - 0-24 hrs: 10% penalty
  - 24-48 hrs: 20% penalty
  - 48+ hrs: 100% penalty

Project Grading

- Personal work: primary contributor for

  2 (4163) or

  3 (5163)

  “major components”

- Group work: meet project deadlines

Laboratory Details

- Sign-out of robots
- Small soccer field will be set up in DEH 115
- We will have test equipment available for use when I or the TA are available

Laboratory Tools

- AVR-GCC: compiler for Atmel Microcontrollers
- OUlib: library for manipulating the microcontrollers
- Subversion: source code version control
- Doxygen: automatic generation of code-level documentation

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

  (Note: some major components are intended to be shared)
- General discussion is (again) OK

Secure your data

Next Time: Introduction to Analog Electronics

Readings:

- Designing Embedded Hardware (DEH) pp. 65-80 pp.
- Web pages: Electricity and voltage dividers (see schedule)