AME 3623:
Embedded Real-Time Systems

Andrew H. Fagg
Symbiotic Computing Laboratory
School of Computer Science
University of Oklahoma

Teaching Assistant: Alois Winterholler

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

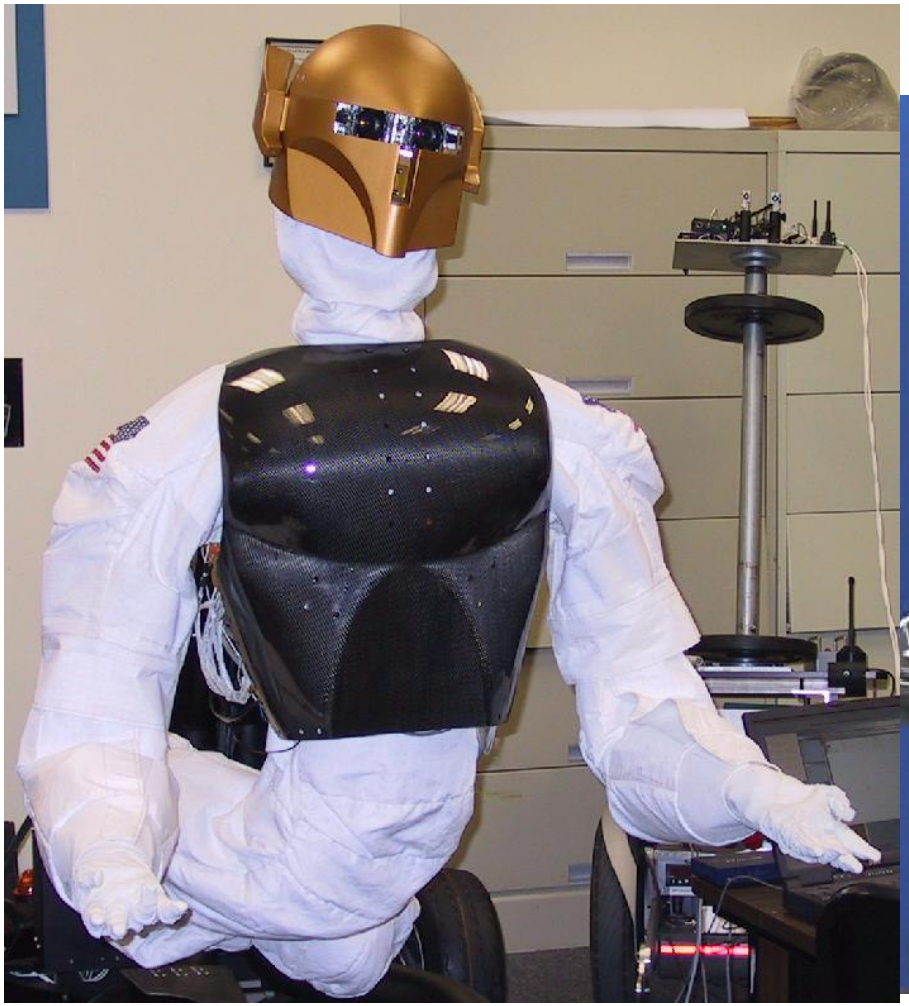
Mark Tilden

Los Alamos National Labs and Wowwee

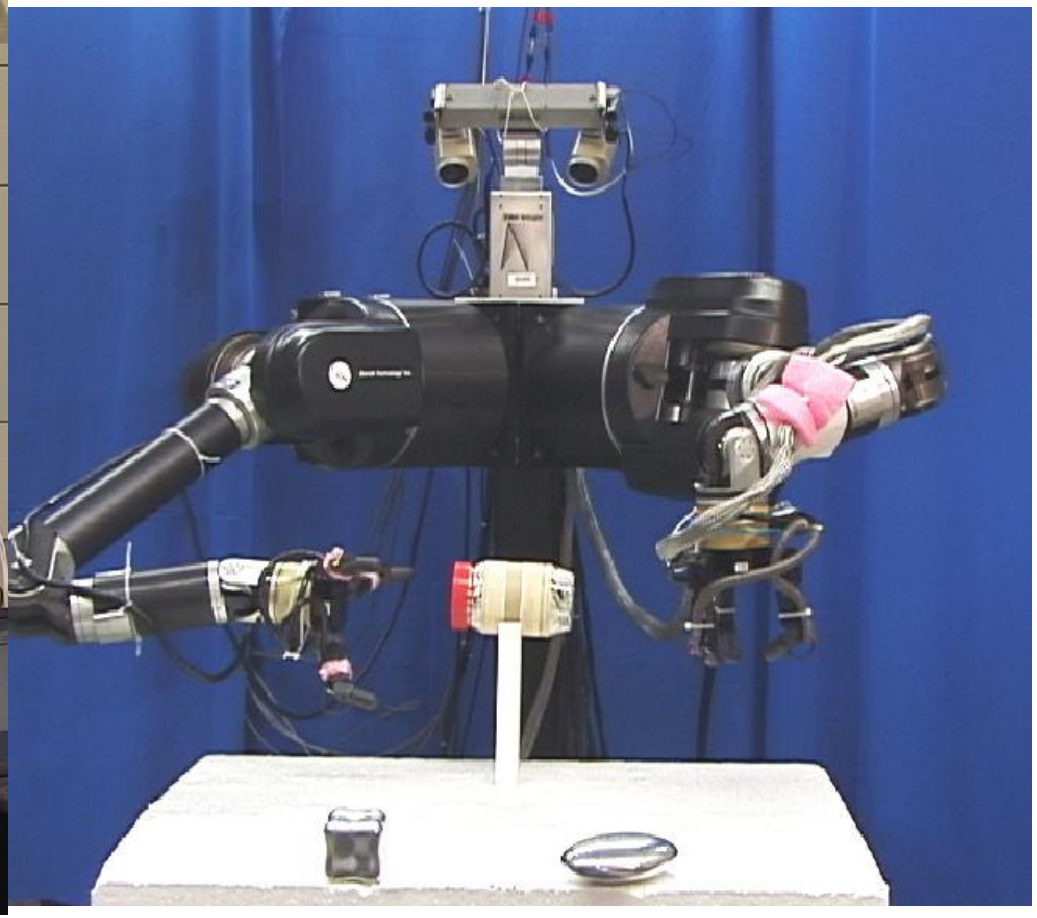
picture from *Robosapiens*

Humanoid Robotics

NASA/JSC Robonaut



UMass Torso



Real-Time Robotic Control

Dual-Limb Coordination

Personal Satellite Assistants

NASA Ames Research Center

picture from *Robosapiens*

Wearable Computing

Intelligent Prosthetics

Hugh Herr
MIT Leg Lab

picture from
Robosapiens


Autonomous Flying Vehicle
USC Robotics

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

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

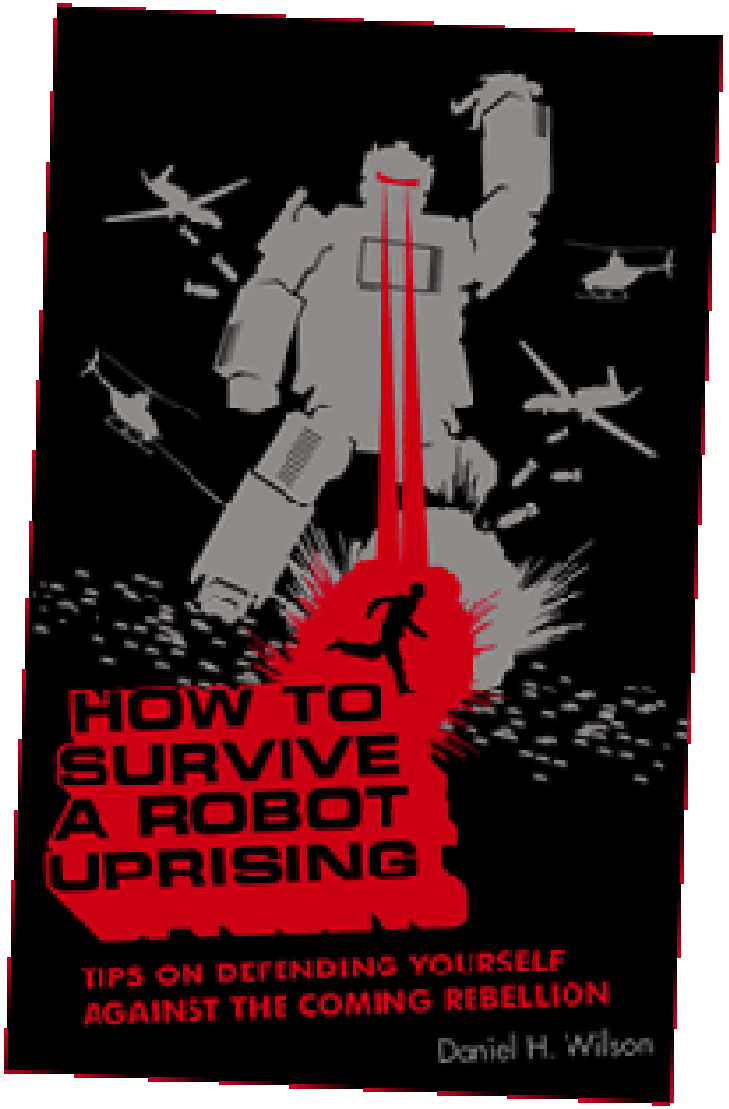
My Assumptions About You

- Circuits and sensors class (or equivalent): basic analog circuits
- Some background in programming
  - We will be using C for several projects
- Everyone has a laptop that can be used for the projects

Sources of Information

- Required textbooks:
  - Embedded Systems Architecture: A comprehensive guide for engineers and programmers, Tammy Noergaard (2005)
  - Embedded C Programming and the Atmel AVR, Richard H. Barnett, Sarah Cox, Larry O'Cull (2003)
- Class web page: www.cs.ou.edu/~fagg/classes/ame3623_s06/
- 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_s06/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%
  - Six homework assignments and several pop quizzes: 30%
  - Four projects: 35%
  - In-class participation: 5%
- Grades will be posted on the Desire2Learn
- Final grades will be computed on a curve

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
  - Robot will search for and follow a sequence of infrared beacons

- Project Topics:
  - Digital logic design
  - Finite-state machines and microcontrollers
  - Sensor processing
  - Inter-processor communication

www.lynxmotion.com

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:
  - 0-24 hrs: 10% penalty
  - 24-48 hrs: 20% penalty
  - 48+ hrs: 100% penalty

Laboratory Details

- Location: EL 124
- Times: both myself and the TA will hold our office hours in the lab
  - Once projects are assigned, we will have the lab open for 18 hrs/week
- Laboratory policies are discussed in the syllabus

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

Reading for Today

- Embedded Systems Architecture (ESA) Chapter 1

Next Time

- Introduction to digital logic and Boolean Algebra
- Readings:
  - ESA 3.1, 3.4, 3.5.1, 3.6 (not flip-flops)
  - Web pages on basic gates and Boolean algebra

“Bion:” An Experiment in Sensor Networks and Art

- New York Sculptor’s Guild 60th Anniversary Retrospective
- Hillwood Musuem, Long Island University
- Jan 30th – April 8th