

AME 3623: Embedded Real-Time 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

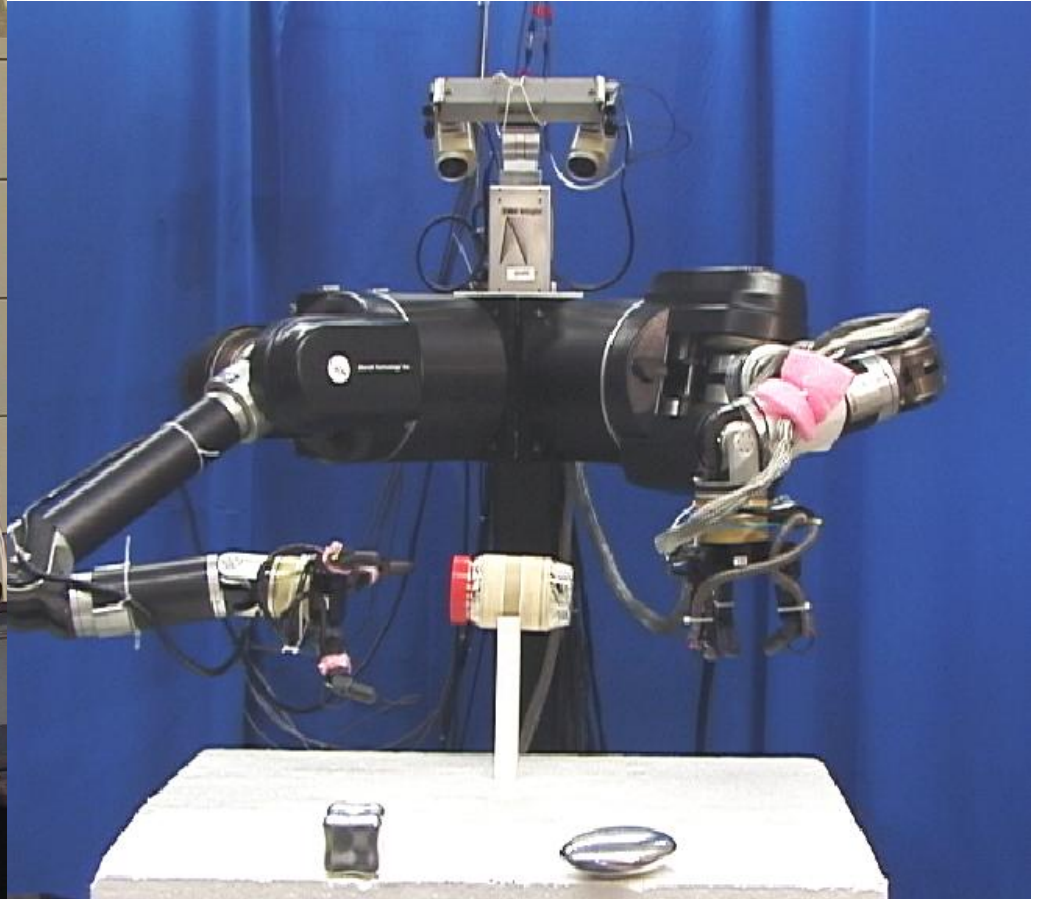


Humanoid Robotics

NASA/JSC Robonaut



UMass Torso



Real-Time Robotic Control



Andrew H. Fagg: Embedded Real-Time Systems: Introduction

Dual-Limb Coordination



Personal Satellite Assistants

NASA Ames
Research Center

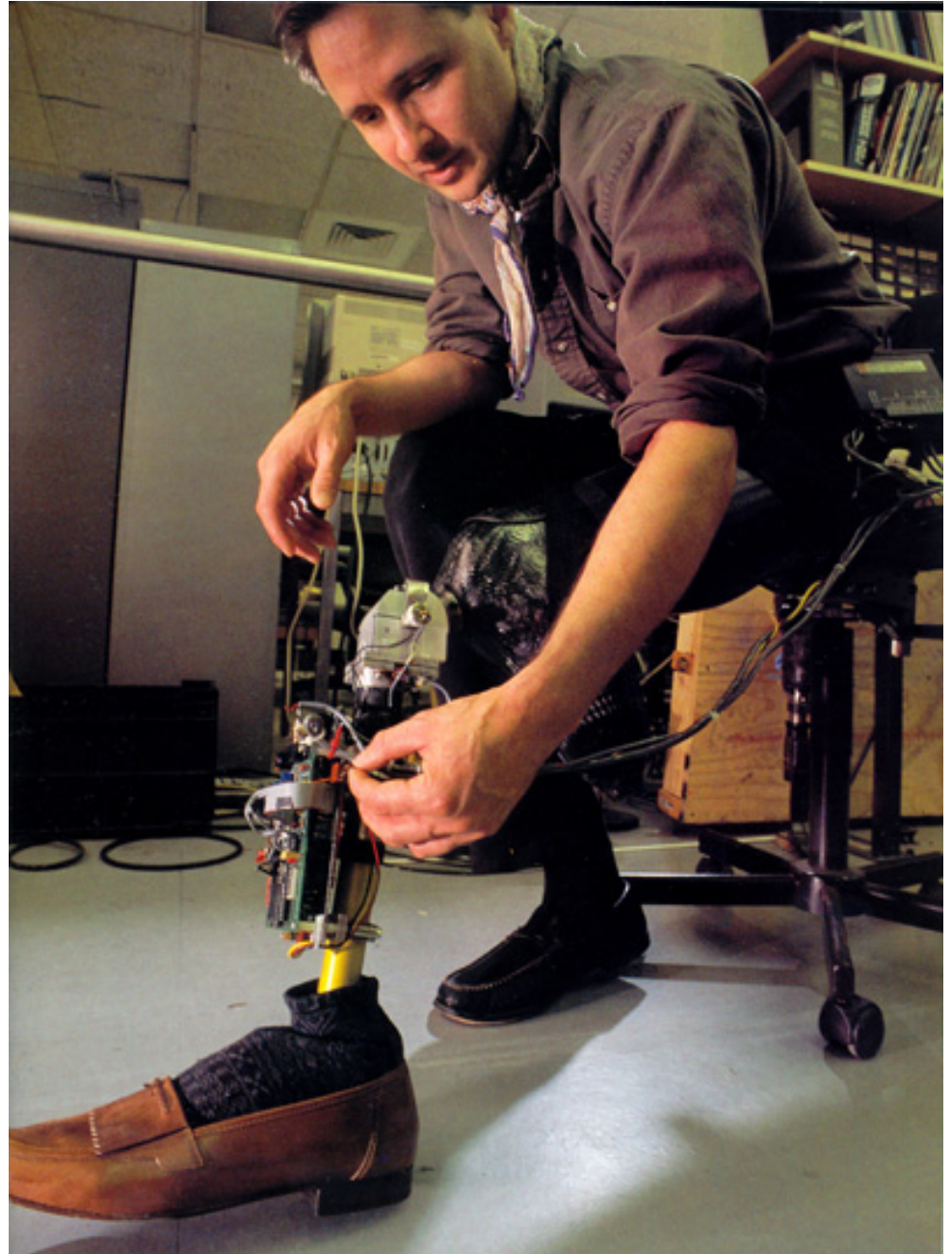
picture from
Robosapiens



Intelligent Prosthetics

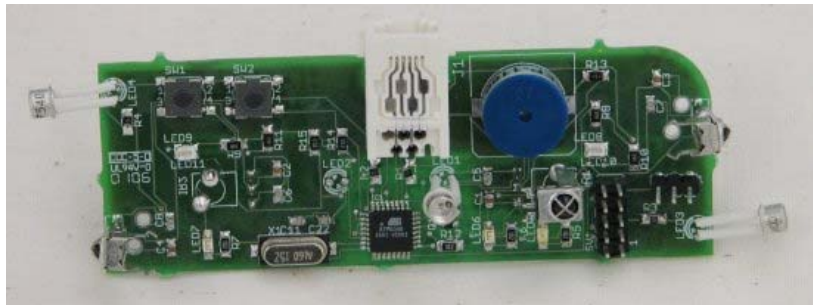
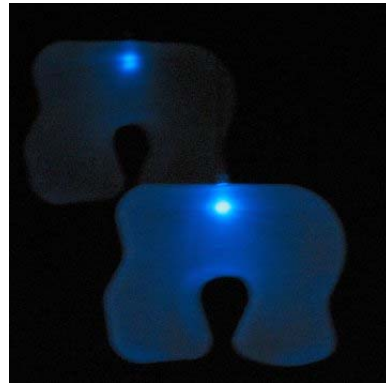
Hugh Herr
MIT Leg Lab

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/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 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,
- design, program and debug embedded sensing and control software,
- work in collaborative teams to solve system design and implementation problems, and
- communicate in both oral and written forms with team members.

Sources of Information

- Primary readings: web pages and book sections (posted on D2L)
- Optional textbooks:
 - Designing Embedded Hardware, John Catsoulis, O'Reilly, 2005, **2nd Edition**, ISBN: 0-596-00755-8
 - 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
- Desire2Learn: learn.ou.edu

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



Andrew H. Fagg: Embedded Real-Time Systems: Introduction

Class Schedule

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

- Lecture plans
- Required reading

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%
 - Four homework assignments and several pop quizzes: 25%
 - Five 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

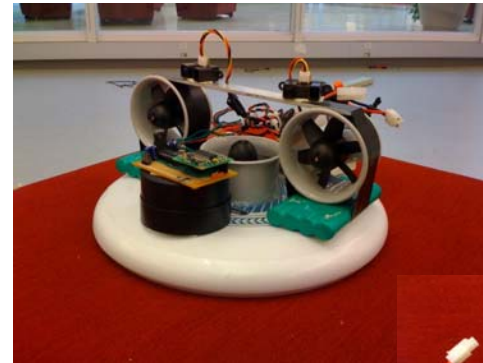
Homework Assignments

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

- Control of a hovercraft

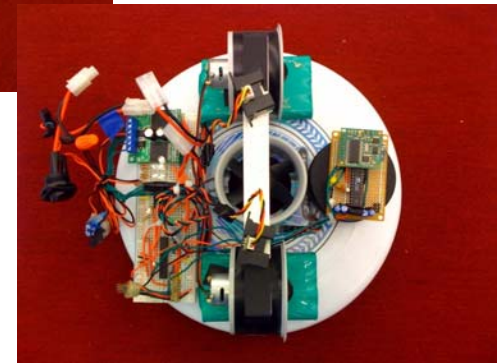


- Project Topics:

- Sensor interface and processing

- Intra-processor communication

- Finite-state machines and microcontrollers



Project Grading

Group grades are a function of:

- Code correctness and readability
- Documentation
- Demonstration and presentation

Individual grades:

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

Group Projects (cont)

- Groups will be of size 3-4 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

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

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, 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: see the schedule page