AME 3623: Embedded Real-Time Systems

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

Teaching Assistant: Mark Woehrer
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 (so 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 Hasboro

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*
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

• To gain an understanding of:
  – Basics of computer architecture
  – Theory of embedded system design
  – Practical issues in embedded system implementation

• To gain hands-on experience with embedded systems
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
  – As part of the lecture, we will discuss basics of C syntax and semantics

• Everyone has a laptop that can be used for the projects
Sources of Information


• Class web page: [www.cs.ou.edu/~fagg/classes/ame3623_s05/](http://www.cs.ou.edu/~fagg/classes/ame3623_s05/)

• Blackboard

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

• Lecture
• Class email list: time-critical messages to the class
• Blackboard announcements
• Blackboard 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%
  – Four projects: 40%
  – In-class participation: 5%

• Grades will be posted on the Blackboard

• Final grades will be computed on a curve
Exams

• Closed book/closed 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 the Blackboard
  – Text part of your answer in raw (ASCII) format only
  – Figures in postscript or pdf
  – 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
  – Infrared serial communication
  – Integration: communication and control
Group Projects (cont)

• Groups will be of size ~4 and will be assigned
• Be ready to demonstrate in class on the due date
• 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: TBD
• Times: both myself and the TA will hold our office hours in the lab
  – Once projects are assigned, our hope is to have the lab open for 20 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., understanding the homework and/or 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

• Introduction to digital logic and Boolean Algebra

• Readings:
  – ESP chapters 1 and 2.1-2.3
  – Begin web pages on digital logic (see the “schedule” web page)