

AME 3623: Embedded Real-Time Systems

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What is an Embedded System?

What is an Embedded System?

Fundamentally about the bit meeting the atom and the photon...

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

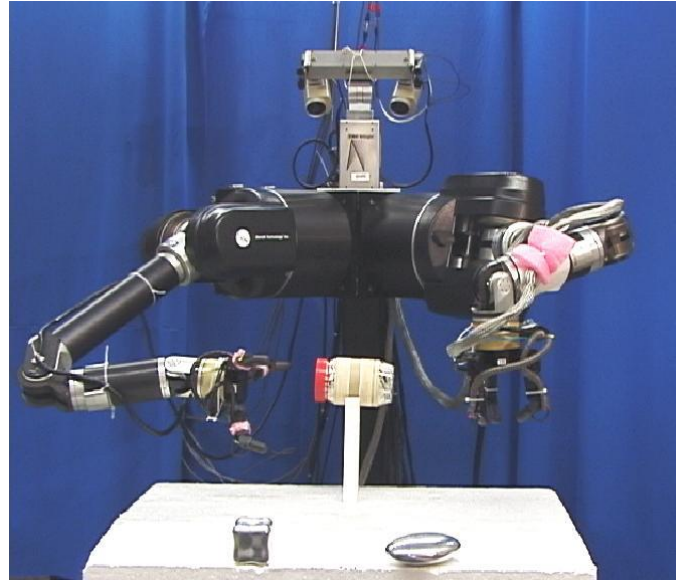
What is an Embedded System? (cont)

- 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 outputs that can change quickly
- Often a higher expectation of reliability

Examples of Embedded Systems

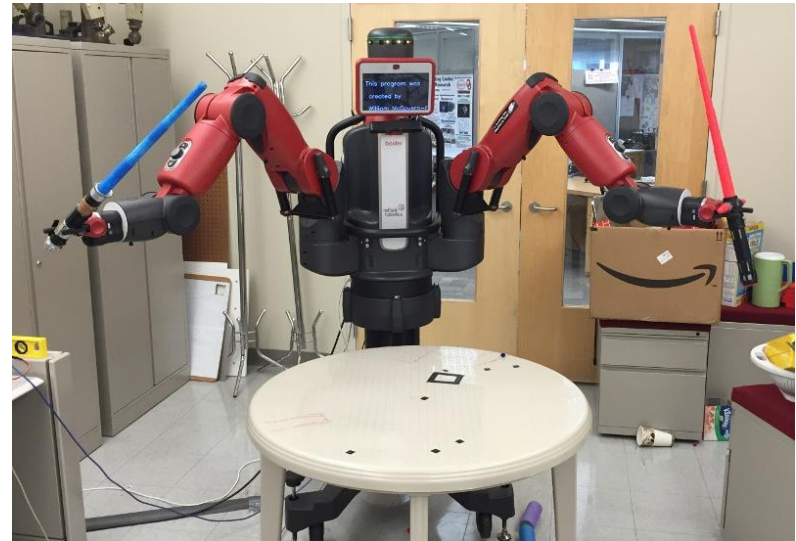
Humanoid Robotics

NASA/JSC
Robonaut



UMass Torso

OU “Yatima”



Robotics

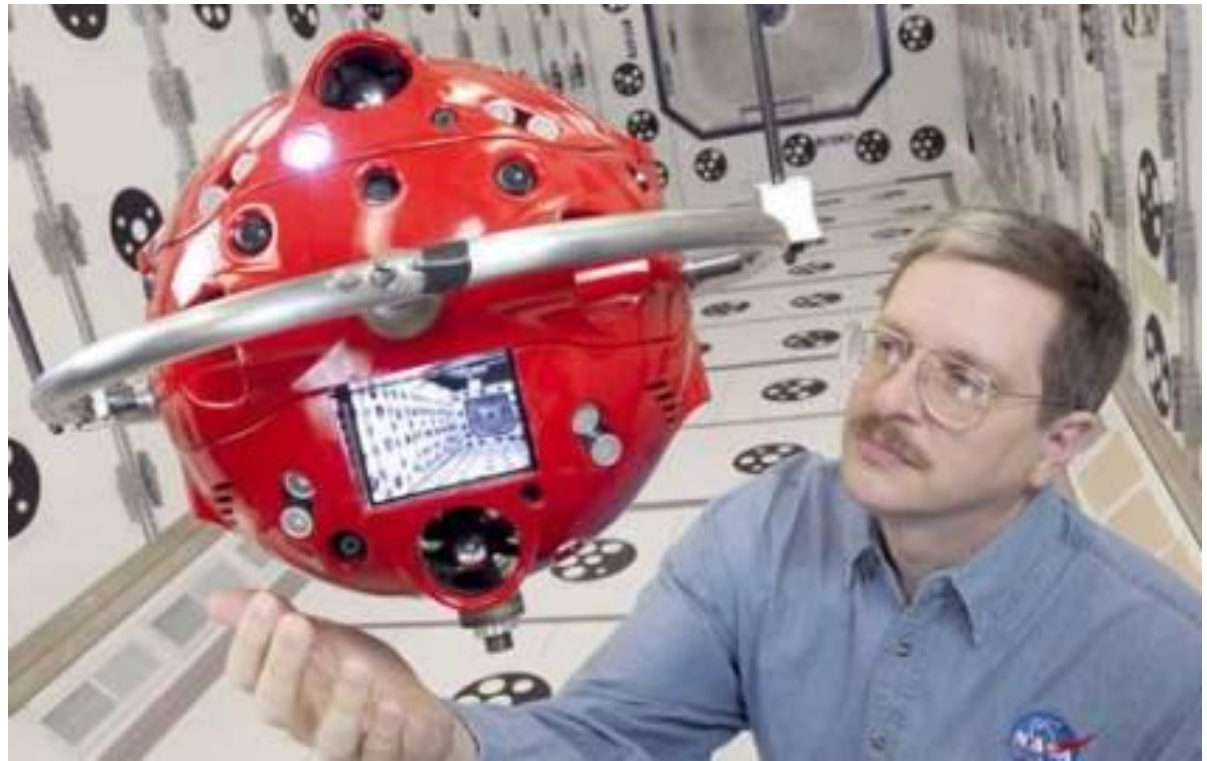
Mark Tilden
Los Alamos
National Labs
and Wowwee

picture from
Robosapiens

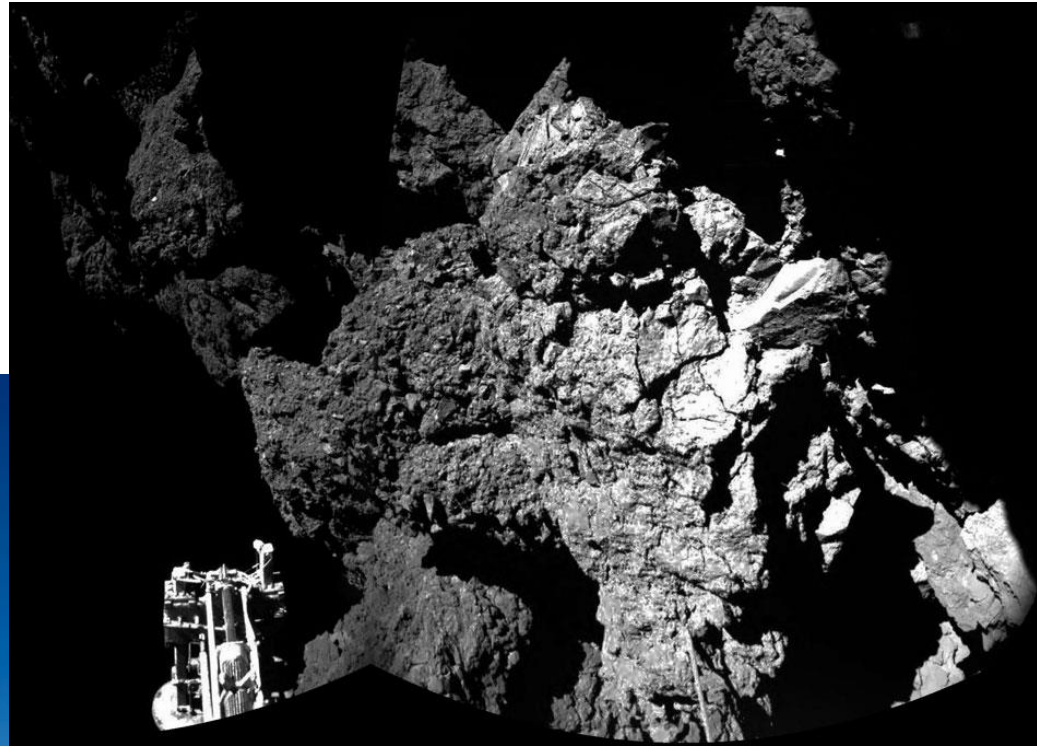


Personal Satellite Assistants

NASA Ames
Research
Center



Space Missions



Space Missions

SpaceX



Rosetta

Intelligent Prosthetics

Hugh Herr
MIT Leg Lab

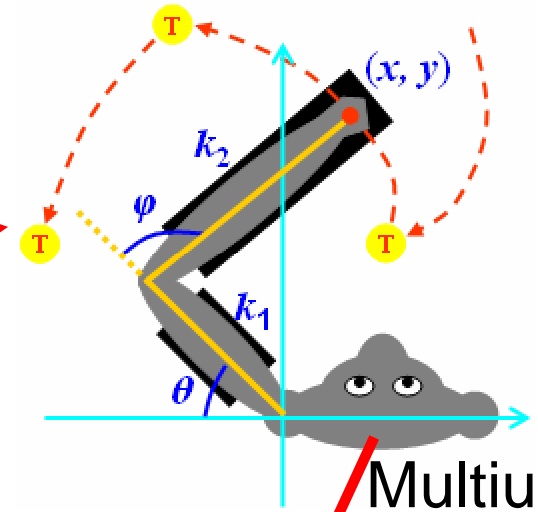
picture from
Robosapiens



Brain-Machine Interfaces

Estimate of
intended
movement

Command
prosthetic arm



Multiunit
recording

Predictive
model

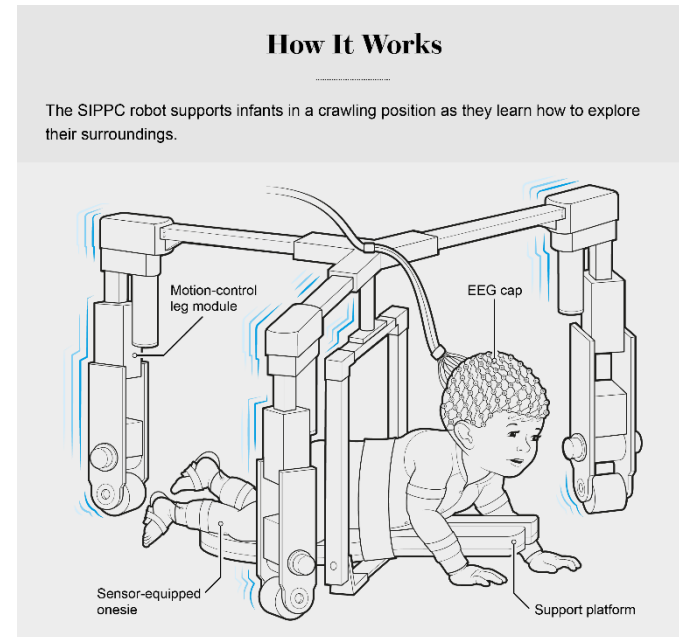


In collaboration with Nicholas G. Hatsopoulos and Lee E. Miller

Real-Time Activity Recognition for Assistive Robotics



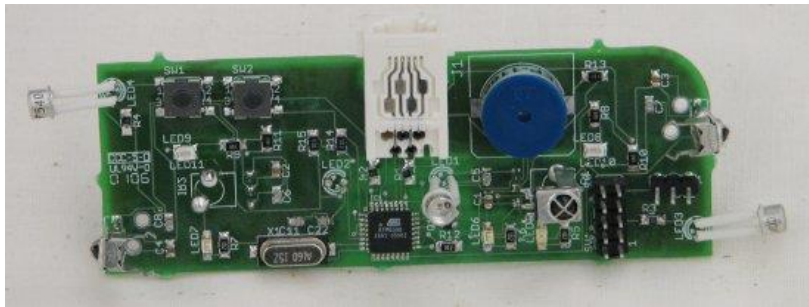
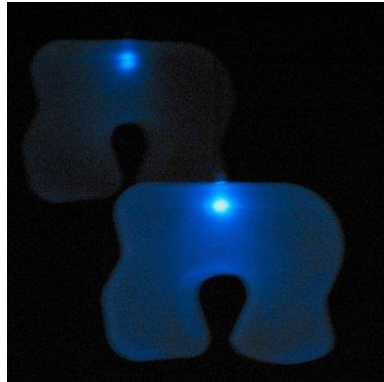
OU Crawling Assistant
(Kolobe, Fagg, Miller, Ding)



Scientific American (Oct 2016)

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)
- One course background in programming
 - We will be using C for all projects
- Everyone has a functional laptop that can be used for the projects

How We Will Proceed

Embedded Systems is a mix of software, circuit, actuation, sensing and control

- Blend of theory and practice
- Practice requires practice:
 - Very hands-on
 - Don't be afraid to try things (but care must be taken)

Course Goals

In this course, you will:

- Design embedded circuits
- Use code and circuit design tools,
- Design, program and debug embedded sensing and control software,
- Work in teams, and
- Practice your communication skills.

Sources of Information

- Primary readings:
 - Book: *Programming Embedded Systems* from Zyante
 - Selected web pages
- Class web page:
www.cs.ou.edu/~fagg/classes/ame3623
- Canvas: canvas.ou.edu

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



Preparing for Lecture

- Readings: you are responsible for reading these **before** our class time.
- The Zyante book includes a set of questions listed under “Participation Activities” in each chapter. Doing these questions is your homework (due by **8am** the day that the reading is assigned).
- In class, we will address any questions that you have about the materials, expand on what you have already done, and do quizzes/in-class exercises (some of which will be graded)

Class Schedule

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

- Lecture plans
- Required reading
- Assignments
- Due dates

Note: this schedule can change

Channels of Communication

- Lecture
- Canvas announcements
- Canvas messaging system: time-critical messages
- Canvas 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%
 - Zyante activities: 15% (Keep highest N-1)
 - In-class quizzes and exercises: 10% (Keep highest M-1)
 - Eleven small projects:
 - 23% the work by your group
 - 22% your personal contributions to programming
- Grades will be posted on Canvas
- Final letter 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 within one week

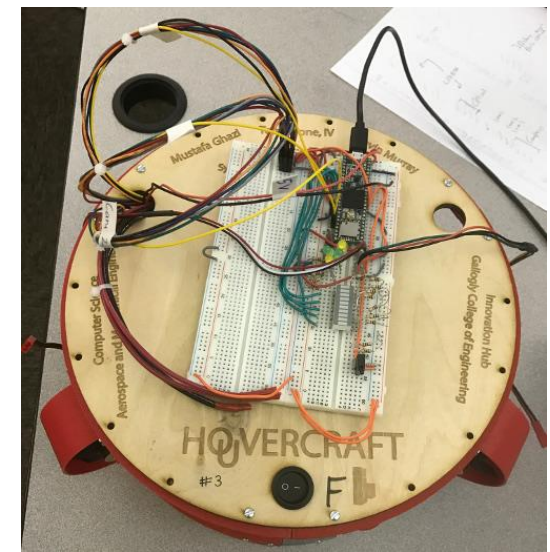
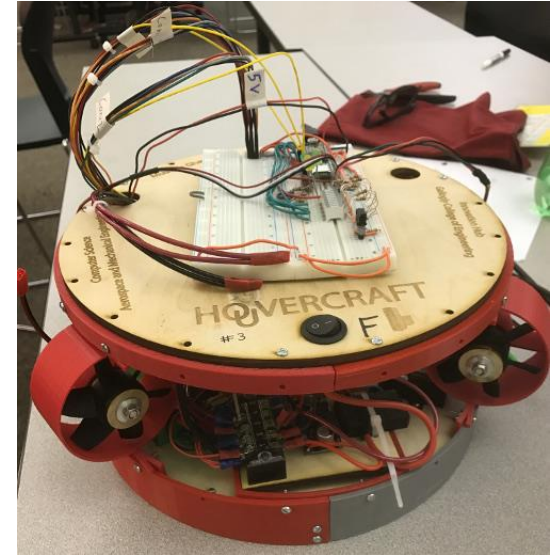
Group Projects

Focus: hovercraft control system

Each project:

- Discuss new project on Thursday
- In most cases: due the following Thursday (8:00am)
- Different components:
circuit, mechanical, software,
documentation

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



Project Topics

- Embedded processor programming (we are using “Teensies” this year)
- Analog processing and sensor models (distance sensing)
- Sensing lateral velocity
- Sensing heading and heading change
- Proportional-derivative control
- Finite state machines for mission-level control

Project Grading

Group grades are a function of:

- Code correctness and readability
- Documentation of code and circuits
- Demonstration

These are assessed during a short “code review” with me or the TA

Project Grading

Individual grades:

- Group grade scaled by the degree of your contribution to the group work (generally, this is balanced)
- Personal software contributions: must accumulate 3 software components over the course of the semester (1 available for most projects)

Group Projects (cont)

- Lab space: Felgar Hall 300
 - Will work out room availability soon
- Groups will be of size 2-3 and will be assigned
- Be ready to demonstrate project by the due date
- Projects require more than a day to complete
- Code/documentation will be handed in through your group's "subversion" tree
- 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 and laptop use (except for classroom exercises)

***More details in the syllabus

Proper Academic Conduct

Homework assignments (Zyante) :

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

Proper Academic Conduct

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 okay
- Software components: everyone must take primary responsibility for at least three

Secure your data

Next Time

- Zyante registration
- Readings:
 - Introduction to Embedded Systems
 - Analog circuits review
 - Diodes
- Catme survey coming soon via email (your first homework assignment)