EECS 507: Introduction to Embedded Systems Research
Course Goals, Organization, and Logistics

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Outline

Embedded system definition

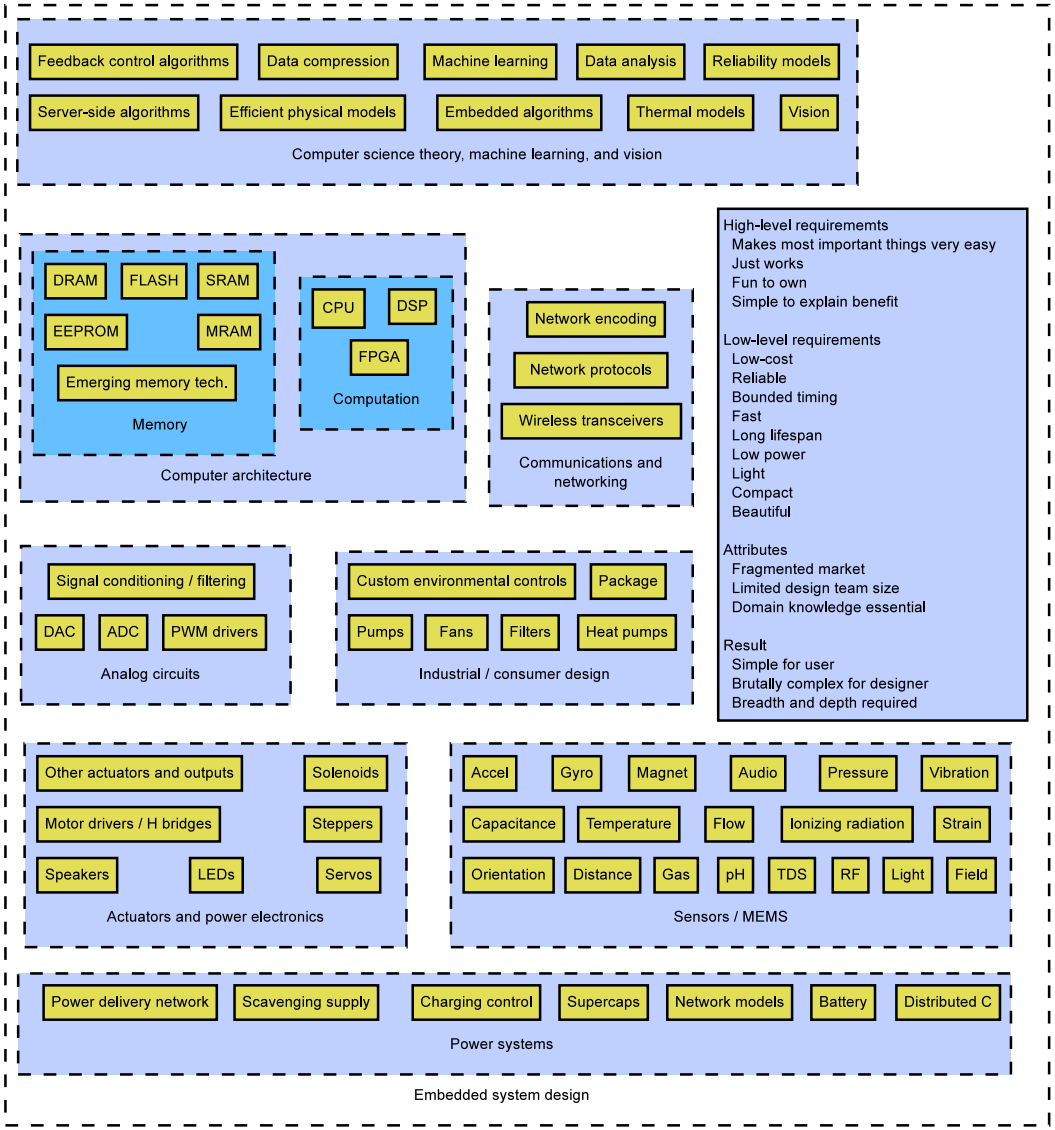
An (application-specific) computer
within something else
that is not generally regarded
as a computer.

Significance: if it's working right, it may not even be noticed.

Common embedded system requirements

- **Mobile:** limits PCB and power supply size.
- **Wireless:** power and reliability implications.
- **Reliable:** consider cars.
- **First time correct:** field repairs difficult.
- **Rapidly implemented:** IP reuse, automation, corner cutting.
- **Low price:** competition between many companies.
- **High-performance:** massively parallel, using ASICs.
- **Low power:** battery life and cooling costs.
- **Secure:** complicates design analysis.
- **Integrated w. physical world:** noise / security / control / other implications.
- **Hard real-time:** deadlines must not be violated.

Embedded system structure



Embedded systems market

- Dominates general-purpose computing market in volume.
- ∼$100-billion in 2020, projected to grow to ∼$150-billion/year by 2025.
- Similar in monetary size to general-purpose computing market.
- Growing slightly faster than general-purpose computing (∼5%/year).
- Car example: over half of value from embedded systems, zero a few decades ago.

Waves in computing

- ∼1980: personal computers.
- ∼1995: the internet.
- ∼2010: smartphones.

What's next?

- ?: Wearables.
- ?: Internet-of-Things.
- ?: New forms of communication.
- Others?
- When?

Prediction

Law of Toys

Every new class of computer systems will initially be seen as a toy by most.

As it becomes socially and commercially important, nearly everybody will act as if it was always obvious . . .

. . . even those who claimed it would always be a toy.

Advice

If logic dictates change, ignore the naysayers.

However, consider customer demand carefully.

Embedded systems market fragmentation

Application-specific.

Divergent hardware and software.

Limited market size for each class.

Many small–moderate size companies.

Limited engineering staff.

Implication

Embedded systems engineers must have deep knowledge of many levels of the design process.

Course goals

My goals

Prepare you for independent research on embedded systems.

How?

Develop broad background in major embedded system related research areas.

Your goals?

Examples

Distinguish between objectives and design.

Understand design as an optimization problem.

Estimate energy and thermal characteristics of an embedded system.

Understand energy consumption, performance, and reliability characteristics of many wireless communication standards.

Explain the architectural and algorithmic implications of focusing on particular embedded domains, e.g., automotive, wearable, or mobile.

Identify main security vulnerabilities of a given embedded architecture.

Implement several algorithms appropriate for ultra low power machine learning on resource-constrained platforms.

Etc.

Commitment

Will do my best to

- structure the course to help you toward the goals,
- revise structure based on my observations and your feedback,
- treat you fairly, and
- share my experience.

Some find me scary...

"You are a good professor and I like you, but I'm scared of you."

— Project advisee at graduation, after requesting a photo with me.

Something about my demeanor (serious, high-energy, very blunt) makes me difficult to approach to many students.

... but I like helping students

Ignore it and come to office hours if you want to talk about the class, embedded systems related career, entrepreneurship, etc.

$$\text{Serious} + \text{blunt} \neq \text{annoyed} + \text{grumpy}.$$

Everybody schedules 20-minute meetings with me, in groups of four.

- I'll ask you about your goals for the course and career, and about your background.
- Ask me anything.
- I'll make in-person and Zoom slots available.
- These aren't supposed to be project teams. They are just to make the schedule manageable and encourage discussion.

Course structure

Most undergraduate courses	**This course**
Highly structured	Less structured, topics change based on student interest
Material on which all agree	New and therefore contentious material
Canned material	Substantial material based on personal experience
Closed-ended labs/project	Open-ended project
Structure prods students to do what is required	Students must be responsible and interested for the course to succeed

Main expectations

Time per week

- 10–15 hours/week for those without projects.
- 20–30 hours/week for those with projects.

Behave honorably.

Do the assignments.

Actively participate in the search for good ideas during paper discussions.

For project version: develop and evaluate a novel idea related to embedded systems.

This course is optional

- Relatively unstructured.
- A lot of reading.
- Read/understand the papers you don't present.
- Give several presentations.
- Projects will take time, more time than one credit would suggest.
- Nobody requires this course to graduate.
- If it looks interesting, welcome.
- If it looks too burdensome or unstructured, drop it.

Your teacher: Robert Dick

History

- 2.5-year CE Bachelor's while working as an electronics technician and television station business manager.
- Graduate studies from Princeton University.
- Visiting Researcher at NEC Labs, America, where technology went into their smartphones.
- Mandarin course at Peking Normal University.
- Visiting Professor at Tsinghua University.
- Professor at Northwestern University.
- Founding CEO of direct-to-consumer Stryd athletic wearable electronics company.
- Professor at University of Michigan.
- $>$100 research papers on embedded system design, best paper awards, several products.
- Organized IEEE Design and Test special issue on topic for the second portion of this course.

Outline

Justification for course structure

Your participation and attention are essential to the success of the course.

Consider paper discussion and project presentations.

Lectures

Your attendance is required.

Email me if you need to miss due to illness or travel.

Tell me before class if you need to leave early due to an unavoidable conflict.

There will be a few guest lectures by experts on particular topics.

Initially, lectures will take the entire class period.

Later, much of the class period will be spent on research paper presentation and discussion.

Exams and quizzes

Midterm exam.

Final exam

Cumulative but focusing on material after midterm.

Some quizzes may be delivered

- Accounting for at most 15% of the exam portion of the course grade.
- Primary purpose: determine your current state of understanding so I can best allocate lecture and reading assignment time.

Reading

One research paper per class on average.

Paper summaries

- Summarize each paper using the template provided.
- I grade a random subset.
- Other students also provide feedback, but not grades.

Paper summary critiques

- Critique randomly assigned summaries by other students.
- I will spot check these critiques and may penalize poor ones.
- Based on past experience, students almost always do well on these.
- They are quick, and often help fill in gaps in understanding.

Paper presentations

Starts in in mid-September.

You will be notified at least a week in advance.

You will need to read the paper in detail and prepare slides.

Summarize the paper briefly and indicate promising applications, areas of discussion, and connections with other work and concepts.

You will have at least a week's notice of assigned presentation requirements.

Others are expected to read the paper in full and come with questions and observations.

I will also ask questions, and comment/summarize if necessary.

Projects

Required for four-credit version of course.

Extensions of research ideas introduced in the course or novel ideas.

Generally, theory or design concepts validated via prototypes.

Quality sufficient for a research conference publication.

Report should be at a level enabling submission to a conference if another 100 hours were spent on revision.

Team or individual work are both permitted.

Project presentations

- Teams will present their projects to the entire class.
- The class provides feedback.

Competition and collaboration

Not constrained to a particular number of As.

If the class as a whole does very well, more As.

Converse also true.

Collaboration on understanding the papers and making projects great will generally increase the number of As.

Don't hold back on hard questions. "I don't know but will follow up via Piazza" is a perfectly legitimate response...

...unless it is on a very basic concept from the paper you are leading.

Website

https://robertdick.org/iesr/.

Simple hand-written website to manage course handouts and assignments.

Grades will be shared through Canvas.

Piazza

- For administrative notification and discussion.
- Required: do not miss Piazza announcements.

Topics of interest thread

- Questions about embedded systems related topics that might not be related to items in the syllabus.
- May influence lectures and course topics.

Grading scheme

Without project

- Summaries of assigned reading and critiques: 35%
- Presentation and questions: 35%
- Exams and quizzes: 30%

With project

- Summaries of assigned reading and critiques: 30%
- Presentation and questions: 30%
- Exams: 20%
- Project: 20%

Outline

Homework

All due 31 August.

Estimated total time: $<$30 minutes.

Look at every link in the website menu. More will appear during the course.

Download and review the slides from the first lecture.

Make a post on Piazza under "topics" indicating your main areas of interest related to embedded systems.

Select a time for your meeting with me.

https://docs.google.com/spreadsheets/d/1QX0VV4369N6LCBzsoMe_bcWEDpDLMwdV_hnMZB1Kpp8.

TA support

Need to estimate long-term attendance to determine TA support.

Who is likely to stick with one of the two course versions?

I will post a one-minute Piazza survey on this today. Complete it this evening.