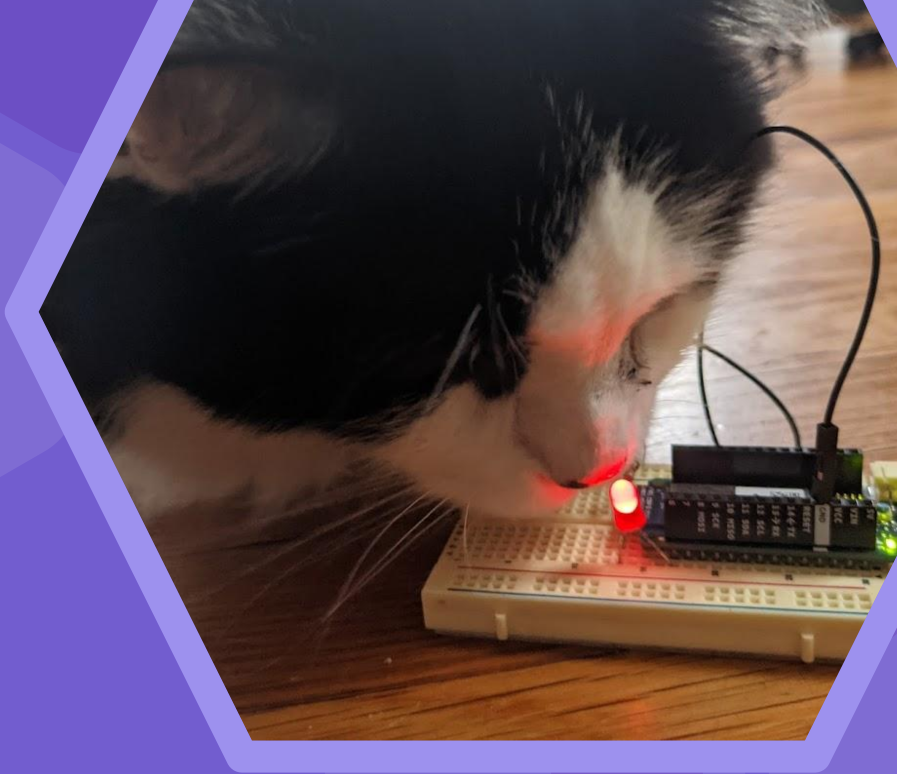
CSCI 1600: Real-time and Embedded Systems



Course staff

Arun!

Stephen!

Milda!

Not counting laptops and phones, estimate the number of computers in this classroom

Class estimates/examples:

Card swiper
Projector
Smart watches
Av control
Projector backdrop controller
Speakers
Cameras
AC/HVAC
Air purifier

What are some other examples of embedded systems you can think of?

Other examples:
Cars
Medical devices
Home appliances
Laser tag
Traffic lights
Gaming consoles
Smoke detectors
Card readers
Security systems
Wireless headphones
Motion-sensitive dispensers

Choose a device we mentioned.

Discuss:

- *What is the device meant to do?*
- *What other devices does it communicate with?*
- *How does the device interface/interact with the outside world (sensors, buttons, outputs)?*
- *What sorts of data does it process, and what computations does it have to do?*
- *Can it cause damage (to itself, its environment, people) if it malfunctions?*

Meant to do
Roomba - clean the surfaces
Nuclear reactor - give you electricity
Elevator - takes you up and down
Car - take you places
Bypass - regulate your heart
Traffic light - regulate traffic

Interface/interact
Cars - cameras and sensors
Roomba - maps out (distance, bumpers); communicates with phone
Traffic light button
Pacemaker - communicate with server, sensors to monitor heart
Elevator buttons

Safety implications
Nuclear reactor - environmental damage
Traffic lights - serious accidents
Elevator - people :(
Smart fridge - food poisoning
Roomba - unclean
Fire alarm - ears hurt
Motion sensor door - inconvenience
Alarm system - missing items

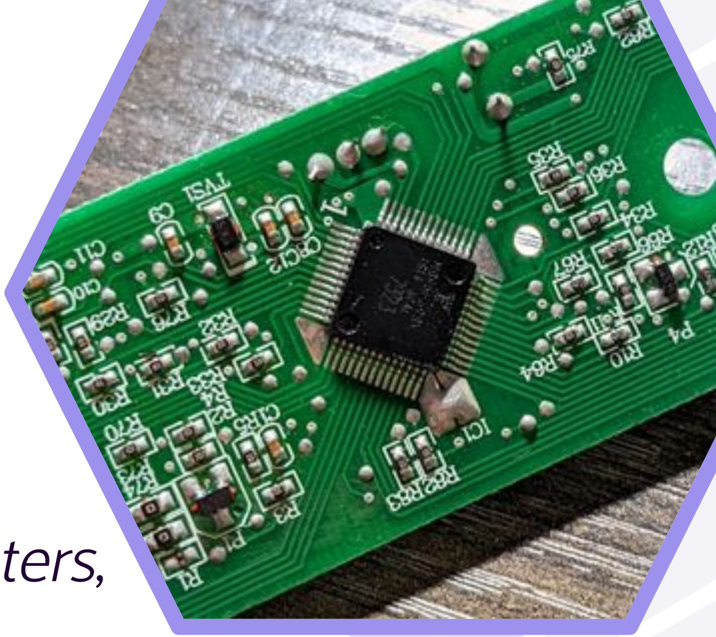
Communicate
Wireless headphones - bluetooth
Elevator - talk to central systems
Cars - multiple embedded systems (CAN)
Fire alarm - sprinkler system

Data/computations
Greenhouse: compare humidity, temperature (raw sensor data)
Elevators - scheduling protocol
Signal filtering - wheel speed sensor
Mapping
Headphones - calculate opposite signal (DSP)

Embedded systems

Controlled by a **microcontroller**

CPU, memory, IO in one chip



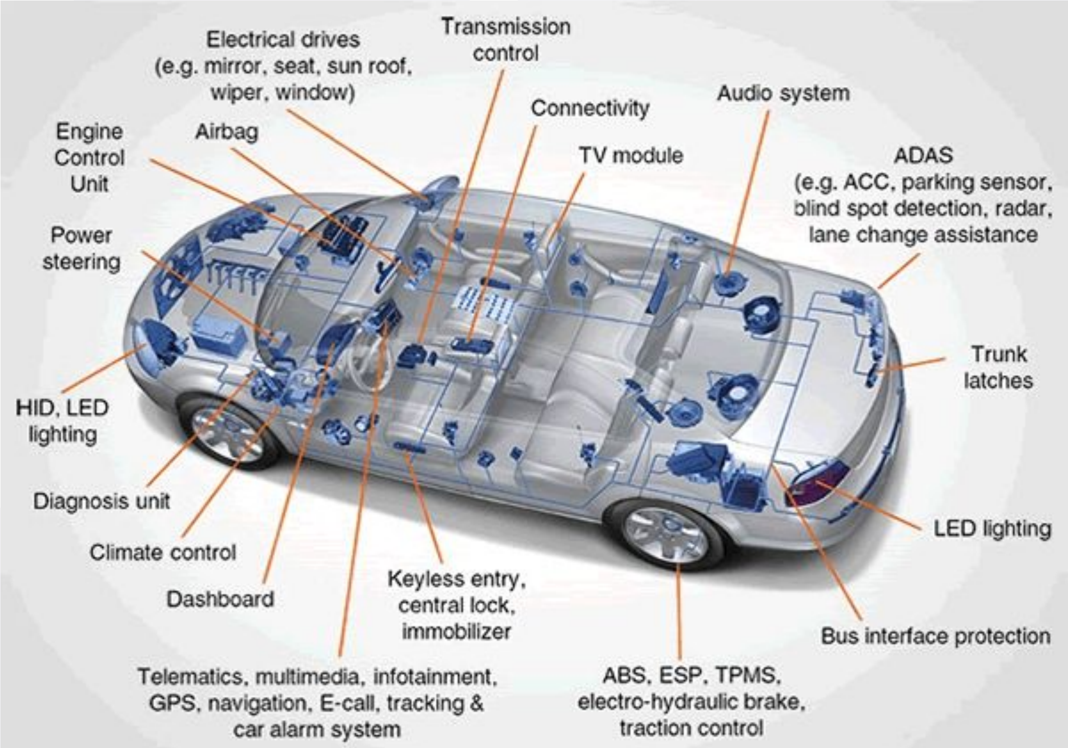
Contrasted with *general-purpose computers*, **embedded systems**:

- Are made for a specific purpose
- May be less “visible”
- Interface with the physical world
- Have timing constraints that affect correctness (**real-time systems**)

Some examples

Images creative commons. For credits, see last slide

How many different embedded systems can you think of that make up a car?



*Thomas Scannel, "*Automotive Connectivity Evolves to Meet Demands for Speed & Bandwidth*", 2017*

Some products are made up of **distributed** embedded systems

Challenges

Constraints
Memory space
Form factor
Power
No OS*/set API/architecture

Engineering
Safety
Software/hardware design process
Cost at scale

Real-world interactions
Interface with peripherals
Peripheral failure
Communication protocols
Harsh environments

Verification & Validation
Timing analysis
Modeling physical properties
HW *and* SW testing and debugging

Pick two challenges. How do they affect each other?

Constraints
Memory space
Form factor
Power
No OS*/set API/architecture

Real-world interactions
Interface with peripherals
Peripheral failure
Communication protocols
Harsh environments

Engineering
Safety
Software/hardware design process
Cost at scale

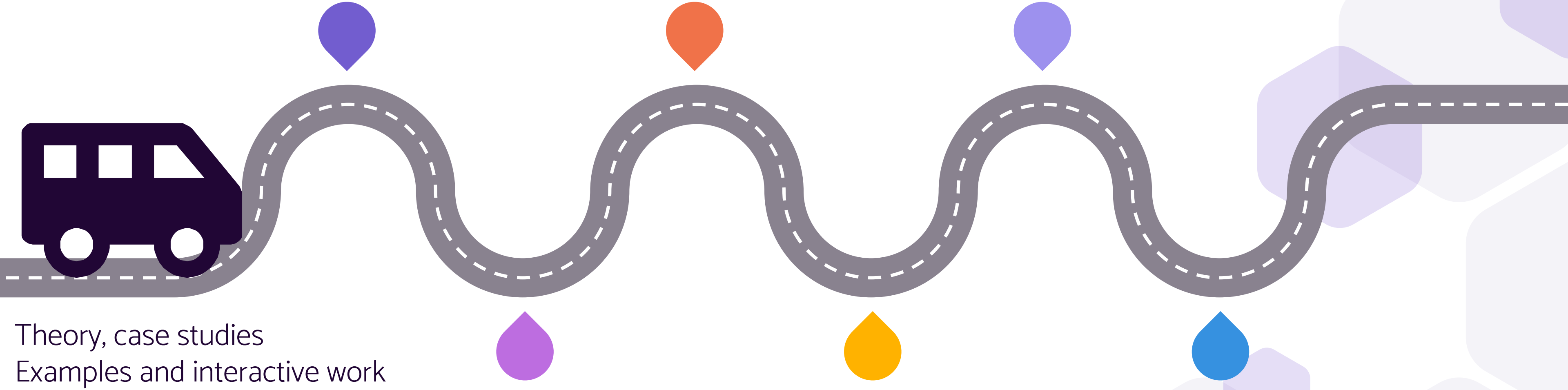
Verification & Validation
Timing analysis
Modeling physical properties
HW *and* SW testing and debugging

Roadmap of the class

Background, hardware concepts

Engineering process

Safety, security, and correctness



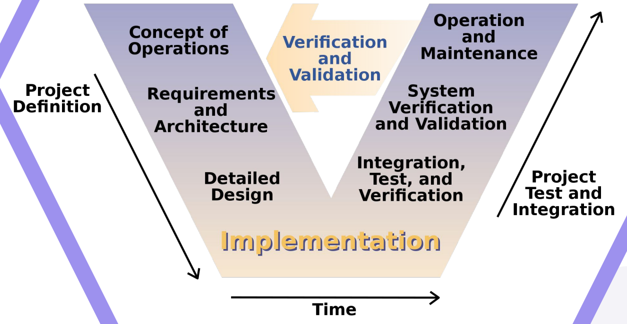
Theory, case studies
Examples and interactive work
Hands-on labs

How microcontrollers work

Applications

Your cool embedded project!

Image from http://en.wikipedia.org/wiki/V-Model



Throughout the class

How design, implementation, verification/validation connect

How HW influences SW and the other way around

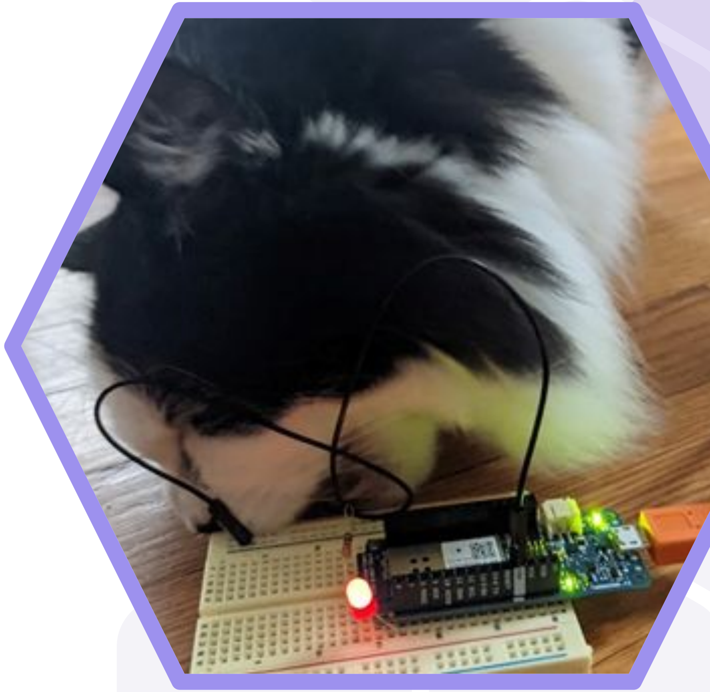
Societal impacts of embedded technology

Summary

Embedded is everywhere

Embedded is cool!

Embedded has interesting challenges



Enrollment cap

- 40 students max, strictly enforced
  - This is effectively a new class and we want to make it a good experience!
- No wait list
  - Keep checking c@b!
  - If you don't intend on taking this class, please drop it

Break

Community

This is a **brand-new** version of the material

I've taught embedded before, but not at Brown

Communication is a two-way street

- I will explain why I'm doing what I'm doing
- I intend to establish enough trust that you come to me with problems/suggestions/feedback *early*

Ways you can give me feedback

E-mail

In person (after class, in office hours)

Anonymous form

Via TAs (anonymous or not)

DE&I, accessibility, culture issues: department and university-wide resources

→ **Feedback only works if I follow up on it**

I intend to establish enough trust that you come to me with problems/suggestions/feedback early

→ ***What would help earn that trust?***

Suggestions

Discuss feedback in class
Respond to emails

Course structure

Homeworks

...prepare you for...

Concepts presented in lecture

...prepare you for...

Hands-on experience in lab

further assessed in

Group project

Homeworks

Low-stakes (graded on effort)

Examples:

- Read or watch background material, answer questions
- Briefly research and present a case study
- Give your opinion on an open-ended question

Done individually, turned in via Canvas as slides

Due morning of lecture (late not accepted, 2 dropped)

Lectures

Participation based on homework and concepts presented in class

Part of HW grade (after shopping period)

Examples:

- Present homework or in-class questions
- Work through technical problems in groups
- Practice engineering process

Labs

Synchronous, Tues. and Thurs evenings

- **You must sign up for a lab section**

Ideally done in pairs (exceptions for social distancing)

Require Arduino IoT Kits (available at bookstore)

Rubric-based grading

- Demo and individual post-lab report (**due a week later**)

Group project

No exams for this class → convince me you **met the learning goals** via the project

Demo & project report, revisions after feedback

Open-ended (with suggestions)

Must include concepts from class

More details after shopping period

Website, Canvas, Ed

http://cs.brown.edu/courses/csci1600/

Website for: syllabus, labs, homeworks, hours

Canvas for: assignment turn-in, grades, lecture capture, readings

Ed for: discussion, questions, announcements

Textbook

Lee/Seshia: Introduction to Embedded Systems

Available free online, linked from website

We will be using this as a reference/jumping around in it, but also drawing from other background sources

Remote Asynchronous

Class is recorded automatically using lecture capture, will be available on Canvas after class

Class attendance is **strongly encouraged**

- Participation is a large component of in-class learning
- Remote participation: videos, Ed discussion
- We will post assignments early to facilitate remote participation

D E & I

Engineering involves working **with people** to create artifacts that will be used **by people**

- Your work impacts others

Course has a major participation and teamwork component → inclusion and respect

I want to hear how I can do better, too

What should our community standards be for equitable, inclusive, open, and respectful collaboration and participation?

Community standards

Expectation of good intent from classmates
Be aware of the space you take up (be ok with not talking for a bit)
Discuss the idea not the person
Check in with each other

Accessibility and accommodations

Syllabus lists resources:

- Student Accessibility Services (SAS)
- Undergraduate & Graduate deans
- CAPS
- Also each out to me if you need extensions/accommodations for mental health

Academic Integrity/Collaboration

You are expected to collaborate for a large part of the course (labs & projects)

- TAs and I will expect each person to be able to explain every part of the group work

Individual work on homework & lab writeups

- Work must be your own
- Cite any outside sources used

Summary

New course looking for feedback

Course components: homework, lecture, lab, group project

Participation (and broader engineering context) means we treat each other with inclusion and respect

What classroom practices have enabled your learning in the past? Where do you see room for similar practices in this class?

Ideas

Make you chunk up the project in small pieces

discussions/polling (questions that make you explain your reasoning, speak with partner first before asking for answer)

Different lab partner every time

Releasing solution code for labs (for group projects)

High-level debrief of labs

Breaks - two of em

Next up

I will update syllabus based on our discussion

Lab 1: Introduction to Arduino

- Tuesday/Thursday next week
- If bringing laptop, install the IDE beforehand

Homework 1: due next Friday 11am

Lecture 2: Sensors and I/O

- "Chevrolet Camaro & Cadillac Escalade" by crash71100 is marked with CC0 1.0
- "Microwave" by Alabama Extension is marked with CC0 1.0
- "Airplane" by viZZZual.com is licensed under CC BY 2.0
- "2011 BUICK REGAL - Plant assembly line" by 2011 BUICK REGAL is licensed under CC BY 2.0
- "Big MRI" by Muffet is licensed under CC BY 2.0
- "Bosch SHE3AR75UC Ascenta 24' Stainless Steel Full Console Dishwasher" by Goedeker's is licensed under CC BY 2.0
- "My kronoz smart watch" by chrisf608 is licensed under CC BY 2.0
- "File:Nao Robot (Robocup 2016).jpg" by ubahnverleih is marked with CC0 1.0
- "ecobee3 lite Smart Thermostat" by shop8447 is marked with CC0 1.0
- "New traffic light on Bank Plain, Norwich" by sebastiandoe5 is marked with CC0 1.0
- "Wind power plant" by Mathias Appel is marked with CC0 1.0
- "Carol M. Highsmith's Texas Photograph" by Carol M Highsmith is marked with CC0 1.0
- "XBOX Controller @ BarcampLondon5 - Day 1" by Cristiano Betta is licensed under CC BY 2.0
- "Drone 2" by Michael Khor is licensed under CC BY 2.0