Embedded Software

CS 145/145L

Caio Batista de Melo

- Homework 5 is due tomorrow

- Project 5 is due end of finals week
  - But no labs next week, use edstem if you need help

- Please submit your course evaluations
  - Extra credit on P5 demo
  - Help improve this and future courses
  - https://evaluations.eee.uci.edu
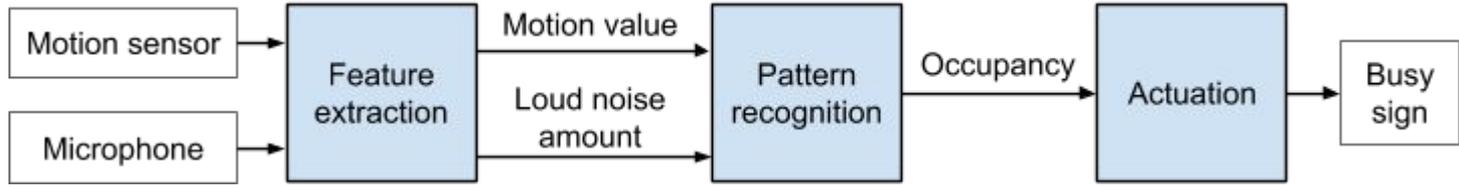 - Closes on 2022-06-06 at 7:50am

Agenda

- Pattern Recognition
  - Feature Extraction
  - Recognition

- Field Programmable Gate Arrays (FPGAs)
  - What?
  - Why?

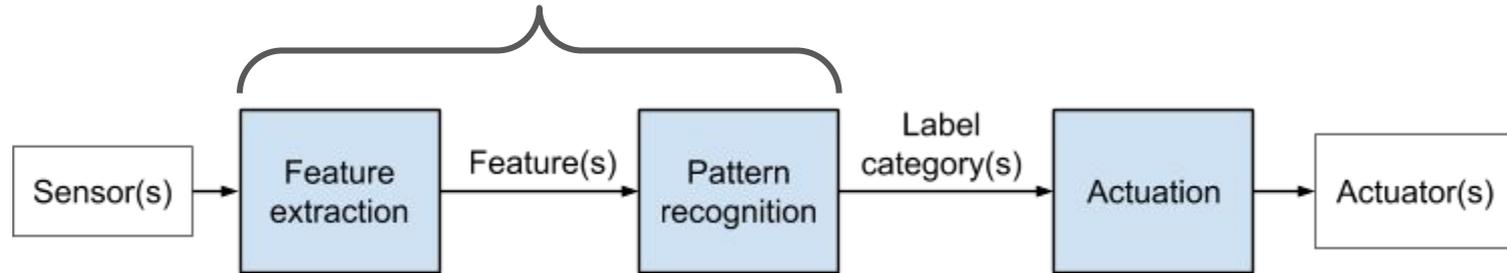- Life after CS145

Pattern Recognition

Occupancy Room Detector

This is DSP!

Let's take a look at these two new boxes
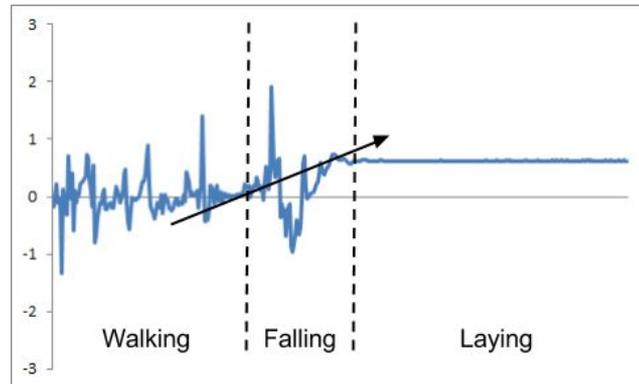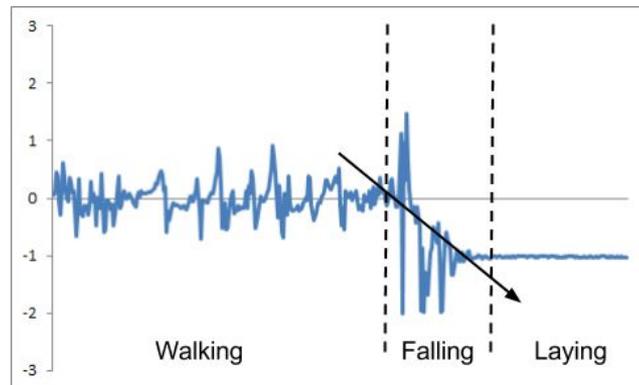

Generic Framework

Feature Extraction

Generating meaningful data from signal

Examples:

- Speed or distance for a vehicle

- Number of voices for a smart speaker

- Empty spot in a parking lot

- Screen attention

Pattern Recognition
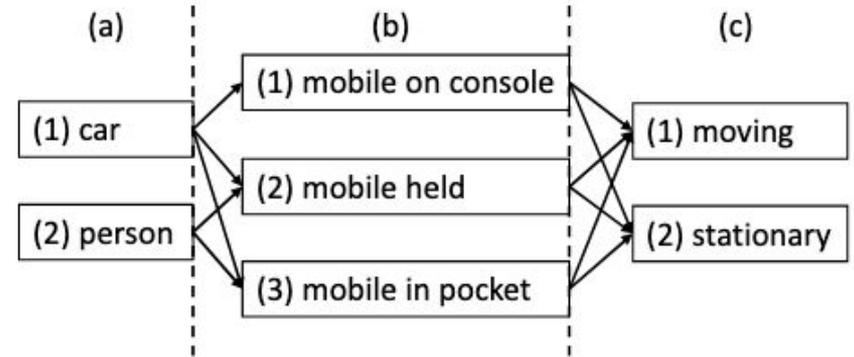
Figuring out what the features mean

Examples:

- Speed or distance for a vehicle
  - ➤ Highway or local street? Safe braking distance?
- Number of voices for a smart speaker
  - ➤ User or TV? Which user? Speaking to me?
- Empty spot in a parking lot
  - ➤ Available or not
- Screen attention
  - ➤ User reading something, keep screen on

https://ieeexplore.ieee.org/abstract/document/8861724/
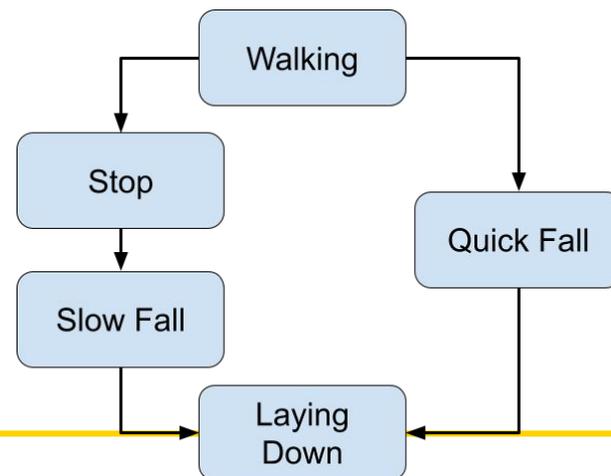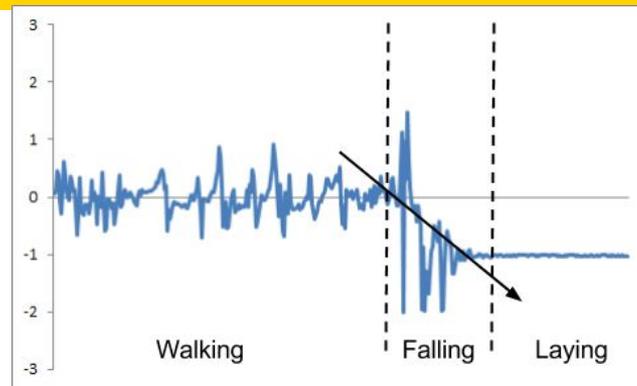
Pattern Recognition Example

https://dl.acm.org/doi/abs/10.1145/3358175
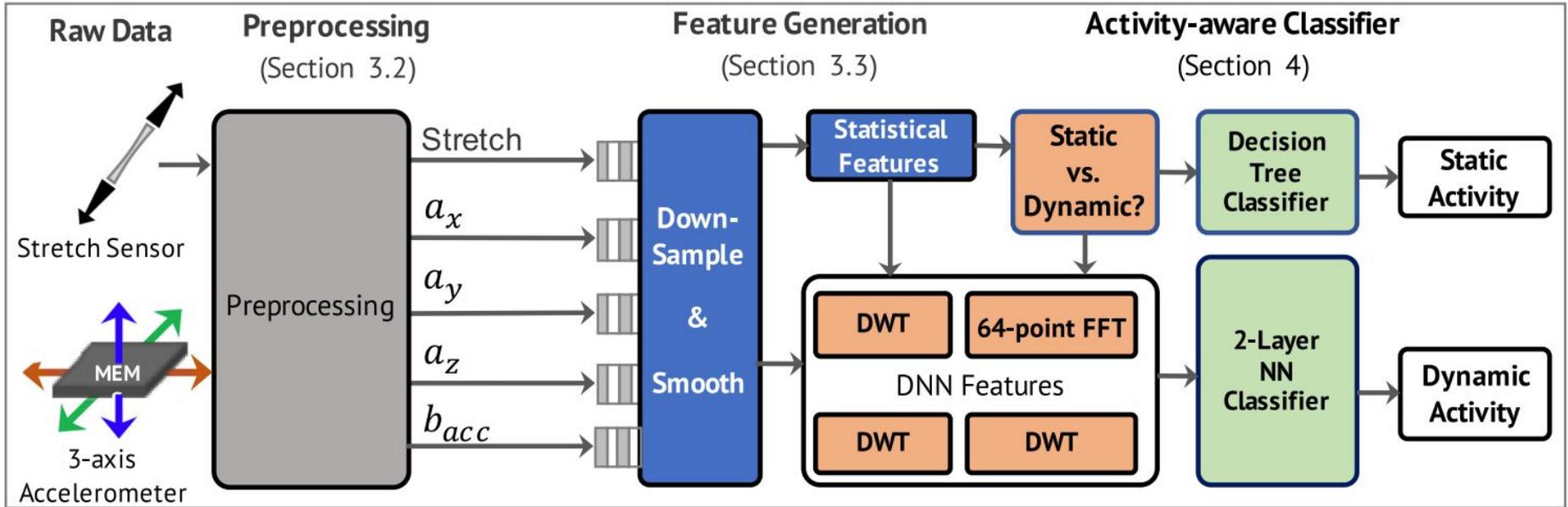
FPGAs

Hardware Accelerators

- Some problems are hard…

- Like division!
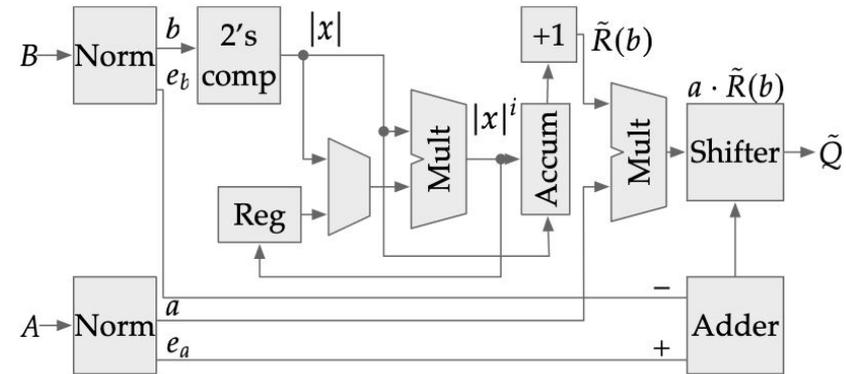
- Integer division has a latency of 9–17 cycles for 16-bits and 9–25 for 32-bits

- Integer multiplication takes only 3 cycles

Average accuracy between 92.5% and 99.0% with a latency between one and seven cycles

https://dl.acm.org/doi/abs/10.1145/3287624.3287668

Custom Hardware (e.g., Accelerators) Problem

Expensive to tape out

	INCLUDES ACCESS TO EDA TOOLS + AUTOMATED DESIGN FLOW	INCLUDES FULL CHIP REFERENCE DESIGN	INCLUDES SILICON FABRICATION	INCLUDES PACKAGING AND EVALUATION BOARD	INCLUDES SOFTWARE / TEST	DESIGN SUPPORT / EXPERTISE NEEDED	TOTAL DEVELOPMENT COST
MPW Service Provider	✗	✗	✓	✗	✗	No support / high-level of expertise needed	$$$
Contract a Design Services Provider	← ------------- Depends on service provider ------------- →					Experience managing chip development projects	$$$$$
Hire an In-house Design Team	← ------------- Additional cost required ------------- →					No support / high-level of expertise needed	$$$$
Create your Chip using chipIgnite	✓	✓	✓	✓	✓	Large design community and library of example projects	$

https://efabless.com/

Custom Hardware (e.g., Accelerators) Problem

Really expensive to tape out

Chip Creation Made Simple

chip**Ignite** provides you with a pre-built chip for integrating your custom design and an automated open-source design flow making it easy and affordable.
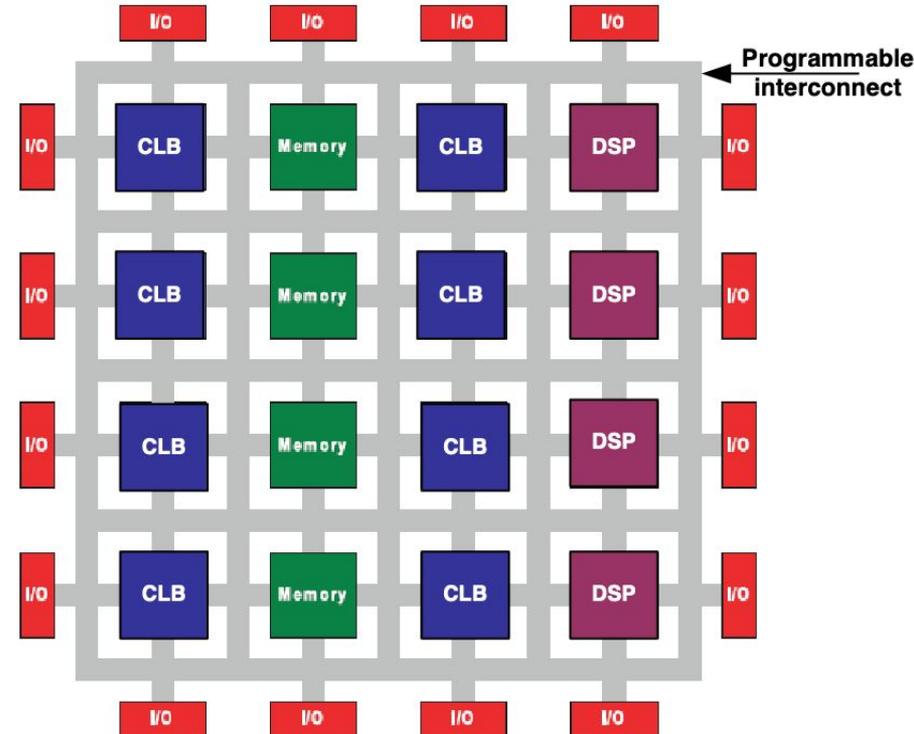
Only **$9750** per project

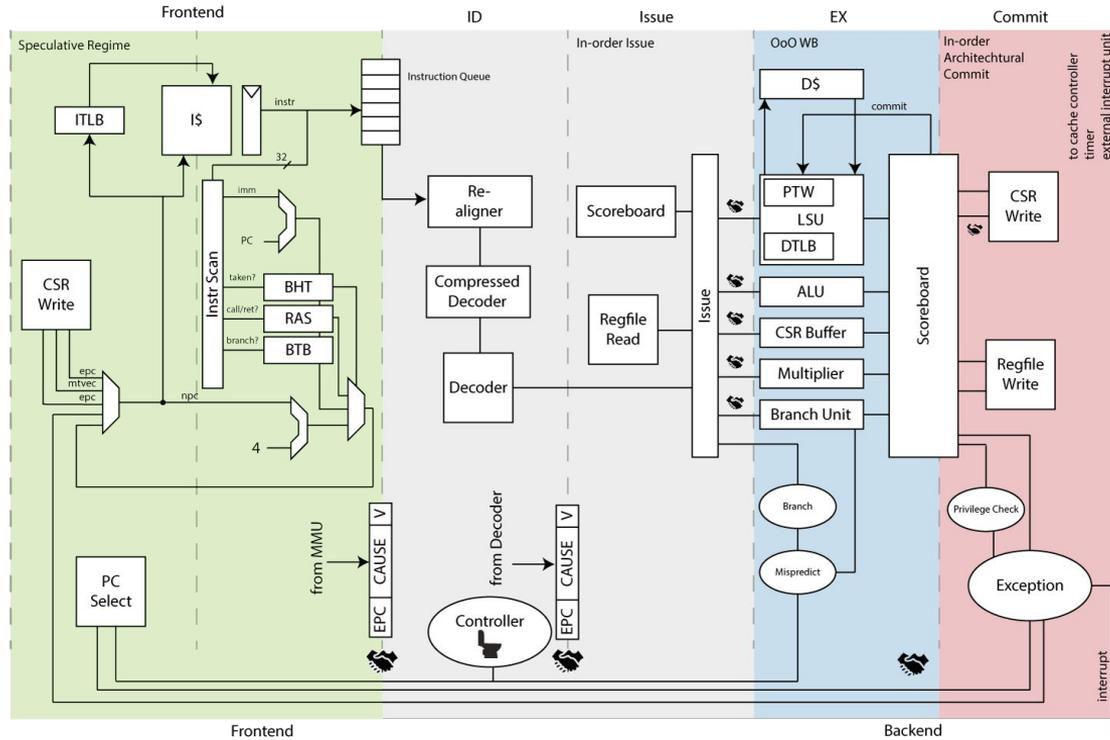https://efabless.com/

Field Programmable Gate Arrays (FPGAs)

- FPGAs let you define your circuit

- Allows for rapid prototyping

- Adds an overhead due to flexibility

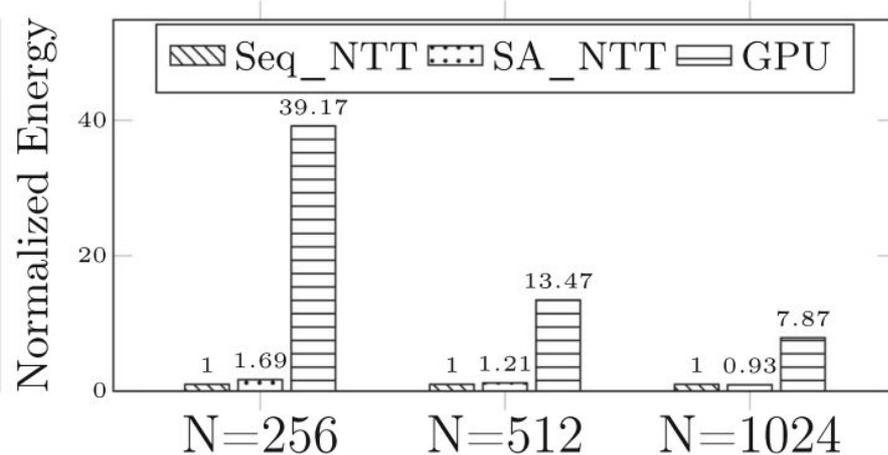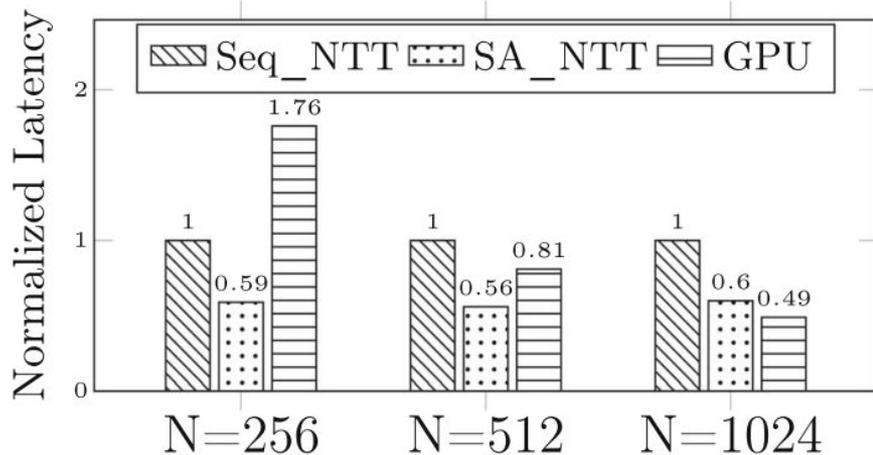- Can be much cheaper (< $100)

- Debug before taping out a chip

https://www.researchgate.net/publication/290929451

https://github.com/lowRISC/ariane

FPGA Example

Future

DIY Projects

ATmega32 ideas:

- https://atmega32-avr.com/projects/

- https://circuitdigest.com/atmega32-projects

- https://bestengineeringprojects.com/electronics-projects/atmega-projects/

- http://myclassprograms.blogspot.com/p/atmega32-avr.html

- https://github.com/topics/atmega32

Can also look into other cheap options (e.g., Arduino, Raspberry Pi).

Other UCI Courses

- ## CS 151: Digital Logic Design
  - ➢ Opens up other classes (152, 153, 154)

- ## CS 147: Internet of Things (IoT) Software and Systems
  - ➢ Similarly structured to 145, projects with arduino boards

- ## CS 111: Digital Image Processing
  - ➢ "Introduction to the fundamental concepts of digital signal and image processing…"

- ## CS 143A: Principles of Operating Systems
  - ➢ Opens up other classes (131, 133, 143B, 146*)

- ## CS 132: Computer Networks
  - ➢ Opens up other classes (133, 134)

Grad School?

Graduate Programs in Embedded Systems (ranked by distance):

- https://mecps.uci.edu/

- https://jacobsschool.ucsd.edu/mas/wes

- https://www.colorado.edu/ecee/academics/graduate-programs/professional-masters/embedded-systems-engineering-and-internet-things

- https://www.cis.upenn.edu/graduate/program-offerings/mse-in-embedded-systems/

Not an exhaustive list! Can also look into CS/CSE/EECS programs.
You can also likely go directly into industry!

Enjoy your summer :)