CPSL
Cyber-Physical Systems Laboratory

CSE 521S Projects

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AIM: AI and IoT for Medicine

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- Data-driven tools for precision medicine
  - Phenotype complex diseases
  - Predict individual outcomes and treatment effects
  - Discover risk factors
  - Support clinical decisions

- Extract knowledge from diverse data

Electronic Health Record (EHR)
- **Collected in hospitals**
- **Complex and high-dimension data**

Internet of Things (IoT)
- **Longitudinal monitoring in daily life**
- **Noisy and lossy data**

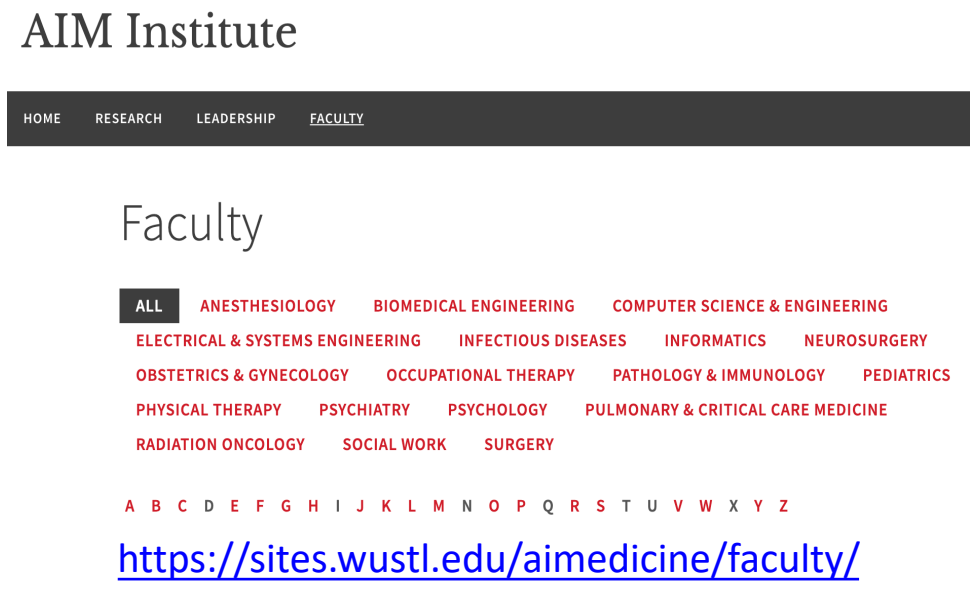
Bridge the Gap between AI and Medicine

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- AI in medicine
  - Apply off-the-shelf AI to medicine
  - **Limitations in face of hard medical problems**
- AI in computer science
  - New techniques are developed at an explosive rate
  - **Largely ignored and rarely applied to medicine**
- AI + Medicine
  - Tackle **hard** medical problems with **advanced** AI

AIM Institute: AI and IoT for Medicine

- Interdisciplinary hub for **AI+Medicine**
- Grow **collaboration** across engineering & medicine
- Create **competitive edge in recruiting**
- Build infrastructure for **large research initiatives**
- Translate AI and IoT to **health care**



https://sites.wustl.edu/aimedicine/faculty/

Department/Division	#Faculty
Computer Science & Engineering	13
Biomedical Engineering	5
Electrical & Systems Engineering	5
Anesthesiology	8
Neurosurgery	5
Obstetrics & Gynecology	4
Psychiatry	4
Physical Therapy	3
Pulmonary & Critical Care Medicine	2
Informatics	2
Pathology & Immunology	2
Pediatrics	2
Occupational Therapy	2
Infectious Diseases	1
Radiation Oncology	1
Surgery	1
Psychology	2
Social Work	2
Total	**64**

A Research-Oriented Class on AIM

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- **Projects 60%**
  - Proposal and presentation: 10%
  - Demo I: 5%
  - Demo II: 5%
  - Final report and demo: 40%
- Critiques 30%
- Participation 10%

- Mini **research** experience on AIM
- **Interdisciplinary**: co-taught by researchers from CS and medicine

Project

- **Three** students per team
  - Need permission for a bigger or smaller team.

- Develop/integrate **software/hardware**
- Perform **experiments** on real systems and data
- Write a **paper**
- **Demos**

- Opportunity to contribute to the **Smart Kitchen** project

Support People with Subjective Cognitive Decline

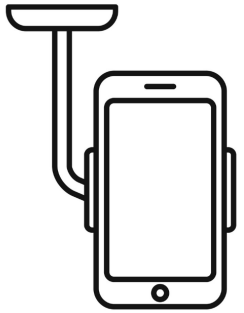
- Many people with cognitive impairment struggle to complete daily activities
- Use AI to recognize cognitive errors and support daily functions



Simple Cooking Task

Make oatmeal on the stove

+



Smart Camera

Capture performance and detect errors

+



Smart speaker

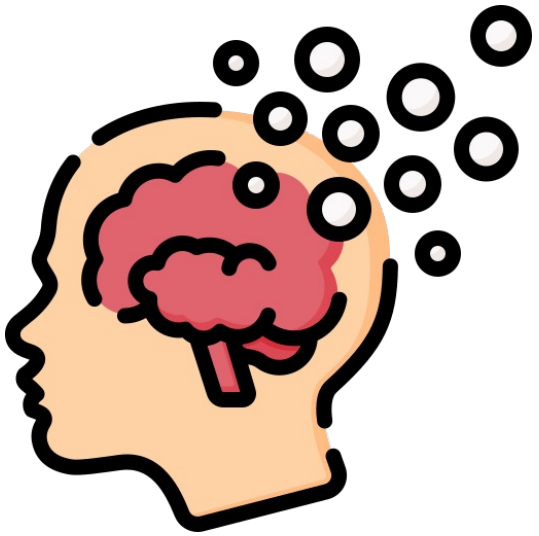
Deliver context-sensitive cues

Joint work with Lisa Connor, Carolyn Baum, Yejin Lee (Occupational Therapy), Ruiqi Wang (CSE)

Why is this important?

Subjective Cognitive Decline (SCD) is self-reported MEMORY PROBLEMS that have been GETTING WORSE over the past year.

- 1 in 9 people over 45 experience SCD
- 30.3% of women with SCD live alone
- 35.5% of African Americans with SCD live alone



Sources: CDC & Alzheimer's Association; National Post-Acute and Long-term Care Study (2020); National Poll on Healthy Aging (2022)

https://www.flaticon.com

SCD interferes with daily functional tasks

- 51% experience SCD-related functional difficulties
- 52% of African Americans need assistance with household activities
- 66.2% have 2 or more chronic conditions that need management
- 33.7% report frequent mental distress



Source: CDC.gov/aging

But we need to support independent living



Source: National Poll on Healthy Aging (2022)

However,

- 88% of adults 50-80 believe that it is important to remain in their homes as long as possible
- Desire to age in place due to cost and importance of independence

Smart Kitchen System



Simple Cooking Task

Making oatmeal on the stove

+

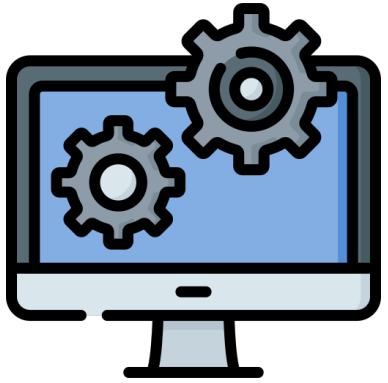


Video capture

Video capture people with SCD performing the task & making errors

Embedded AI computing

+



Performance Breakdown Recognizer

Train deep learning model with videos annotated with error types by clinicians

+



Adaptive Cueing Agent

Deliver context-sensitive cues to support performance by smart speaker

Interdisciplinary Collaboration between Occupational Therapy & Computer Science

Steps

1. Pick your favorite topic
2. Form a team
3. Propose a design
4. Analyze and Implement your solution
5. Evaluate your solution
6. Demo 1, 2 and Final Demo
7. Write a technical report

Get Started Early

- Think about topics and ideas
- Talk to TA and me
- Put together a team

- A **lot** of work (and fun) throughout the semester!

Teaming

- Everyone should be in a **three**-member team
  - unless you receive special approval from TA for a different size
- Use **Piazza** to "Search for Teammates"
- Email TA (ruiqi.w) your team members by **Tuesday, September 12**
  - One email per team
- Join one group on Canvas > People > Groups.
- We will help make sure everyone has a team.

Proposal Presentation

- In class on **9/19**
- **6 min** per group
  - 5-min talk + 1-min Q&A
  - 4 slides
  - Rehearse in advance
- Your **elevator pitch!**
- Email TA your slides before class

Written Proposal

- One proposal/team, one page
  - Team members
  - Concise description of project
  - Responsibilities of each member
  - Equipment needed

- Written proposal due: **9/19, 11:59pm**

Demo I&II

Demo I

- In class on **10/17** and **10/19**.
- **10 min** per team.
- Must show something **real**.

Demo II

- In class on **11/14** and **11/16**.
- **10 min** per team.
- **Substantial** progress → final demo.

Final Demo

- Set up and **test** your demo in advance.
- Preparation & dry-run: in class on **12/5**
- Final demo: in class on **12/7 (1pm - 3:30pm)**.
  - 10 min per team.
- All expected to attend the entire session. It'll be fun!
- Submit a video before class as backup.

Final Report

- Submit by **12/12, 11:59pm**

- Report
  - Style follows conference papers in the reading list
  - 6 pages, double column, 10 pts font
  - Use templates on the class web page

- Materials
  - Web page
  - Slides of your final presentation
  - Source code
  - Documents: README, INSTALL, HOW-TO-RUN
  - Video

Suggested Outline

- Abstract
- Introduction
- Goals and Requirements
- Design
- Implementation
- Experiments
- Related Works
- Lessons Learned
- Conclusion and Future Work

Peer Review

- For fairness in team projects.

- Email me on **12/12**
  - Percentage of contributions of each team member.
  - Brief justification.

Logistics

- TA for projects: Ruiqi Wang
- Email TA or me for appointments to discuss ideas
- All work will be submitted on Canvas

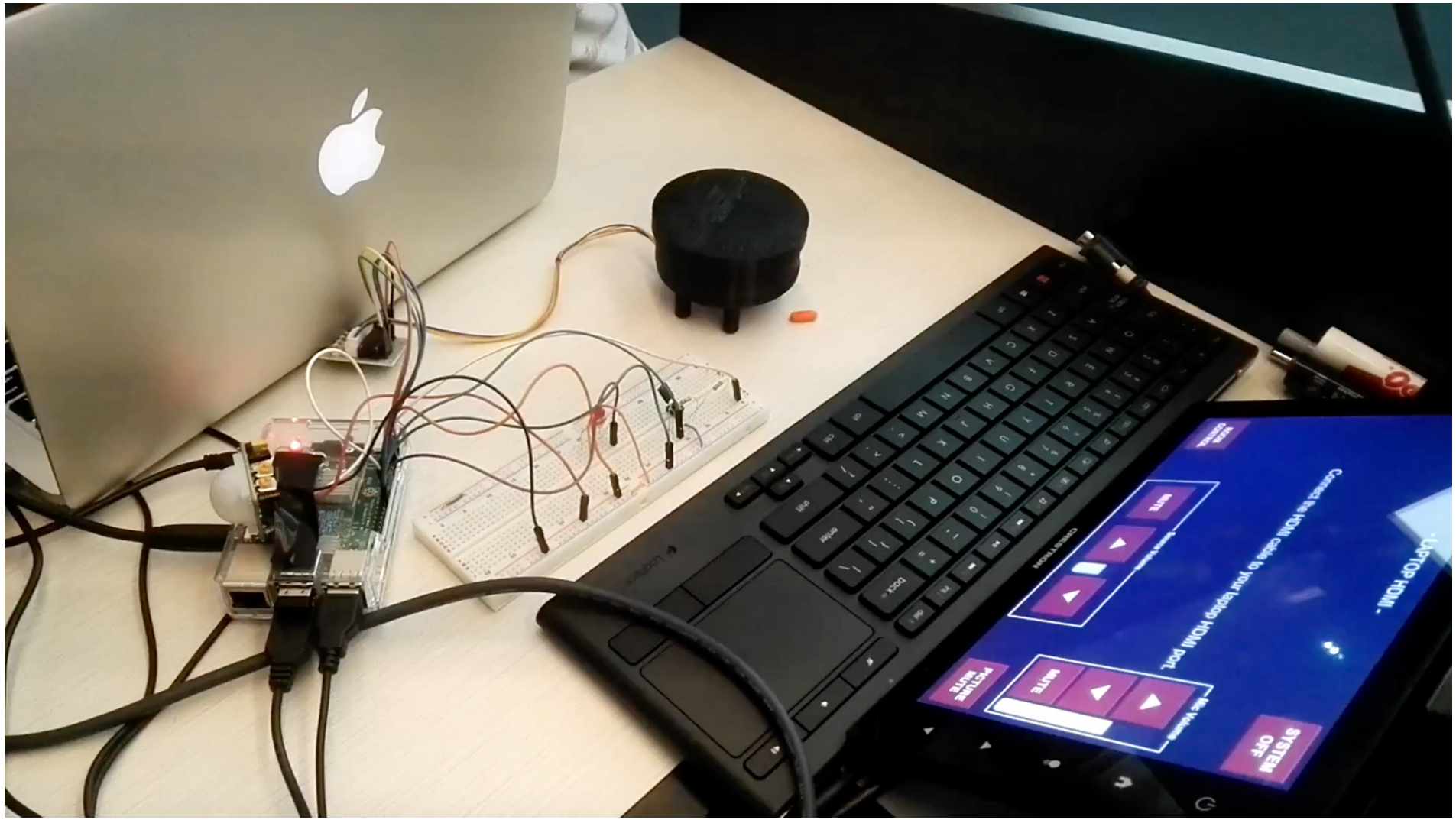
Logistics

- Guidelines and slides are on the class **homepage**.
  - http://www.cse.wustl.edu/~lu/cse521s/

- Communication will be through **Piazza**.
  - E.g., Search for teammate

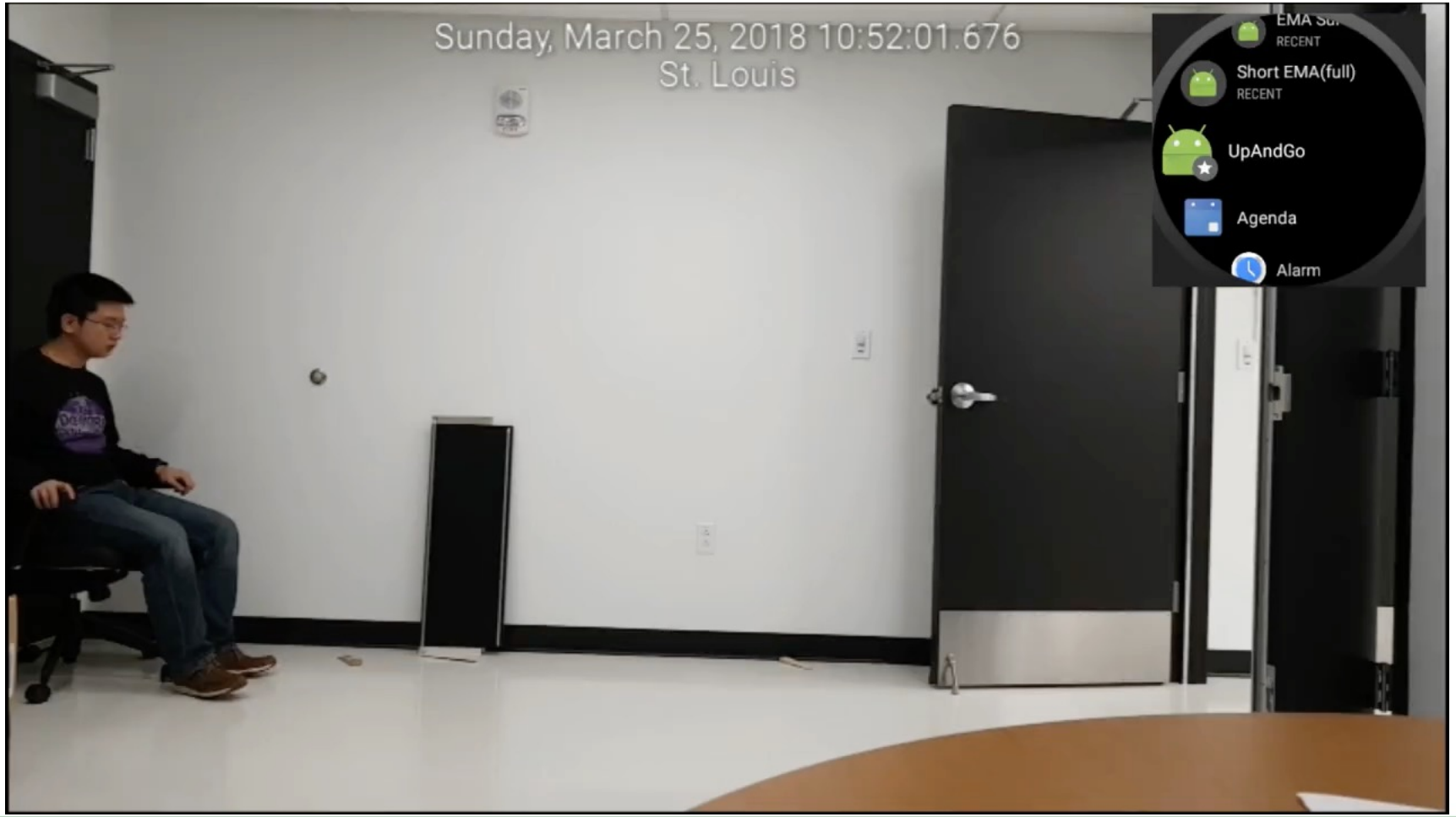
Automated Medicine Dispenser

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Timed Up and Go with Smartwatch

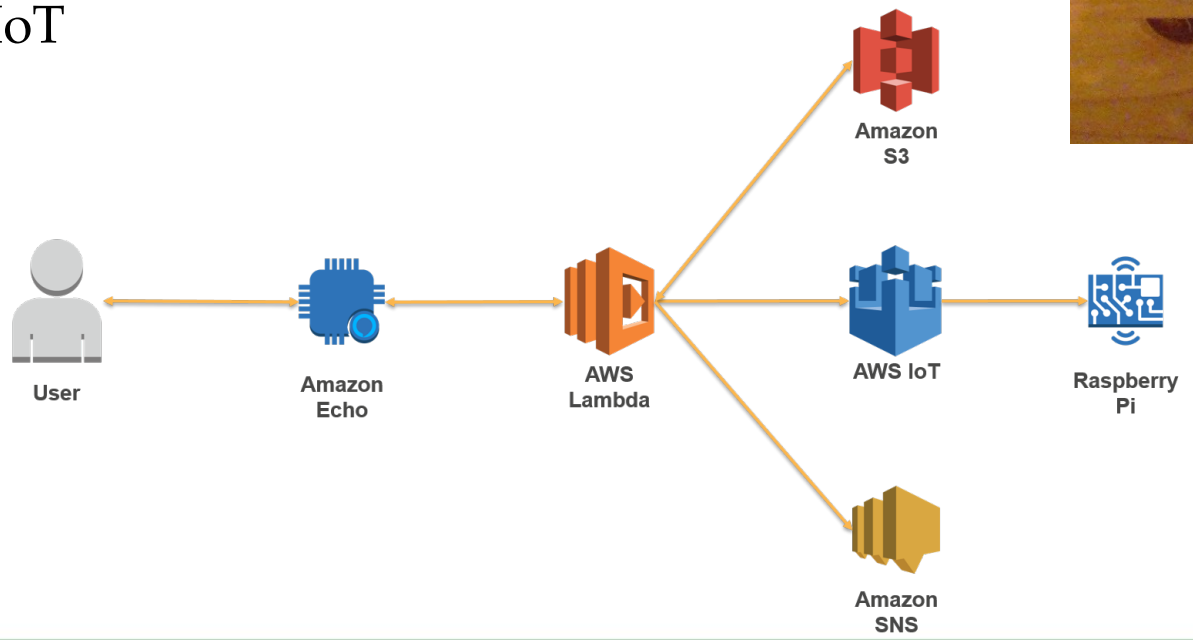
- Prompt user about assessment
- Upload data to the cloud
- Analyze gait and motion
- Feedback to physicians and user



Spice Bot: Spice-Blend Automation

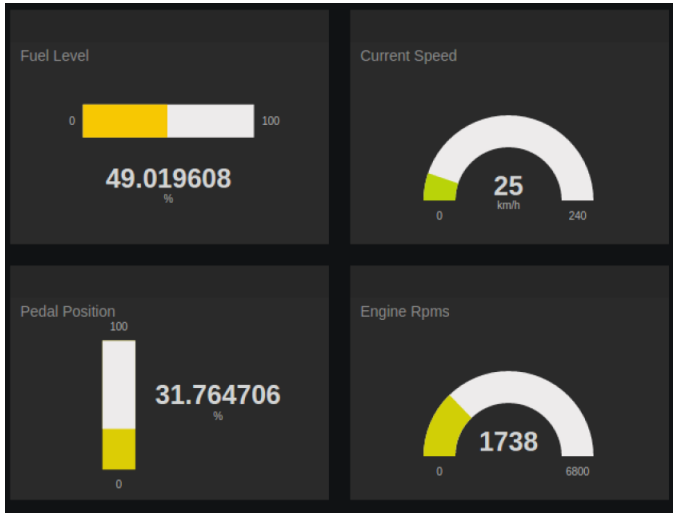
- 3D-Printed Prototype
- Voice-Control-Interface
  - Amazon Echo
- Actuator Control
  - Raspberry Pi
- Control Command Interpretation
  - AWS IoT

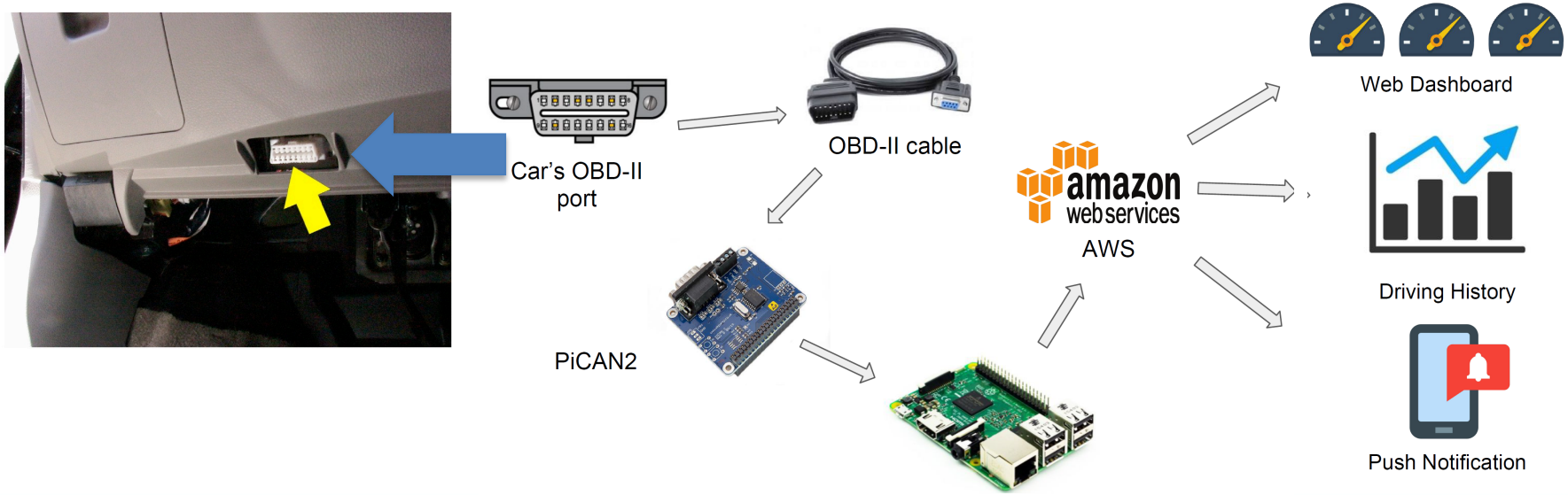




Car Informatics in the Cloud

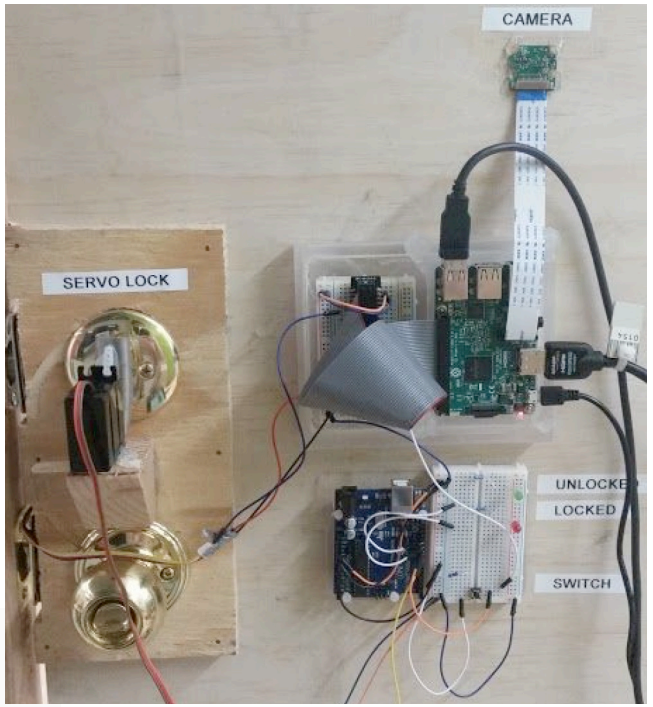
- Pull real-time OBD data from a car
- Upload to Cloud and display stats in real-time

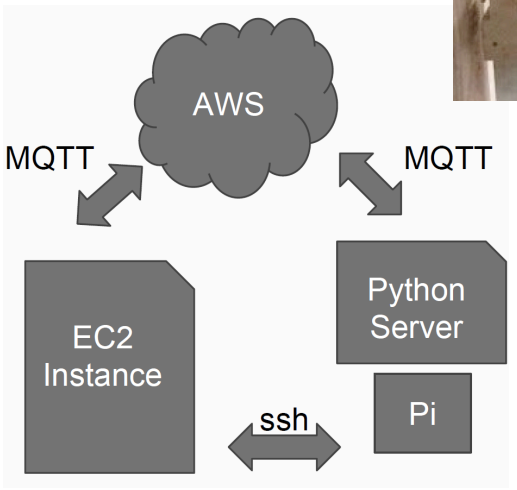




Smart Lock

- Remote doorway system
  - Live video
  - Arrival (motion) detection
- Web application
  - Node.JS server on an EC2 instance
  - Live video via ssh tunnel
  - Engage/disengage lock







Structural Health Monitoring



Next Class

- Computer Vision Tutorial (Ruiqi)