What is CS & IT Research?

CS & IT Research Seminar Flash Talks

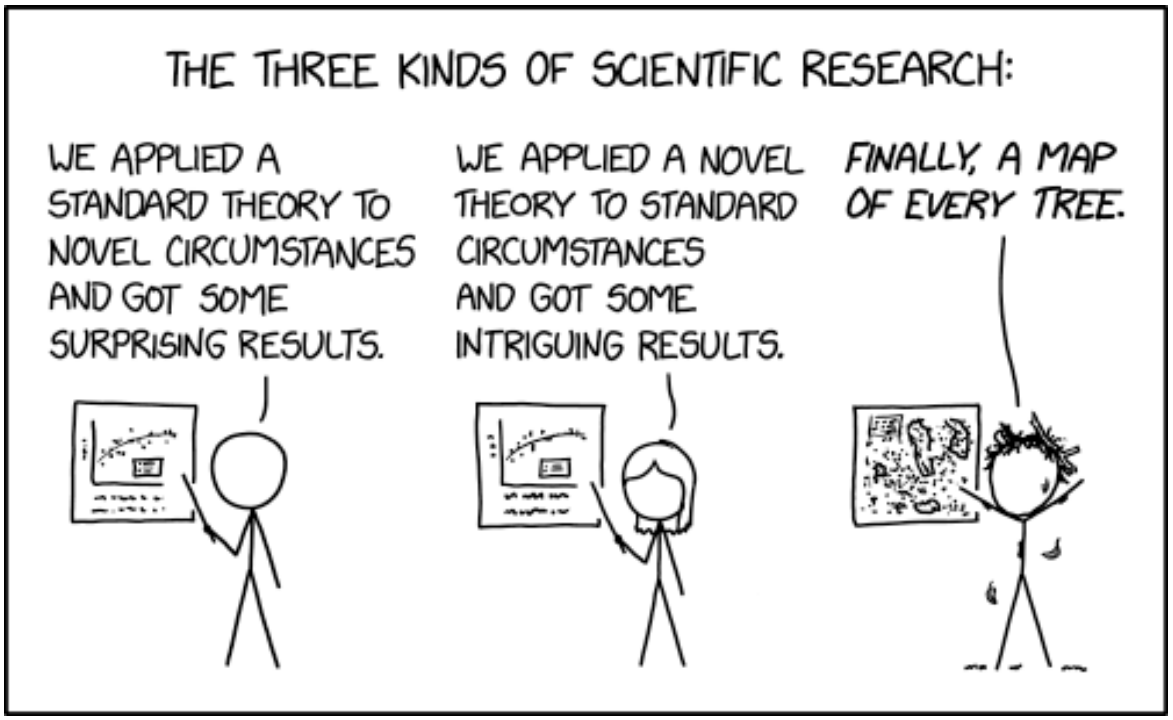
The Faculty of JMU CS September 19, 2025

Warm-up question

- In your own words, **what is research**?

Fall 2025

JMU CS



https://xkcd.com/2977/

"What is Research?"

Seminar Talk

Warm-up question

- In your own words, **what is research**?

(answers courtesy of a past CS 470 class)

What is research?

- *"Research is the process of finding information."*
- *"Looking for credible information pertaining to a specific topic."*
- *"Utilization of academic, peer-reviewed publications in order to better understand or solve a problem."*

What is research?

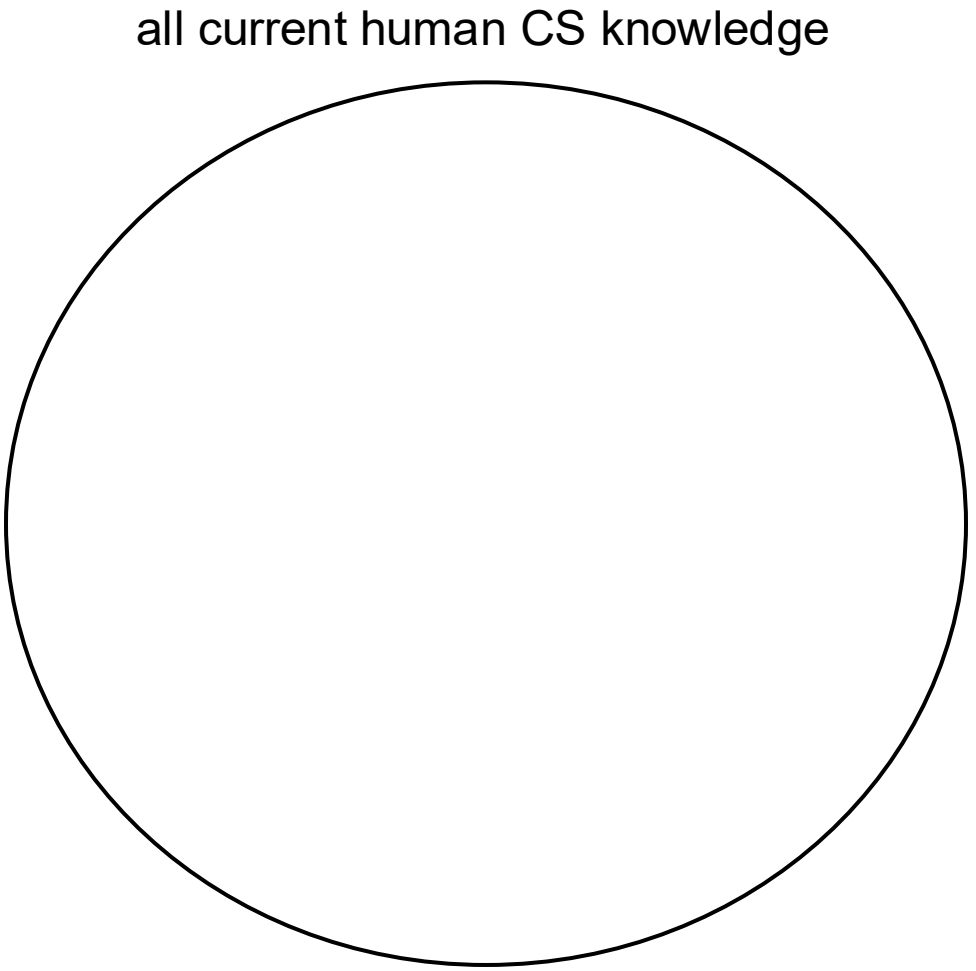
- *"Working at the edge of knowledge in a field attempting to push that frontier a little further with your work."*
- *"Thorough investigation into a subject, with the end result of finding new information."*

What is research?

- The former definition is secondary research
  - Wikipedia: "*summary or synthesis of existing research*"

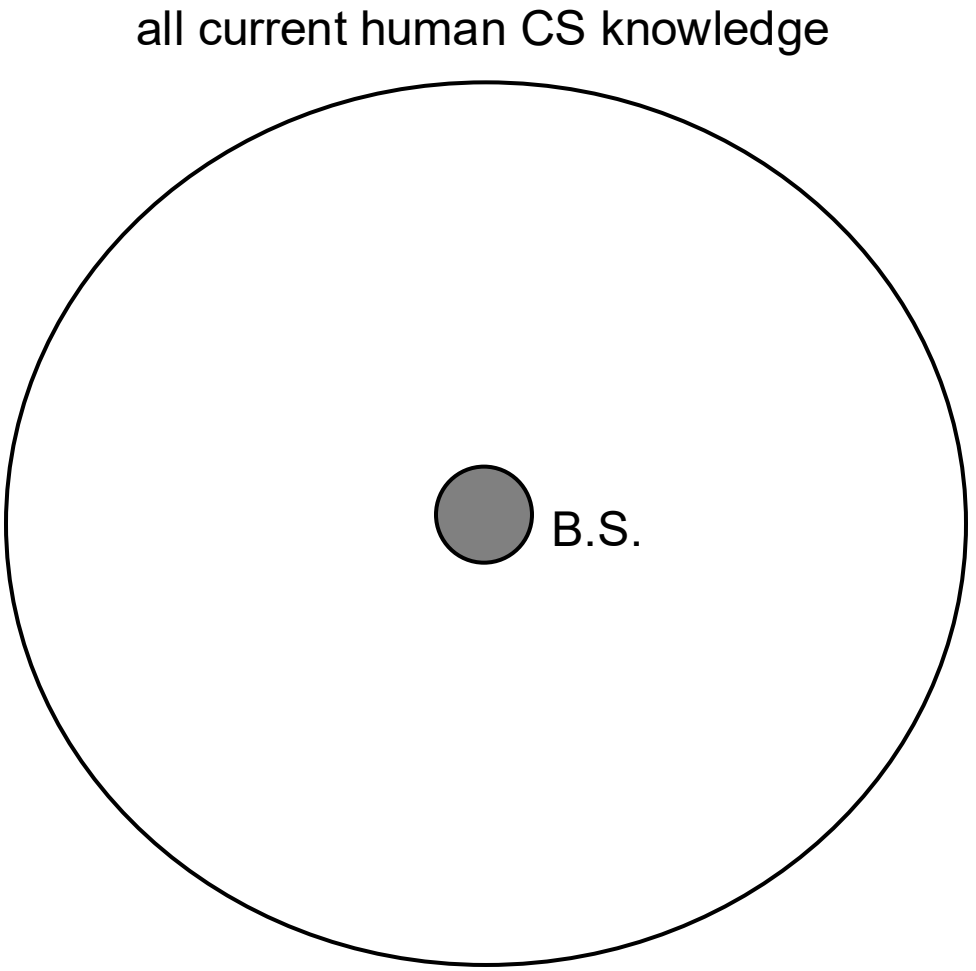
- The latter definition is primary research
  - OECD 2015: "*creative and systematic work undertaken to increase the stock of [human] knowledge*"
  - Goal: **novelty**!
  - Many subcategories:
    - Purpose: theoretical vs. applied
    - Target: formal vs. natural vs. social
    - Methodology: scientific vs. historical vs. artistic

Knowledge (visualized)



based on http://www.happyschools.com/bachelors-vs-masters-vs-phd/

Knowledge (visualized)



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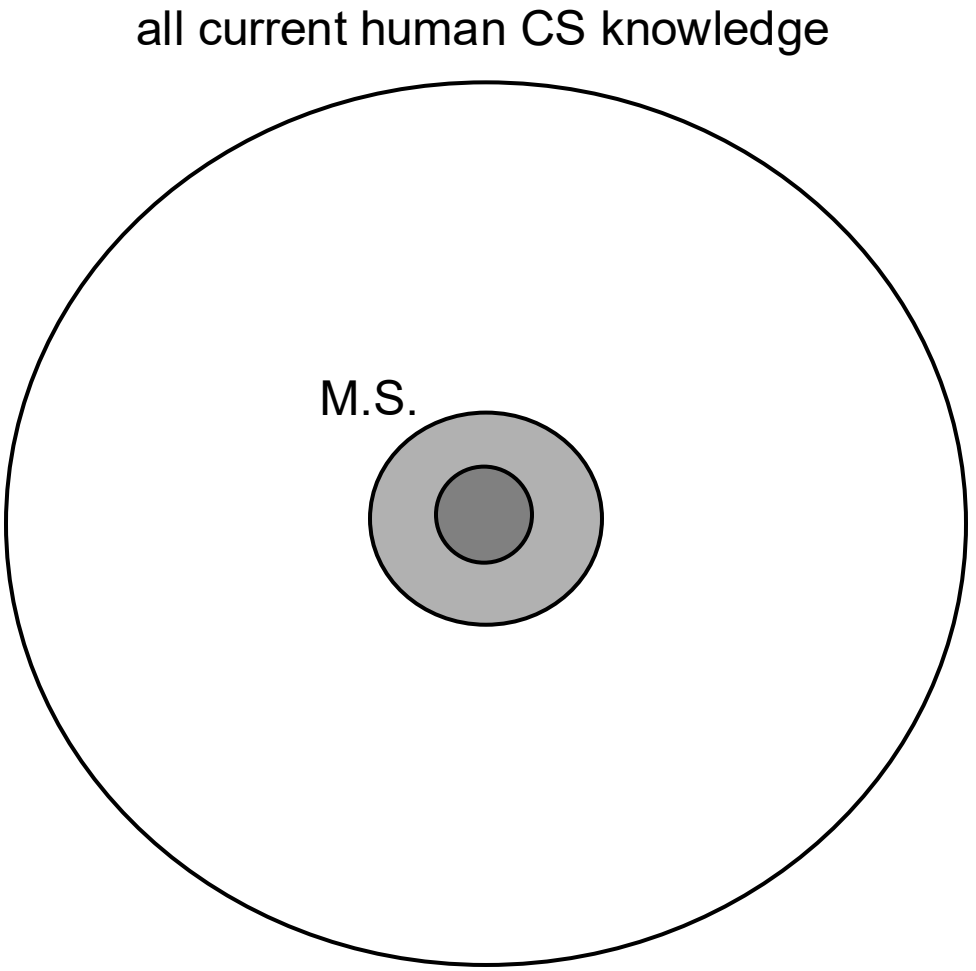

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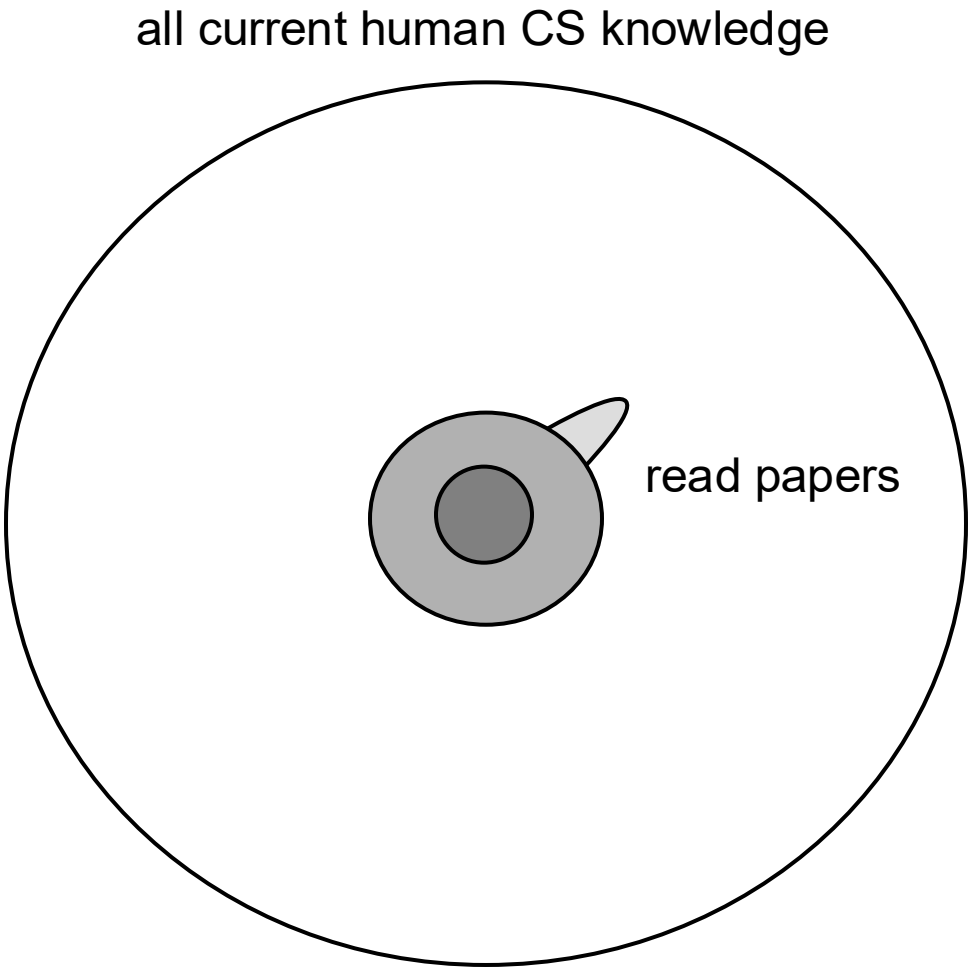

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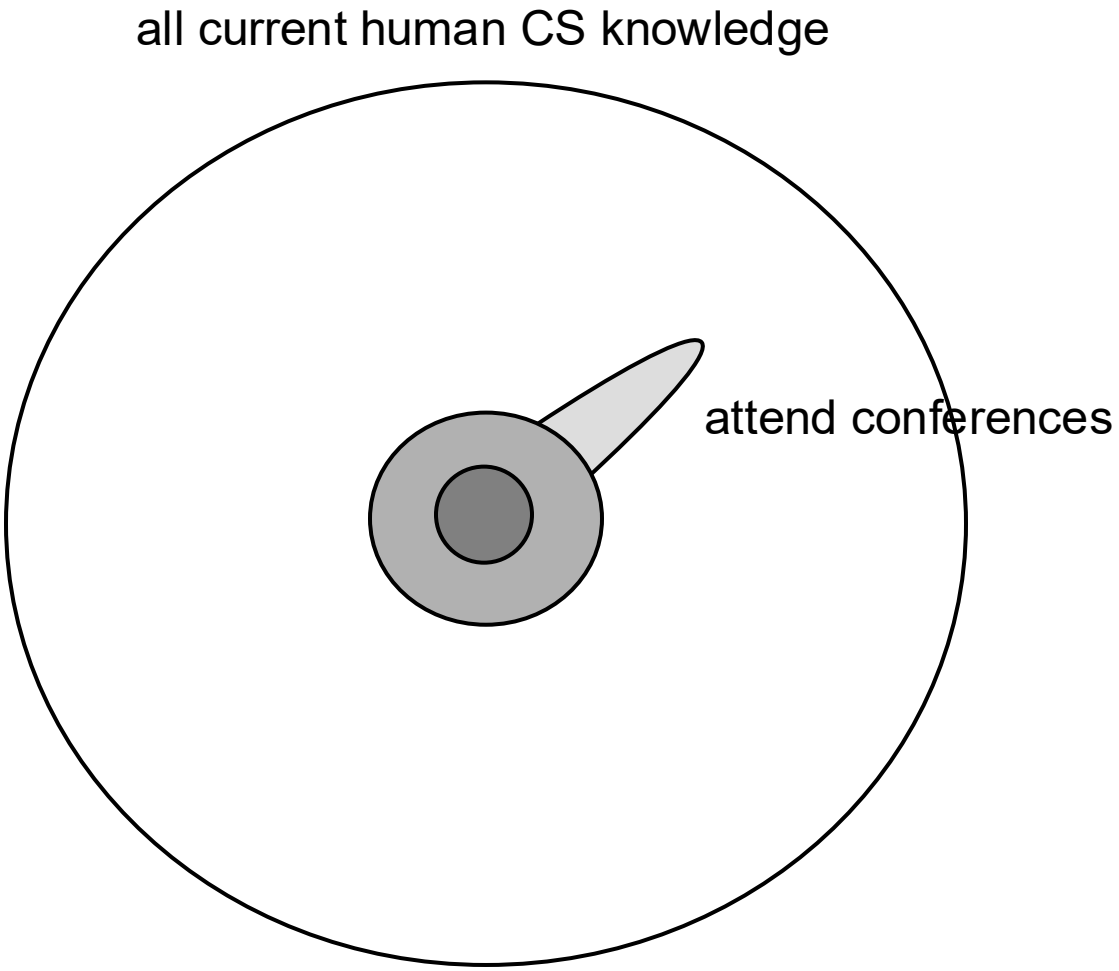

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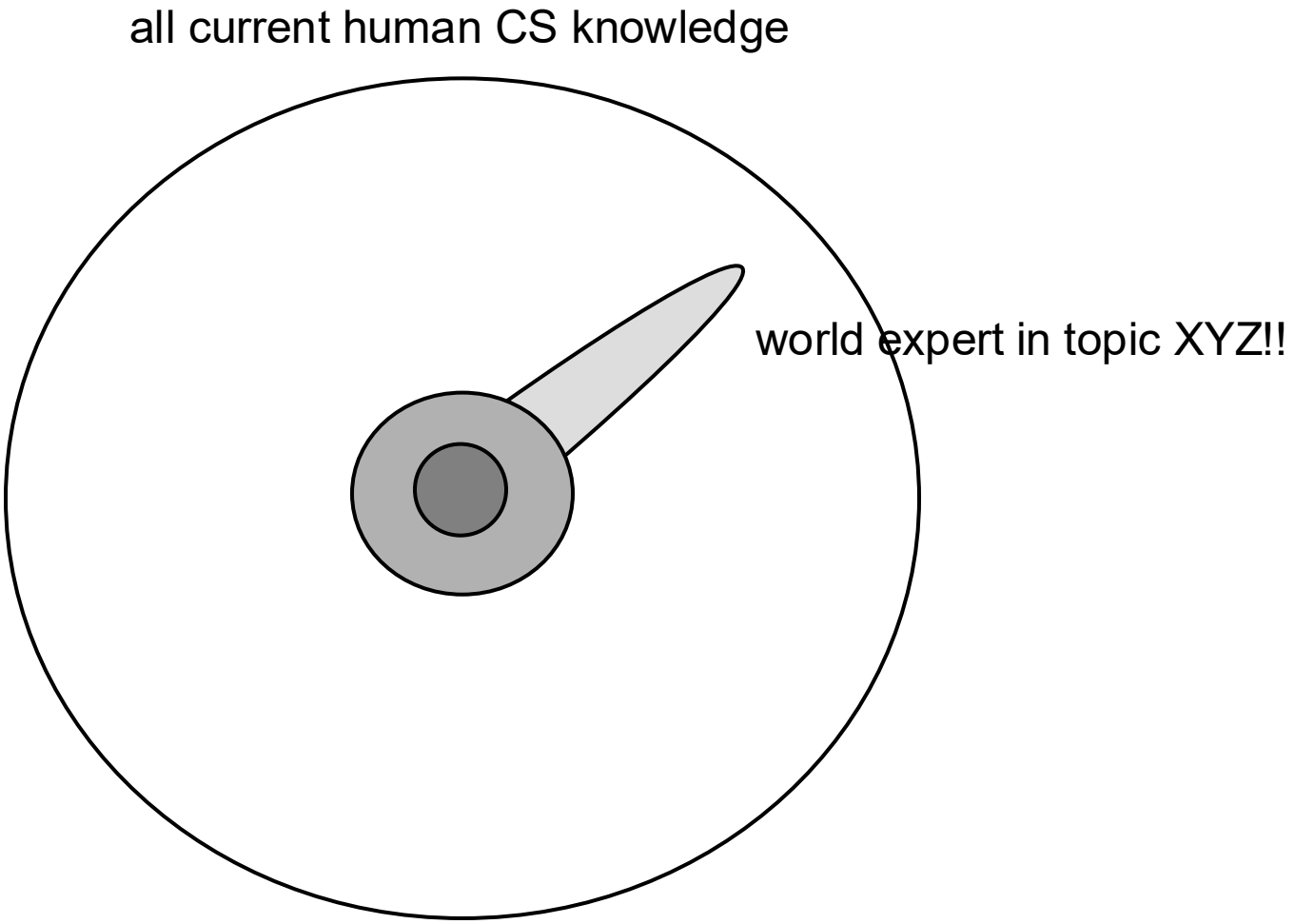

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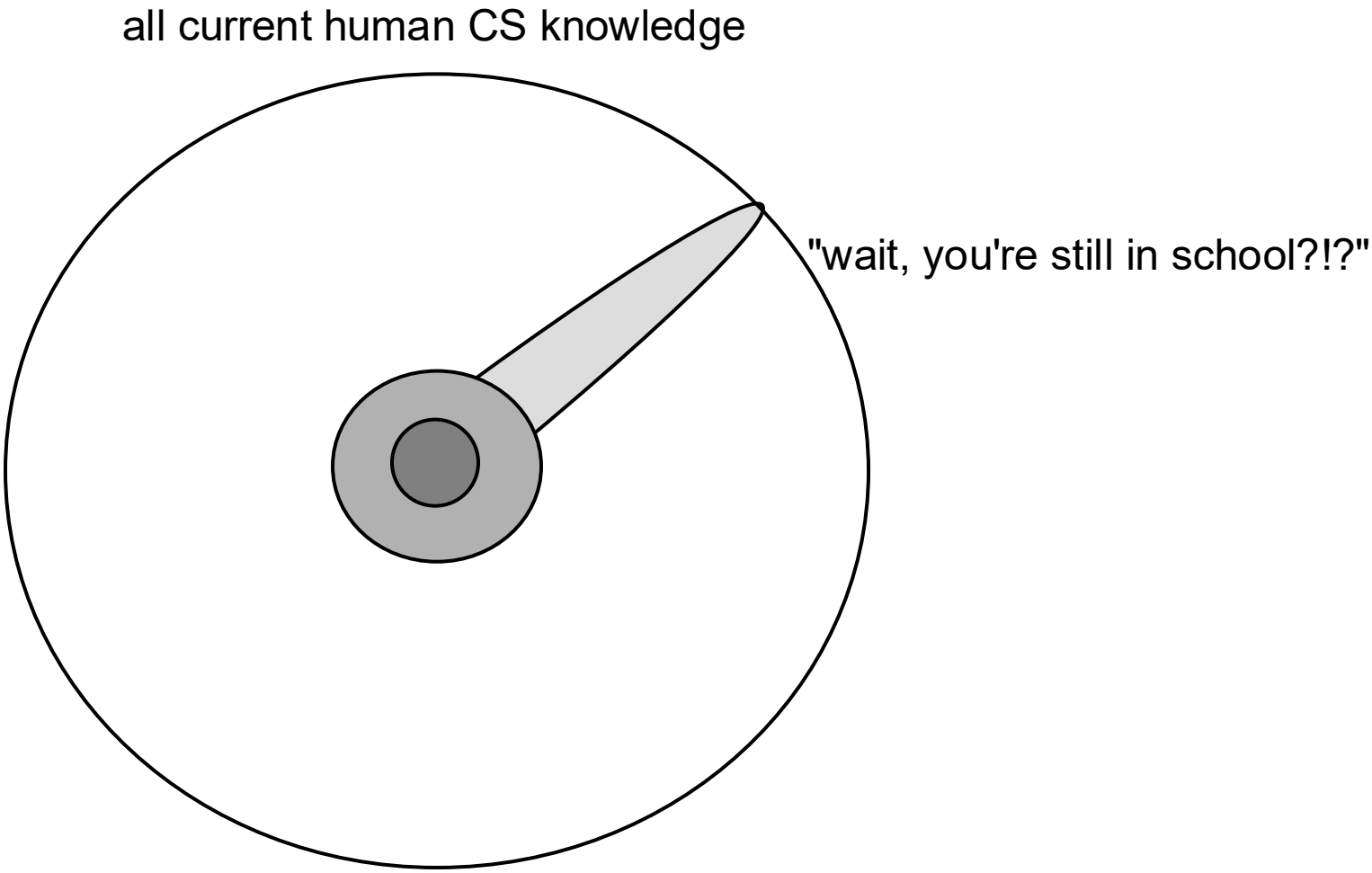

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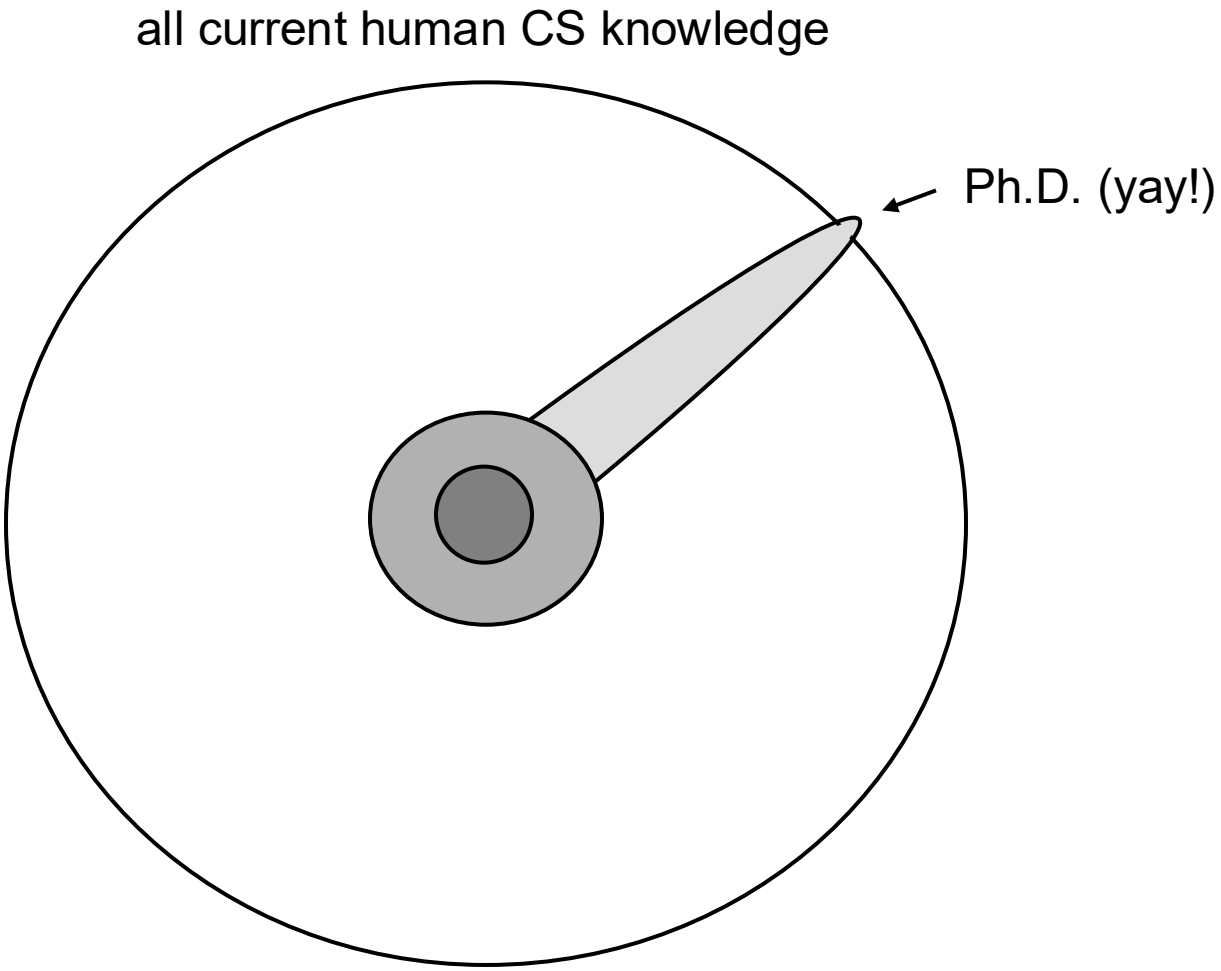

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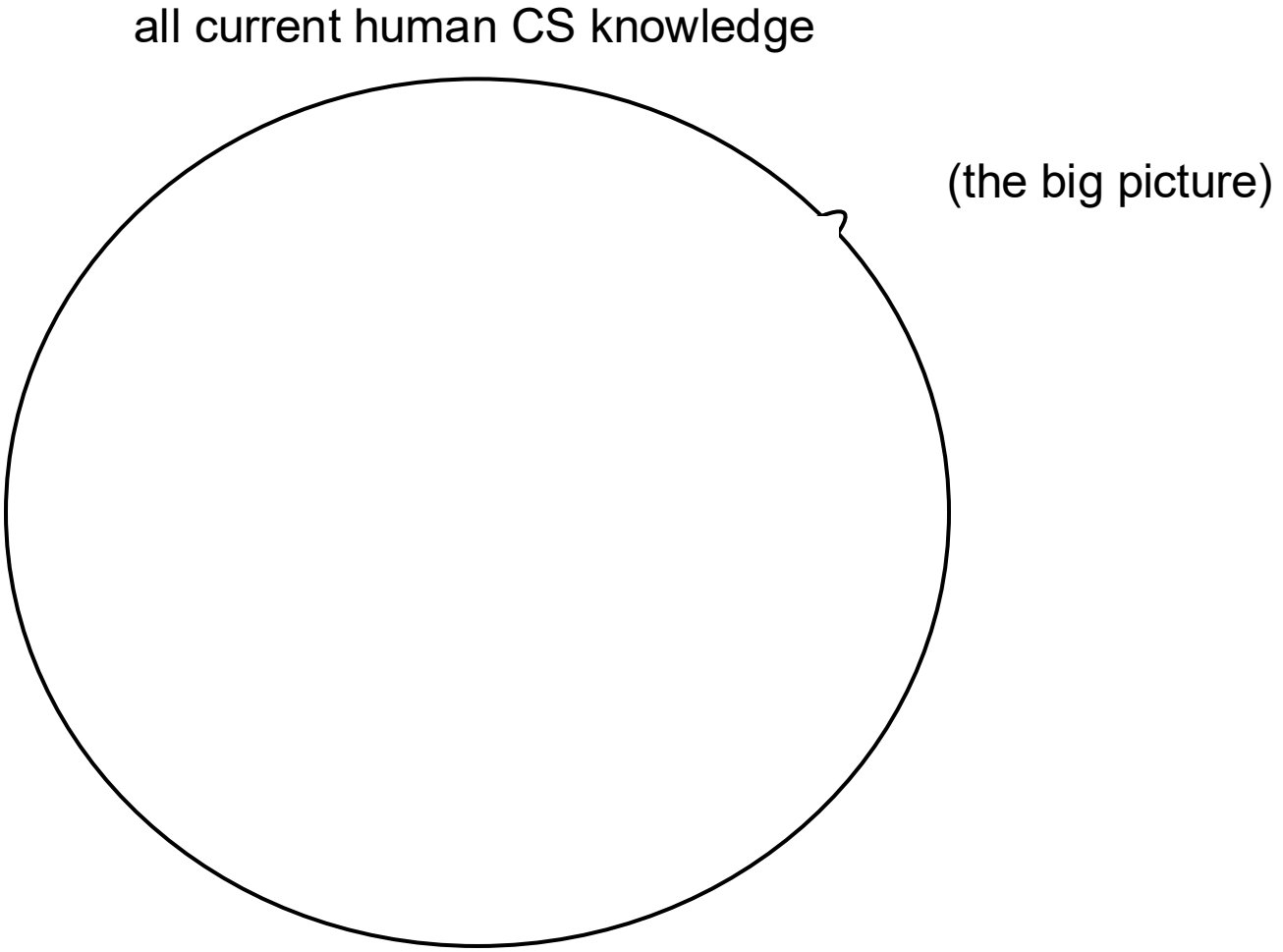

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Another perspective

- As faculty advisors ...
  - Undergrad projects: we have a reference solution
  - Graduate projects: we know a solution is possible
  - PhD projects: we **think** a solution might be possible

What is research?

- *"Research is the process of systematically casting a fishing rod into the unknown and hoping that you reel in something worthwhile.*
- *Sometimes you catch nothing, sometimes you get something worthwhile, and sometimes you get something that looks worthless until it's published by somebody else three years later.*
- *But regardless you slowly begin to learn about the world on the other end of that hook."*

If that is what, now how?

- My Advisor from UVA (Bill Wulf)
  - “We don’t really know how so we use the apprentice model.”

If that is what, now how?

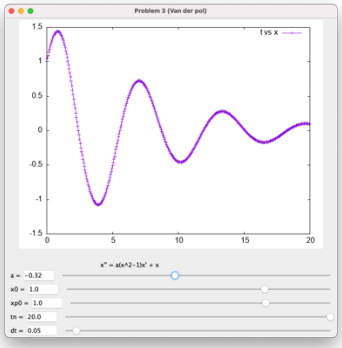
- My Advisor from UVA (Bill Wulf)
  - "We don't really know how so we use the apprentice model."
- More detailed references
  - How to pick an advisor
    - "Getting Started in Undergraduate Research"
  - How to read a paper
    - "How to Read an Engineering Research Paper"
  - What I wish I knew/organization
    - "Organizing your Research and Developing your Research Skills"
    - "Everything I Wanted to Know about CS Graduate School at the Beginning But Didn't Learn Until Later"

My research interests (Mike Lam)

- Program analysis (CS 430, 432)
- Systems-level software tools (CS 261)
- High-performance computing (CS 470)

ADAPT

Tool to rigorously quantify each input's effect on an output



FloatSmith

Tool to automatically transform a program to use *mixed* precision

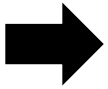
Jmodev

Visualization system for parameter changes in ODE solver
(Collaboration with colleagues in Math & Stats department)

Teaching Systems

Course design for CS 261 (project framework, labs, videos, etc.)

```
...
double a = A;
double x[N];
double y[N];
...
```



```
...
float a = A;
float x[N];
double y[N];
...
```

Dr. Shrestha
Dr. Molloy
Dr. Johnson
Dr. Mayfield
Dr. Stewart
Dr. Veiga
Dr. Belsare
Dr. McCoy
Dr. Sprague
Dr. Weikle
Dr. Lee
Dr. Duan
Dr. Bowers
Dr. Ayub

ThoughtSwap

Deeper-Meaningful
Conscientious Classroom Discourse

Draft - Depict - Depose

Anonymity*
Ephemerality
Swapping

- Exploratory Research
- Study Implementation/Data Collection
- Application Development
- Data Analysis
    - Mixed Method

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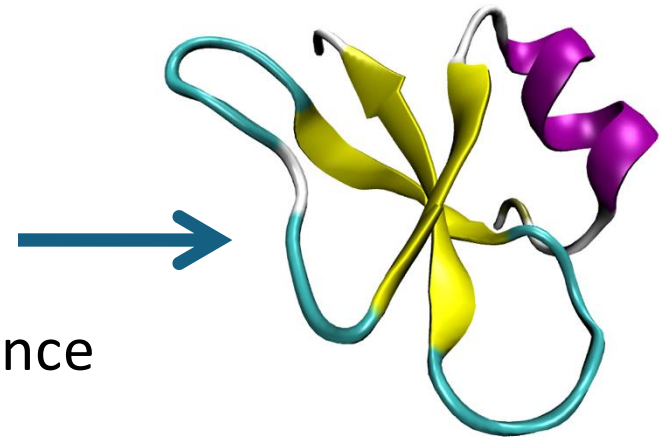
Protein Structure Prediction

Amino Acid Sequence

GIGDPVTCLKSGAICHPVFCPRRYKQIGTCGLPGTKCCKKP



3-D Structure
(Tertiary Structure)
1GB1 rendered with VMD

Less than 1 day to find the sequence

Approximately 6 months to get the structure

Changes to the structure can:

- Cause loss of immunity to viruses
- Cancers
- Other diseases

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Amino Acid Sequence

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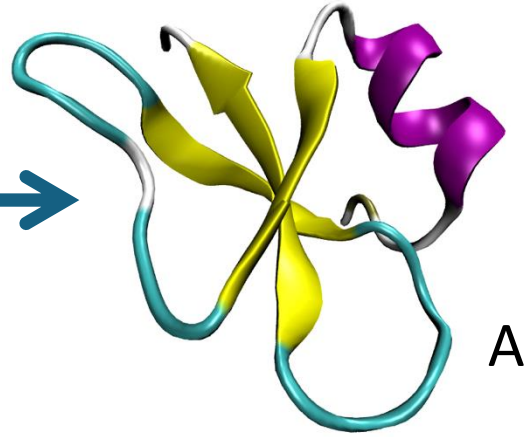

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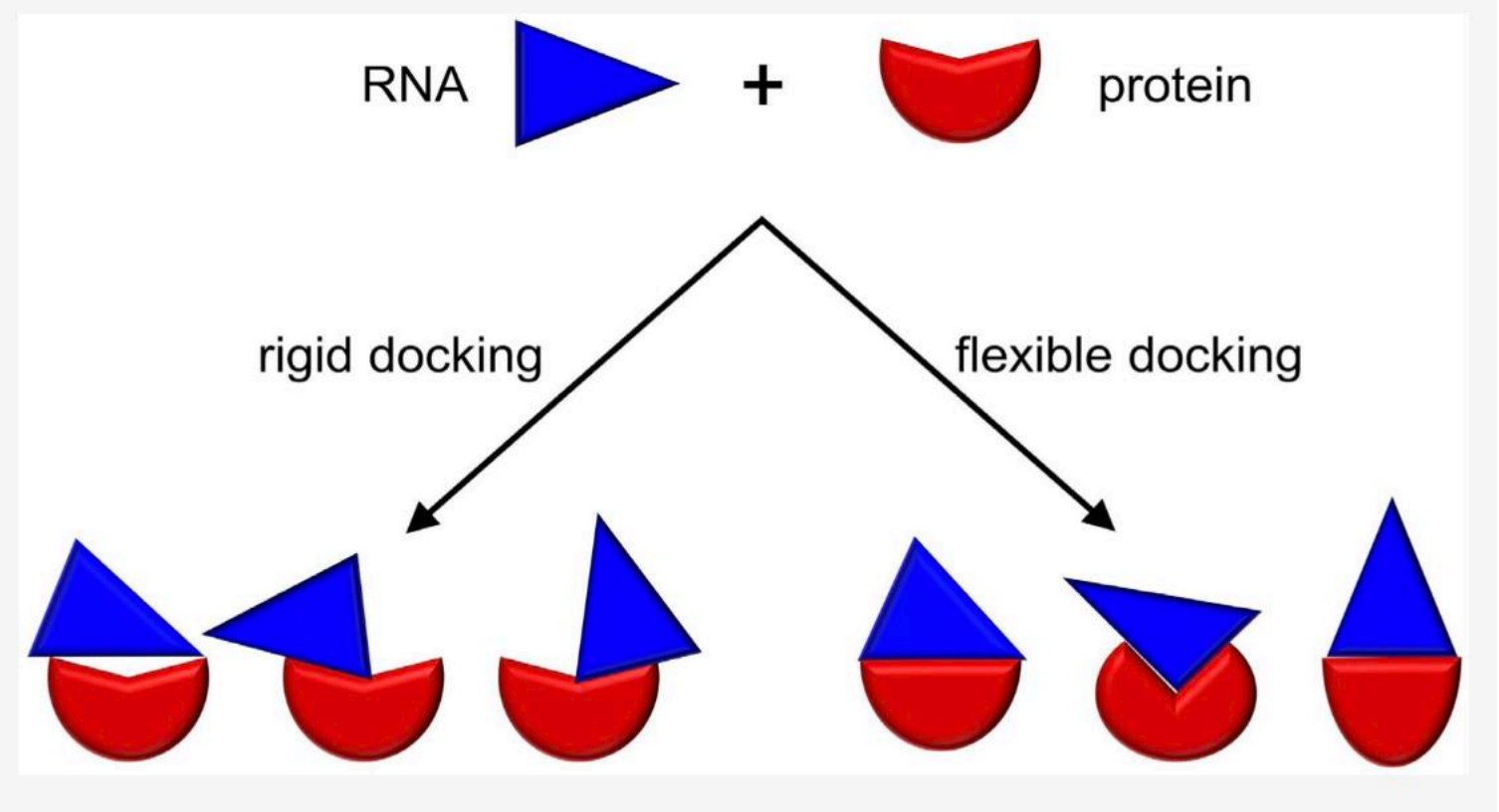
RNA Flexibility



Question: What changes to the sequence cause *relevant* changes in the structure or changes its flexibility?

Figure from Nithin, C.; Ghosh, P.; Bujnicki, J.M. Bioinformatics Tools and Benchmarks for Computational Docking and 3D Structure Prediction of RNA-Protein Complexes. *Genes* **2018**, *9*, 432.

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Dr. Chris Johnson (johns8cr)

StepWise

- a stepwise debugger that needs user to do all the work
- Honors project with Rafael Dietsch
- TypeScript and WebGL

Twoville

- language for making fabricable designs
- needs makers and lesson designers
- outreach opportunities

Dear Computer

- interactive CS 430 textbook
- needs data analysis
- lightly funded
- prerequisites: CS 430

Draftboard

- weaving designer: from photo to personal textile
- collaboration with Drs. Rebecca Field and Laura Taalman

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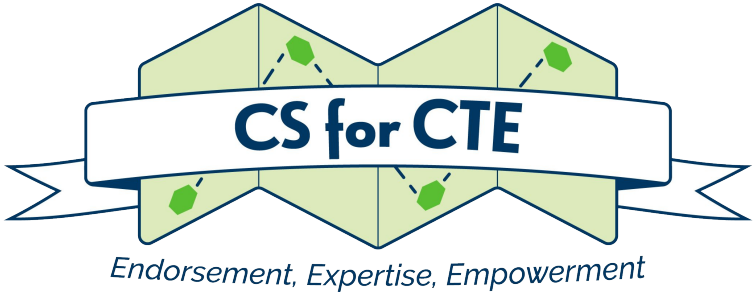
Praxly: An Online IDE for the Praxis CS Test Pseudocode

Chris Mayfield, Chris Johnson,
Ellona Macmillan, Meghan Riordan, Linnea Hellner

This material is based upon work supported by the National Science Foundation under Grant No. 2219770. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

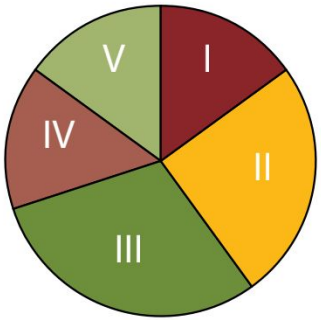


- Design personalized professional development
- that is effective in training high school teachers
- from a variety of education and CS backgrounds
- to teach higher-level CS courses.

Also…pass the CS Praxis Test (for endorsement)

Test at a Glance

Test Name	Computer Science
Test Code	5652
Time	3 hours
Number of Questions	100
Format	The test consists of a variety of selected-response questions, where you select one or more answer choices; questions where you enter your answer in a text box; and other types of questions. You can review the possible question types in chapter 2.
Test Delivery	Computer delivered



Content Categories	Approximate Number of Questions	Approximate Percentage of Examination
I. Impacts of Computing	15	15%
II. Algorithms and Computational Thinking	25	25%
III. Programming	30	30%
IV. Data	15	15%
V. Computing Systems and Networks	15	15%

The Problem

- ETS Praxis exam uses its own, unique pseudocode
- Teachers must read and interpret the pseudocode, often without prior coding experience

```
void mystery ( int n )
    while ( n ≠ 1 )
        if ( ( n % 2 ) == 1 )
            n ← 3 * n + 1
        else
            n ← n / 2
        end if
        print ( n )     // print a space after the number
    end while
end mystery
```

Code Tracing Practice

Praxly

> **Prompt:** What does the program below do? Try to read the code and/or trace it and try to predict the results.
> When you are ready to read the answer, run the program to see what it does.

```
1  print "How old are you?"
2
3  String age ← input()
4  int ageInt ← int(age)
5
6  print "You are approximately " + age * 365.25 + "
7
```

Run | Reset | Open

```
How old are you?
5
runtime error occurred on line 6:
bad operand types for MULTIPLICATION,
left: String, right: double
```

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A Liberal Arts Exploration of Participation

Research projects featuring undergraduate students working to responsibly wield their powers for Great Good

Dr. Michael C. Stewart, Fall 2025
https://hcientist.com

About Dr. Stewart

Human

- from Charlotte, NC
- puedo hablar un poquito de español
- je parle une petit peu de français
- 2.5 siblings
- 1st gen college student
- 2nd gen immigrant to USA
- have an invisible disability
- 2.9 undergrad GPA
- partner + 2 children
- likes to cook, eat, travel, hike, play games (board, video), build technologies, teach students!, and conduct research in **Human** Computer Interaction

Computer

Industry

- **IBM** ’07, ’10
- **Red Hat** ’07-’09
- **Xerox Research Centre Europe** ’13
- **Amazon** ’20-’21

Academia

UNC

- BS in CS ’07
- Other foci: Math, Women’s Studies

Virginia Tech

- MS in CS ’13
- PhD in CS ’18

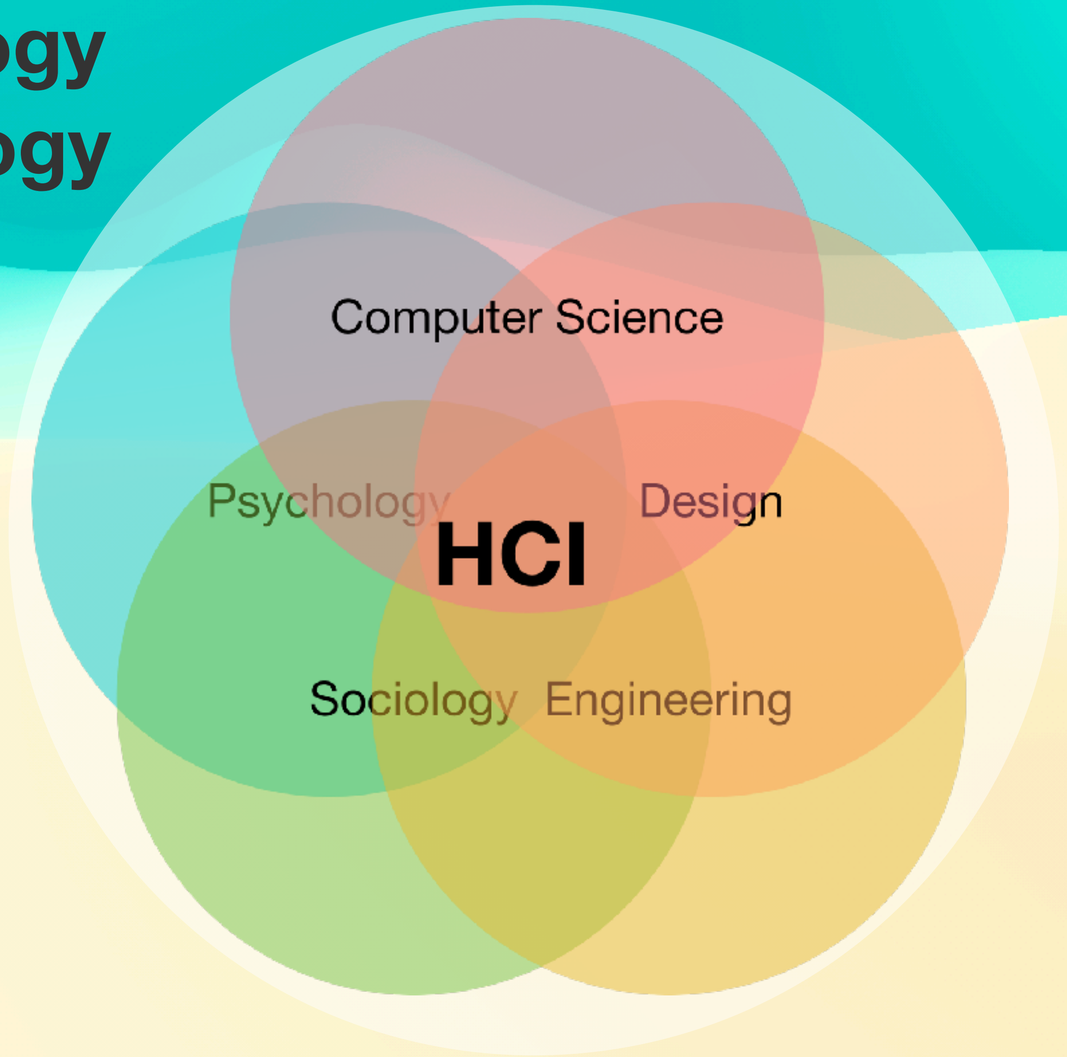
JMU

- teach: 159, 159, 343, 347, 447

Human-Computer Interaction

Interdisciplinary research area centered around the way people use technology (or don't) and the effects of technology use on people.

1. **Gather qualitative and quantitative data about people and systems** (evaluate)
2. Produce Implications for Design
3. Design
1. Evaluate (**Gather qualitative and quantitative data about people and systems**)



musicpr.org

MusicCPR

About Login

Welcome to Music CPR

MusicCPR is a free platform that facilitates music teachers' collection of individual student achievement data that aligns with ensemble repertoire and artistic processes (create, perform, respond, connect) described in National Standards for Arts Education.

Students

- Free
- Web App
- Connect with the repertoire
- Perform Activities for pieces assigned by your teacher
- Compose countermelodies
- Reflect on your experiences

Teachers

- Free
- Standards-aligned
- Web-based
- Assign activities
- Grade students' work
  - give individual performance feedback
  - export for use in other tools

Standards-Based Music Education

Teachers who provide their students with a standards-based music education facilitate opportunities for every student to develop skill and knowledge related to creating original music, performing their own and others' music, responding to music, and connecting in, around, and through music. While MusicCPR is framed through these four artistic processes as conceptualized in National Standards for Arts Education, most states have comparable policy documents that outline what should be part of students' P-12 music education experiences. MusicCPR is intended to bridge the gap between these policies and common practice by providing a free, research-based resource for any music teacher who wishes to provide their students opportunities to create, perform, respond, and connect through activities grounded in large ensemble repertoire.

musicpr.org

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Arts Education.

My primary research project right now is centered around a special purpose learning management system for band and orchestra classes…

Students

- Free
- Web App
- Connect with the repertoire
- Perform Activities for pieces assigned by your teacher
- Compose countermelodies
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standards-based music education facilitate opportunities for every student to develop skill and knowledge related to creating original music, performing their own and others' music, responding to music, and connecting in, around, and through music. While MusicCPR is framed through these four artistic processes as conceptualized in National Standards for Arts Education, most states have comparable policy documents that outline what should be part of students' P-12 music education experiences. MusicCPR is intended to bridge the gap between these policies and common practice by providing a free, research-based resource for any music teacher who wishes to provide their students opportunities to create, perform, respond, and connect through activities grounded in large ensemble repertoire.

but for whom tho?

Accessibility

ac·ces·si·bil·i·ty | əkˌsesəˈbilədē |

noun

1 the quality of being able to be reached or entered: *the restoration project involved repairing the roof and improving accessibility.*
- the quality of being easy to obtain or use: *students were concerned about the accessibility of quality academic counseling.*

2 the quality of being easily reached, entered, or used by people who have a disability: *many architects believe that accommodating wheelchairs is all there is to providing accessibility.*

3 the quality of being easily understood or appreciated: *the accessibility of his work helped to popularize modern art.*

Accessibility

sometimes abbreviated
“a11y”

```
accessibility
 ccessibilit
```

```
a      11     y
```

ac·ces·si·bil·i·ty

able to be reached or entered:

easy to obtain or use:

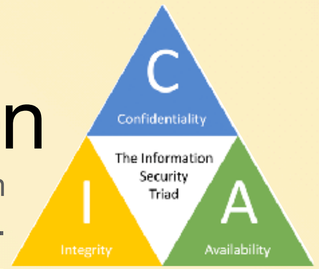
by people who have a disability

easily understood or appreciated:

Accessibility

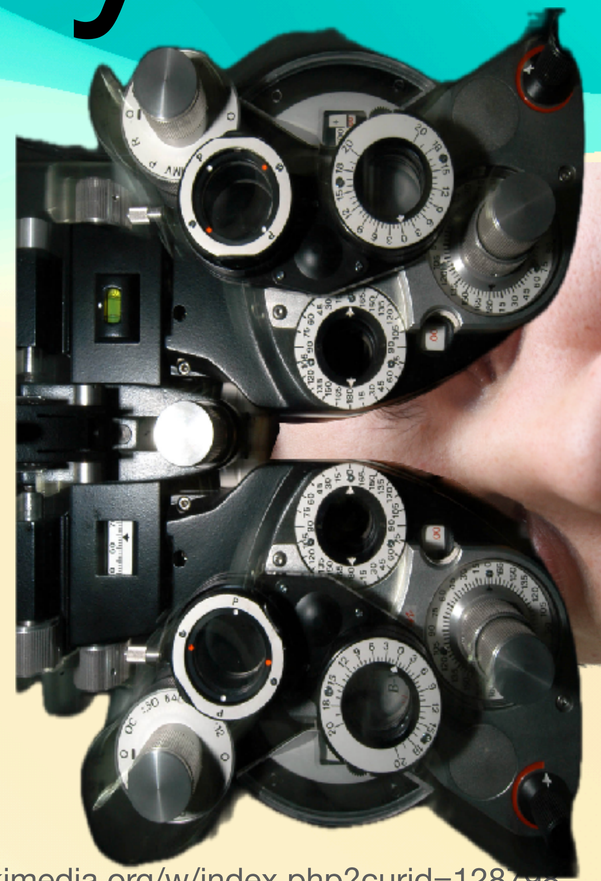
1. has it been designed such that people with disabilities find it easy to use?
2. has it been designed such that people from different backgrounds and cultures can easily understand or appreciate it?
3. has it been designed such that people who speak different languages can easily understand or appreciate it?
4. has it been designed such that people with different levels of education and vocabulary can easily understand or appreciate it?
5. available and usable by authorized parties when required?

Nikander, Jussi & Manninen, Onni & Laajalahti, Mikko. (2020). Requirements for cybersecurity in agricultural communication networks. Computers and Electronics in Agriculture. 179. 105776. 10.1016/j.compag.2020.105776.



Accessibility

1. disability
2. cultural relativity
3. language
4. complexity
5. available



Accessibility

1.disability ❌

Many students who play adaptive instruments would be unable to submit their performance as required in MusicCPR

4.complexity

5.available

Accessibility

1. disability ✕

2. cultural relativity ✕

Learning “western classical” music is legitimized (what do the students listen to outside of class with friends and families?)

3. available

Accessibility

1 disability

MusicCPR is in english only

2.cultural relativi

3.language

4

5

This is Michael Richards' mindset when he thinks about Harrisonburg City Public Schools, one of the most diverse school divisions in the state, where more than 75 languages are represented.

https://www.dnronline.com/news/harrisonburg/officials-say-diversity-of-language-provides-opportunities-challenges/article_9da9e2c7-dafa-5eb2-b6cb-35d17864c7d1.html

Daily News-Record

LINGUAL LABYRINTH

Officials Say Diversity Of Language Provides Opportunities, Challenges

By MEGAN WILLIAMS Daily News-Record
Nov 1, 2019 Updated Mar 11, 2024 2

1 of 4

Laura Nelson, a Harrisonburg High School teacher, works with her students on an activity in her English language learners class on Oct. 22. Students returned from winter break on Monday.

Diversity is a strength for a school division. It allows for more flexible creative thinking, which is how students succeed whether in the workforce or higher education.

This is Michael Richards' mindset when he thinks about Harrisonburg City Public Schools, one of the most diverse school divisions in the state, where more than 75 languages are represented.

"It's important to develop that flexible, creative and critical thinking, and we do it in a natural environment," the division's superintendent said.

Accessibility

Loading the local (almost no records in database) admin page once required ~2900🤦 database queries

3.language

4.complexity

5.available

Accessibility

1.disability

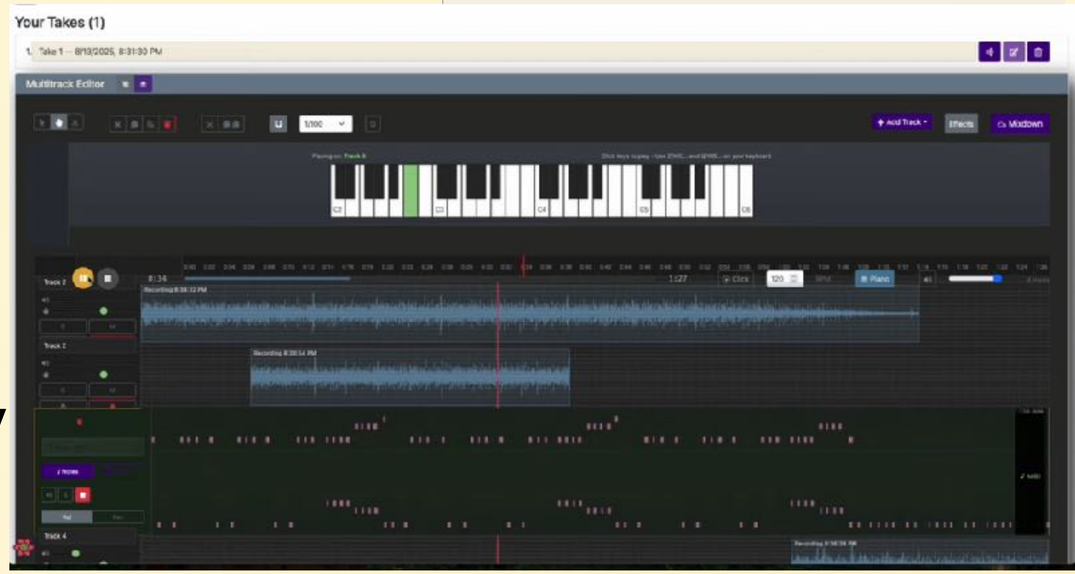
2.cultural relativi

Joshua

Matt

Shree

5.availability



My interests

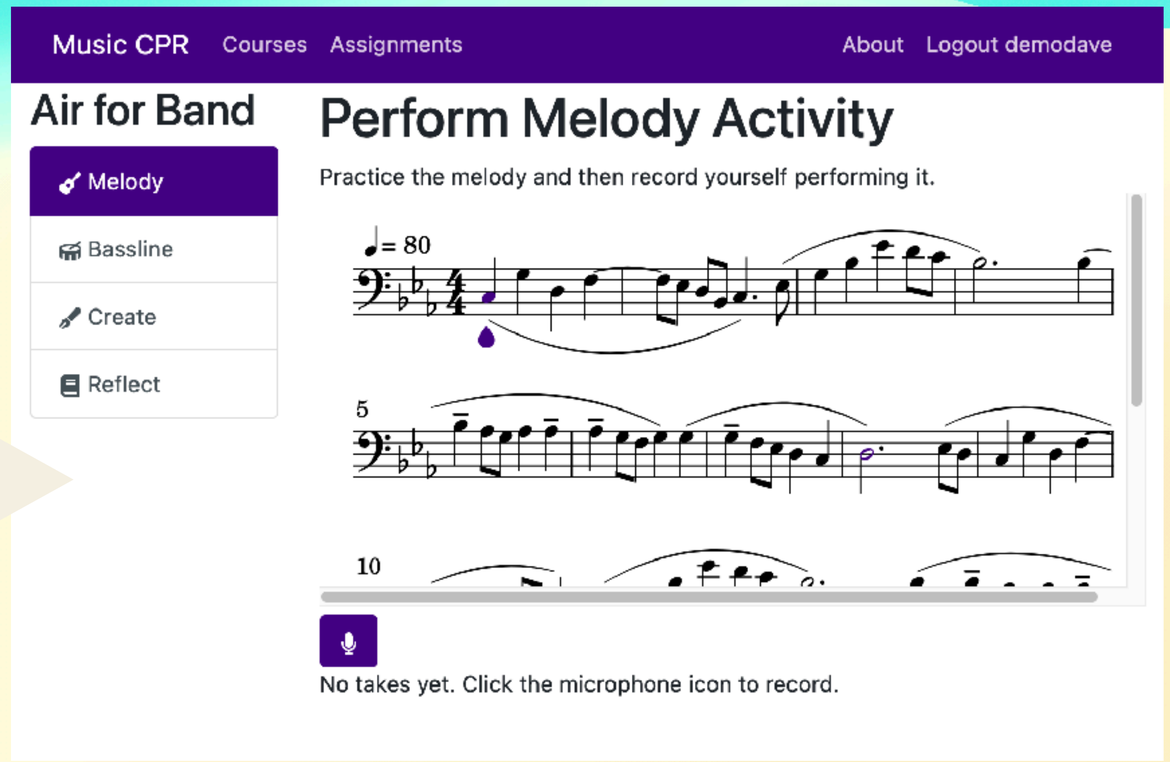
Generally

- Power
- Togetherness
- Education
  - CS
  - Computational Thinking
  - EdTech

https://musiccpr.org/about

Currently: MusicCPR

- effecting change to practice, canon, & tradition through tech
- (tech) design for belonging, community



Accessibility

1. disability
2. cultural rela y
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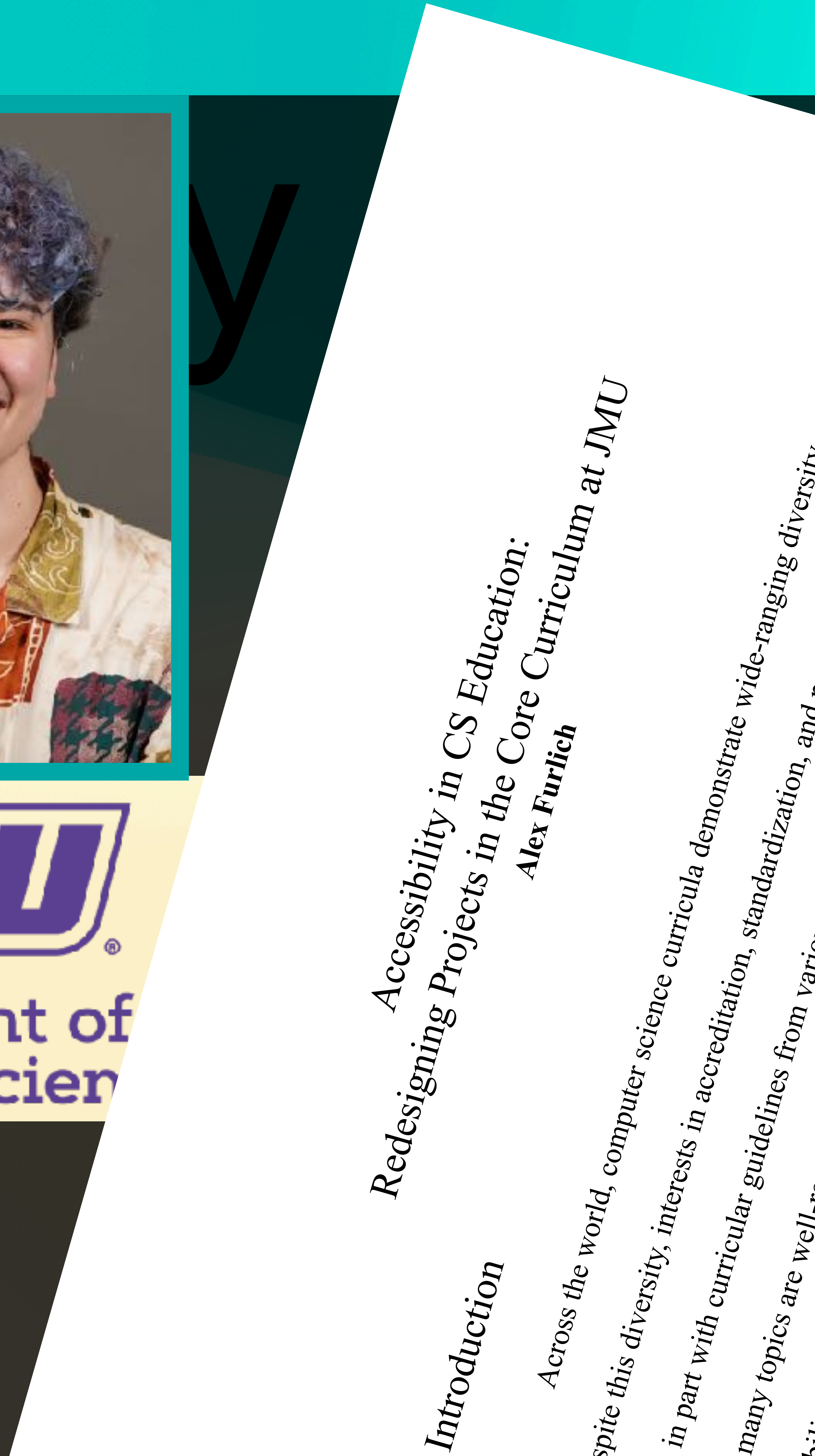
4. complexity
5. available

Alex

JMU
Department of
Computer Scien


Accessibility in CS Education:
Redesigning Projects in the Core Curriculum at JMU
Alex Furlich

Introduction

Across the world, computer science curricula demonstrate wide-ranging diversity
spite this diversity, interests in accreditation, standardization, and
in part with curricular guidelines from vari
many topics are well

Department of Computer Science

College of Integrated Science and Engineering

EASTMAN SCHOOL OF MUSIC
UNIVERSITY of ROCHESTER

FREDONIA
STATE UNIVERSITY OF NEW YORK

NATIONAL ENDOWMENT for the ARTS
arts.gov

Investigators

- Lisa R. Caravan, DMA (Assistant Professor, Department of Music Teaching and Learning, Eastman School of Music, University of Rochester)
- Alden H. Snell, II, Ph.D. (Associate Professor, Department of Music Teaching and Learning, Eastman School of Music, University of Rochester)
- Michael C. Stewart, Ph.D. (Assistant Professor of Computer Science, James Madison University)
- David A. Stringham, Ph.D. (Professor of Music; Executive Director, Office of Creative Propulsion, James Madison University)

Collaborators

- Abdullah Mohammed Ali (Undergraduate Student, James Madison University)
- Jerome Donfack (Undergraduate Student, James Madison University)
- Alex Dumouchelle (Undergraduate Student, James Madison University)
- Zoey Fox (Consultant)
- Jonah Giblin (Undergraduate Student, James Madison University)
- Benjamin Guerrero, MM (Preparing Future Faculty Fellow, James Madison University; Ph.D. Candidate, University of Rochester)
- Luke Hennessy (Undergraduate, James Madison University)
- Matt Wolffe(Undergraduate, James Madison University)
- Thomas Hassett (Undergraduate Student Alumnus, School of Music; Innovation Leader, Center for Inclusive Music Engagement; James Madison University)
- Chris Hopkins (Undergraduate Student, James Madison University)
- William Jedrzejczak (Undergraduate Student, James Madison University)
- Heidi Lucas, DMA (Visiting Assistant Professor of Brass and Music Education, University of Delaware)
- Brandon McKean (Systems Administrator, Department of Computer Science, James Madison University)
- Pete Morris (Systems Administrator, Department of Computer Science, James Madison University)
- Zamua Nasrawt (Consulting Musician and Web Developer)
- Liem Nguyen (Undergraduate Student, James Madison University)
- Meara Patterson (Undergraduate Student, James Madison University)
- Phil Riley (Lecturer in Computer Science, James Madison University)
- Khadijat Oluwasanmi (Undergraduate Student, James Madison University)
- Isaiah Ortiz (Undergraduate Student, James Madison University)
- Eliza Samuels (Undergraduate Student, James Madison University)
- Nathan Self (Consulting Musician and Web Developer)
- Paweł W. Woźniak, Ph.D. (Associate Professor, Interaction Design and Software Engineering division, Department of Computer Science and Engineering, Chalmers University)
- Lauren Yu (Web Developer)
- Joshua Hairston (Undergraduate Student, James Madison University)

We want YOU!

to feel invited to participate in research

- FYRE - first years 💰
- NSF REU - summer 💰
- Honor's Thesis (CS 499)
  - 6 credits of upper level CS credit
  - last 3 semesters: 1, 3, then 2 credits
- independent study? (CS 497)

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Dr. Duan
Dr. Bowers
Dr. Ayub

Supporting Decision-Making and Education with AI, Provenance and Interactive Visualization

Carolina Veiga
Postdoctoral Fellow

PhD
Computing

Master
Biosystems Engineering

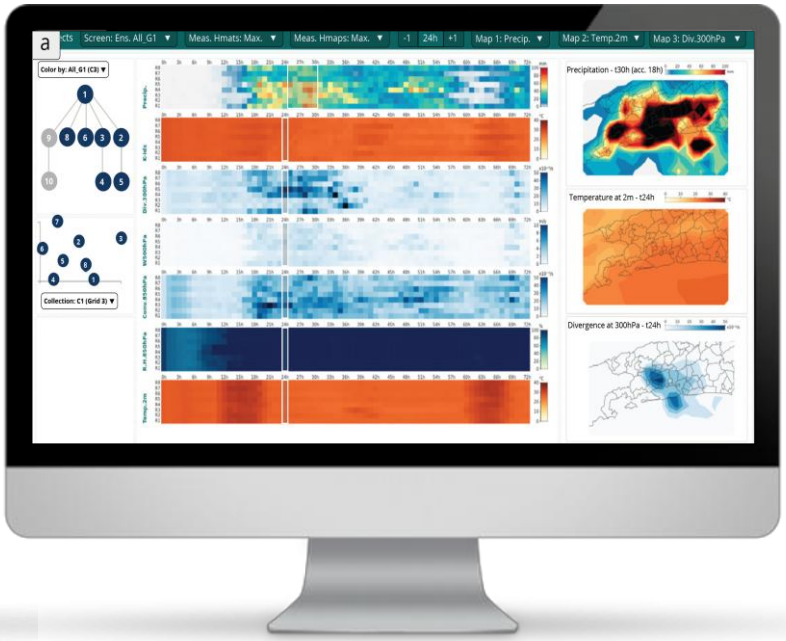
Undergraduate
Environmental Engineering

How to support weather experts **analyze** forecast data to identify extreme weather risks and make informed decisions?

X-Weather
Souza et al. 2022 C & G

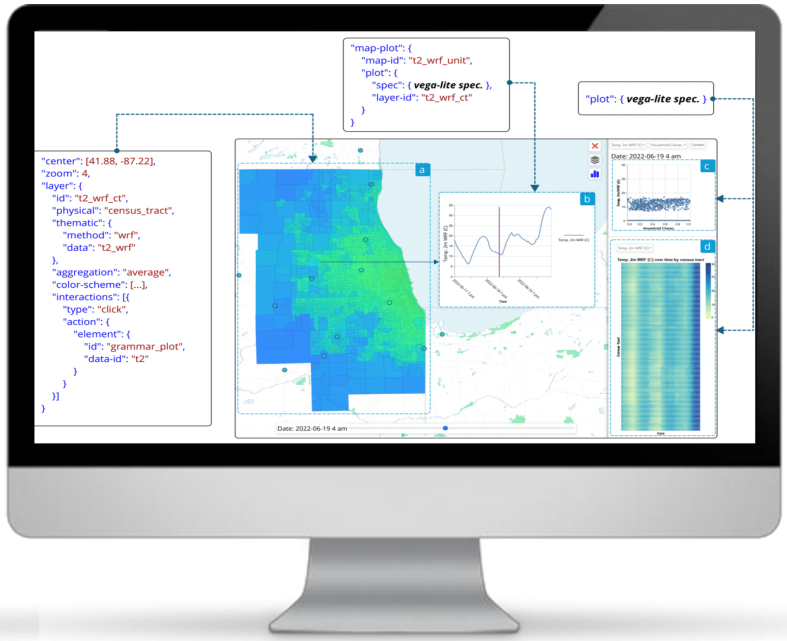
How to support weather experts **generate** and **analyze** forecast data to identify potential risks of extreme weather events and make informed decisions?

ProWis
Souza et al. 2024 TVCG



How to support **diverse stakeholders analyze** weather forecasts, satellite, and station data in correlation with sociodemographic information to make informed decision and advance EJ?

e-JUST

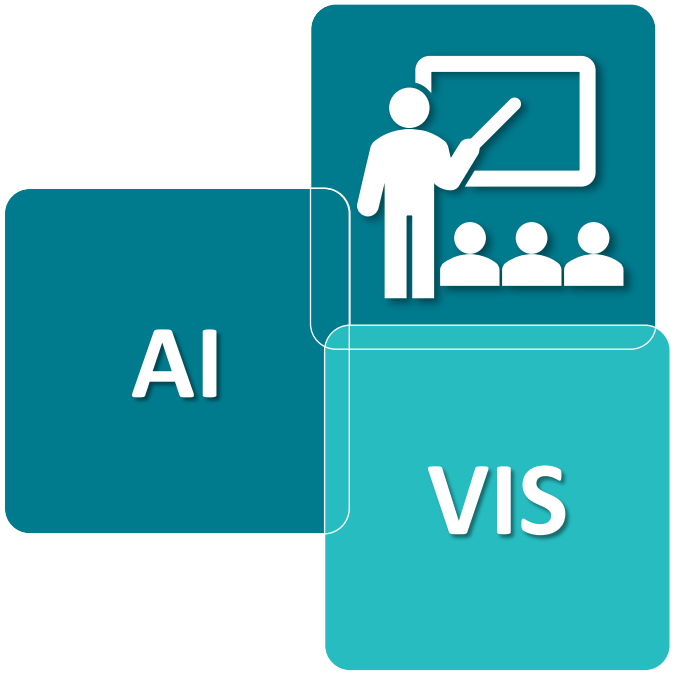


How **to facilitate the creation** of urban visual analytics workflows?

Curio
Moreira et al. 2025 TVCG

How to support **human-AI collaboration** in urban visual analytics to manage diverse datasets, coordinate workflows, and integrate multiple analytical methods?

Urbanite
Moreira et al. 2026 IEEE VIS 2025



Systematic Literature Review of AI and Data Visualization Practices and Pedagogies

How can educators adopt AI for complex data visualization in the classroom?

How is AI being used in Data Visualization education?

How can AI enhance professors' and students' capabilities?

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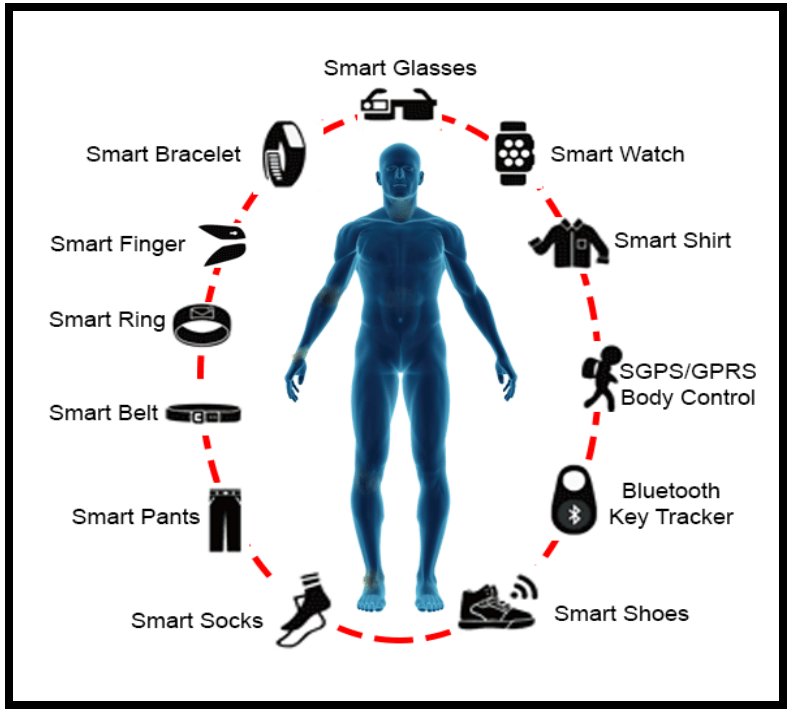
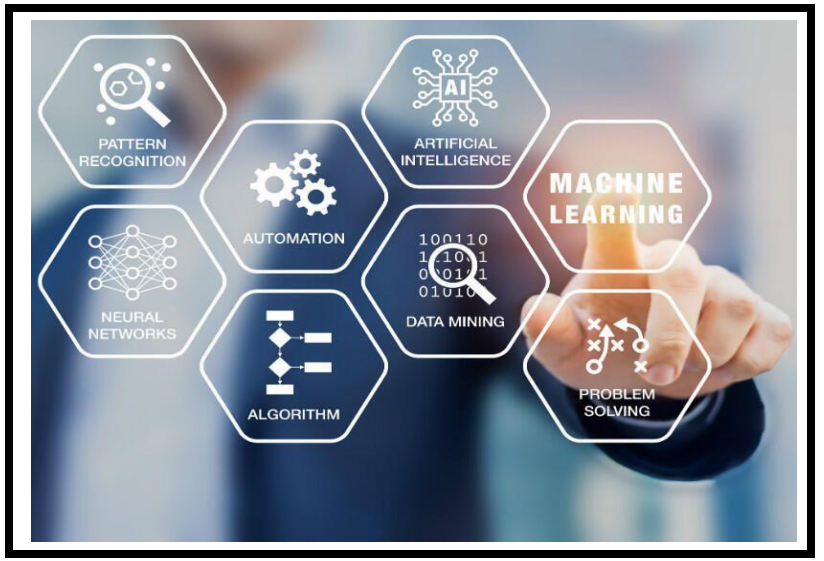
WISE AI LAB
Wellness Intervention And Support Estimation

Transforming wearable data into actionable health insights

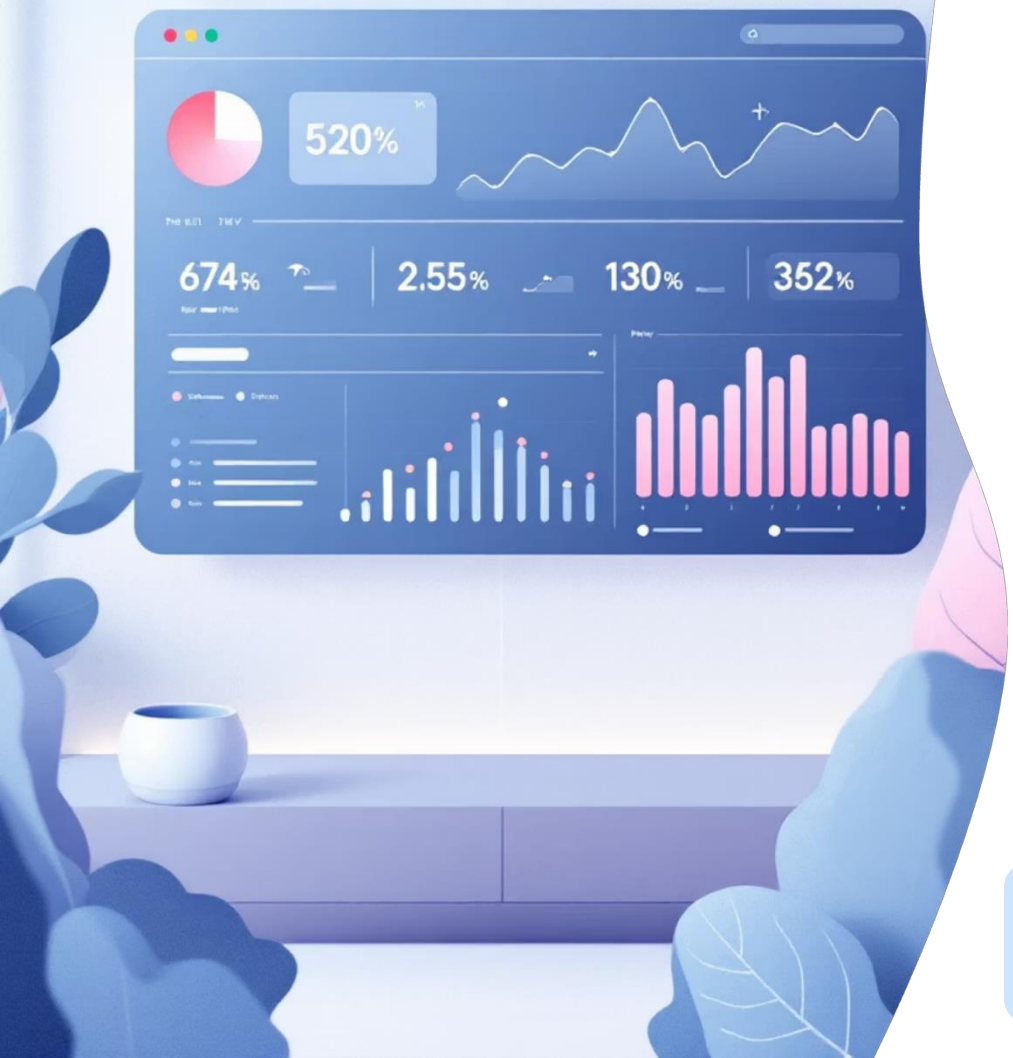


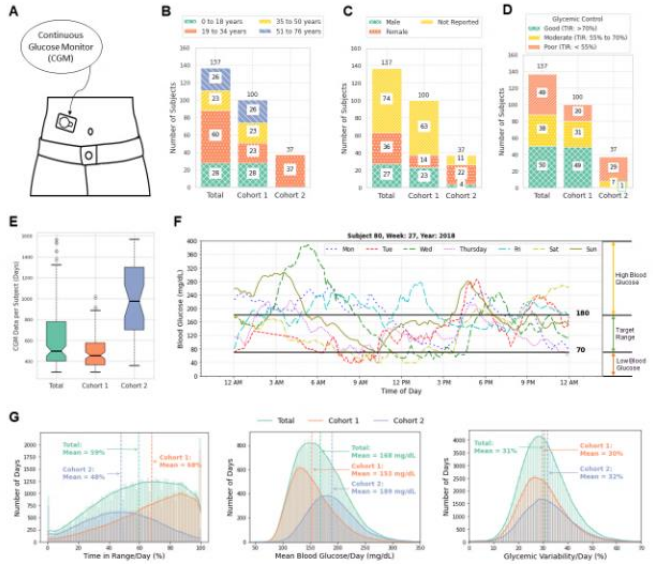


Wearable Sensors

Algorithm Development

Digital Interventions





Wearable Sensor Technology

We develop advanced algorithms to process continuous physiological data from smartwatches, fitness trackers, and specialized medical devices.

Behavioral Pattern Analysis

Using machine learning to identify subtle behavioral changes that predict health risks, medication adherence, and treatment outcomes in real-time.

Sleep & Recovery

Analyzing sleep patterns, heart rate rate variability, and recovery metrics to metrics to optimize health interventions

Physical Activity

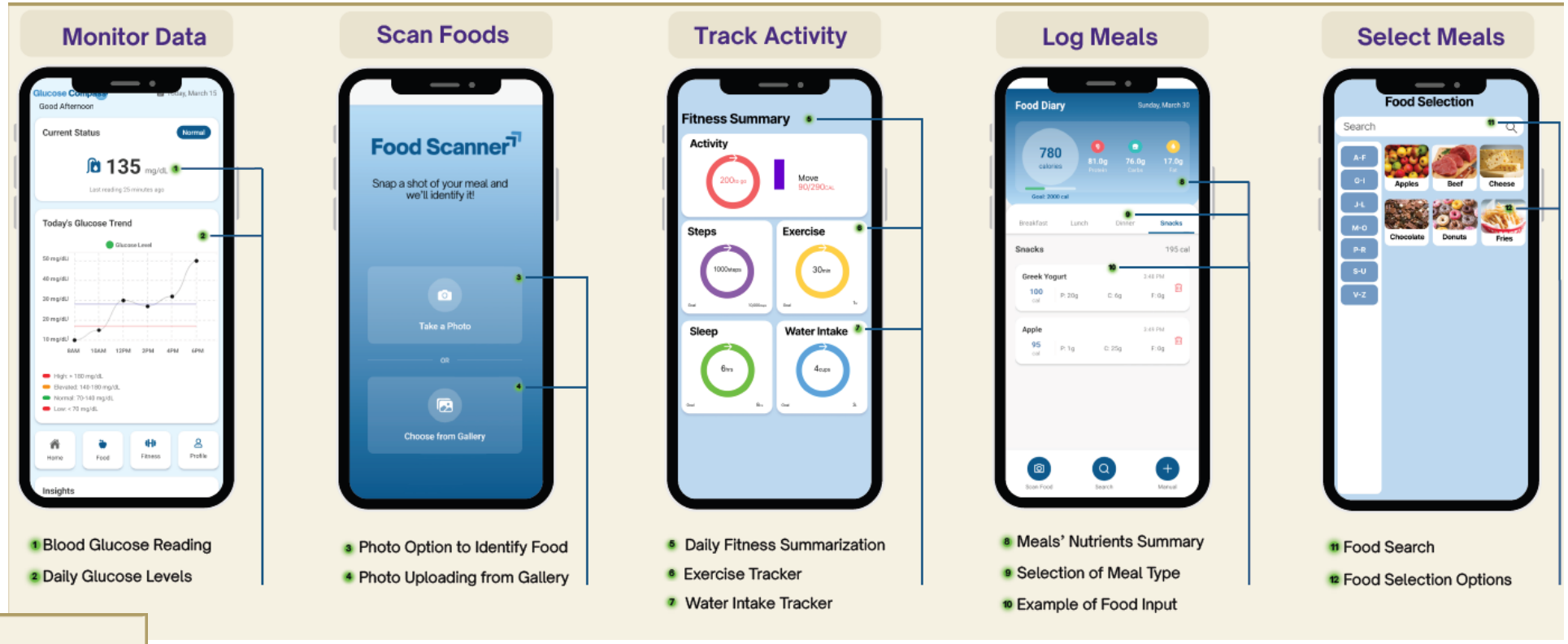
Tracking movement patterns, exercise compliance, and sedentary behavior for personalized fitness recommendations

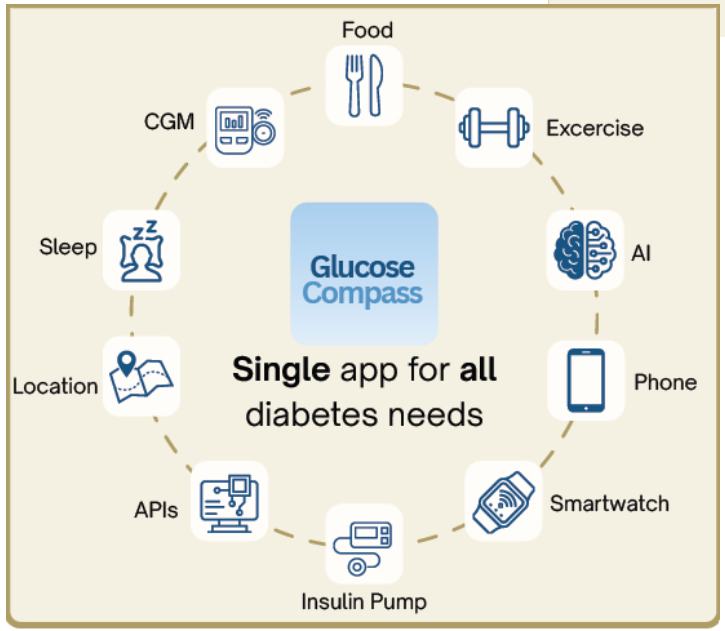
Chronic Disease Management

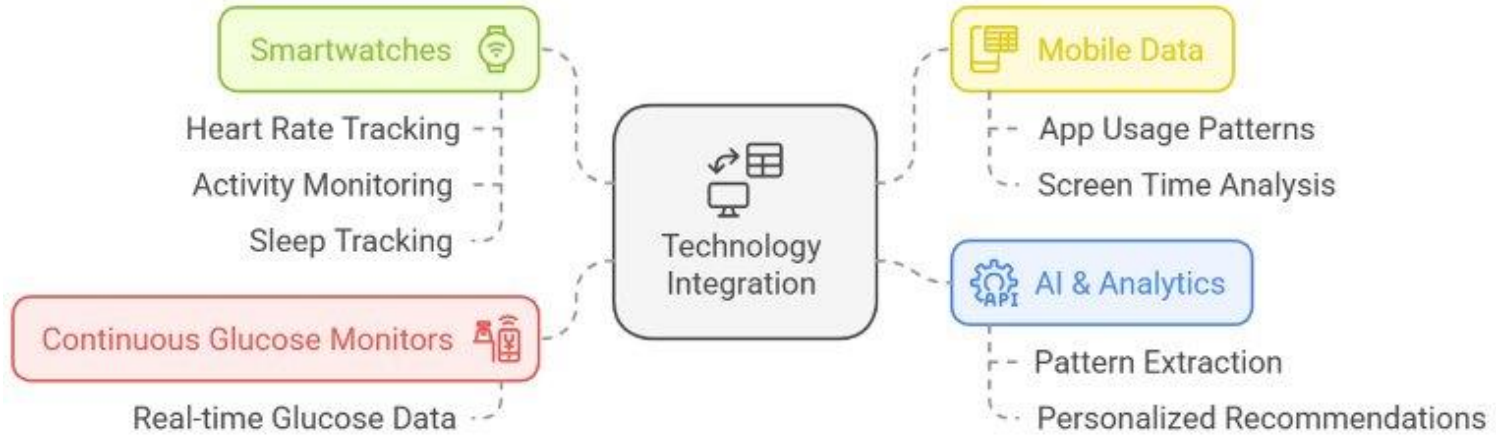
Monitoring vital signs and behavioral indicators to prevent complications and improve quality of life

Ready to get started?

Contact Dr. Belsare at
belsarpp@jmu.edu







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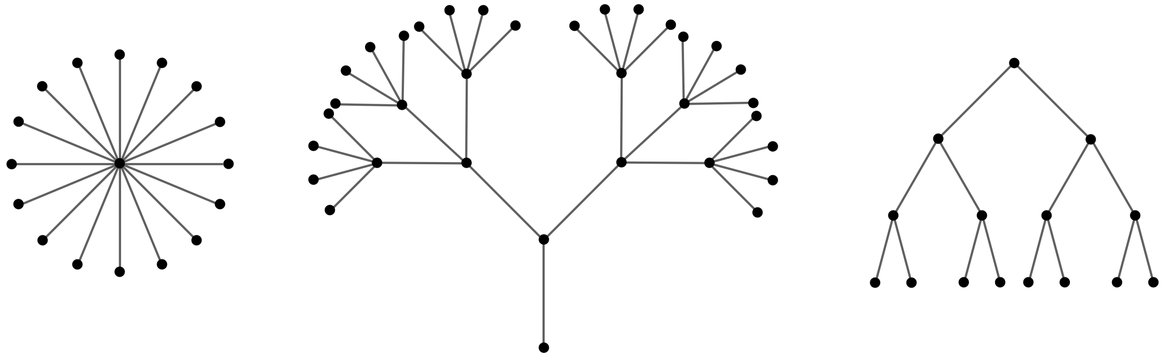

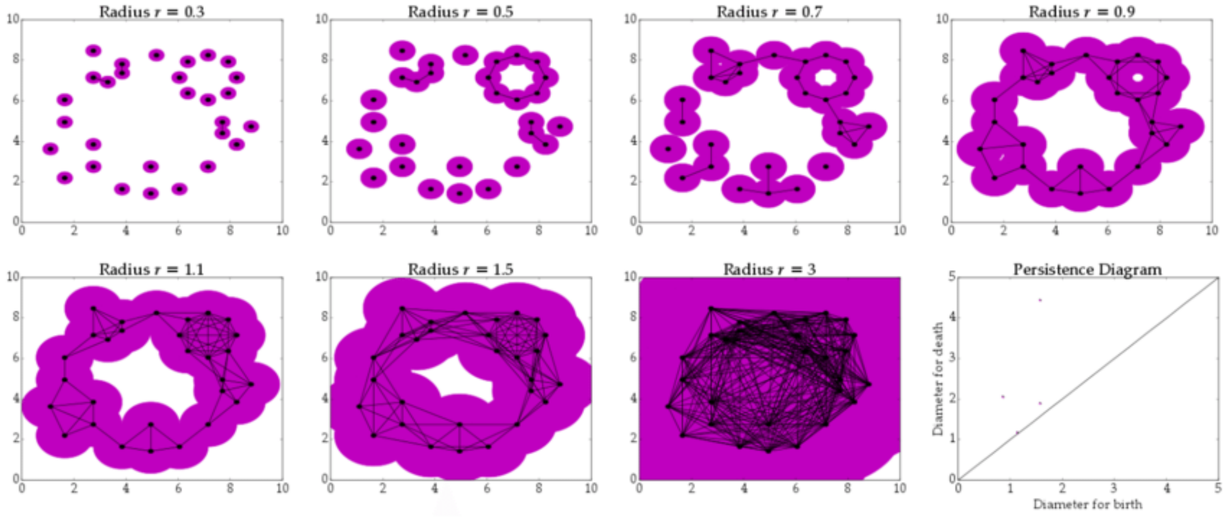

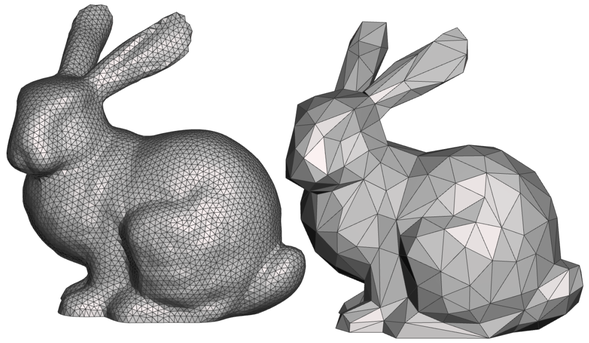

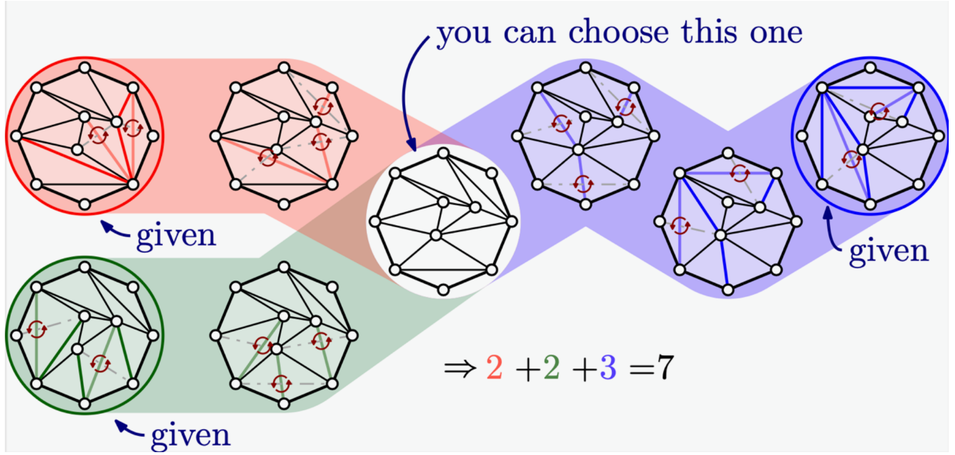

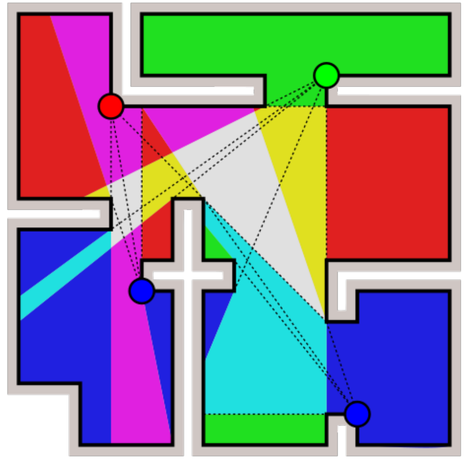

Brad McCoy

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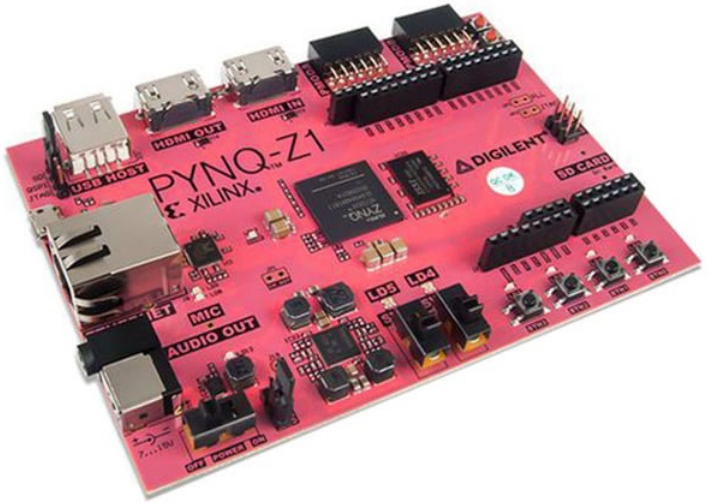
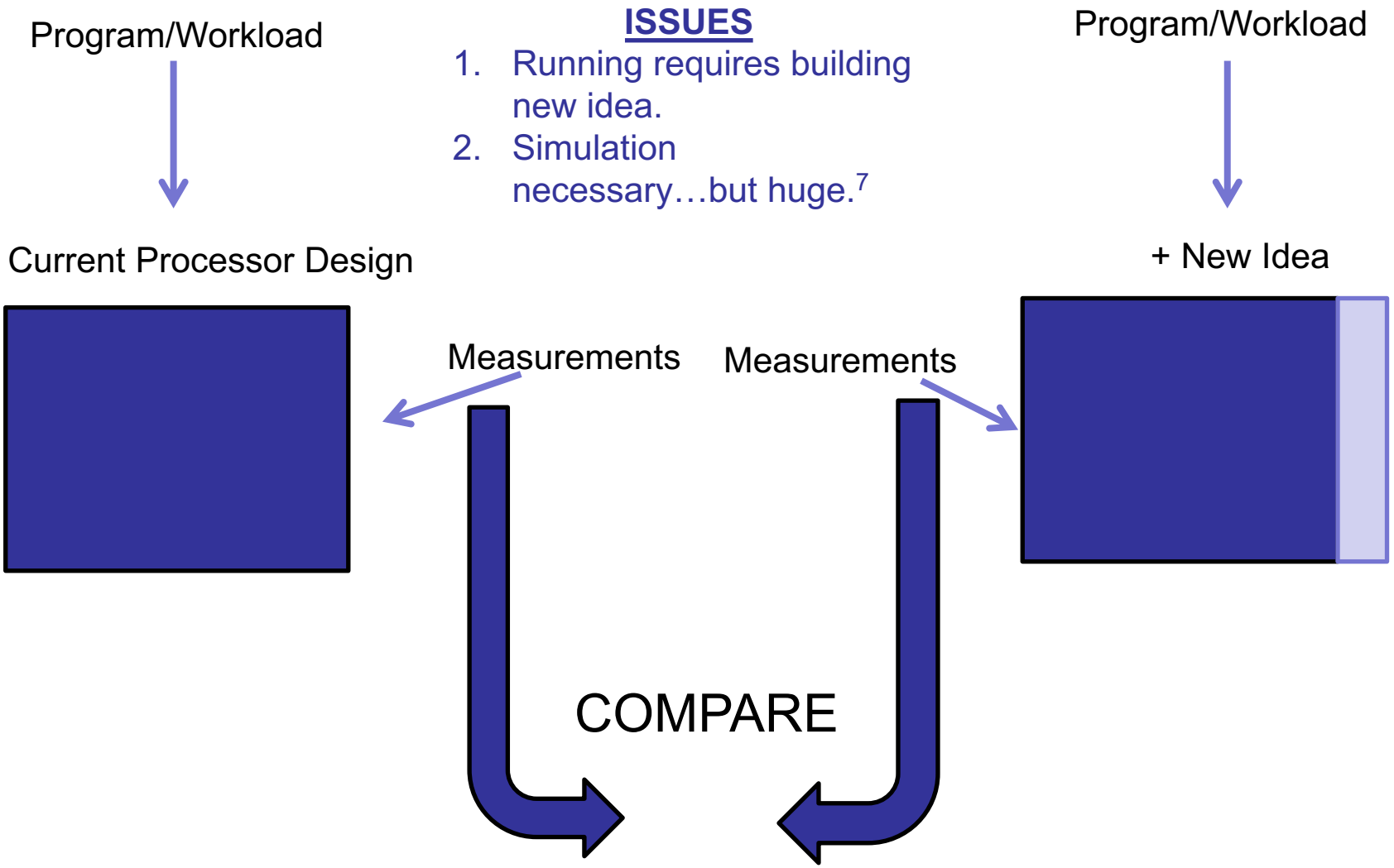
Dee A. B. Weikle



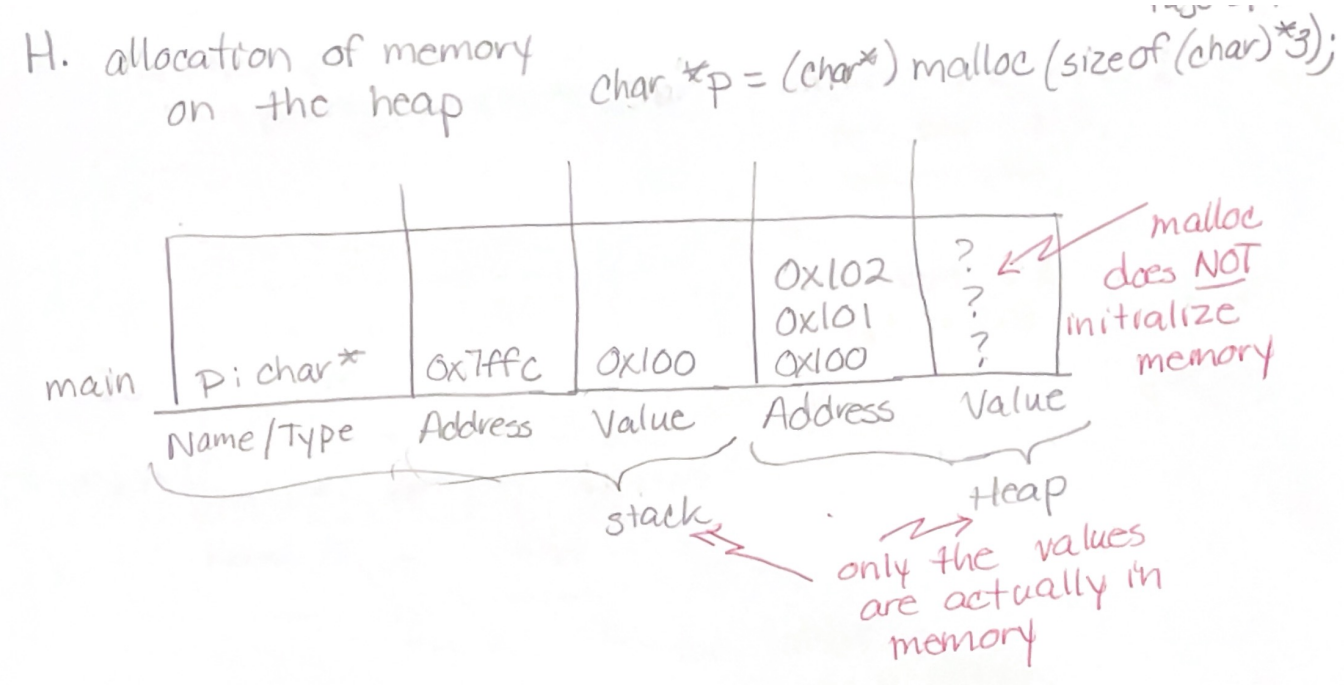
Research Interests

- Education (Fourth Hour, TA programs, POGIL, memory diagrams)
- Computer Architecture (E-Flynn, fpga projects)

Computer Architecture



Memory Diagrams



Memory diagrams across the curriculum (including assembly language)

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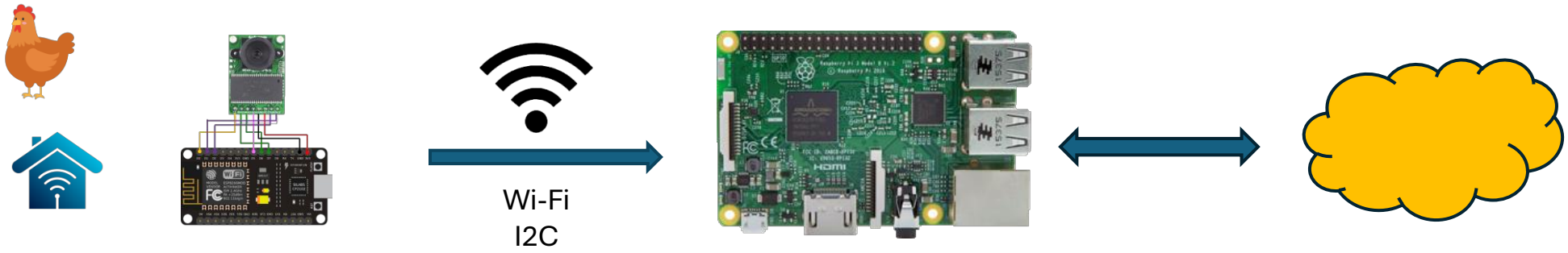
IoT enabled Applications – Dr. Lee

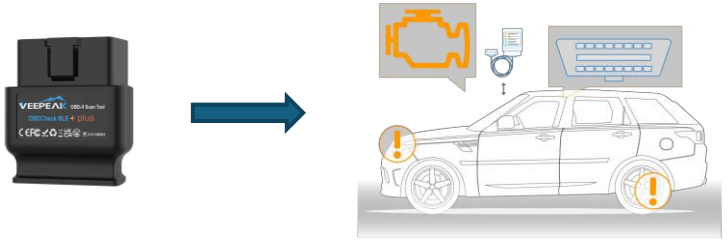
- Chicken Coop
  - Build affordable chicken coops with a variety functionalities, such as temperature control, automated feeding, predator-proof.
- Home Automation, Voice, and Entry Network [1)]
  - Build a unified smart home system that integrates facial recognition for secure, hands-free access and voice commands for seamless home automation.
  - Skill Set: networking protocols, data collection and analysis, machine learning



1) A. Willis, W. Portlock, S. Lee, and H. Chang, “Home Automation, Voice, and Entry Network,” Systems and Information Engineering Design Symposium (SIEDS 2025), May 02, Charlottesville, VA, 2025.

ML enabled Applications – Dr. Lee

- Electric Vehicle Driving Range Estimation
  - Develop a predictive model for estimating the remaining driving range of electric vehicles (EVs) using On-Board Diagnostics (OBD-II) technology, with a focus on personalized driving behavior and environmental factors.



- AI-Generated Image/Voices Detection [1)]
  - Authentic and Synthetic Image/Voice Detection in Video conference setting
  - Skill Set: video streaming protocols, data collection and analysis, deep learning

1) M. Shike, M. Irfan, S. Lee, and A. Salman, “Deep Learning-Based Detection of AI-Generated Voices Using Spectral Features,” IEEE International Conference on Machine Intelligence and Smart Innovation (ICMISI 2025), May 10 – 12, Egypt, 2025.

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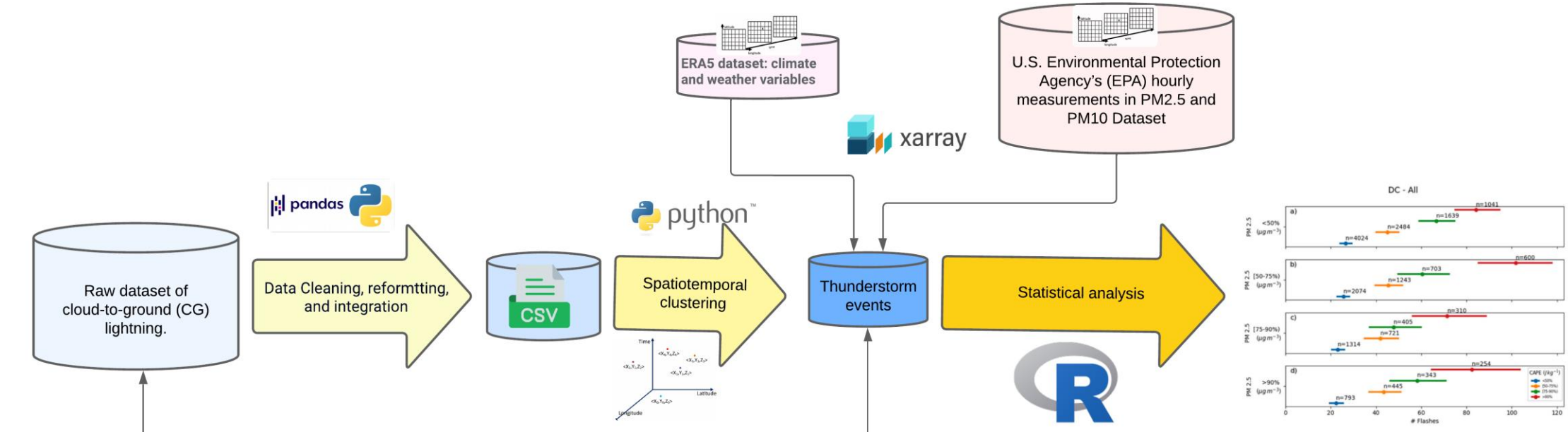
Dr. Ayub

About me

- **Name:** Zhuojun Duan, PhD
- **Teaching:**
  - **This fall:** CS240 & CS412
  - Spring 2025: CS149 & CS240
- **Research Interest:**
  - Algorithm design and analysis
    - Game theory in IoTs
  - Data Analytics

My current project: the Study of thunderstorm-aerosol relationship



Duration: 12-year period (2006–2010; 2013–2015; 2017–2020)
Two areas: Washington, DC & Kansas City
Source: National Lightning Detection Network(NLDN)
Size: 7,207,567 flashes and 14,796,725 flashes

DC: 196,836 thunderstorm events
Kansas: 310,209 thunderstorm events

Publications

- Bentley, Mace, Tobias Gerken, **Zhuojun Duan**, Dudley Bonsal, Henry Way, Endre Szakal, Mia Pham, Hunter Donaldson, and Lucie Griffith. "Toward untangling thunderstorm-aerosol relationships: An observational study of regions centered on Washington, DC and Kansas City, MO." *Atmospheric Research* 304 (2024): 107402.
- Sae-Jung, Jojinda, Mace L. Bentley, **Zhuojun Duan**, and Endre Szakal. "Developing an urban thunderstorm climatology for the Bangkok Metropolitan Region." *Singapore Journal of Tropical Geography* (2024).
- James Agresto, ***Zhuojun Duan,*** Bentley, Mace, Tobias Gerken, *Analyzing Ground-lightning Dataset Using the Density Based Spatial Clustering of Applications with Noise (DBSCAN), IPCCC2024,(Poster paper)*

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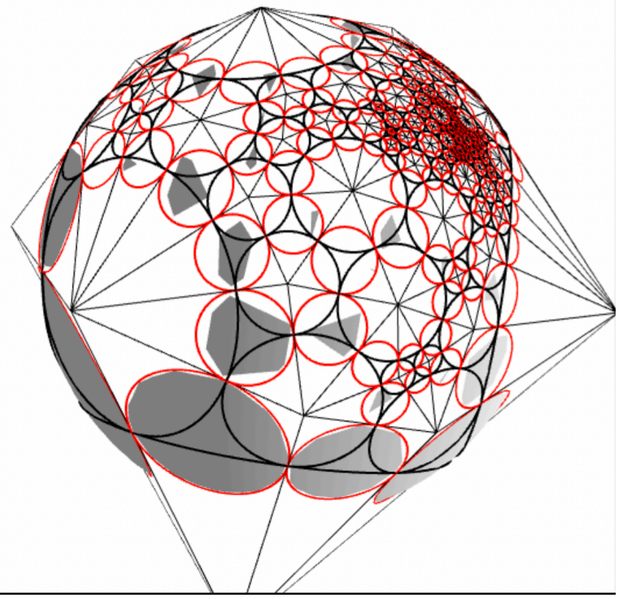
Dr. Ayub

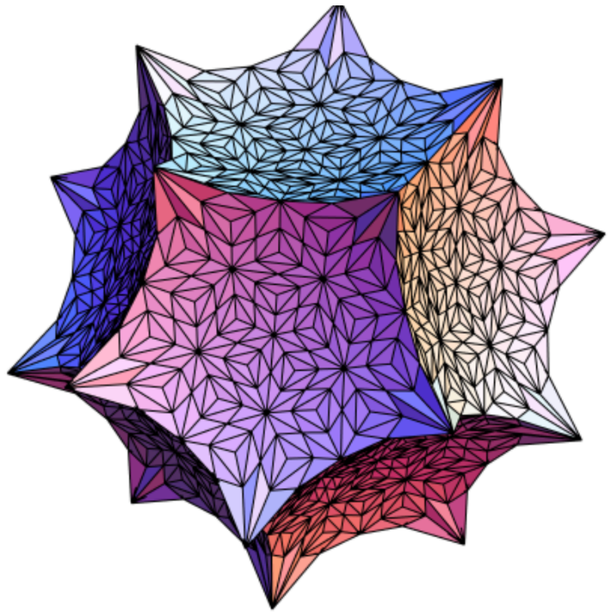
```
objs.addAll([shrinkDisk(v.data, oldToNewDisk) for v in cppoly.verts])
objs.addAll([getInvCPlane(f, oldToNewDisk) for f in cppoly.faces])

sketch.saveScene("Scene 6: Inversive distance c-polyhedron")

# Scene 7: Another inversive distance c-polyhedron

objs.clear()

oldToNewDisk2 = {}

def shrinkDisk2(disk, diskMap):
     norm = disk.dualPointOP3.toPointE3().toVectorE3().norm()
     eps = (3 * (norm - 1.0) / 4) * (random.random() * 1.5)
     fact = (1.0 + eps) / norm
     newDisk = DiskS2(disk.a * fact, disk.b * fact, disk.c * fact, disk.d)
     diskMap[disk] = newDisk
     return newDisk

objs.addAll([shrinkDisk2(v.data, oldToNewDisk2) for v in cppoly.verts])
objs.addAll([getInvCPlane(f, oldToNewDisk2) for f in cppoly.faces])

sketch.saveScene("Scene 7: Another inversive distance c-polyhedron")

sketch.restoreScene("Scene 1: Random 100-vert polyhedron")
#sketch.restoreScene("Scene 5: without the Koebe-polyhedron")

print "Loaded."
```

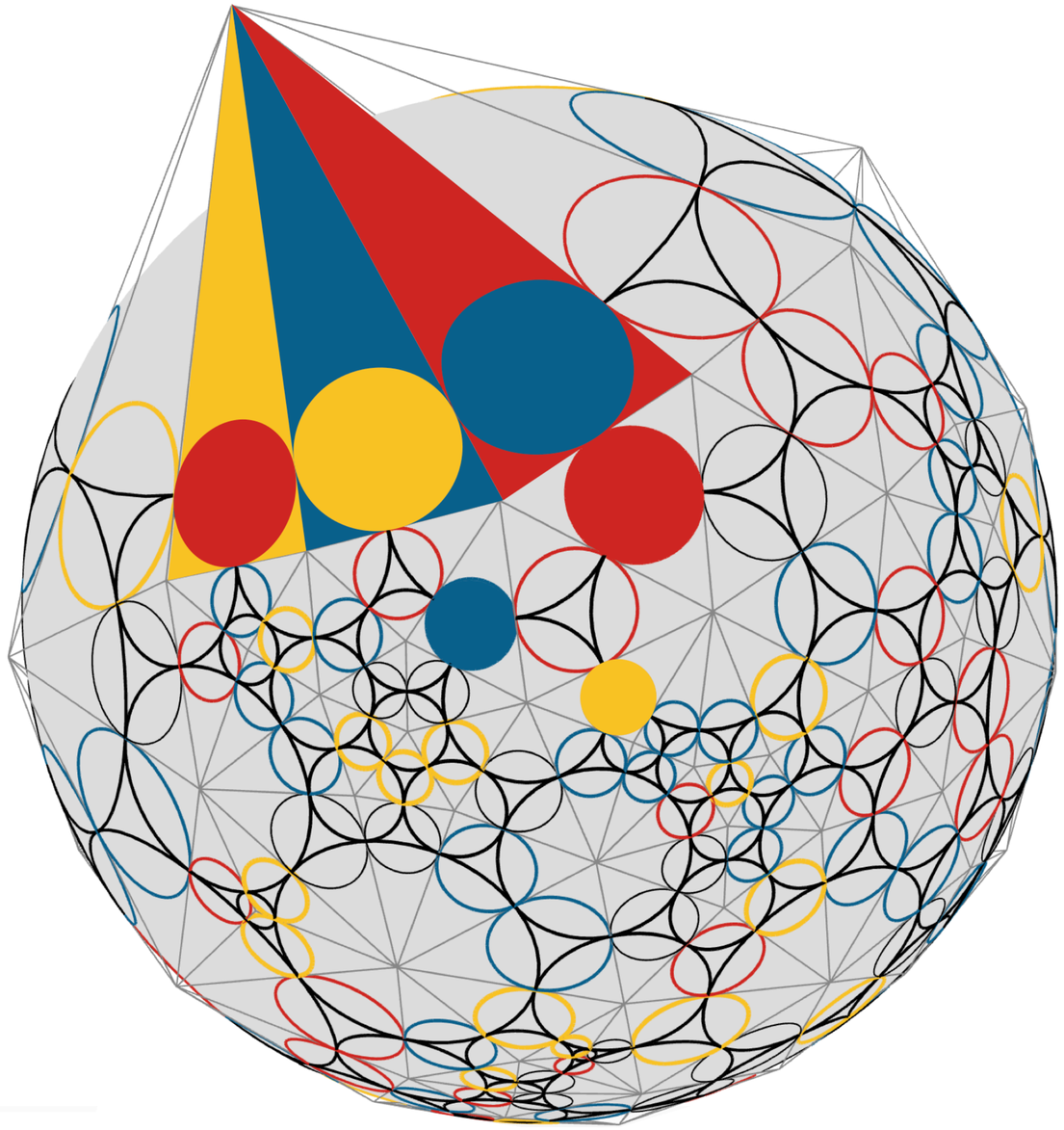
Jython Console Output

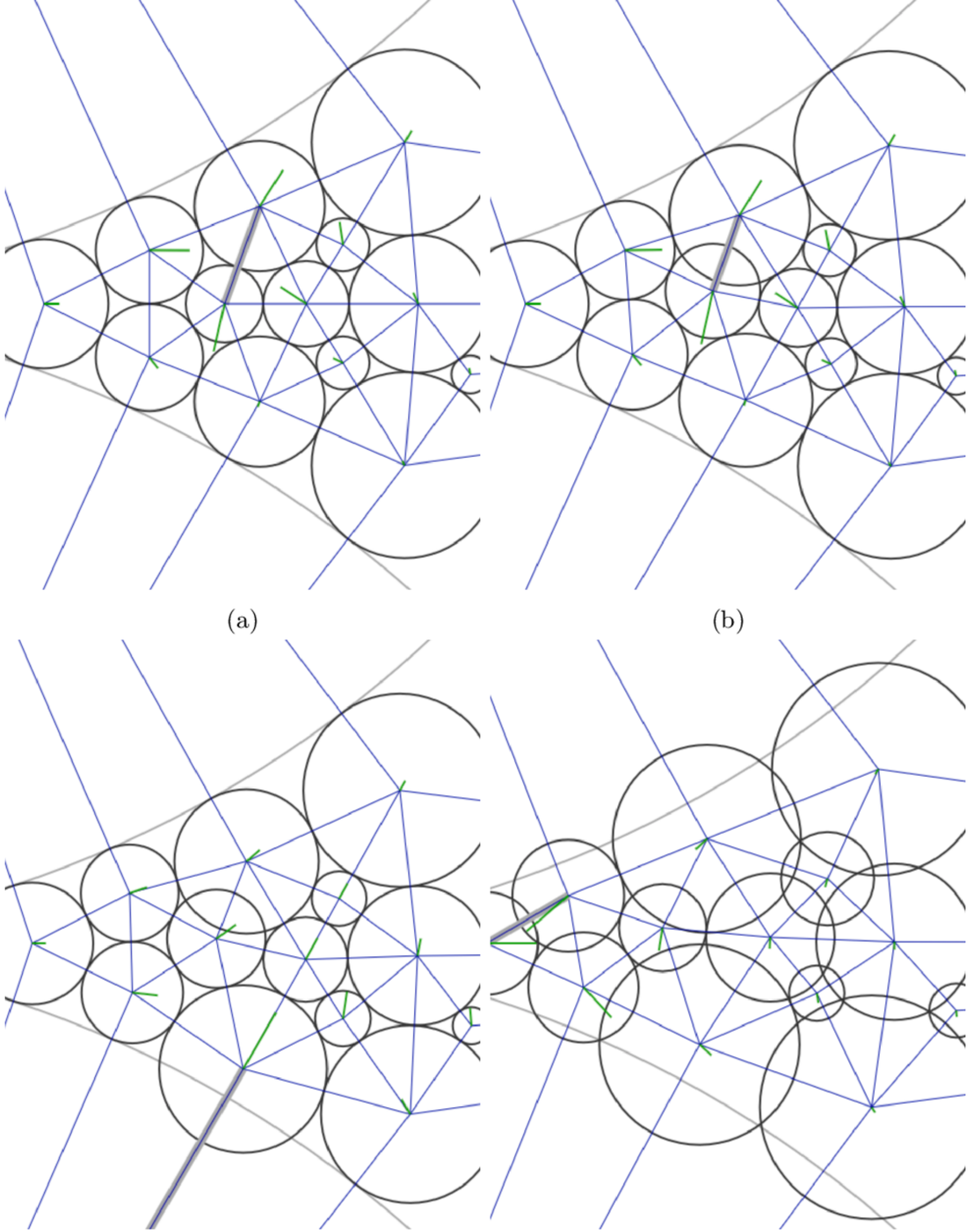
Loaded.

Open Save Clear Console

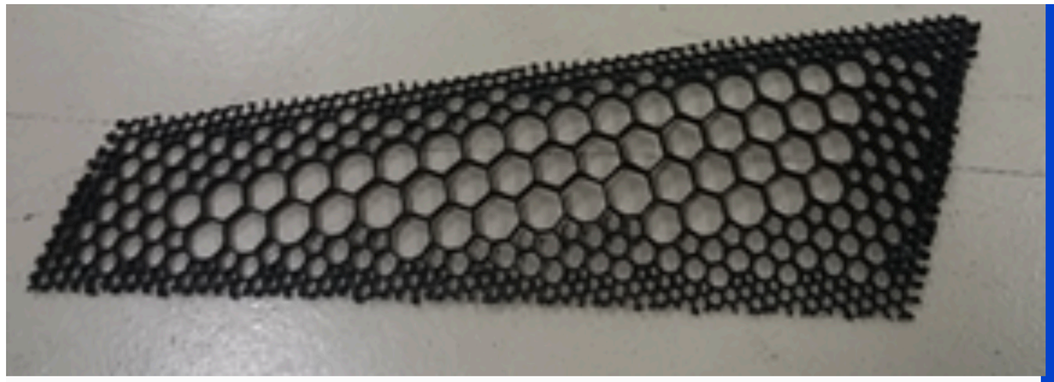


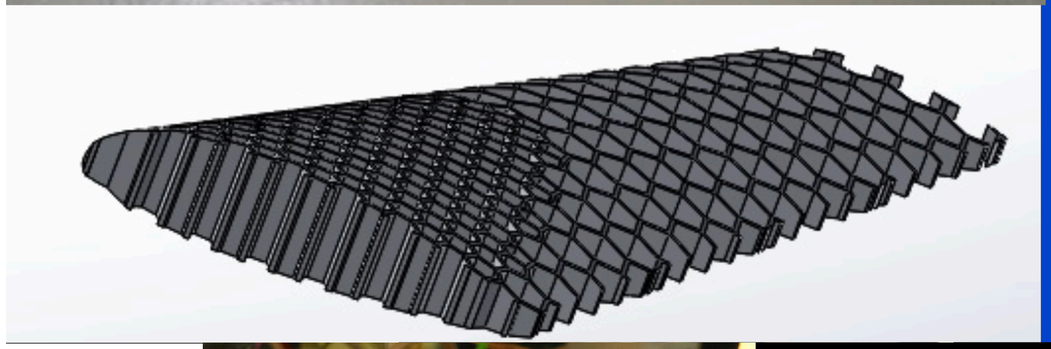


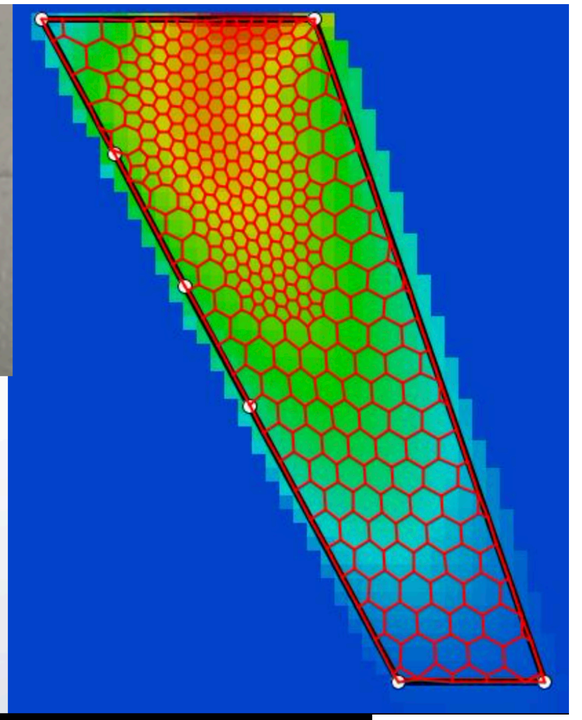


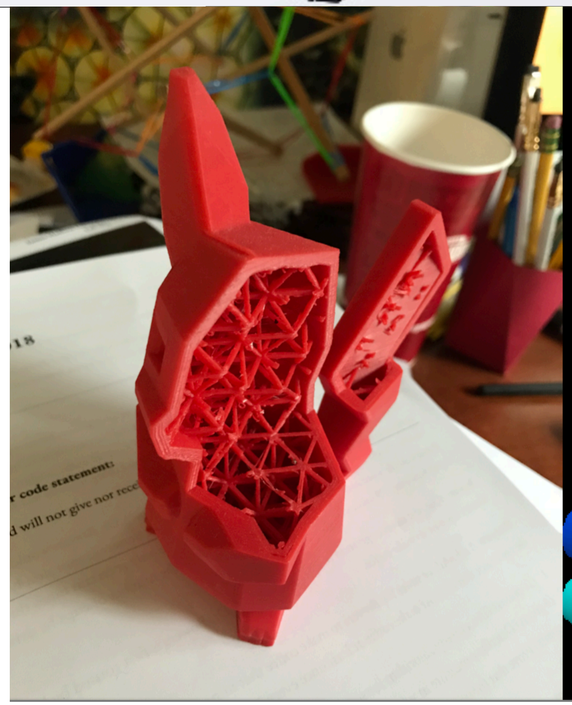


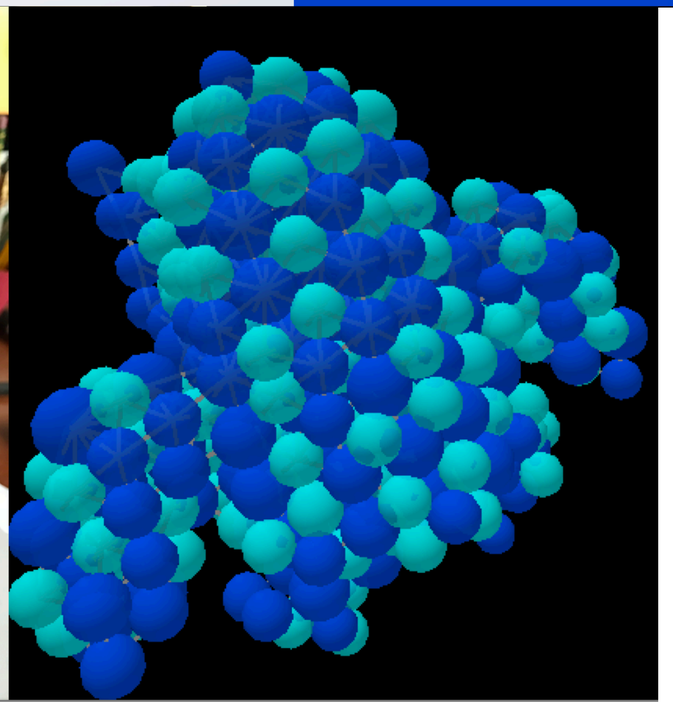
(a) (b) (c) (d)











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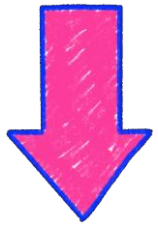
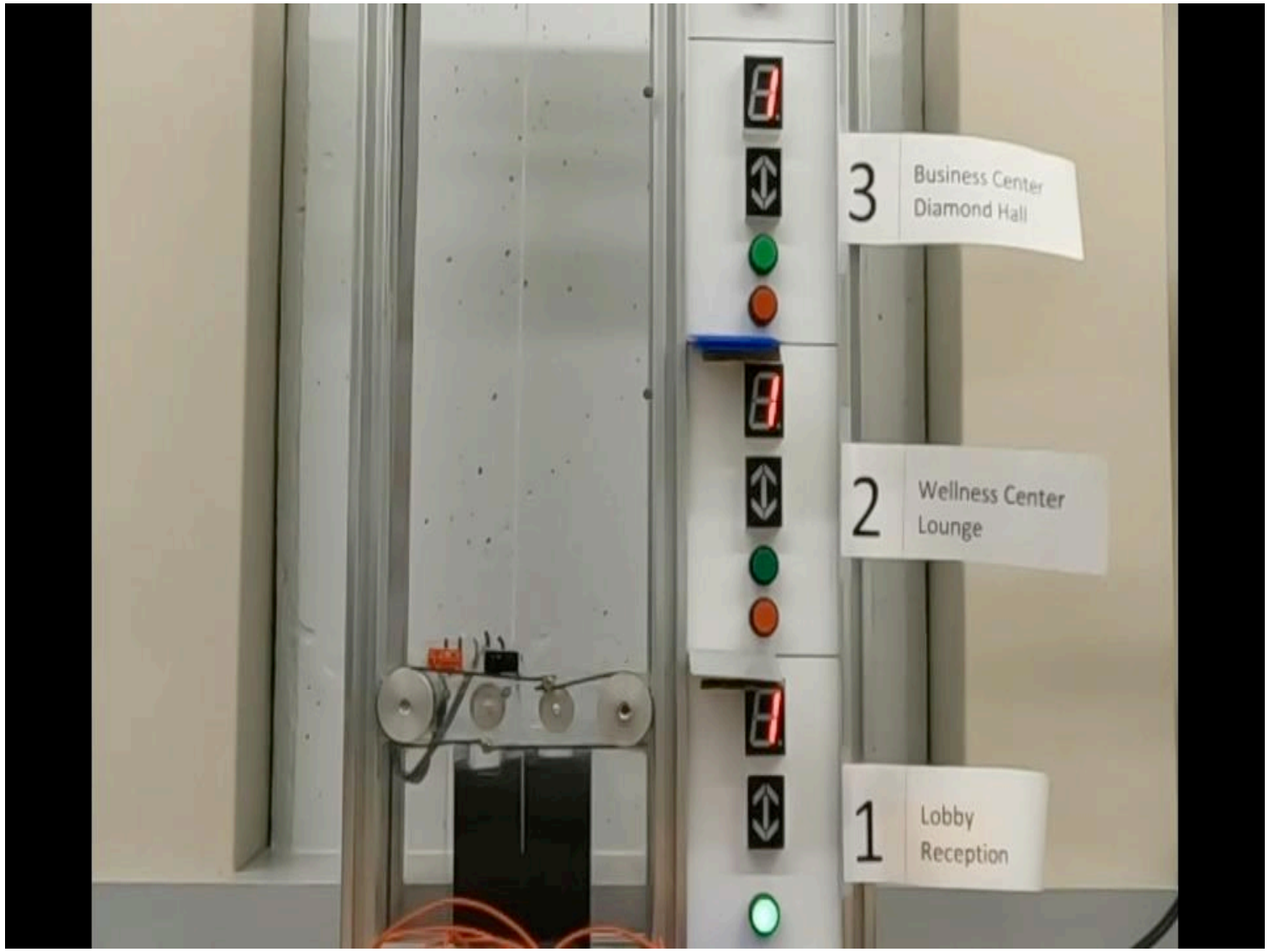
Imagine you're in an elevator and this happens…

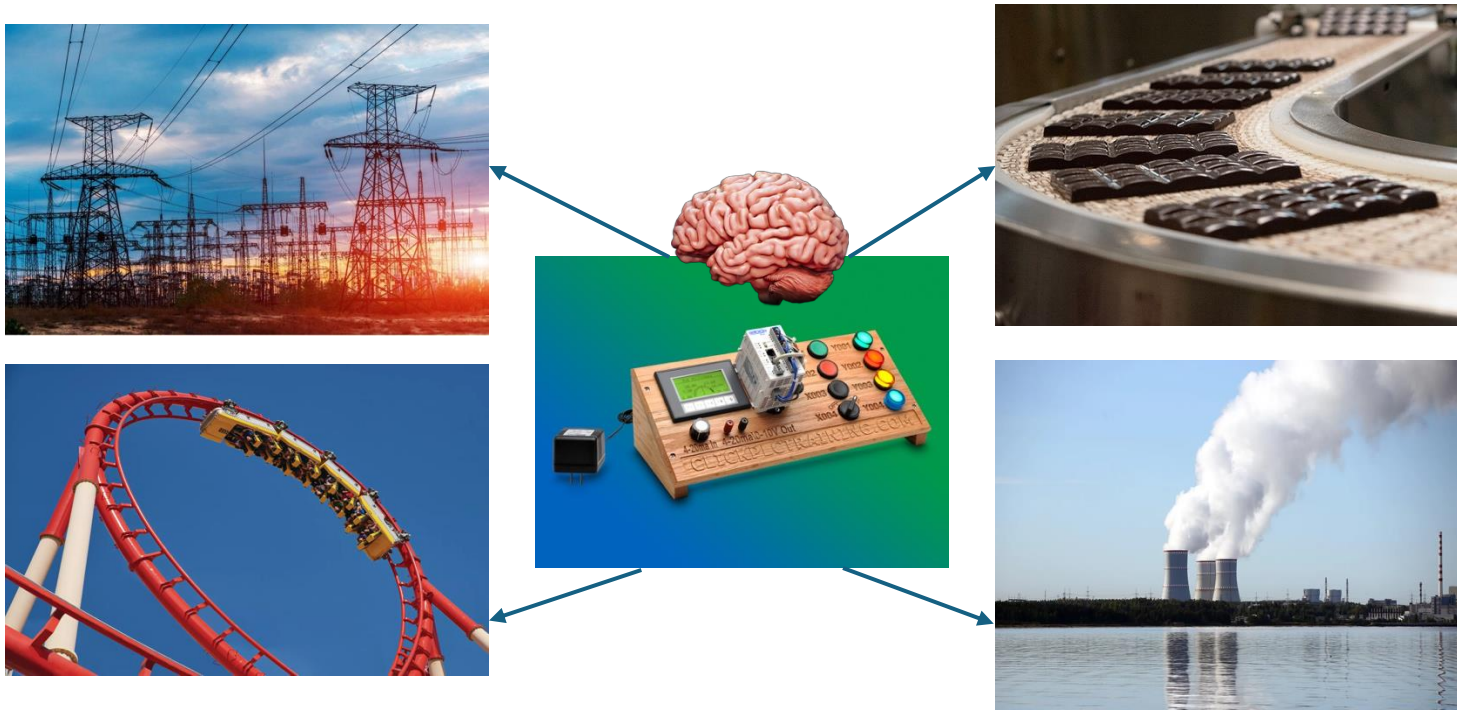


Controller



Programmable Logic Controllers

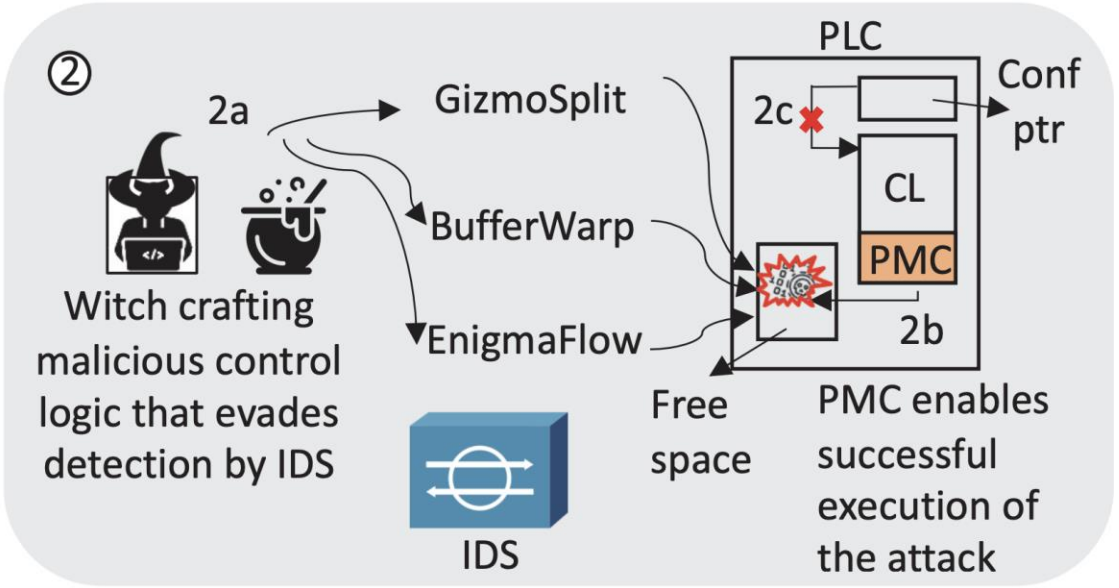
- Physical processes such as nuclear plant, power grid, oil and gas pipeline are controlled by Programmable Logic Controllers (PLC)
- Small computers that run a program to monitor the physical processes
- Many different vendors
- Examples: GE, Omron, Schneider Electric, Mitsubishi, and many more….



Attacks and Defense

- Different Attack Vectors
  - Authentication Bypass
  - Return Oriented Programming
  - Direct Firmware Object Manipulation
  - Control logic injection
  - Redundant Address Pins

- Detection
  - Side channel electromagnetic
  - Wavesleuth (using audio signals)
  - CLAD (Hybrid of static and dynamic analysis)



Impact

- You get to find problems before attackers do and get credit for it
- CVEs: CVE-2023-2310, CVE-2021-32980, CVE-2021-32984, CVE-2021-32986, CVE-2021-32982, CVE-2021-32978, CVE-2021-32926, CVE-2020-15791

- You get to secure the critical infrastructure. Remember the Colonial Gas Pipeline attack?