

Research in ECE

Rutgers Undergraduate Research wreak

Prof. Anand Sarwate, Rutgers ECE, September 2023

What is ECE?

Any technology that uses computers or electronics



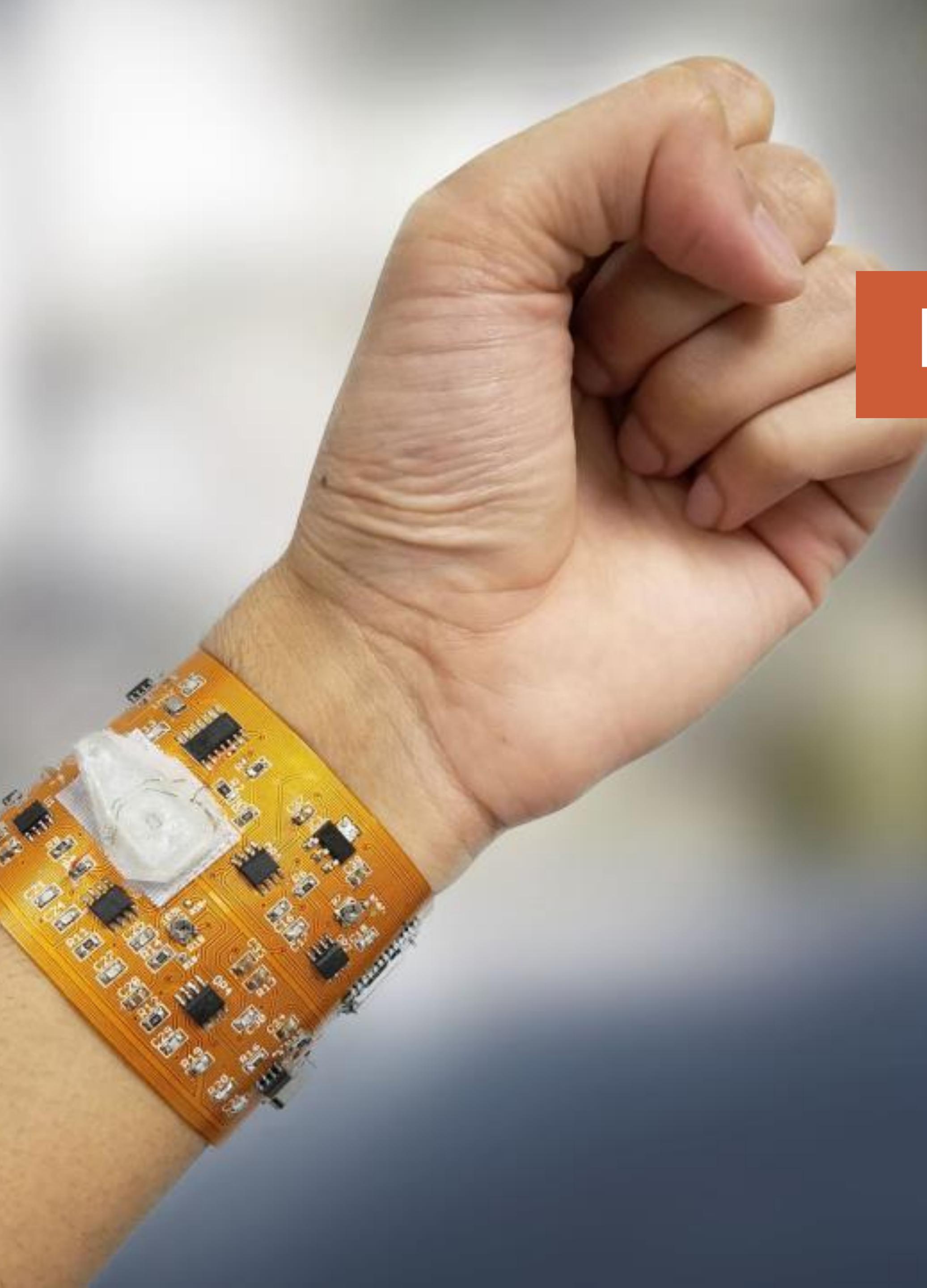
- Energy systems to support carbon emissions reduction
- Controls and communications systems for smarter robots in surgery
- Medical instrumentation and image processing for disease diagnostics
- IT and security for information and data safety on the Internet and online transactions
- Faster processors for advanced TV and gaming
- Nanotechnologies for the study of microorganisms
- Computer circuits supporting faster networks and processors for smartphones and other devices

Major research areas at Rutgers ECE



- Communications
- Networking
- Signal and Information Processing
- Computational Sensing
- Machine Learning
- Systems and Controls
- Computer Engineering
- Software Engineering
- Cybersecurity
- Solid State Electronic





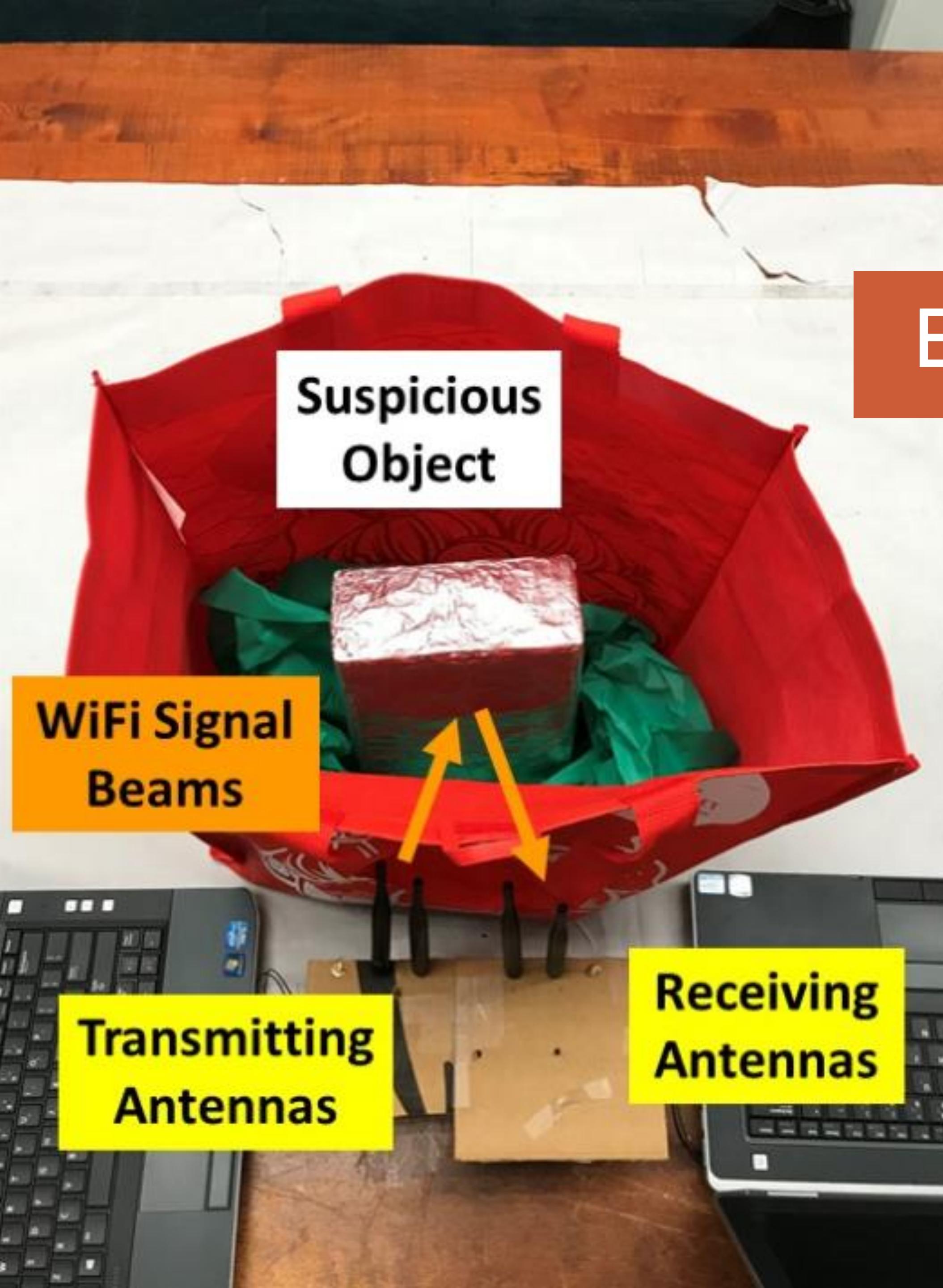
ECE Out Front

Electrical and computer engineering faculty members are part of the team that created a smart wristband with a wireless connection to smartphones that could monitor health and environmental exposures.



ECE Out Front

Prof. Javanmard is developing an all-electronic platform that can rapidly identify drug-resistant cancer cells in patients and prescribe a course of treatment.

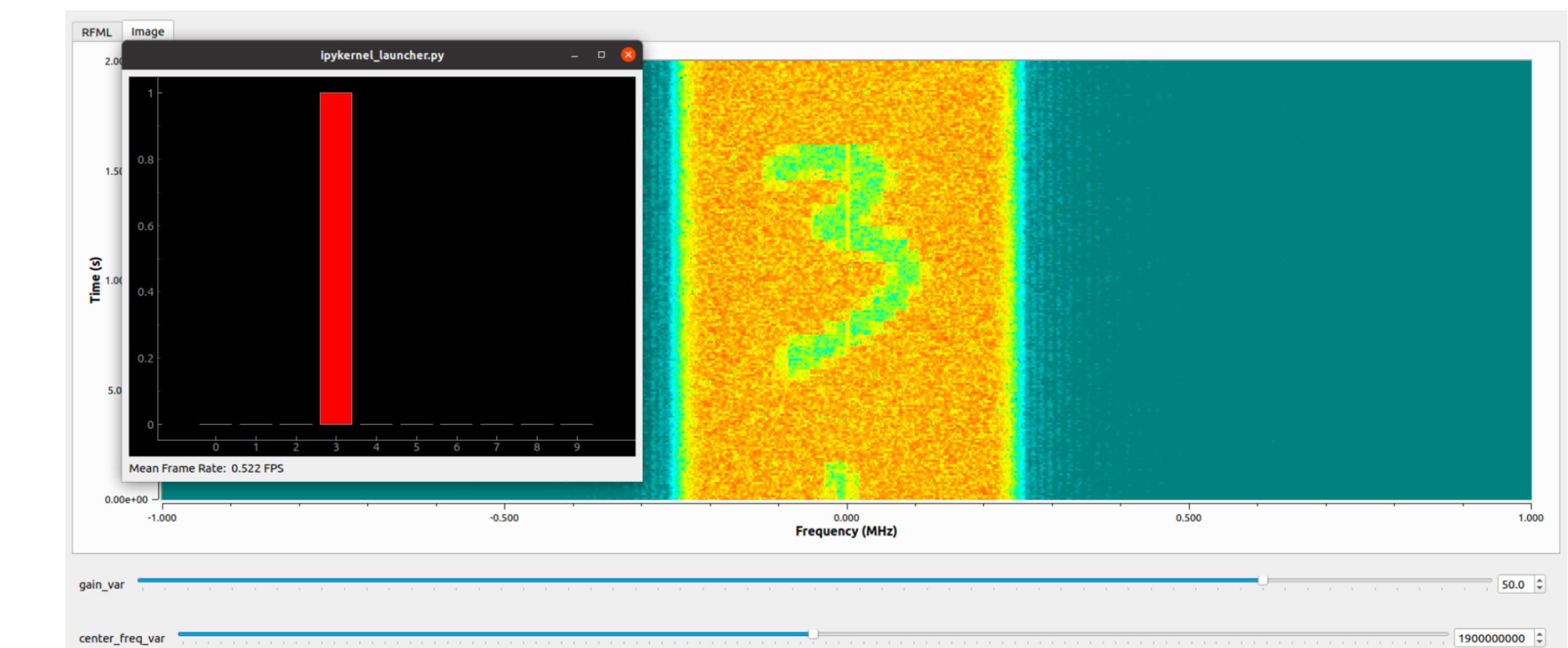
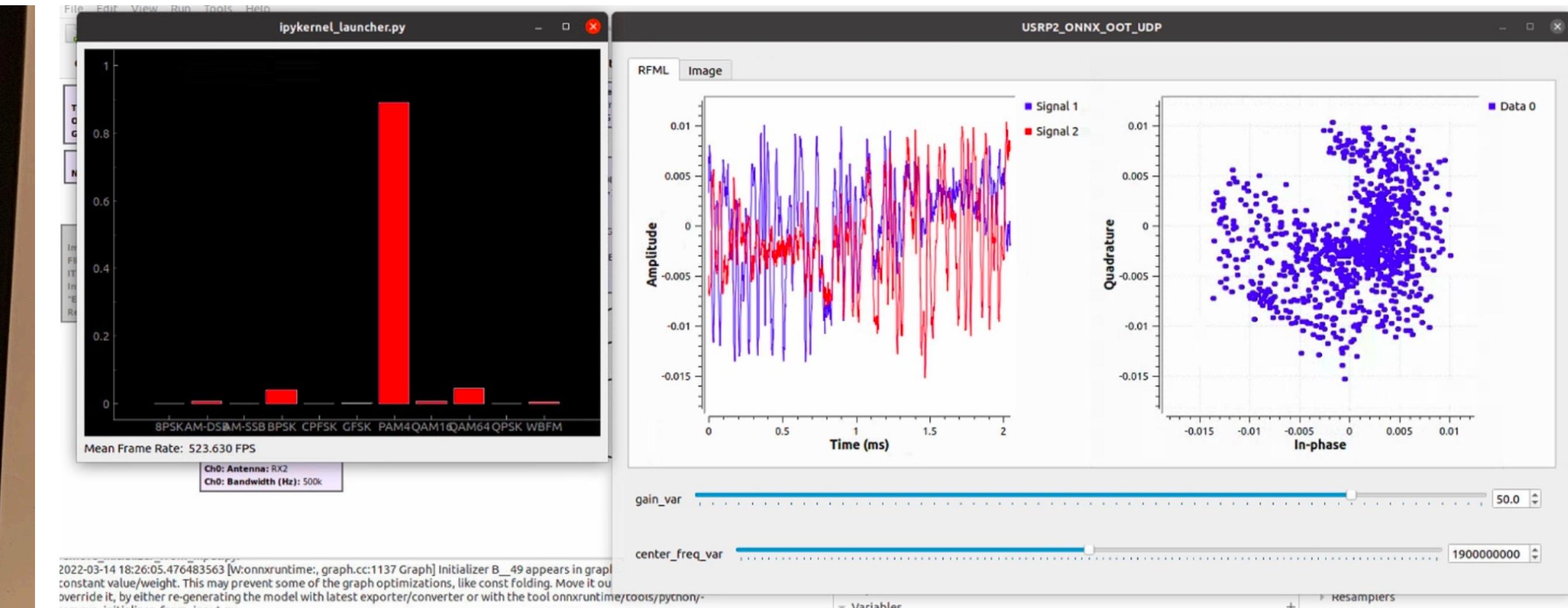
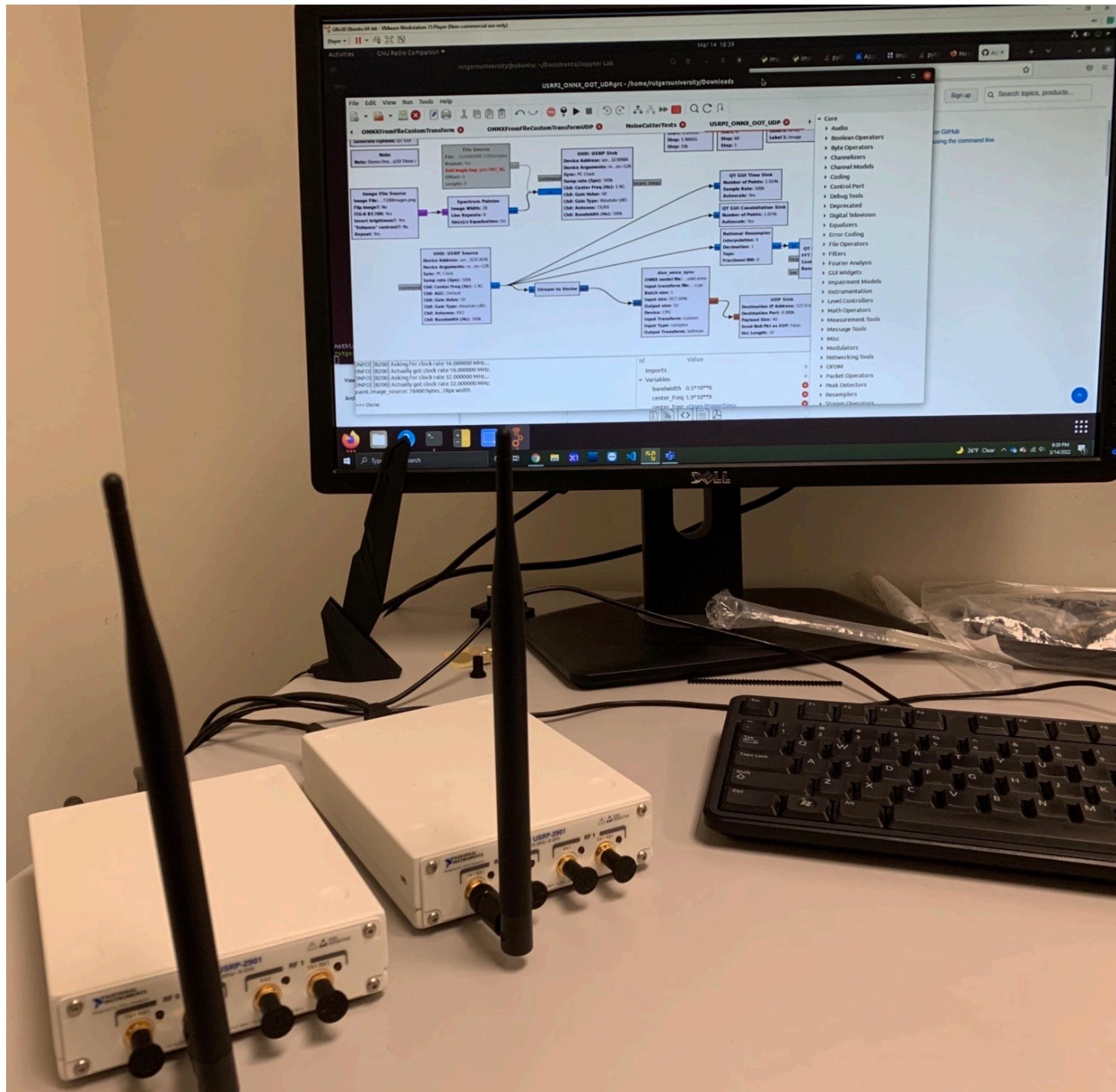


ECE Out Front

Prof. Jennifer Chen's suspicious object detection system can easily detect weapons, bombs, and explosive chemicals in bags. It uses a system that analyzes what happens when WiFi signals penetrate and bounce off objects and materials.

Machine Learning for Radio Frequency Wireless Communication

- Sending invisible signals through the air and decoding them with AI
 - The closest thing we have to magic!



What is research anyway?

Warming up with a few questions



- What do you think does “doing research” involves?
- What about it seems interesting or appealing to you?
- What do you think you’ll get out of it?



Research is multifaceted

There's no single answer...

In a research project you get to work on a project with a professor or their research group. What you do depends a lot on the kind of project!

- Group projects vs. individual projects
- Finding related work (reading papers) vs. running experiments
- Programming vs. “hands-on” work with lab equipment
- Mostly remote vs. mostly in-person
- During the semester vs. during the summer

Why do research?

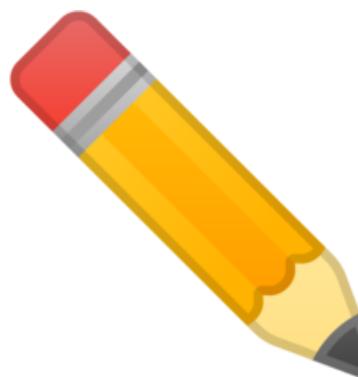
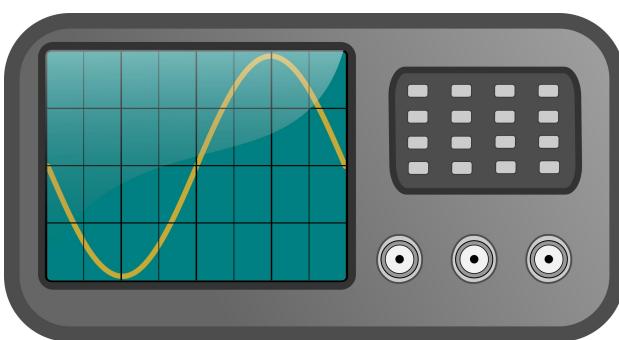
There are a ton of reasons

There are many benefits to doing undergraduate research:

- Get to learn about the cutting-edge (more than you get in classes).
- Develop professional skills: lab work, programming, technical writing, technical communication.
- Get to see what grad school might be like.
- Work more closely with professors (recommendation letters, references).
- Can get paid (in money or course credit)

What would I do in a research project?

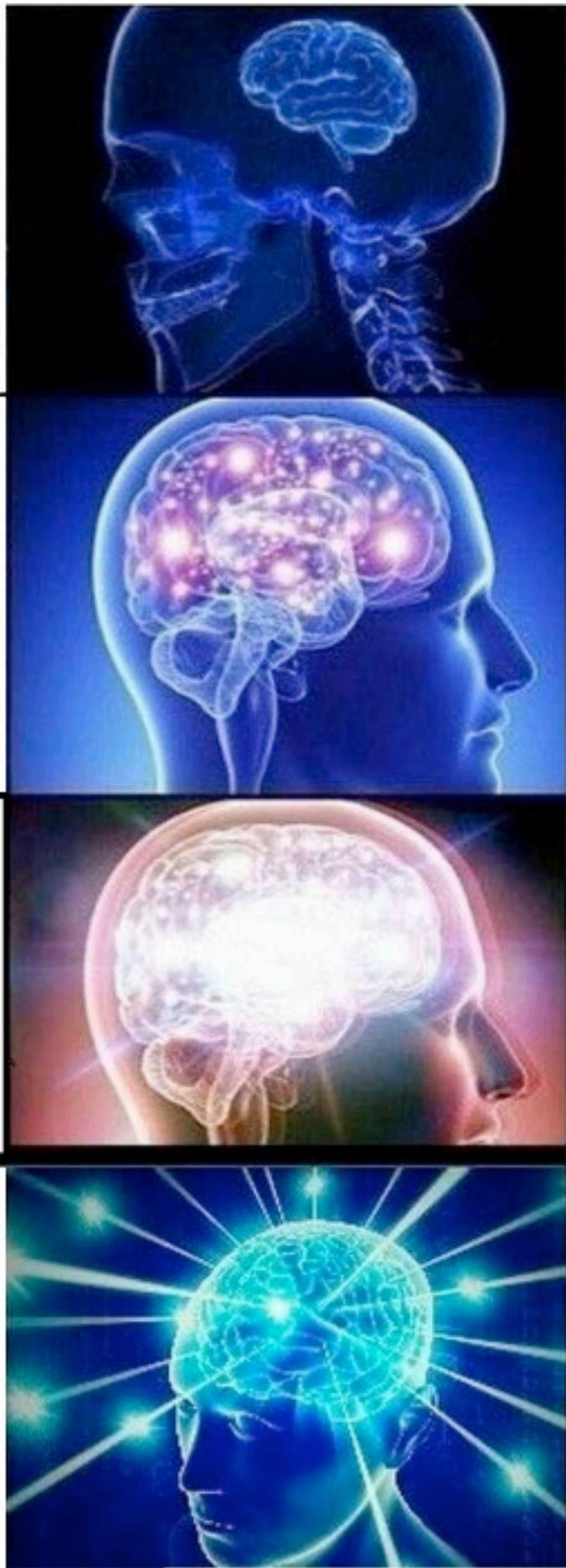
The work is quite variable



- Reading papers and background research
- Programming/simulations
- Data analysis and visualization
- Fabricating or testing devices
- Building circuits/boards/sensors
- Data collection

Do I know enough to do research?

It depends on what you want to do...



Some projects definitely require having some background knowledge or skills from specific courses. Other projects may be accessible to first-year students.

More important is that you are:

- Interested and open-minded
- Resourceful and motivated
- Willing to put in the work

You might not have an opportunity to work on your dream project, but you can still get a lot out of it.

Do I have the time to do research?

Successful work takes time!

Think of research as a serious time commitment: ***as much as a regular class.***



- Regular meeting times each week
- Required time in lab, time sheets, etc.
- Maintaining consistent communication about progress.

Most importantly, you have to be self-driven and make time each week **even though there are no homework deadlines or quizzes.**

Finding a research project

Different ways to get started

There are many options

- **Programs at Rutgers:** WINLAB Summer Internship, Aresty Center, JJ Slade (for seniors)
- **Summer programs:** Research Experience for Undergraduates (REU) programs at many different universities on different topics.
- **Research internships:** many at government or government-funded labs: Department of Energy, NIST, MIT Lincoln Labs, JHU Applied Physics Lab.
- **Work with a research group:** working with a prof/group at Rutgers or elsewhere

Summer research outside Rutgers

A chance to explore new places

Summer is a good time to get involved in a full-time research experience since it won't conflict with classes. These programs sometimes have more *structure*, with talks, professional development, mini-courses, etc.

- **REU Programs:** the National Science Foundation (NSF) funds a large number of STEM programs for undergrad research at many universities (e.g. search for “NSF REU Engineering”).
- **Federal agencies and labs:** <https://www.energy.gov/eere/education/internships-fellowships-graduate-and-postdoctoral-opportunities>
- **Other summer research programs:** MIT Lincoln Labs, Johns Hopkins Applied Physics Lab, etc.

**Deadlines are end of Fall Semester to Early Spring Semester
Need 1-2 Letters of Recommendation**

Research at Rutgers

Opportunities all year round

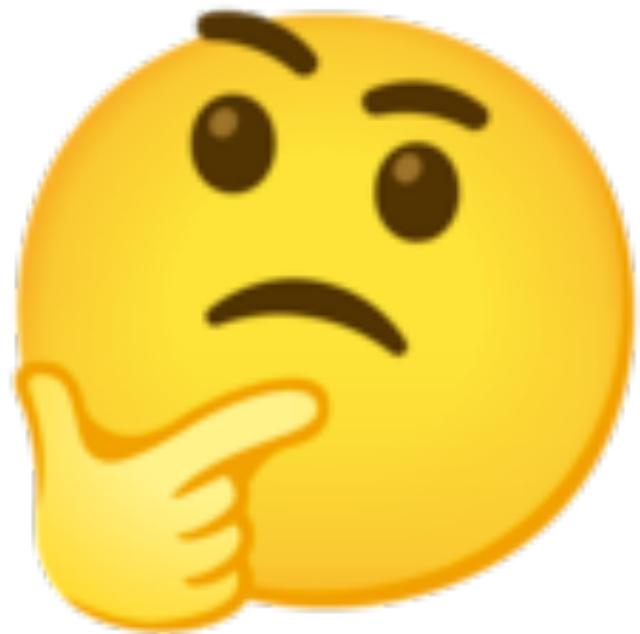
There are summer and school-year opportunities at Rutgers:

- **Aresty Center:** Summer Science Program, Research Assistant Program (2 semesters, 3 credits), <https://aresty.rutgers.edu/>
- **WINLAB Summer Internship:** <https://winlab.rutgers.edu/>
- **Directly working with a professor:** You don't have to only look for opportunities in ECE! The skills ECE students have are in high demand all over campus!

Deadlines vary: sign up for mailing lists!

Looking for a research position

Overview of steps to take



Most professors will not have a job advertisement for “open positions” so you have to ***do some legwork***:

1. **Self-reflection:** what am I interested in and what do I want to get out of it?
2. **Look at your options:** labs/professors’s websites or Google Scholar (<https://scholar.google.com/>) will give you a sense of what they work on.
3. **“Pre-research research”:** challenge yourself by looking at some recent papers.

Google Scholar



Digging a little deeper

Gauging your interests and their interests

1. What projects have they been working on recently?
Research topics are often different than class topics!
2. Try to read the abstract/intro of a paper that sounds interesting.
Show that you have curiosity and self-motivation.
 - What real-world issue this paper is trying to address?
 - What kind of work is involved? Programming? Designing circuits? Lots of experiments and comparisons? Proving theorems?
3. If it seems interesting... email the professor.
Do not copy-paste the same email.

What is deep learning?

Is a “framework” an algorithm?

What kind of imagery?

What is channel selection? What makes it “dynamic”?

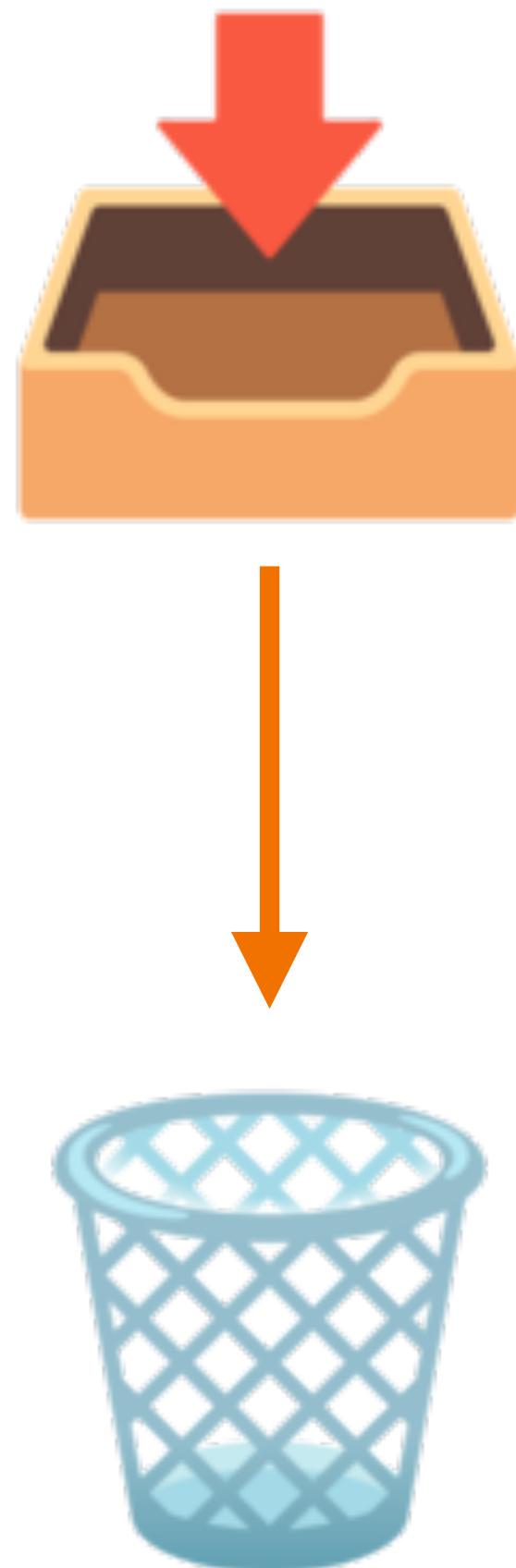
A Deep Learning Framework Based on Dynamic Channel Selection for Early Classification of Left and Right Hand Motor Imagery Tasks

Publisher: IEEE Cite This PDF

Jiazen Hong ; Foroogh Shamsi ; Laleh Najafizadeh All Authors

How not to email

What's wrong with this?



Dear Professor,

I hope you are doing well! My name is [REDACTED] and I am very interested in any research opportunities you might have. I'm attaching my resumé. Please let me know if you have time to meet with me.

Sincerely,

[REDACTED]

Some tips for a good email

Being thoughtful makes a good impression



Things to do in an email:

- **Make it personal:** Introduce yourself!
- **Show that you've done some pre-research research!**
 - Why is research interesting to you?
 - What paper did you look at? What was interesting/confusing?
 - What kind of work are you interested in?
- **Respect people's time.**
 - Suggest a few times you are free.
 - Zoom or in-person or either?



An example email

Don't copy paste this either 😅

Dear [REDACTED]

My name is [REDACTED] and I am a sophomore majoring in ECE. I am taking probability this semester and am enjoying it quite a lot. I wanted to get a chance to use what I learned outside of class and I thought doing a research project would be a good way to do that. I am also considering grad school in the future.

Explains who you are and what you're interested in



Show that you did a little pre-research



Open to new ideas, suggest specific times to meet



I tried to read your paper on “High Dimensional Inference with Random Maximum A-Posteriori Perturbations” but it was a bit challenging for me. I looked up “Gibbs distributions” but I found physics stuff that I wasn’t sure had to do with the image processing in Figure 1. I want learn more about “applied probability” though, especially if there was some programming component. Do you have projects like that?

If you have time to talk about this or other research opportunities, please let me know! I am generally on Busch campus Monday, Tuesday, and Friday, and am free before noon or after 4:40.

Sincerely,

[REDACTED]

Possible responses

It can go many different ways

- **Sure, please come to my office on Monday at 10:** yay!
- **No response:** wait a few days and then send a follow-up.
- **I'm busy for the next N weeks, after that is ok:** do they have time to supervise another project? Can you talk to a grad student?
- **I don't have time for another student:** don't take it personally!
- **I don't have an appropriate project right now:** see above!

Doing research for credit or pay

Feels awkward to bring up...

Many of the more formal research programs offer credit or pay for research.

- More structured programs at RU (Aresty, JJ Slade) give course credit.
- Summer programs (REUs, internships) almost always come with a stipend.

Doing research “informally” with a professor/lab is more complicated because you have to show that you will be able to do the work, will make time for the work, and won’t ghost.

- Cold-calling about registering for “Special Problems” (ECE 491/492) without some track record is often a non-starter.
- Professors sometimes have a budget in the grant to pay hourly but how do you convince them that you’re a good investment?

Is unpaid research worth it?

Maybe, maybe not

How can you build a track record? Many students “try it out” (unpaid) for a semester.

- “Trying it out” gives you a chance to back out if you decide you don’t like it, but it means you are possibly doing work and getting only “experience”.
- The “formal” programs (Aresty, REUs, etc.) have expectations and accountability that “informal” research does not.
- Ask up front whether you can switch to credit/pay if things go well (and what is the criterion for “going well”).

Doing the work

Succeeding in your research experience

- **Get organized.** Consider using a research journal or some other way of keeping track of what you've done and what you plan to do.
- **Be prepared for surprises (good, bad, and ugly).** Research has a lot of starts and stops.
- **Stay in communication with your advisor/mentor.** Don't ghost!
- **Engage in self-reflection.** Remember why you are doing this research project and how it fits into your goals.