



Robotics in Maintenance - Fermilab TARGET Internship

Drew Stephens & Nubia Zapata

Fermilab TARGET Internship 2024 Final Presentation

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Drew Stephens

- Rising senior computer science student at Lane Tech College Prep in Chicago
- FIRST Robotics Team Captain
- Intern as an engineering instructor
- Volunteer robotics instructor

Why Fermilab?

I chose to apply at Fermilab because I am both deeply interested in the research being done here and because I saw it as a good opportunity to network with those my age and meet like-minded people.



Nubia Zapata

- Rising senior at Proviso Math and Science Academy in Forest Park
- Programming co-captain for First Robotics team
- Im currently interested in becoming a biomedical engineer or computer scientist

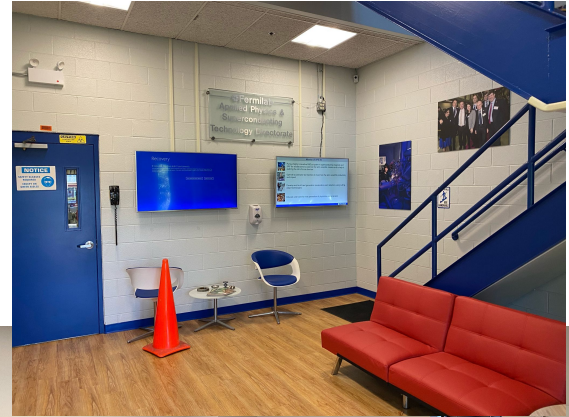
Why Fermilab?

I decided to apply to apply to Fermilab because I wanted to gain experience working in the STEM field, and get to know others who had similar career interests as me.



Our workplace

- We worked at the Industrial Center Building (ICB) in the industrial complex on-campus at Fermilab
- The primary use of our building is to assemble cryomodules for projects around Fermilab
- We interned under an engineering physicist named Vijay Chouhan who has worked at Fermilab for over three years who studied in Japan and India before his time here

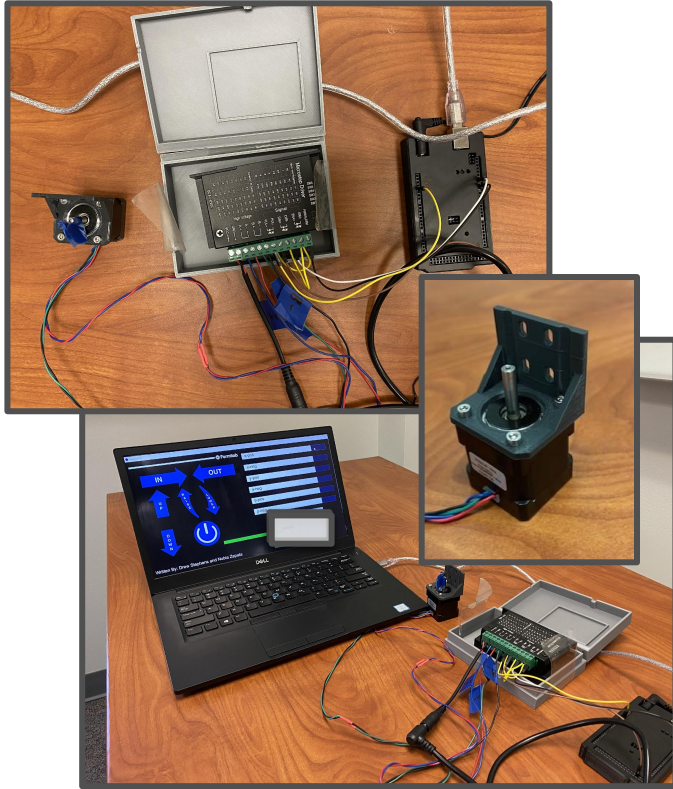


Introduction to our project

- **The goal of our project was to create a robotic arm which aids in the cleaning and maintenance of hard-to-reach spaces here at Fermilab**
- One example of these spaces are cavities, metallic chambers which contain an electromagnetic field needed to accelerate charged particles
- Even one tiny dent or impurity in the inside surface of a cavity can cause RF (radio frequency) power losses, reduced accelerator efficiency, and more

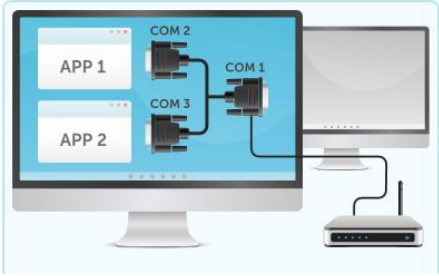
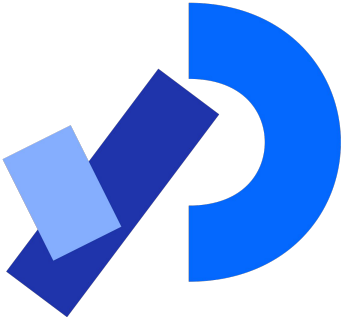


Work with electronics and programming



- To program our device, we primarily utilized an open-source consumer electronics platform known as Arduino
- Being open-source, Arduino allows us to code with full control of its functionalities which we used to our benefit when working with our hardware
- As seen in the photo below, we used stepper motors, commonly found in 3D printers and CNC machines, as well as in some equipment found around Fermilab
- Take a look at some screenshots of the code, as well as the GUI (graphical user interface) on the next slides

Programming languages we used



Our code!

```
serialControl.ino
32 #define stepPinSpin 6
33
34 #define motorInterfaceType 1
35
36 // Create a new instance of the AccelStepper class:
37 AccelStepper stepperXaxis = AccelStepper(motorInterfaceType, stepPinXaxis, dirPinXaxis);
38 AccelStepper stepperYaxis = AccelStepper(motorInterfaceType, stepPinYaxis, dirPinYaxis);
39 AccelStepper stepperPaxis = AccelStepper(motorInterfaceType, stepPinPaxis, dirPinPaxis);
40 AccelStepper steppersSpin = AccelStepper(motorInterfaceType, stepPinSpin, dirPinSpin);
41
42
43 char letter = '\0';
44 int number = 0;
45
46 void setup(){
47   Serial.begin(9600);
48   stepperXaxis.setMaxSpeed(1500);
49   stepperXaxis.setAcceleration(500);
50 }
51
52 void loop(){
53   if(Serial.available() > 0){
54     //=====READING SERIAL INPUT FROM GUI=====
55     if(isDigit(Serial.peek())){
56       number = Serial.parseInt();
57       Serial.print("You entered a number: ");
58       Serial.println(number);
59     }
60     else{
61       letter = Serial.read();
62       Serial.print("You entered a letter: ");
63       Serial.println(letter);
64     }
65     //=====PRESET GUI COMMANDS=====
66     if (letter == 'w'){
67       stepperXaxis.move(800);
68     }
69   }
70 }
```

```
273 public void clear() {
274   cp5.get(Textfield.class,"textValue").clear();
275 }
276 void controlEvent(ControlEvent theEvent) {
277   if(theEvent.isAssignableFrom(Textfield.class)) {
278     println("controlEvent: accessing a string from controller '"
279       +theEvent.getName()+"': "
280       +theEvent.getStringValue()
281     );
282     if(theEvent.getName()=="x-pos"){
283       armX += (float(theEvent.getStringValue()))*0.01;
284       port.write("x"+theEvent.getStringValue());
285     }else if(theEvent.getName()=="x-neg"){
286       armX -= (float(theEvent.getStringValue()))*0.01;
287       port.write("j"+theEvent.getStringValue());
288     }else if(theEvent.getName()=="x-pos"){
289       armY -= (float(theEvent.getStringValue()))*0.01;
290       port.write("y"+theEvent.getStringValue());
291     }else if(theEvent.getName()=="y-neg"){
292       armY += (float(theEvent.getStringValue()))*0.01;
293       port.write("k"+theEvent.getStringValue());
294     }else if(theEvent.getName()=="p-pos"){
295       angle -= (radians(float(theEvent.getStringValue())));
296       port.write("p"+theEvent.getStringValue());
297     }else if(theEvent.getName()=="p-neg"){
298       angle += (radians(float(theEvent.getStringValue())));
299       port.write("l"+theEvent.getStringValue());
300     }
301   }
302 }
```


User's GUI used to control the arm

Fermilab

IN OUT

UP

RAISE

LOWER

DOWN

Power button

x-pos

x-neg

y-pos

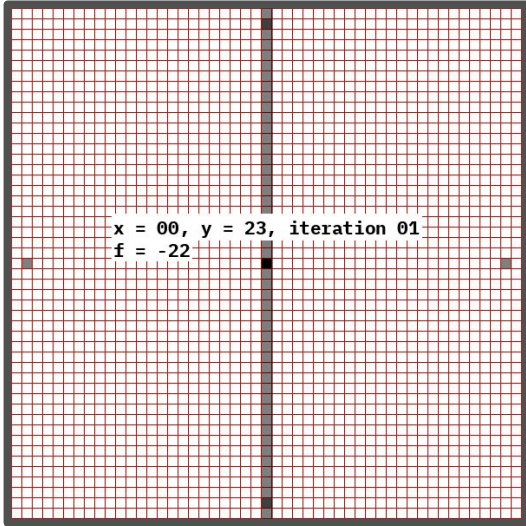
y-neg

p-pos

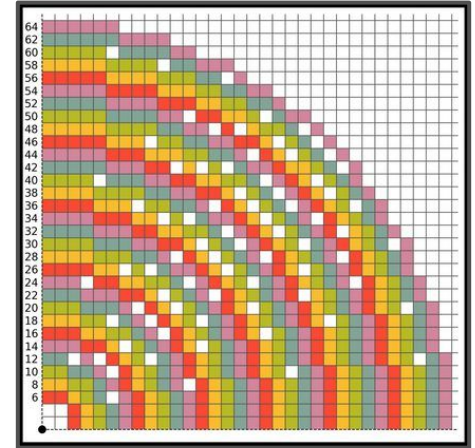
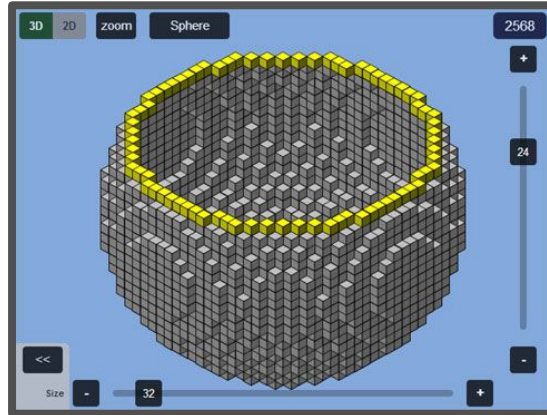
p-neg

Written By: Drew Stephens and Nubia Zapata

Math with the midpoint circle algorithm



- Along with learning more programming languages, we incorporated an algorithm which is used to determine the steps, or movements, needed to rasterize a circle
- Our project was a good opportunity to apply the math taught to us in school to the real world



Favorite workshops

Drew

My favorite workshop was the college admissions workshop where we learned about the process of applying to college such as the important dates to remember.



Nubia

I really enjoyed learning about the daily lives of the particle accelerator operators. It was interesting learning about their journey to working at Fermilab, and some of the crazy things they've experienced while working here.



Favorite tours

Drew

My favorite tour was the walking tour of the campus because it gave me a general idea of the layout of Fermilab as well as what each building is used for.

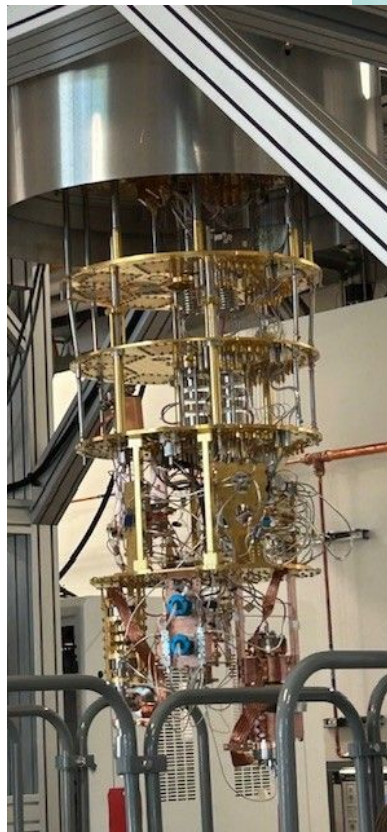


Nubia

My favorite tour was also the tour of the Fermilab campus, because it was our first time really seeing how large Fermilab is, and I liked learning about not just what the buildings were used for, but also a bit about the history of Fermilab.



Tour pictures!



Reflection

Overall, we had a great time at Fermilab! We learned many skills, both related to our project and through the workshops, and were also able to get to know other interns and hear about their interests and projects.



Acknowledgements



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Vijay Chouhan

**And everyone else
who helped us
along the way!**

Thank you for your time!