Snonomo

Pennsylvania Governor's STEM Competition

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Issue/Statistics:

Every winter, snow shoveling accounts for approximately 11,500 injuries and 100 deaths annually. These injuries are caused by strenuous physical activity and loss of balance on slippery surfaces. In a study by the American Journal of Emergency Medicine, researchers recorded over 1,600 cases of cardiac-related injuries between 1990 and 2006 because of people shoveling snow. Elderly citizens, as well as those with preexisting health issues, are put at an even higher risk because of vulnerabilities that develop from age or disease, chiefly a weaker immune system. Furthermore, shoveling a driveway is a time-consuming chore for the average citizen, and people need a convenient, effective solution to this widespread problem.

One of our group's family friends had experienced a fall while cleaning their driveway. During this past winter, there were days where at least 4 inches of snow fell. Our friend's dad had gone to clean this snow off of his driveway to reach work, however, he had slipped and injured his hand. He states, "my hand was injured…It hurt to drive my car to work". This is just one account of injuries while shoveling snow. This is just one account of the 195,000 injuries related to snow cleaning activities.

With more research on this topic, we were able to find that icy driveways have been a root source of many insurance claims and a disruption to neighbor relations. When some people walk long neighborhoods, they may slip in others' driveways and sustain injuries. One true account of this is when Nicole Thompson slipped on a neighbor's driveway. She had sustained severe injuries and simply could not pay for the injuries. She had to do an insurance claim against her neighbor and won her lawsuit, negatively impacting relations between the two parties. All of this could have been prevented had there been a clean driveway, which many people do not consider at the top of their to-do lists.

Solution

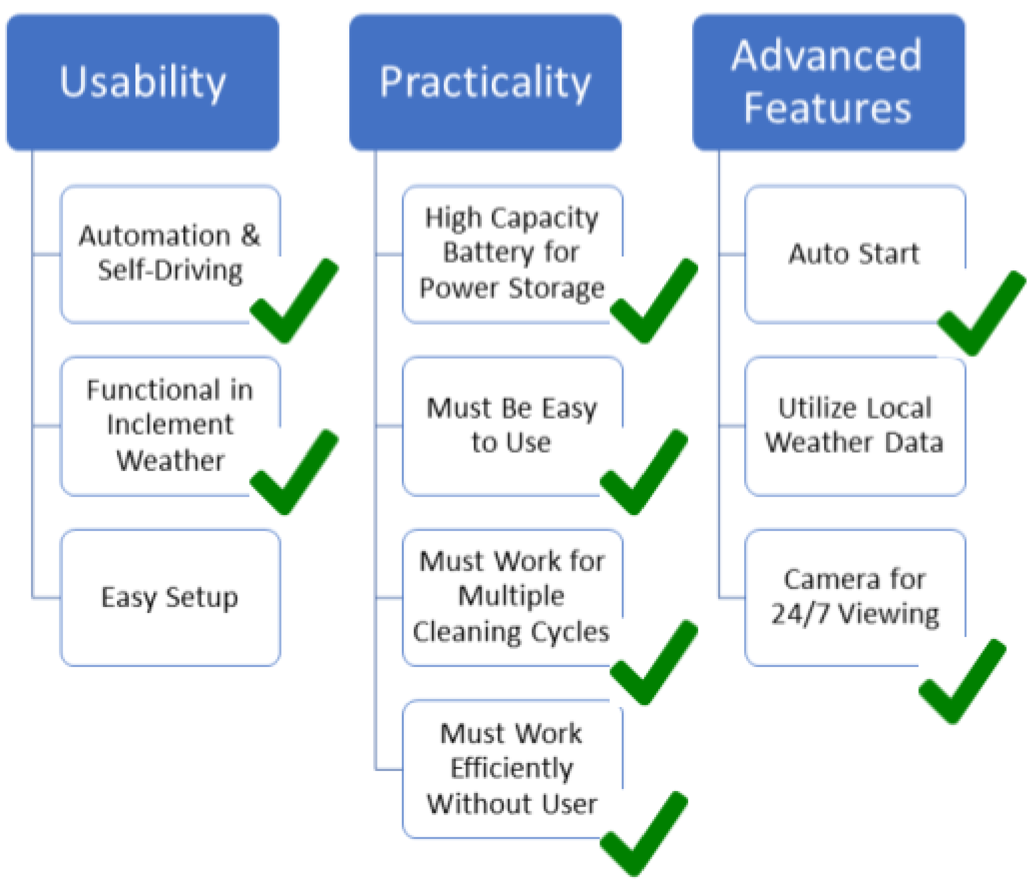
To address this issue, our team has created an autonomous, snow shoveling robot using various hardware and software to ensure clean driveways throughout the wintertime.

Device Inspiration

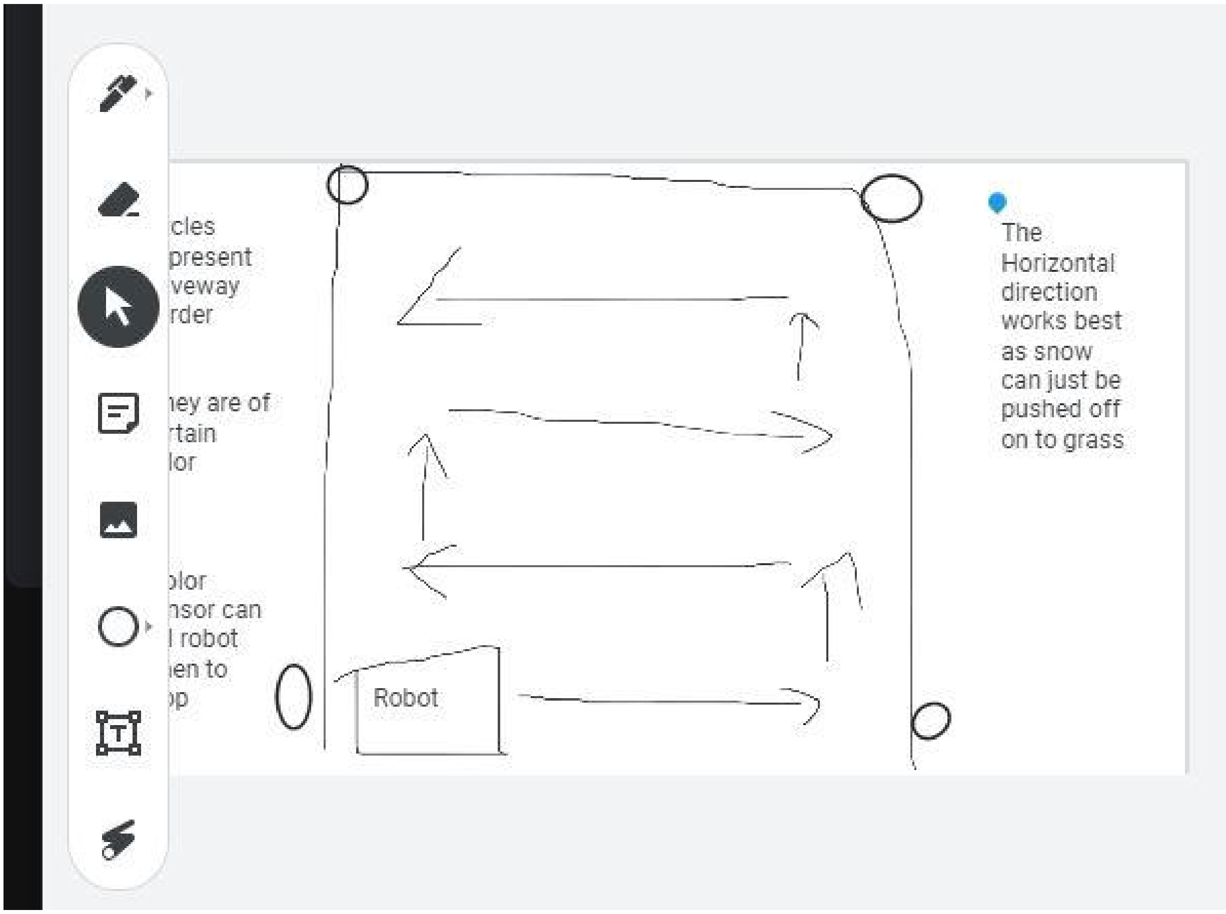
We first thought of this idea when we observed many of our neighbors spending countless hours cleaning their driveways daily during the wintertime. This seasonal predicament birthed our idea to create a snow shoveling robot. We knew there were household cleaning robots on the market such as the Roomba, but we could not find any for automated snow removal.

Device Features/Technicalities

- All Features Thought of During Brainstorming
    - Completed Ones Indicated by Check Mark



Planning


Robot
The Horizontal direction works best as snow can just be pushed off on to grass

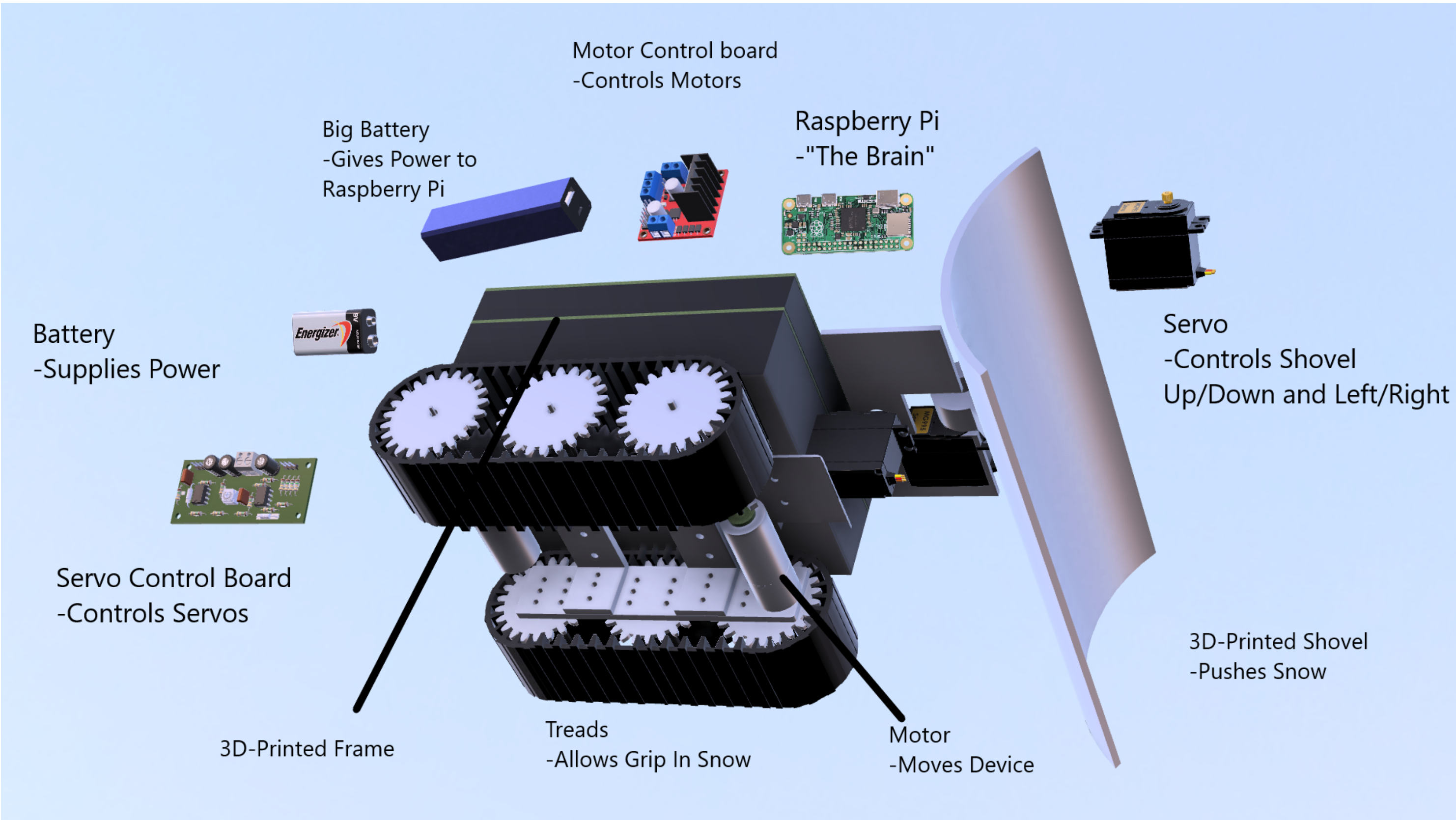
How the Device Works

The autonomous robot is controlled using a Raspberry Pi. A Raspberry Pi is a small computer the size of a Tic Tac box, but with the brains of a PC. This computer runs Python code and uses different libraries to control the robot's different motors, sensors, and servos. The motors move the robot, the servos adjust the scraper's angle and tilt, and the sensors read the robot's surroundings and allow the computer to process it to automatically adjust the robot's angles and direction. The Python code also allows for the user to take over the autonomous features at any time if the user desires to control the robot manually. Code developed over 24 hours including testing, research, and debugging.

Code Snippet:

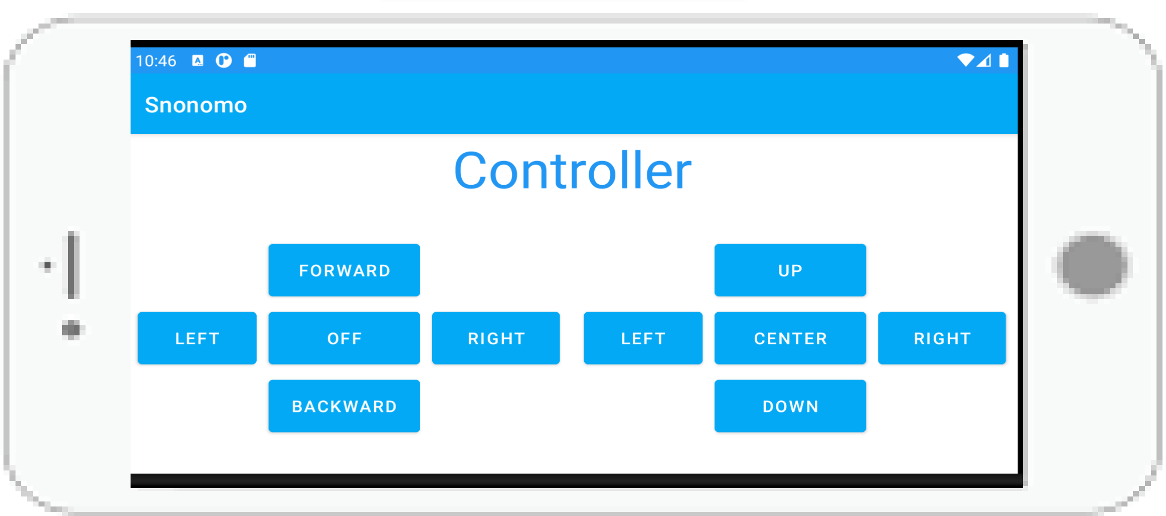
```
def roRight():
    GPIO.output(motor1a, GPIO.LOW)
    GPIO.output(motor1b, GPIO.HIGH)
    GPIO.output(motor1e, GPIO.HIGH)
    GPIO.output(motor2a, GPIO.HIGH)
    GPIO.output(motor2b, GPIO.LOW)
    GPIO.output(motor2e, GPIO.HIGH)
def exitProgram1():
    GPIO.output(motor1a, GPIO.LOW)
    GPIO.output(motor1b, GPIO.LOW)
    GPIO.output(motor1e, GPIO.LOW)
    GPIO.output(motor2a, GPIO.LOW)
    GPIO.output(motor2b, GPIO.LOW)
    GPIO.output(motor2e, GPIO.LOW)
    curses.nocbreak();
    screen.keypad(0);
    curses.echo()
    curses.endwin()
    GPIO.cleanup()
def exitProgram1():
    GPIO.output(motor1a, GPIO.LOW)
    GPIO.output(motor1b, GPIO.LOW)
    GPIO.output(motor1e, GPIO.LOW)
    GPIO.output(motor2a, GPIO.LOW)
    GPIO.output(motor2b, GPIO.LOW)
    GPIO.output(motor2e, GPIO.LOW)

pwm.set_pw_freq(60)


def shovLeft():
    pwm.set_pwm(1, 0, 20)

def shovUp():
   pwm.set_pwm(2, 0, 20)

def shovRight():
   pwm.set_pwm(1, 0, 80)

def shovDown():
    pwm.set_pwm(2, 0, 20)

master=tkinter.Tk()
master.title("Robot Control")

button1=tkinter.Button(master, text="Turn Left", command = roLeft)
button1.place(x=25, y=100)

button2=tkinter.Button(master, text="Forwards", command = roForward)
button2.place(x=100, y=25)

button3=tkinter.Button(master, text="Turn Right", command = roRight)
button3.place(x=175, y=100)

button4=tkinter.Button(master, text="Backwards", command = roBackward)
button4.place(x=100, y=175)

button5=tkinter.Button(master, text="Shovel Left", command = shovLeft)
```

Full Device Build



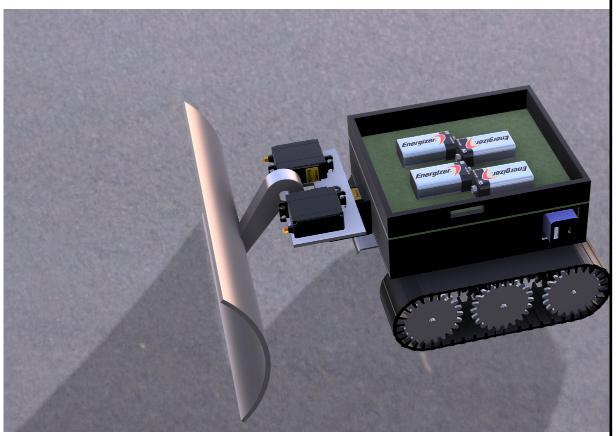
App


10:53
Snonomo
Snonomo
Snonomo
A smart 21st century snow cleaning robot designed for the everyday consumer.
NEXT

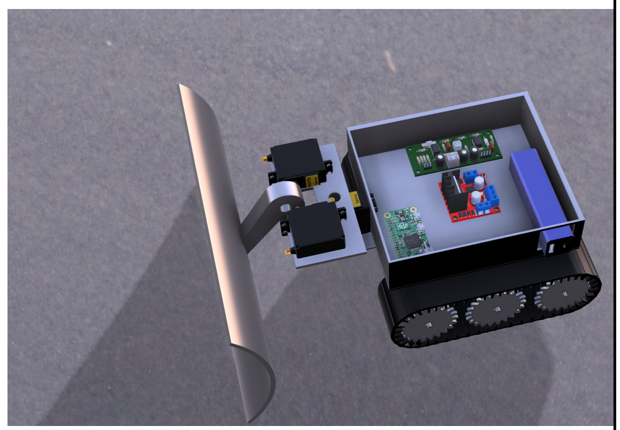

10:46
Snonomo
Controller
FORWARD
LEFT
OFF
RIGHT
BACKWARD
UP
LEFT
CENTER
RIGHT
DOWN

The Snonomo app was created in Android Studio. The app tells the robot what movements to do by a press of a button. For example, pressing forward makes the robot go forward. The app is available on the Google Play Store.

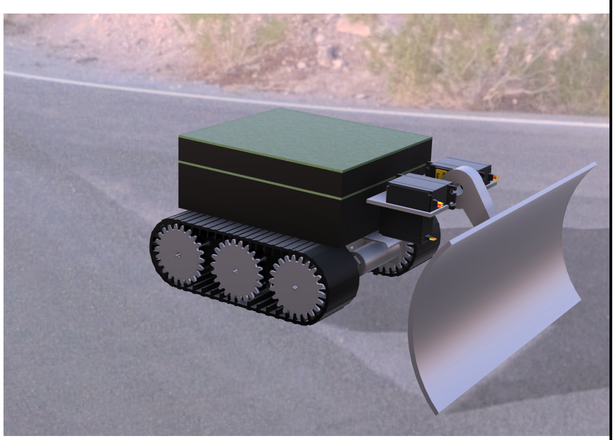
Pre-Build CAD Drawings



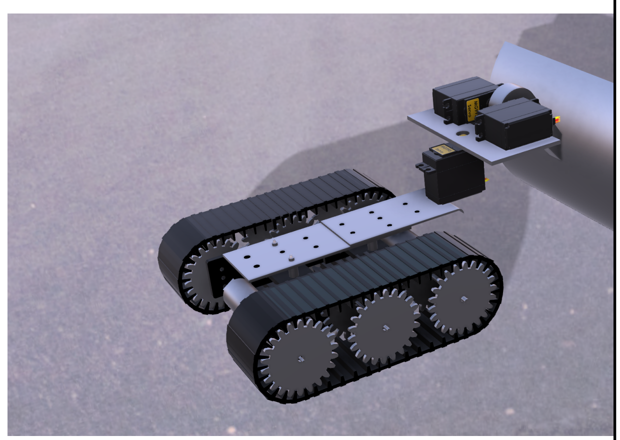
Top Shelf Components



Bottom Shelf Components



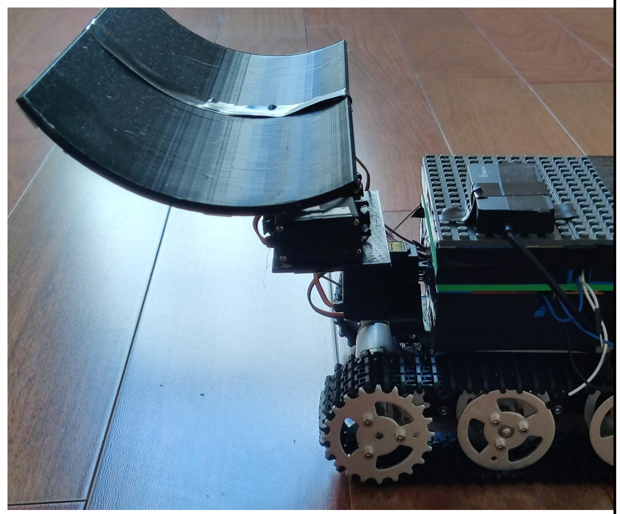
Full View



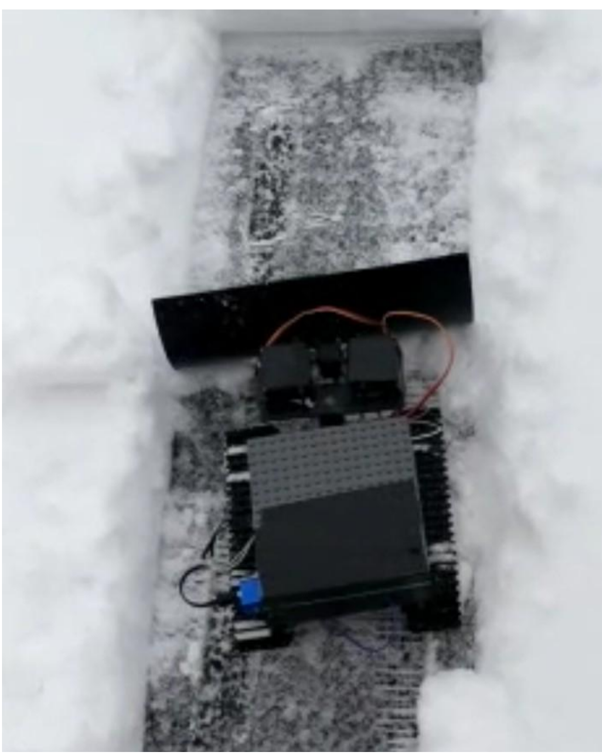
Frame View

Post-Creation Images

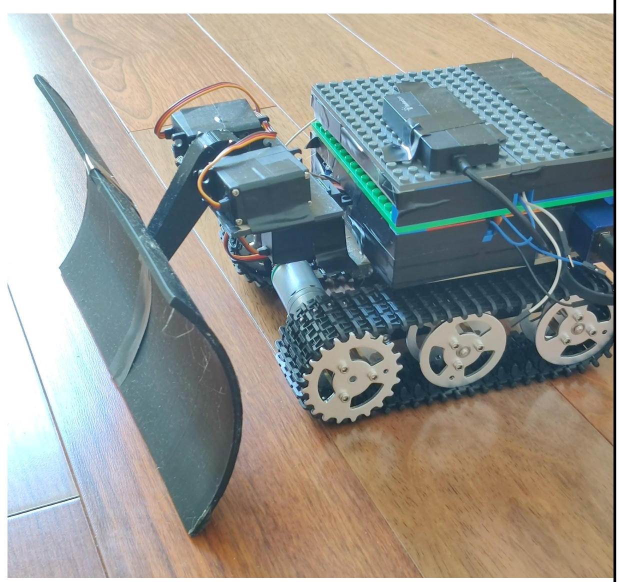
Robot at First Moving Test



Shovel Movement



Snow Removal Test

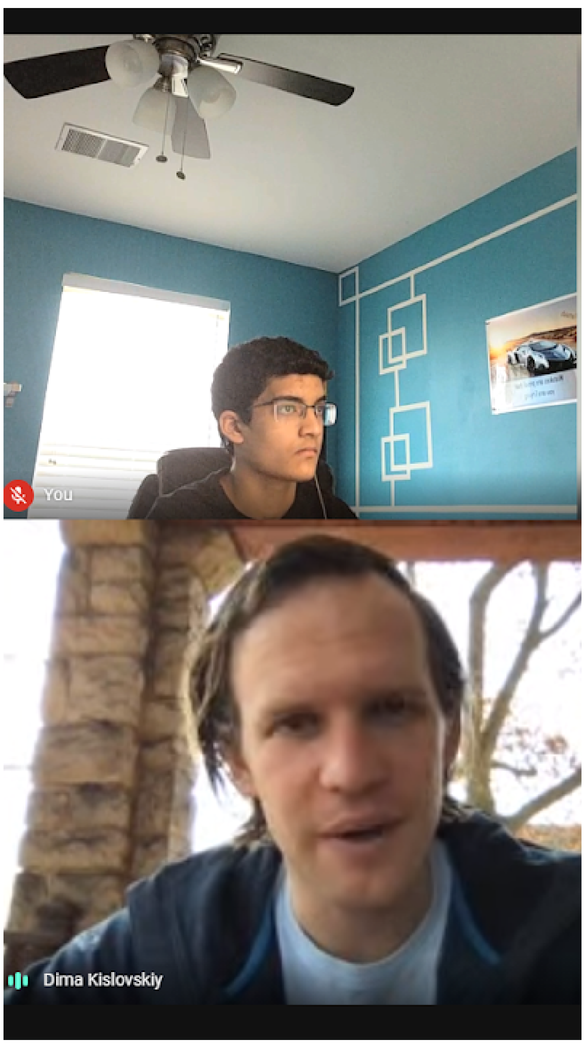


Isometric View

Post-Competition Improvements

1. We plan to make the device a globally used item to ensure more safety during the winter-time
2. The device can have an “ice-breaker”: to break strong pieces of ice
3. The device should be built to withstand strong winds
4. The headlight can be added to make sure of visibility during the night time

Partnership



We have partnered with Aurora Tech to improve our Robot's self-controlling capabilities. With Aurora, we have specifically discussed this with the Director of Product Integration, Dima Kislovskiy. He guided us in our venture to achieve self-driving by discussing different methods of self-driving and how to implement them. He proposed utilizing a GPS and IMU system, which is affordable and offers us a starting point for delving into self-driving. The GPS sensor is used to map out the path the robot should move on and measure where the robot is in relation to the driveway. An IMU sensor uses different technologies like a gyroscope, accelerometer, and other motion sensors to analyze a vehicle's current state of movement. The Raspberry Pi analyzes the input from the IMU to constantly adjust the robot's direction and heading. The GPS and IMU system allows us to begin implementing algorithms and software to achieve self-driving. Mr. Kislovskiy also suggested using a Kalman filter to smoothen out our sensor data and eliminate noise in the measurements. The Kalman filter is an algorithm that uses sensor data from both the IMU and GPS to resolve uncertainties and errors in the data. The Raspberry Pi applies the Kalman filter to post-process the sensor data and move the robot accordingly. The Raspberry Pi works seamlessly with the sensors to accurately drive the robot without human control.

In addition, our team members were able to gain insight on how self-driving technologies are used in the real world and who/how it is created in a mass scale. We plan to follow this path to scale our device and be able to work on self-driving in the future in a large capacity.

In our relations with Aurora, we also discussed with Kat and Gerardo. They assisted us in breaking down how to scale the robot to a market. They shared information that many companies such as theirs already have seasonal cleaning companies. To combat this, we would have to create a leaf blower, and lawnmower to replace these positions. Doing so would allow our device to become a commercial product in addition to the home scale.

Budget

Image	Item	Our Price	Unit Cost (Batch 1000)	Use
	Raspberry Pi	$10.00	$5.18	Control Robot
	Motor Control Board	$7.00	$0.38	Control Motor
	Servos	$24.00	$3.40	Control Shovel Movement
	Servo Control Board	$6.00	$1.81	Control Servo Movement
	Treads/Motor	$48.99	$26.86	Control Vehicle Movement
	TOTAL	**$95.99**	**$37.63**	

Currently, our prototype costs 95.99 dollars. When mass-produced, the cost can decrease to 37.63 dollars.

Resources

https://pubmed.ncbi.nlm.nih.gov/20825768/

https://www.washingtonpost.com/health/the-big-number-snow-shoveling-results-in-about-11500-injuries--including-100-fatalities/2019/12/06/10c46858-178a-11ea-8406-df3c54b3253e_story.html

https://www.google.com/url?q=https://edenapp.com/blog/at-what-age-should-you-stop-shoveling-snow/%23:~:text%3DResearch%2520shows%2520that%2520snow%2520shoveling,to%2520people%2520of%2520all%2520ages&sa=D&source=editors&ust=1613184020113000&usg=AOvVaw0Kmv8W6whyYJJDxVJ8cEqo

https://www.injuryclaimcoach.com/slip-and-fall-lawsuit.html

Introduction to Kalman Filter and Its Applications | IntechOpen

Robust GPS/GNSS: Driving the Future of Autonomous Vehicles | CAST Navigation