SpAceD juNkies

Aerospace Capstone Project

Team: SpAceD juNkies

Members:

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Autumn Edwards

Sukti Tiwari

Desvaun Drummond

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Summary/Abstract

What is space junk? Space junk is not very different from environmental pollution that we have here on Earth. Before the first satellite, Sputnik, was launched into space in 1957 there was no space junk. Since then it is estimated that there are 30,000 pieces of debris larger than a softball in space and more than 100 trillion untracked pieces of space debris in earth's orbit. What we call space junk is any debris left behind by humans in space which is a result of collisions, wear and tear, dropped tools, etc.

The SpAceD juNkie is an autonomous robot that will collect space debris for various reusable means. The solution design has a camera based sensor which scans the debris and determines if it should be stored in the attached basket (for smaller items) or net (for larger items). The robot has a net and basket connected to it and a robot hand that will grab debris and place it in the attached net/basket. The robot has an attached GPS tracker and it is connected to the database that is used to track space debris. Because it is attached to the database it can efficiently go and collect the debris.

For this year a proof of concept was developed to show that the autonomous system is successfully able to identify an object of interest. The chosen object of interest for this project is a tennis ball which was chosen because of its size in comparison to the average dimensions of space junk.

Problem Statement

The need of the Aerospace Corporation's complaint of reducing the amount of space junk and the expense of building new materials that are sent into space is to provide a means of collecting space junk to be reused in the future while being environmentally friendly.

The revised/ proof of concept problem statement states : The SpAceD juNkies autonomous robot will identify an object of interest (a tennis ball).

Design Requirements

Product/Software Specifications

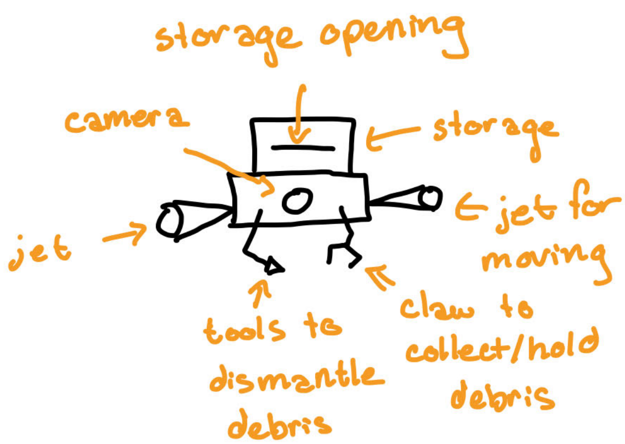
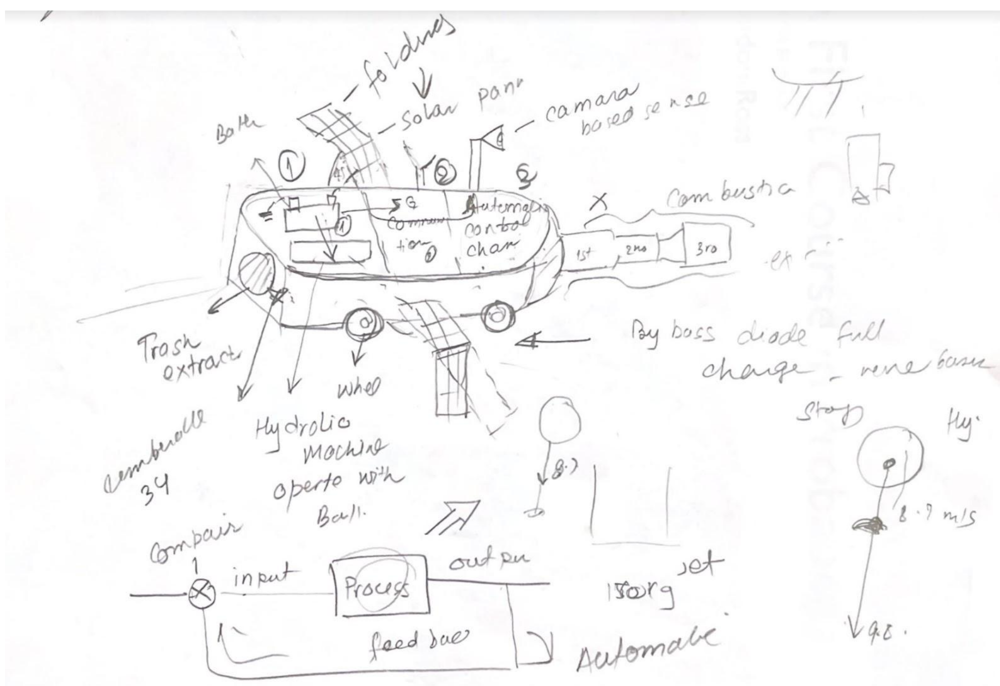
Jetson Nano	NVIDIA Jetson Nano Developer Kit
Web Camera	Logitech C920x HD Pro Webcam
CSI Camera	DEVMO 5 Million Pixels CSI Interface Camera
Solar Charger	Sunny Buddy Solar Charger V13

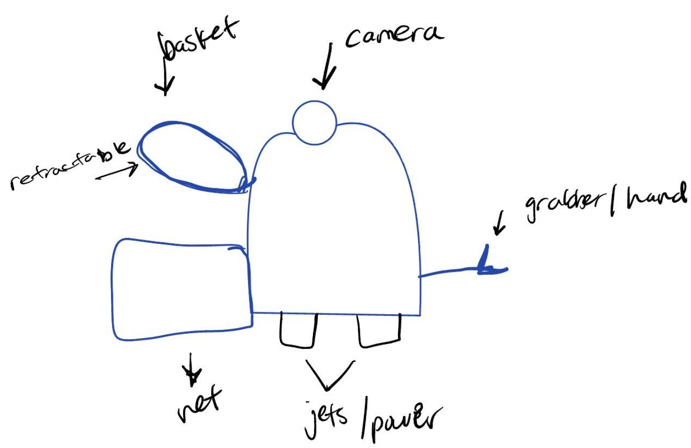
Lithium Batteries	CBJJ 4PCS 3.7 Volts Lithium Ion Battery
Arduino	ELEGOO Uno Project Super Starter Kit Compatible with Arduino IDE
Step Up Converter	1pc MT3608 Boost Converter DC To DC Adjustable Power Converter
Motors	Servo Motor MG995
Laser	Quarton Laser Module VLM 650-03
Satellites	

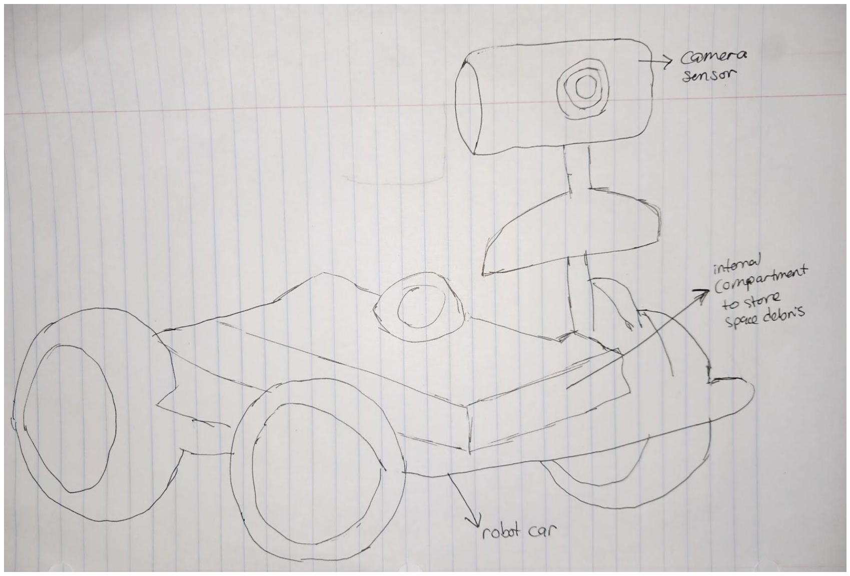
Constraints

Environmental Constraints	Some batteries may not be good for the environment, so use environmentally friendly batteries. Similarly, use environmentally building materials (for robot body)
Socio-Cultural Constraints	Make sure the robot does not grab things it should not, as this could be considered offensive. Also ensure the robot does not go to places it should not for similar reasons.
Compliance (Rules, Regulations, and Standards)	i) Ensuring it satisfies the company rule and the state protocol ii) Ensure it satisfies space regulations

Individual Designs

Nora	 Have a robot with machine learning capabilities. It has multiple jets to help it get around and a camera. It also has tools and a claw to dismantle and collect debris.
Sukti	 This robot is divided into chambers

	1. Power Chamber 2. Communication chamber 3. Automatic control chamber 4. Combustion **Power chamber**: Battery is connected to the solar panel. Whenever the battery discharges, the solar panel charges the battery. It also works as a solar car. The hydraulic system works as the trash extractor and thrower, which creates pressure when throwing the net to collect the trash. **Communication chamber**: This chamber communicates with the user and lets the user know about the location around the robot and the abnormalities. **Automatic control chamber:** This chamber comprises a camera-based sensor that detects the trash and uses the comparator to check the specific limit of the garbage. It is interconnected to all the chambers. If the debris is full, the robot goes to the earth's surface using an umbrella and drops the trash in its disposable net. Again, the robot comes up using the umbrella and does its function. **Combustion chamber**: The combustion chamber is optional.
Autumn	 The on board camera based sensor scans the debris and determines if it should be stored in the attached basket (for smaller items) or net (for larger items). The robot has a net and basket connected to it and a robot hand that will grab debris and place it in the attached net/basket. The robot has an attached GPS tracker and it is connected to the database that is used to track space debris. Because it is attached to the database it can efficiently go and collect the debris.

Desvaun	 To determine if this project idea can be modified and implemented for space debris on a larger scale, this representation is to test if the idea can first work on a smaller scale. A camera based sensor is mounted on a robot car and there is a built-in compartment on top of the car to store the object. A small test object will be used to represent space debris. Once the sensor is locked onto the exact position of the object, a robotic arm on the car will grab the object and guide it to the storage compartment.

Selection of 2 Designs Using Pros and Cons

	Pros	Cons
Nora	• Tools to dismantle debris is an excellent Idea because it can hold more debris in the storage	• Possibly not enough space for storage
Sukti	• Net may be beneficial for easy collection	• 12 x 12 cm is small
Autumn	• Two different collection areas requires less of a limit on size	• Could being attached to the database take more time?
Desvaun	• We are able to see if the project is worth expanding to a more	• There may be an increased difficulty to fully automate the

	sophisticated system for commercial applications once the idea can be implemented on a simpler level	process of moving an object to the storage compartment due to the design

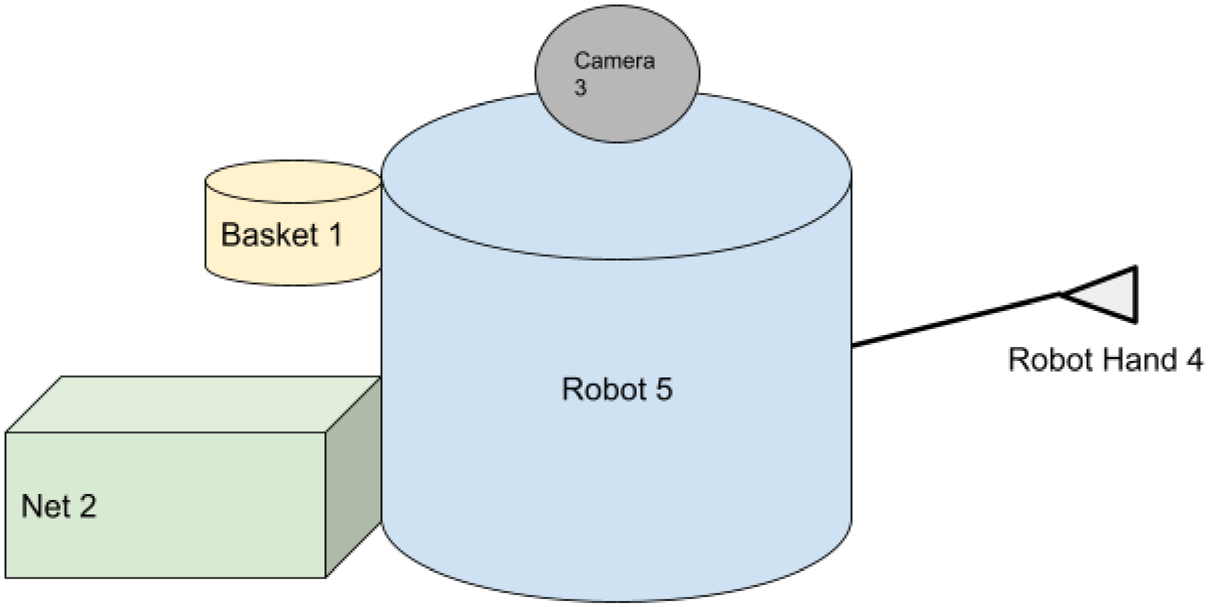
End Result: The two designs that we chose based on the Pros and Cons table are Autumn’s and Desvaun’s.

Decision Matrix

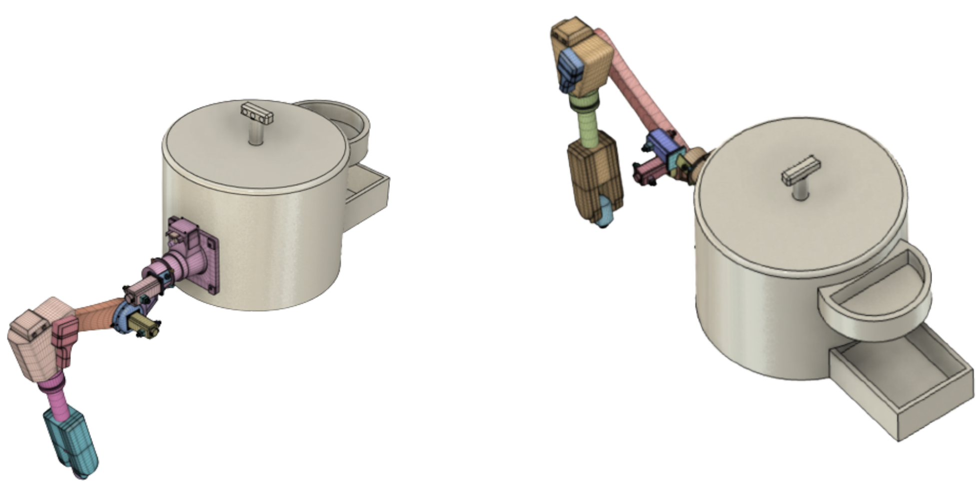
	Storage Space	Space Wt	Available Tools	Tools Wt	Movement	Movement Wt	Computing Equipment	Computing Wt	Results
Autumn's	7		6		4		4		5.5
Desvaun's	5	0.3	3	0.3	6	0.1	6	0.3	4.8

Autumn’s design is chosen based on the decision matrix above.

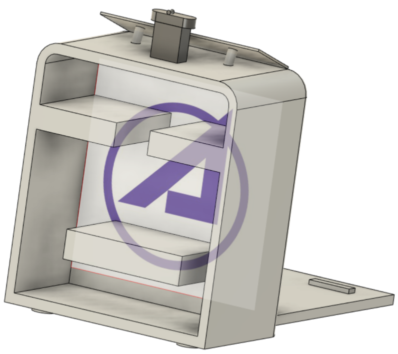
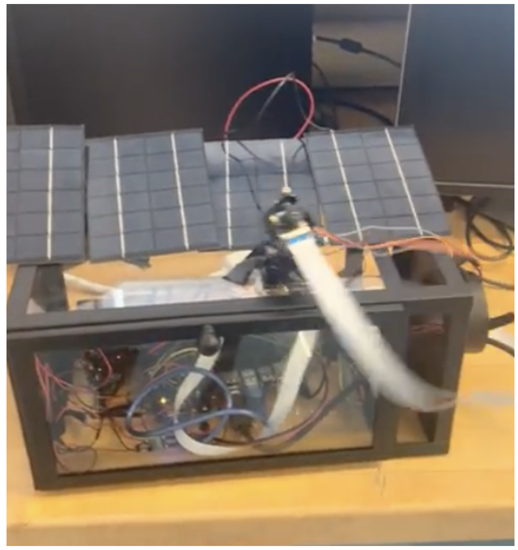
Description of First Semester Design



The on board camera 3 based sensor scans the debris and determines if it should be stored in the attached basket 1 (for smaller items) or net (for larger items) 2. The robot has a net 2 and basket 1 connected to it and a robot hand 4 that will grab debris and place it in the attached net 2/basket 1.



Description of Second Semester Design

The final design consists of a chassis that holds the satellites with the camera, motors, and lasers attached to the Jetson Nano and Arduino.

Project Implementation

*agile workflow
*weekly implementation plan

Sprint #	Increments	Start Date	End Date	Weekly Development Tasks
1	Object Detection Code	02/07/23	02/15/23	Develop Code
		02/14/23	02/21/23	Microprocessor Implementation
2	Power System	02/21/23	03/03/23	Solar, Battery, and Voltage Conversion
		03/03/23	03/06/23	NO WORK - Spring Break
		03/06/23	03/14/23	Connect to Microprocessor

3	Sensors	03/14/23	03/21/23	Add Camera
		03/21/23	03/28/23	Add Proximity Sensor
4	Final Assembly	03/28/23	04/04/23	Connect motors and laser
		04/04/23	04/11/23	Final tests and debug

Project Implementation Process

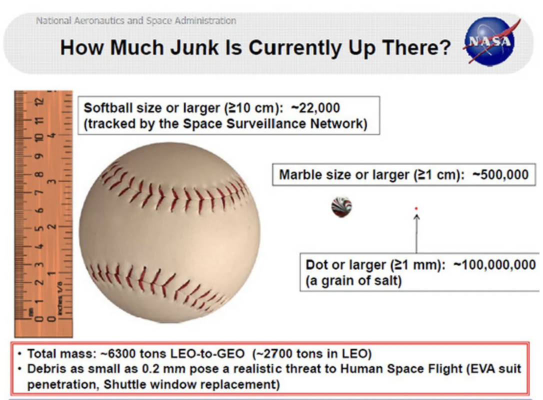
Parts :

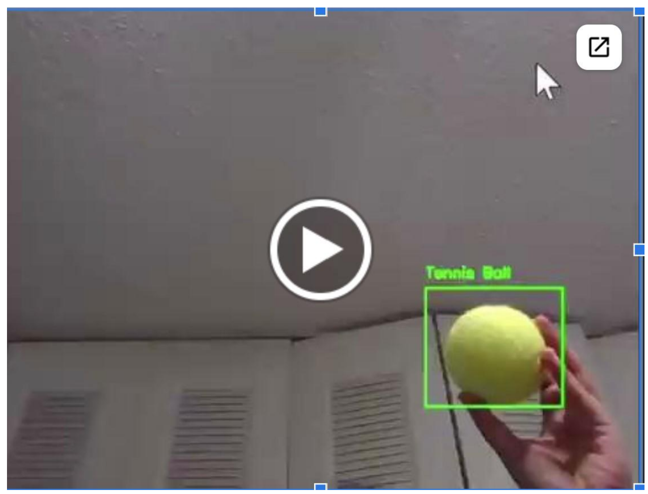
Part Name	Part Use	Link
Batteries	voltage supply	link
Solar Panel	voltage supply	link
Solar Battery Charger	Solar to battery	link
Step Up Battery Regulator	Step up battery voltage to 5 V needed	link
Jetson Nano	processor	link
Raspberry Pi Camera	Camera	link
Servo Motors	motors	link
Laser Pointer	Point the object	link
breadboards	connection	link

Step 1: Object Detection Code

To begin, we connected the Jetson Nano microcomputer to a webcam in order to test its functionality. Since our objective was object detection, we developed a facial detection code and successfully confirmed that it could accurately detect faces. However, we encountered lag issues with the webcam and ultimately decided to switch to the Raspberry Pi Camera for continued use.

After confirming that the camera was working properly, we proceeded to develop a code for object detection with the specific goal of detecting tennis balls. We chose this object as it is similar in size to space debris that we are interested in detecting

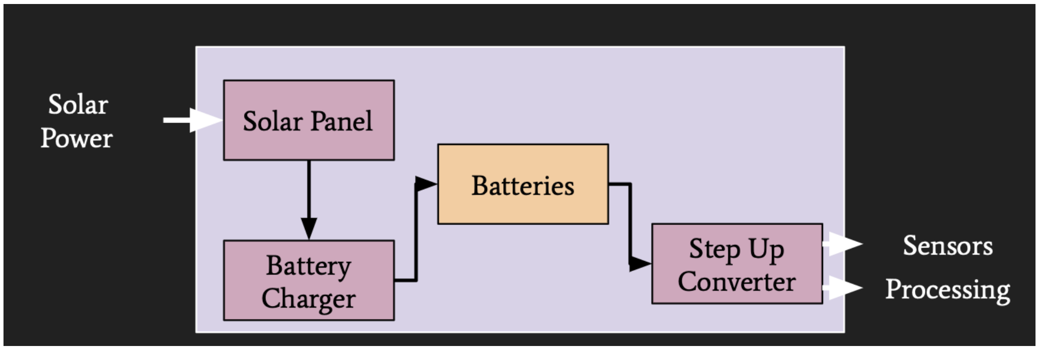




For the code for the object detection.This code employs computer vision techniques to identify the presence of tennis balls in a video stream by applying a color mask to the frames, extracting contours, and then creating bounding boxes and labels around the detected objects. The output video shows the identified tennis balls enclosed by green boxes with labels.

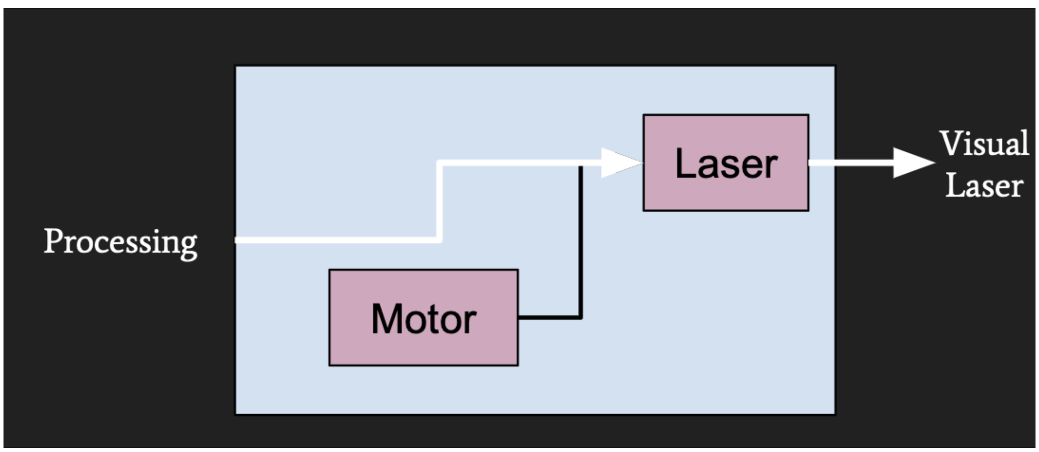
Step 2: Power System

We decided to use a solar power system to power our autonomous robot. In order to store the solar energy we utilized a solar battery charger to supply the batteries with the solar energy. From there we utilized a step up converter to convert the 3.7 V batteries to 5 V which is used to power the Jetson Nano. The diagram below shows the various steps of the power system.



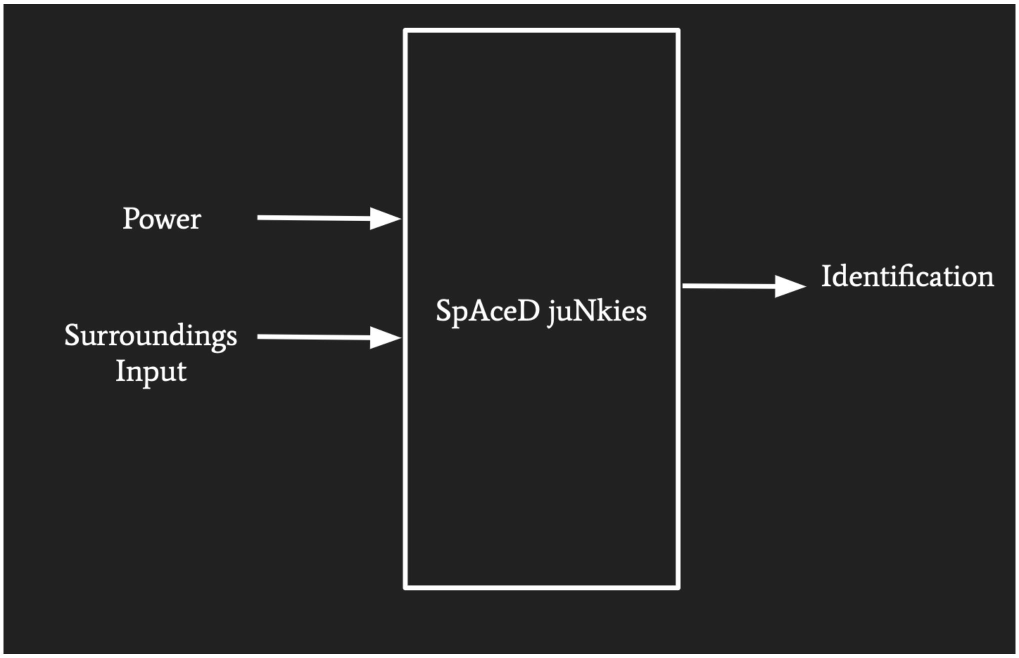
Step 3: Sensors

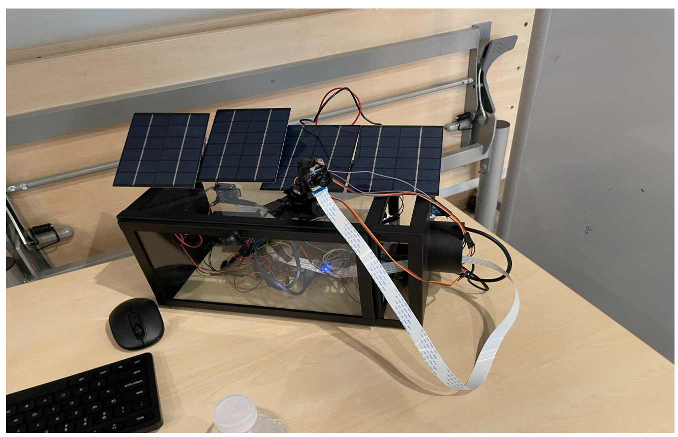
A vital portion of this year's proof of concept was the sensors. This section connected the motors and laser to the autonomous system via a breadboard and arduino IDE. Utilizing the arduino for this setup was vital to the success of motors because of their compatibility with the Arduino IDE.



Step 4: Final Assembly

During the final assembly we were able to successfully complete our proof of concept and show a working system that is able to identify a tennis ball through the means of a laser turning on when detected. We completed our final setup as seen in the pictures below with the solar power system.





Conclusions

In summary, the Aerospace Corporation's request to reduce space debris and lower the cost of sending new objects into space inspired our project. Our aim is to develop an environmentally friendly solution for collecting and reusing space debris. Because this is a multiyear project, our focus for this year was on image detection. However, in the coming years, we plan to design a robot with an arm and basket equipped with the onboard sensors that will scan debris and determine if it should be stored in the attached basket for smaller items or the net for larger items. The robot has both a net and basket connected to it, and a robot hand that will grab debris and place it in the appropriate storage unit.

References

Jones, C. (Mentor, Aerospace Corporation)
Etchey, S. (Mentor, Aerospace Corporation)

https://www.nasa.gov/mission_pages/station/news/orbital_debris.html
https://www.nhm.ac.uk/discover/what-is-space-junk-and-why-is-it-a-problem.html
https://github.com/topics/face-detection