Developer Guide

System Overview

The Swiss Army Spider is designed to move a payload over a 3D plane the size of a piece of letter paper. The payload is attached to three strings which are individually retracted and fed via stepper motors. Stepper motors allow for precise movement control (to three hundredths of an inch per line) while supporting a large range of speed controls with a maximum speed of 30 inches/second per line. Through the Python-implemented GUI, the system can intake a single G-code command line, a text file containing G-code commands, or user inputs from a joystick to control the payload across the 3D plane. The biggest challenge for this project was having to work remotely due to COVID. This limited our ability to work collaboratively in person, as well as use some of the tools and other resources available if the project were held in person.

Electrical Specifications

Max Supply Voltage	35V
Min Supply Voltage	8V
Max Supply Current	2.0A
Nominal Supply Current	1.5A
Holding Torque	40 Ncm per motor
Dent Torque	2.2 Ncm per motor
Operating Temperature	60 Degrees Celsius

Table 1: Electrical Specifications Table

User Guide

Set up

1. When motors are not powered, they must be reset to an initial position.
2. Pull the payload down to the bottom most point of the paper
3. Align the center of the payload with the center and bottom most point of the paper
4. Turn the motors to tighten the strings until each is taut and there is no slack in any of the three threads.
5. Insert in desired tool / writing utensil to begin tests. Ensure the marking device is making contact with the paper.

Wiring

1. Connect each of the V_{mot} pins of the A4988 to the 12 V_{DC} source.
2. Connect each of the V_{ref} pins of the A4988 to the 5 V_{DC} pin of the Arduino.
3. Connect the red wire of the motor cable to A2, blue wire to B2, green wire to A1, and black wire to B1.
4. Connect direction pin of A4988 to D# of the Arduino (# is the even pins assigned in code).
5. Connect step pin of the A4988 to the D# of the Arduino (# is the odd pins assigned in code).
6. Tie all grounds together, and connect back to the Arduino ground pin.
7. For the light sensor, JP1 requires 5 V_{DC} on the pin closest to the edge of the PCB, ground on the inner pin, and an analog pin from the Arduino connected to the pin tied to the resistor (this final pin is determined by code).

Code

Complete Code Setup and Use:

1. Download the current version of Python (v3.9.2 as of March 4th, 2021)
   Go to the official website and click 'Windows' to download the Windows version.
   Click the latest Python release link, and download 'Windows 64 bit installer'
   Run the installer and let it install Python.
2. Download VSCode
   Go to the official website and click 'Download for Windows'.
   Run the installer and let it install VSCode.
   Once opened, click on the 'Extensions' tab on the left sidebar.
   Search the 'Python' extension and install it.
3. Download the Arduino IDE
   Go to the official website and click "Get" under "Windows App"
   Allow the Microsoft store to install the program.
4. Install the necessary Arduino libraries
   Go to tools -> manage libraries
   Search for 'AccelStepper'
   Install the AccelStepper library by Mike McCauley Version 1.61.0
5. Install the necessary Python libraries
   Open the command prompt by pressing the "Windows" key and typing 'cmd' into the search box.
   In the command prompt, enter the following commands:
   'pip install pygame'
   'pip install numpy'
6. Download the 'main_GUIversion.py' file

This file contains the source code for the G-Code implementation.

7. Download the [Arduino.ino file]()

    Open the file in the Arduino IDE

    Connect the Arduino to your computer via usb.

    Select 'COM4' as the Arduino serial port.

    Compile and Upload the .ino sketch to the Arduino

8. Compile and Run 'main.py'

    In the VSCode window, click on 'Run' and then click on 'Run without debugging'. This should open up the GUI.

9. Choose a file or enter a command

    Commands can be entered into the entry box or a file can be selected from the file explorer.

10. Connect a joystick (i.e. PS4, XBOX360) to the computer.

    Click on "Enter Controller Mode" to operate the payload using the left joystick.

    Press 'X' (on PS4) to exit controller mode.

Design Artifact Figures

<u>Block Diagrams</u>

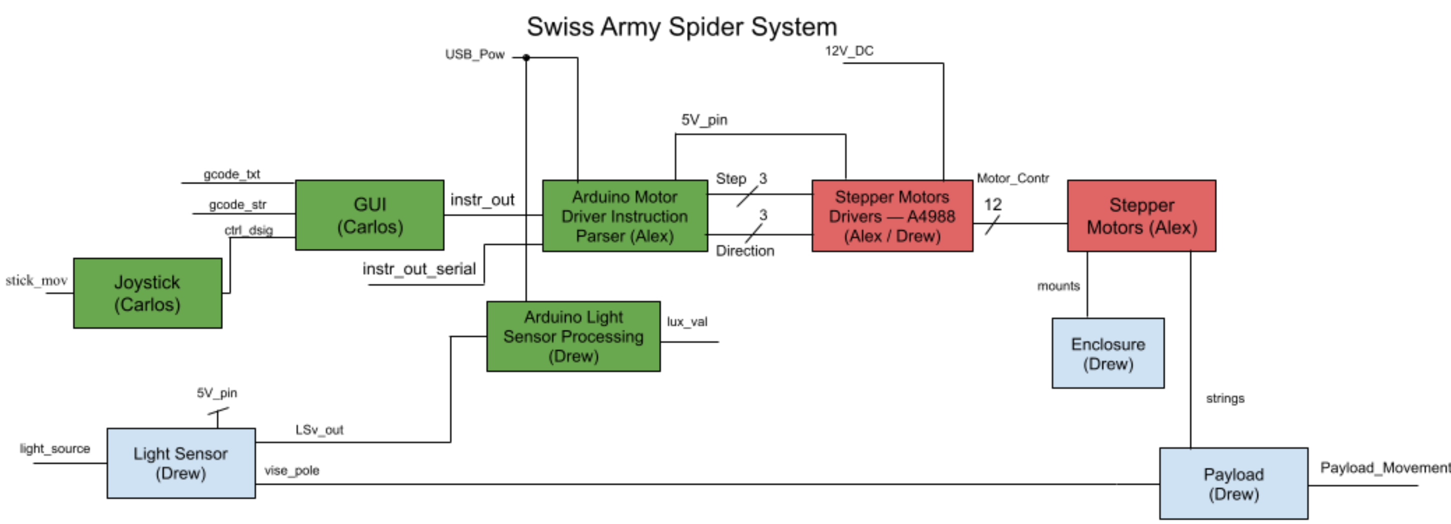

Figure 1: Top Level Block Diagram

The block diagram seen in Figure 1 has three main components: Software/firmware (green), mechanical (red), and manufacturing(blue). The mounts, strings, and vise_pole are all physical connections between blocks. The light_source is physical light, the stick_mov is physical joystick movement, and Payload_Movement is the physical movement of the payload. gcode_txt, gcode_str, ctrl_dsig, instr_out, instr_out_serial, and lux_val are all digital signals sent communicated through the USB channel. USB_pow, 5V_pin, 12V_DC, Step, Direction, and Motor_Contr are all wired communication signals.

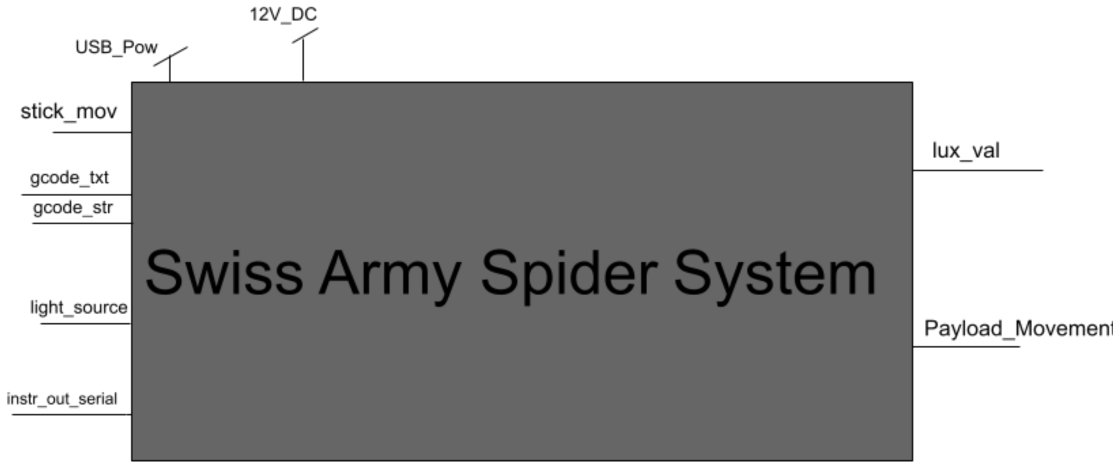

Figure 2: Block Box Diagram

The system is intended to operate with a varying light source input, and either instructions through the serial monitor, a G-code string, a G-code text file, or joystick movement. The 12V_DC source is from a wall-wart connector. The output for lux value can be seen on the Arduino serial monitor while Payload_Movement is the physical movement of the payload.

<u>Schematic</u>

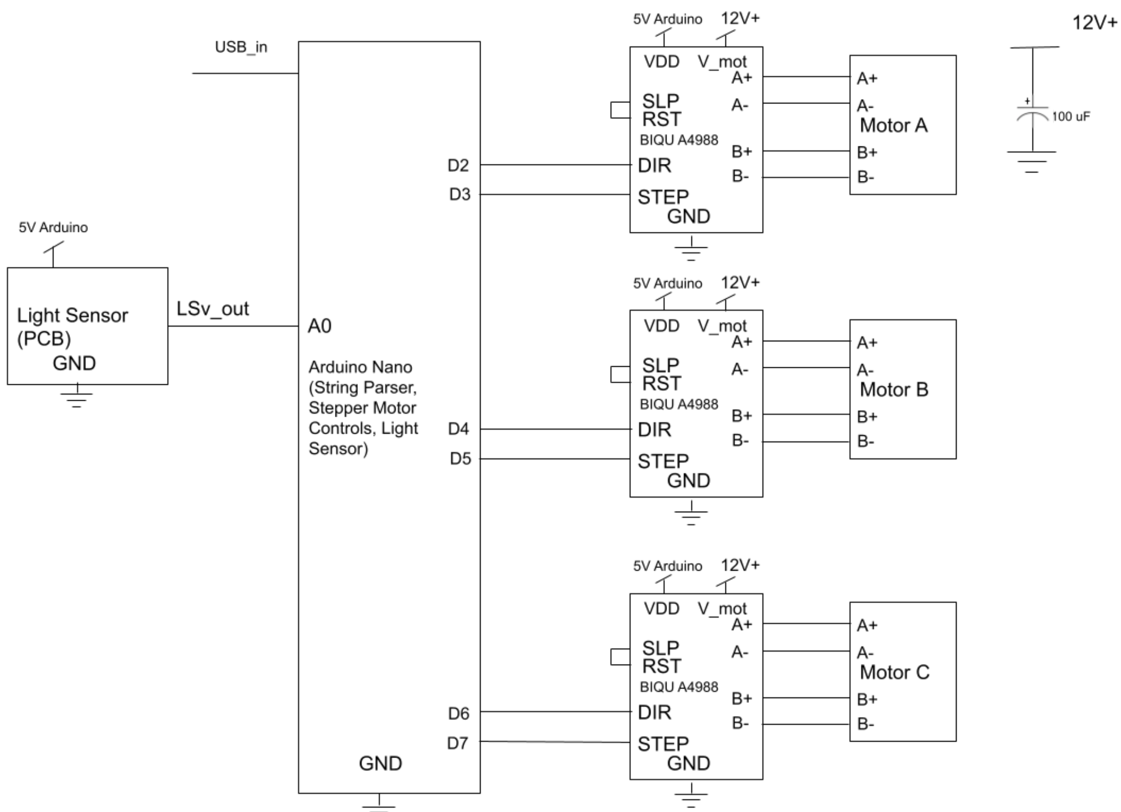

Figure 3: Complete Electrical Schematic

There are two wired inputs into the Arduino Nano: the light sensor output voltage, and the USB cable. Make sure that the light sensor is not being powered with a voltage greater than 5V as the Arduino is only rated for 5V in. For the motor drivers do not power VDD and V_mot with the same voltage. VDD is only rated for 5V whereas V_mot's minimum input voltage is 8V and maximum input voltage is 35V. The output power to the motors is designed to be 1.5A per motor, so work carefully with these wires. Make sure there is a large electrolytic capacitor between V++ and ground for the V_mot input as voltage spikes can damage the BIQU A4988 motor drivers. The SLP and RST pins on the motor driver should be shorted together and every pin not defined in Figure 3 should be left isolated.

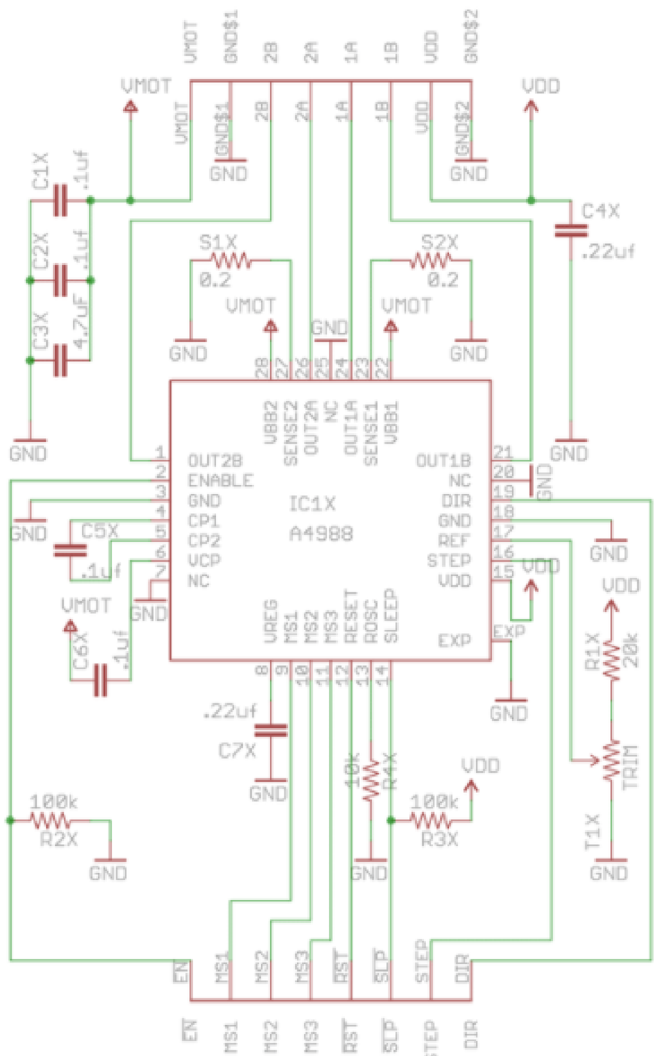

Figure 4: BIQU A4988 Electrical Schematic (source)

These connections should all be pre-installed on the BIQU A4988 motor driver. They are provided here for a better overall picture of how the motor driver functions and any issues that may arise during operation. The inputs to the driver are seen on the bottom in red and the outputs to the driver are seen at the top in red.

<u>3D model</u>

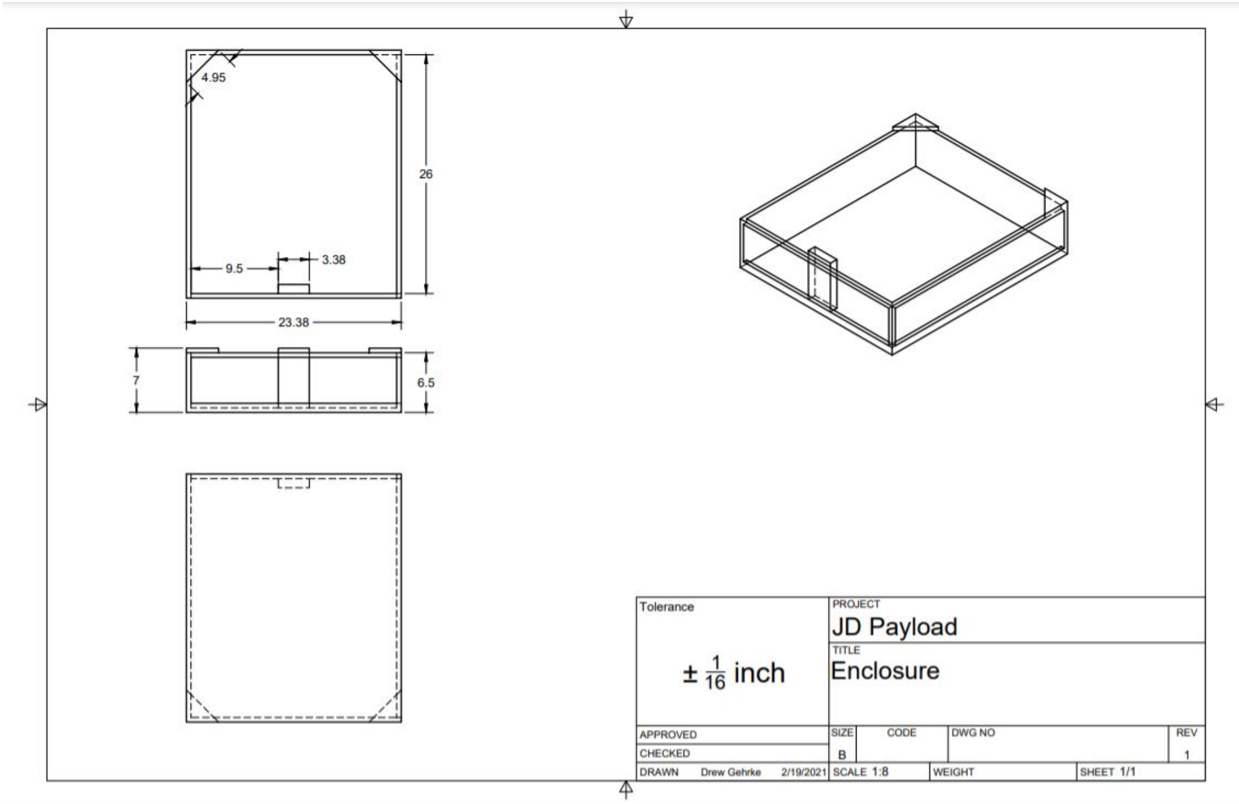

Figure 5: Enclosure 3D Model

The enclosure was constructed with pieces of spare wood from the woodshop at OSU. Two of the sides of the enclosure have openings to allow for easier access to electronics or for viewing capabilities, if needed. Eye hooks were affixed to the top most corners where triangles are located, and one affixed to the top of the block seen at the bottom most point of the enclosure. The actual enclosure is within roughly a 1/16th of an inch. A clipboard was mounted in the center of the enclosure to provide a stable point for a paper to rest and for less Z-axis movement required from the system.

PCB information

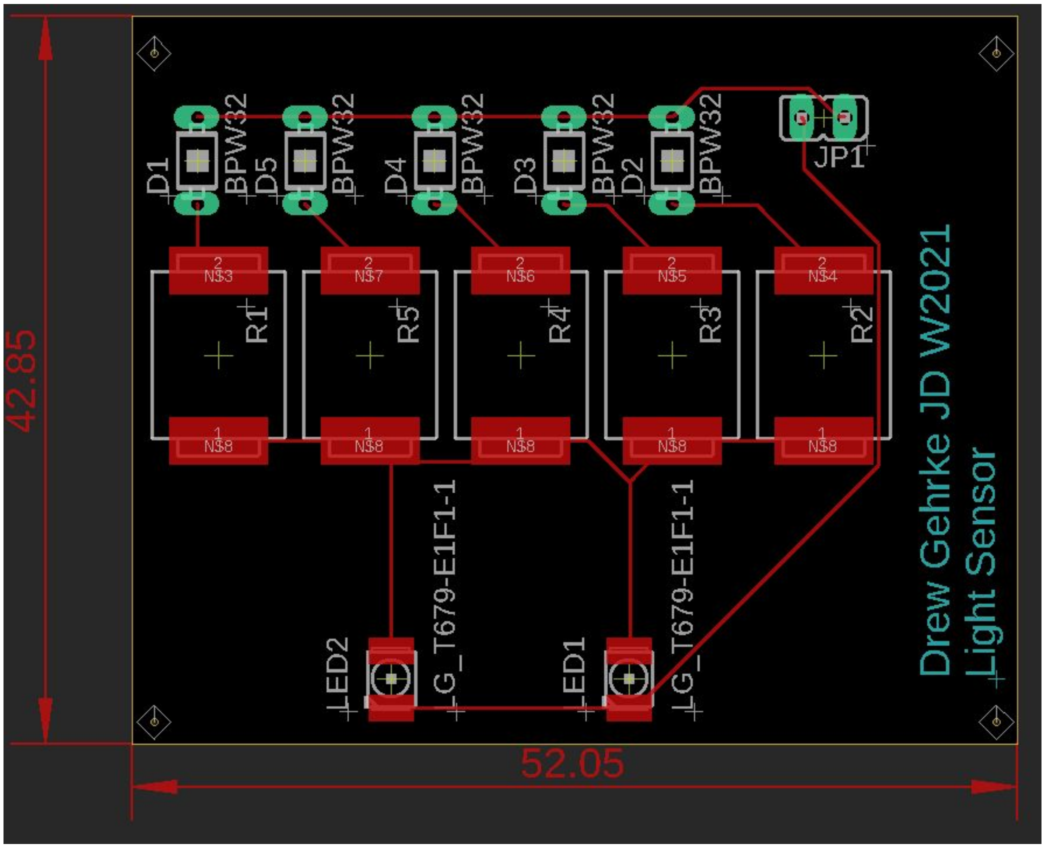

Figure 6: PCB Trace and Dimensions

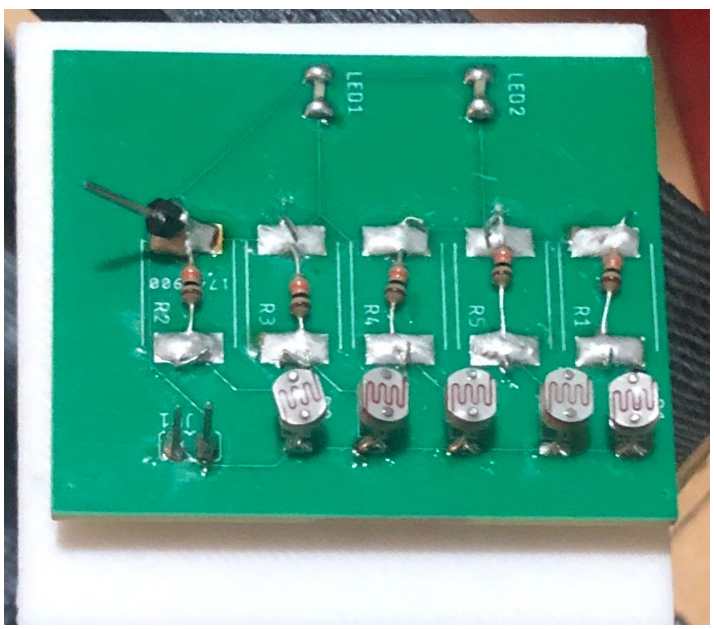

Figure 7: Physical PCB Image

Part Information

Part	Part No.	Unit Price	Quantity	Shipping Cost	Total Price
Jumper Cables	EL-CP-004	$0.06	37	$0.00	$2.15
Prototype Board	B01N3161JP	$9.99	1	$0.00	$9.99
Stepper Motor	17HS4401	$8.66	3	$0.00	$25.99
A4988 Motor Driver	BIQU-K203	$3.17	3	$0.00	$9.50
100 uF electrolytic capacitor	A-0002-F01f	$1.86	3	$0.00	$5.57
50-100k ohm Photocell	GL5539	$5.99	1	$0.00	$5.99
100k Ohm Resistor	EFR-W0P25-A:MF	$0.06	5	$0.00	$0.28
Arduino Nano	EL-CB-005	$2.28	1	$4.99	$7.27
		$0.00			$0.00
12V 3.5A Switching Wall Adapter	AD898F20	$9.00	1	$0.00	$9.00
PCB	H1W-335735	$10.00	1	$20.00	$30.00
Wood for enclosure	N/A	$8.00	1	$0.00	$8.00
Clear String	JN0.30W-F	$2.88	1		$2.88
Styrofoam	N/A	$6.99	1	$0.00	$6.99
Eye Hooks	N/A	$1.66	3		$4.99
DC Power Connectors Power Jacks	PJ-102AH	$0.72	1	$0.00	$0.72
Total Cost					$129.32

Figure 8: Part List