Follow-Me Lunar Camera Drone

Team Bevo-nauts

Clara Ashley, Michal Harris, Javier Diaz de Sandi, Ivan Lopez, Fabian Maldonado
Faculty: Dr. Joshua Keena (instructor), Dr. David Fridovich-Keil (advisor)
NASA Mentor: Chatwin Lansdowne

Contact Information
mem7525@my.utexas.edu

1. Abstract

The Lunar Camera Drone concept is a lightweight, BLE-guided, aerial platform designed to autonomously track astronauts and record visual data during lunar surface operations. The system uses pneumatic thrust, solenoid-valve control, and onboard sensors to maintain stable flight in low gravity. The goal is to minimize astronaut workload while enhancing mission documentation.

2. Background

Historically, lunar mobility has relied on wheeled rovers and rocket-propellant landers. A few examples include the Apollo Lunar Roving Vehicle (Fig. 1), VIPER (Fig. 2), Firefly's Blue Ghost (Fig. 3), and the Ingenuity helicopter (Fig. 4)

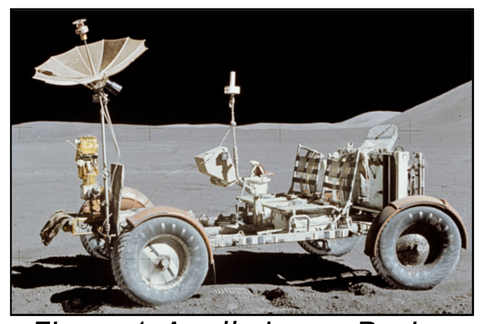
Figure 1: Apollo Lunar Roving Vehicle

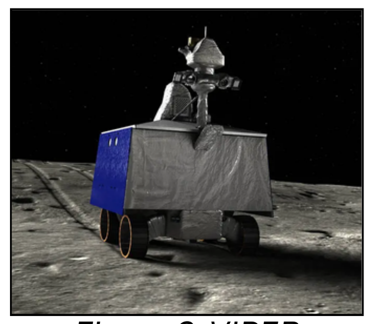
Figure 2: VIPER

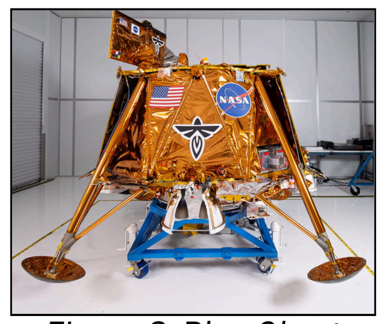
Figure 3: Blue Ghost

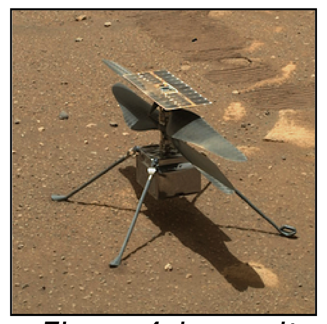
Figure 4: Ingenuity Helicopter

4. Pneumatic System

The drone uses compressed air expulsion as a means of propulsion. With a nozzle diameter of ⅛-inch, initial calculations estimate the thrust to be around 0.735lbs per nozzle, allowing for a total thrust of about 2.93lbs. Using a compressed air outlet in the available lab, two 2-liter bottles are pressurized to around 60psi, which each supply two solenoid valves and their corresponding nozzles (Fig. 8).

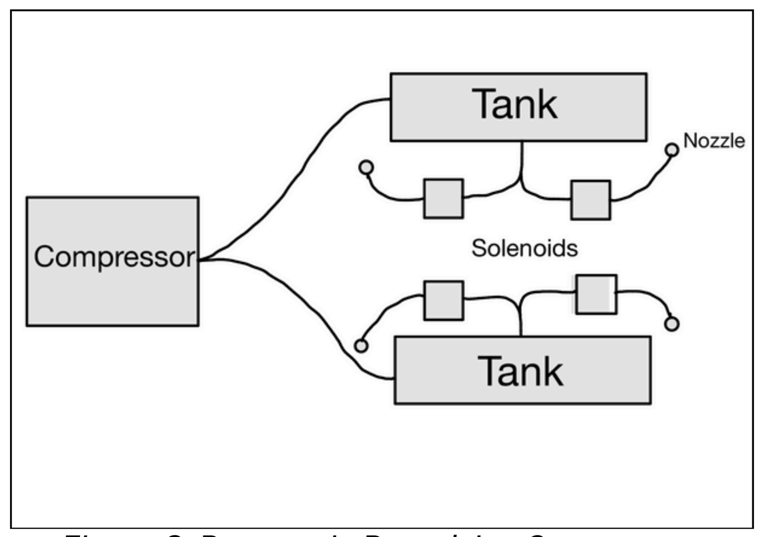

Figure 8: Pneumatic Propulsion System

Figure 9 shows simulated flights of the drone considering different total thrust values. The plot indicates that the total ideal thrust of 2.93lbs is enough for a 25-foot travel distance and 20 ft of altitude if the drone weighs 1.5lbs in lunar gravity (1.62 m^2/s or 0.165g).

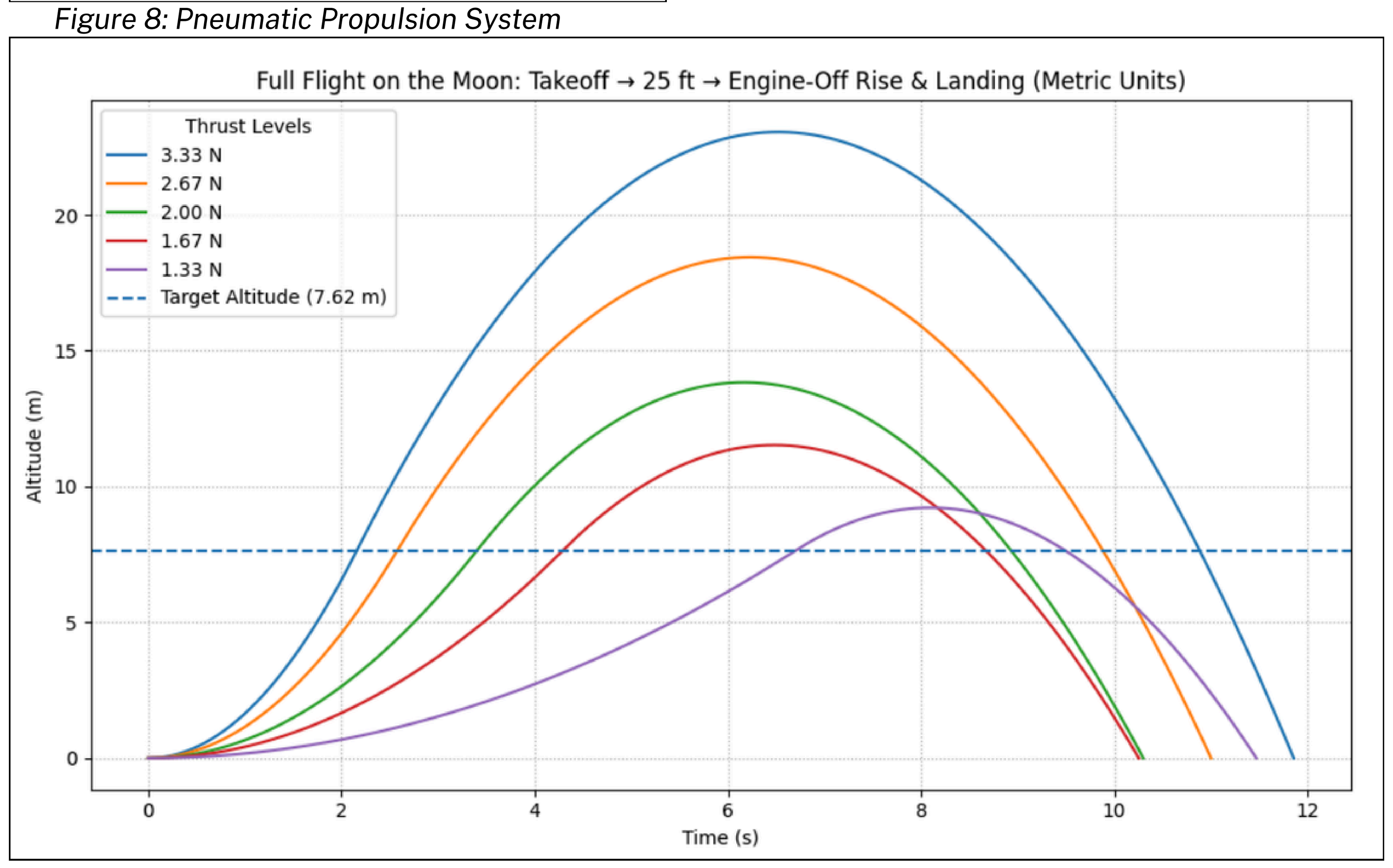

Figure 9: Altitude Reached at Varying Thrusts vs Time

Design Overview

Using a morphological matrix, unweighted and weighted Pugh charts, and initial calculations, the team chose a nimble drone design. Figures 5 and 6 show initial sketches of concept variants from the morph matrix.

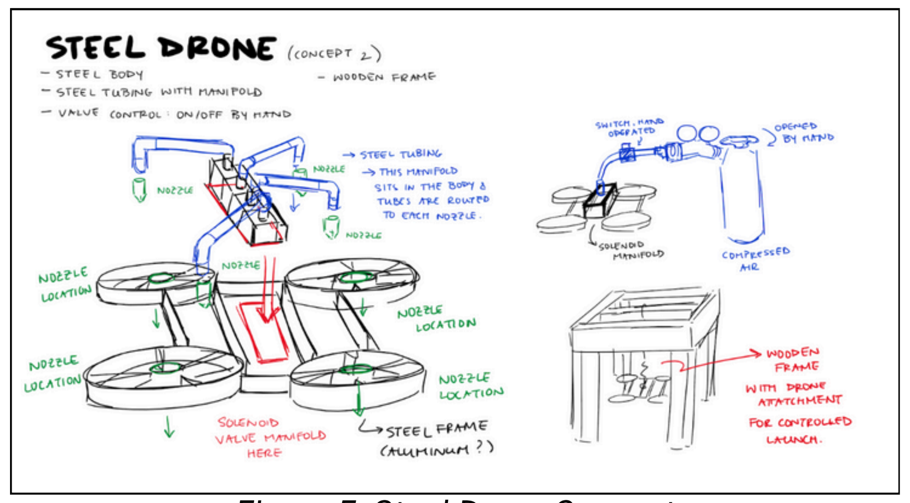

Figure 5: Steel Drone Concept

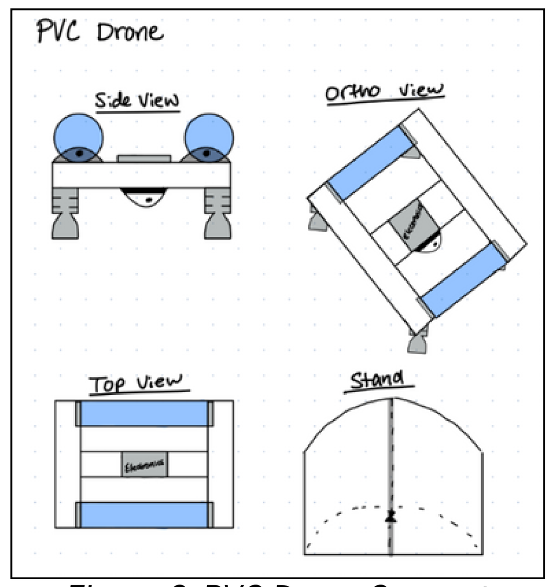

Figure 6: PVC Drone Concept

The final design is a laser-cut drone body made of pine for quick prototyping, a soft plastic tubing pneumatic system with solenoid valves, a unique valve control system for compressed air propulsion, and four cylindrical propulsion outputs. Figure 7 shows the computer-aided design (CAD) of the drone body. Two 2-liter bottles were chosen as intermediate compressed air tanks for distribution to the pneumatic system.

5. Valve Control System

The nozzle output and the balance of the drone is controlled by a closed loop feedback control system, although the system is still in progress. An accelerometer determines any significant deviation in any primary axis ('X', 'Y', or 'Z'), from which an Arduino Uno sends the command to any solenoid to open more or less frequently. By opening and closing rapidly using PID control, the drone will make small adjustments. Figure 10 shows simulated thrust command initiation versus craft hover time using the valve control system.

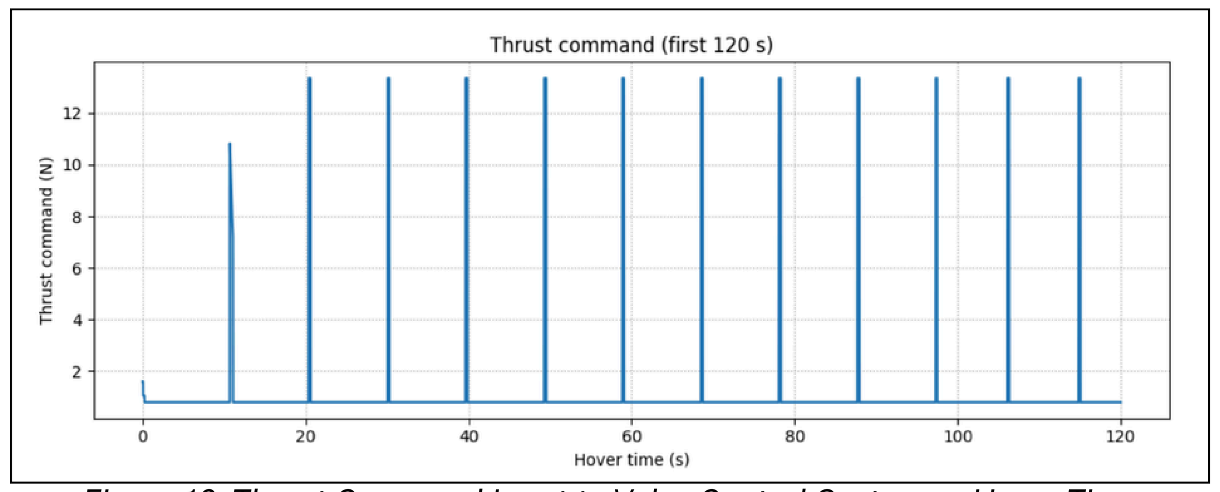

Figure 10: Thrust Command Input to Valve Control System vs Hover Time

The valve system closed loop feedback control is described in Figure 11 below.

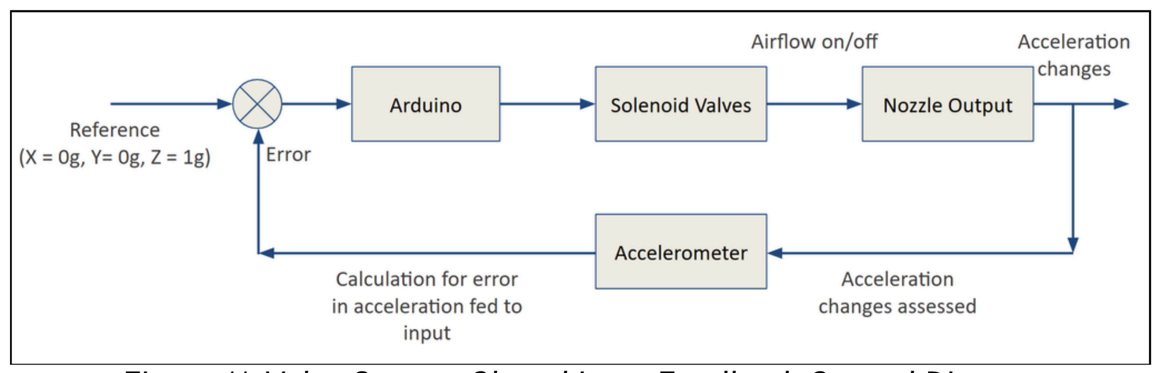

Figure 11: Valve System Closed Loop Feedback Control Diagram

6. Electronics

The drone concept tracking method makes use of bluetooth low energy (BLE) and beacon for maintaining a set distance from the user. This distance is measured constantly using the Received Signal Strength Indicator (RSSI) method, although this feature is also in progress.

3. Problem Statement

Lunar exploration requires inexpensive, robust, hands-free, aerial craft, which are few and far between. This project hopes to create a lunar drone prototype which will solve the above problems by staying within budget, meeting the load capacity requirements of carrying greater than 0.5 lbs, autonomously following the user, and flying for longer than 20 minutes.

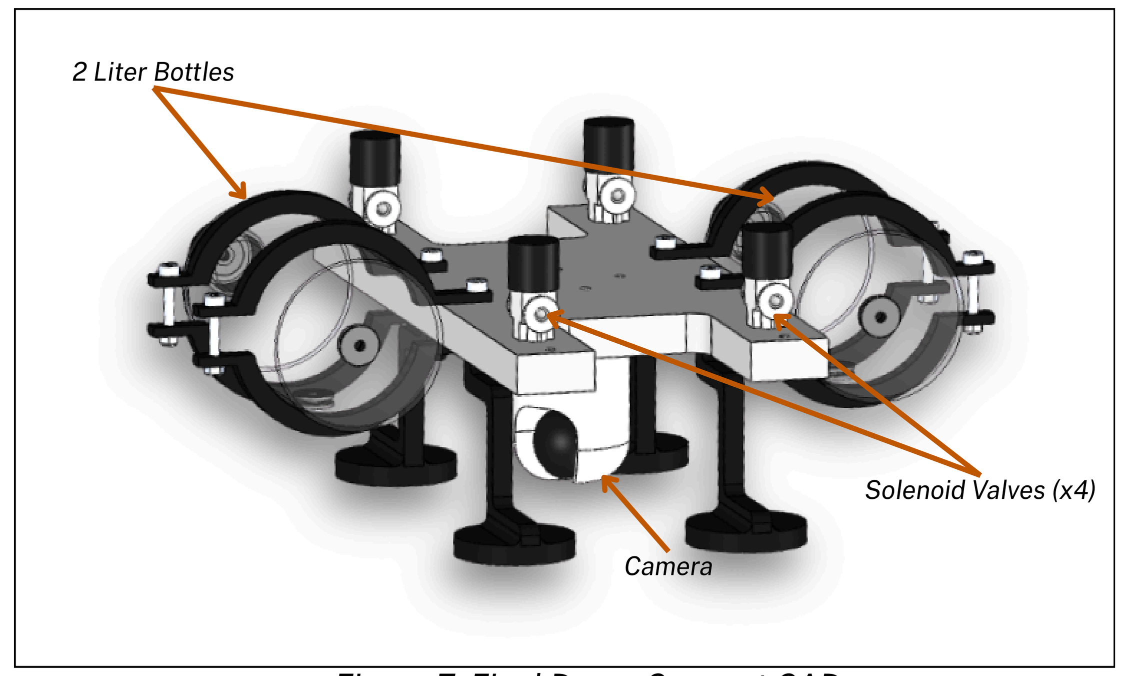

Figure 7: Final Drone Concept CAD

7. Testing and Results

A thrust test stand was designed and 3D-printed for use with a load cell (Figure 12). Currently, testing is in progress and the code for the load cell is shown in Figure 13. The current prototype is shown in Figure 14. As of now, the prototype has succeeded in meeting the weight criteria, while awaiting testing of the thrust and control systems. The electronics are also awaiting installation after coding refinement.

```
float calibration_factor = 106.622428; // Specific to the load cell
float calibration_offset = 10863;

void setup() {
  Serial.begin(9600);
  Serial.println("Initializing the scale...");

  scale.begin(loadCellDataOut, loadCellSCK); // Initialize the HX711

  scale.set_scale(calibration_factor); // Set calibration factor
  scale.set_offset(calibration_offset); // Set calibration offset
  scale.tare(); // Reset the scale to 0 (tare)

  Serial.println("Scale initialized. Place a known weight for calibration if needed.");
  Serial.println("Send 't' to tare the scale.");
}

void loop() {
  if (Serial.available()) {
    char command = Serial.read();
    // if t is pressed, tare the scale
    if (command == 't') {
      scale.tare();
      Serial.println("Scale tared to zero.");
    }
  }
```

Figure 13: Load Cell Code for Thrust Measurement

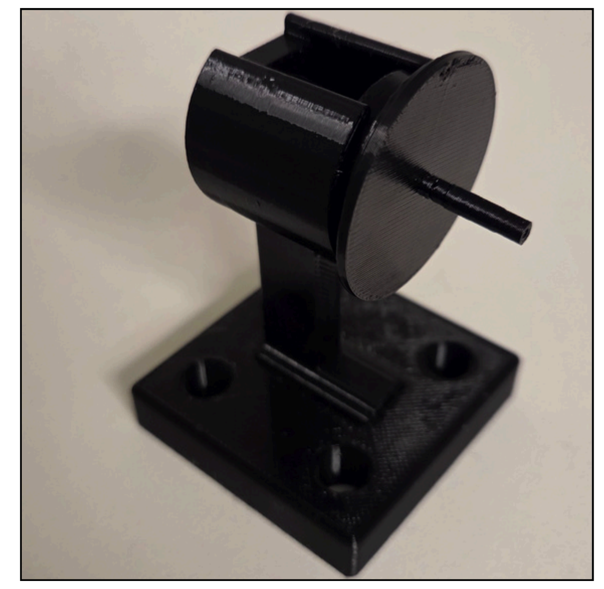
Figure 12: Thrust Test Stand 3D Model

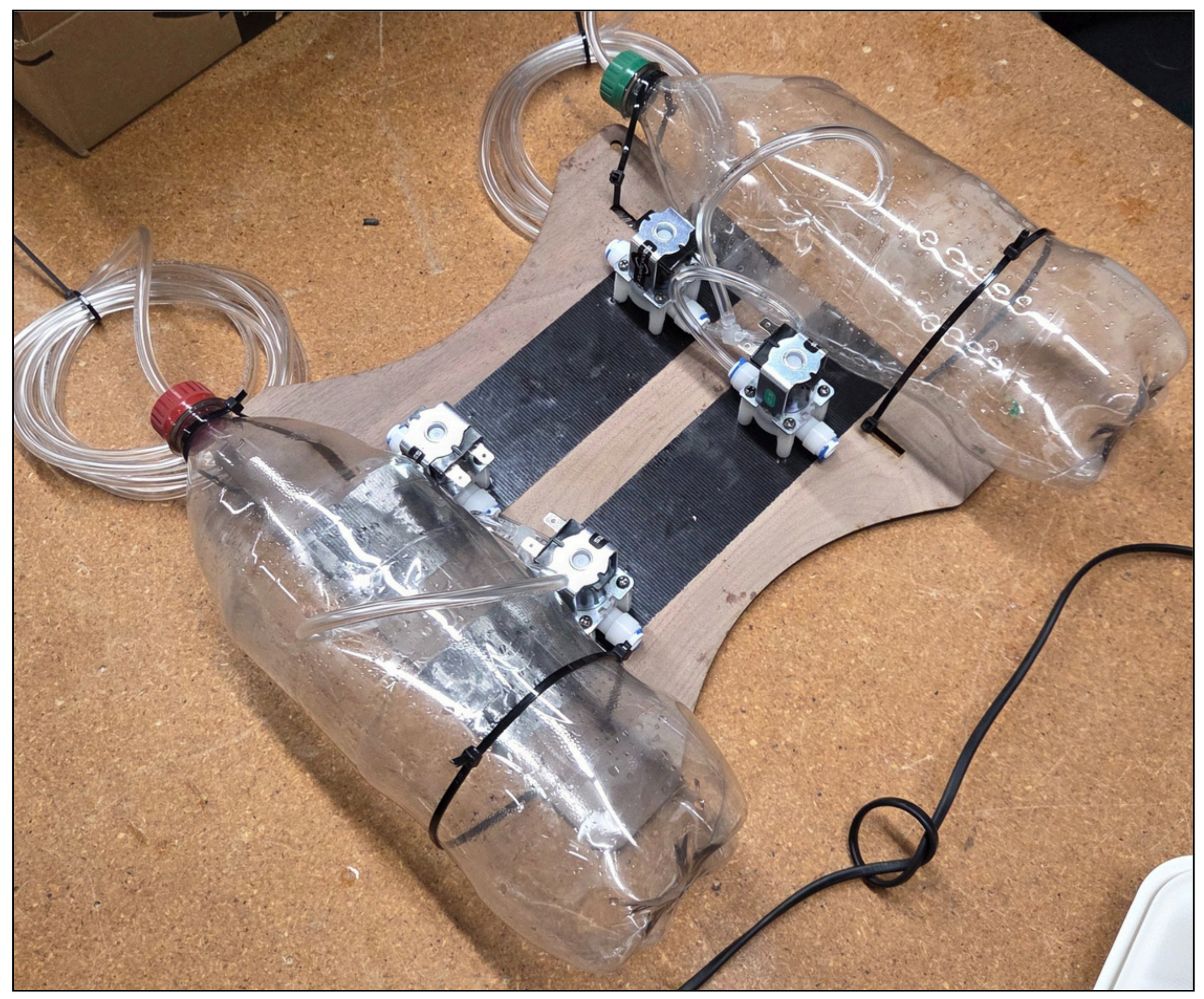
Figure 13: Current Prototype In-Progress