ENGR 290 FALL 2024 Project

ENGR 290: Introductory Engineering Team Design Project

Prepared by Team: 2

Section: N

Fabio Binu Koshy

Sarvesh Sai Rajesh

Abhishek Thakur

Xinran Hu

Youssef Tassine

Course Instructor: Dr. Rastko R. Selmic

Technical Lead: Mr. Dmitry Rozhdestvenskiy

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1-Problem Definition

The hovercraft project demanded precise attention to stability and weight distribution to navigate a track with obstacles and turns smoothly. Components need to be strategically placed on the Styrofoam base to ensure balance and minimize tipping or uneven lifting risks. Programming the hovercraft in Pure C AVR required integrating multiple components and maintaining synchronization, with live trials on the demo track providing valuable insights for refinement and optimization. Several key issues needed resolution:

- Ensuring directional movement and control of the hovercraft during operation.
- Maintaining a uniform lift to support stable hovercraft operation.
- Achieving balanced mass distribution across the hovercraft to prevent tipping or uneven lift.
- Stabilizing the hovercraft during turns while accurately calculating yaw.
- Detecting obstacles along the track and dynamically adjusting the hovercraft's direction.
- Properly identifying the track endpoint to stop the hovercraft.

These challenges required careful testing and debugging to ensure the hovercraft could navigate the track, respond to obstacles, and maintain stability during operation.

2-Requirements and Specifications

The hovercraft should finish the track in two minutes with stable hovering and turning. It should go through the maze without interruption, continuously. For this, stability in turns was very important to avoid spinning or imbalance. A sensor should be used to detect obstacles and change the direction of the craft to avoid collision. At the end of the track, a sensor should detect a horizontal bar and stop with reliability. Moreover, the speed had to be low enough to minimize its vulnerability due to collisions.

Specifications:

Kit 1 - Part 1:

1. IR Sensor: IR Analog Rangefinder (GP2Y0A21)

- An infrared proximity sensor with a 10–80 cm range, ideal for responsive close-range detection.

2. Ultrasonic Sensor (HC-SR04)

- A high-accuracy sensor measuring 2–400 cm with ±3 mm precision.

Kit 1 - Part 2 :

1. IMU: MPU-6050 Gyroscope & Accelerometer

- A compact, precise motion sensor with gyroscope and accelerometer functions.

2. Servo Motor (HS-311)

- A reliable, high-torque motor for smooth steering control.

Kit 2 :

1. Lifting Fan (AFB1212SH)

- High-airflow fan for stable hovercraft lift.

2. Propulsion Fan (Model MEC0251V1-0000-A99)

- Durable fan for efficient thrust generation.

3. Battery (Rhino 460 2S 20 C series)

- Compact, high-discharge 7.4V battery for stable operation

3-Conceptual Design

3.1-System functional block diagram

A functional decomposition diagram of the hovercraft shows how the different onboard components interact amongst themselves and with the external world. The processor was used minimally in the preliminary design review as little was known about it. Below is the control board shown receiving input from the code and interfacing with different components, such as the sensors for wall and obstacles detection. The battery provides power to the control board, which then supplies power to the propulsion and lifting fans. This set of fans provides propulsion and lift; primarily, these operate based on sensor input.

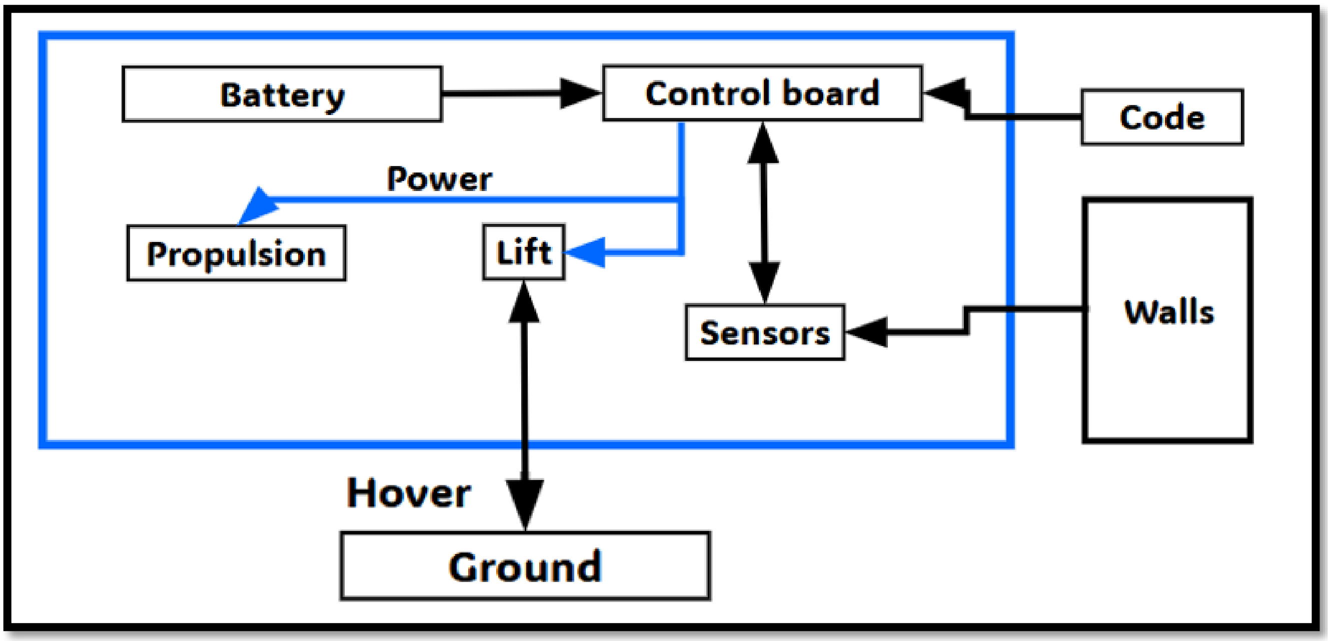


Figure-1: System functional block diagram

3.2-Alternative concepts

Two hovercraft designs were brainstormed and investigated to stable lift, efficient propulsion, and reasonable coding difficulty within weight and power constraints

Concept A: Circular Base design

Concept A features a lightweight Styrofoam round base (Figure 2). The central brushless DC fan creates an air cushion by filling a flexible skirt and lifting the craft. It has a rear fan for forward movement and a servo motor system to adjust the thrust direction in order to turn left, right or straight.

Components: Moderate (one lift fan, one propulsion fan, IMU, two batteries, one ultrasonic sensor, one IR sensor, control board, and one servo motor).

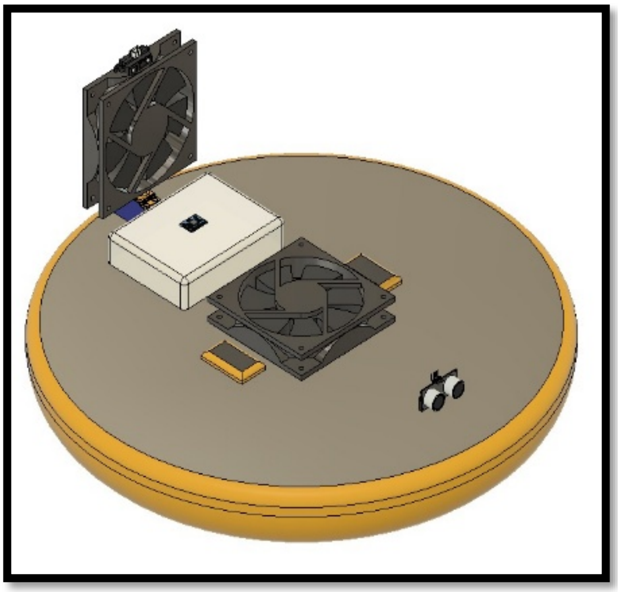


Figure-2: Circular Base Design

Concept B: Two propulsion fans and a U-Base design

Concept B features a U-shaped foam base (Figure 3). It has one main lifting fan in the center and two fans for propulsion, one at the back and one at the front. These propulsion fans are attached to servo motors, which allow them to move and help control the direction.

Components: Higher (one lift fan, two propulsion fans, IMU, two batteries, ultrasonic sensor, one IR sensor, control board, and two servo motors).

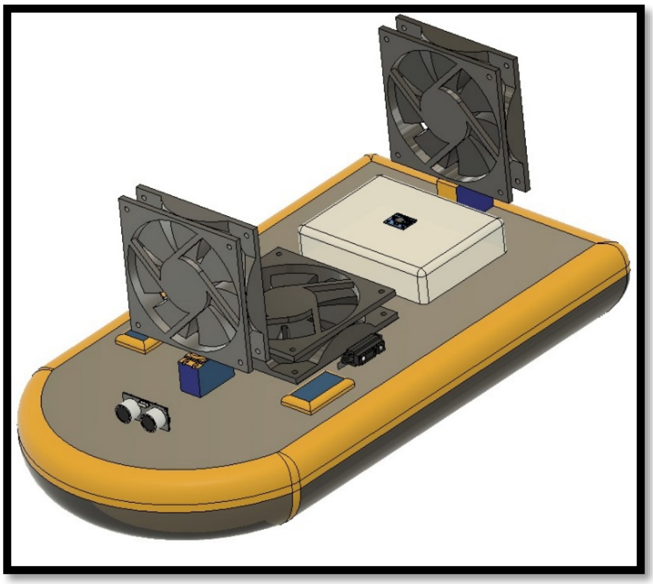


Figure-3: U-Base Design

3.3-Evaluation of alternatives

We analysed three hovercraft designs: Concept A (round base), Concept B (U-shaped base), and the selected design (rectangular base). We looked over the big six: number of parts in design, base shape, code setup, power usage, hover height, and weight. We compared these factors in order to determine which design would work best as a stable, efficient, and controllable hovercraft.

Concept A: Circular Base design

Concept A has only nine elements altogether, such as one lift fan and one propulsion fan. The concept design is focused on simplicity and ease of assembly. The circular base will provide symmetrical flow of air for stable lifting; however, component placement and skirt design are complicated. Efficient coding utilizes IMU data for thrust and yaw control, while sensors handle obstacle detection for reliable operation. Power consumption remains moderate at lower hover heights of 2–3 cm but increases significantly for 4–5 cm. Weighing approximately 514 g, its rear-mounted components cause slight tilt, affecting lift uniformity. While functional, Concept A’s limitations in efficiency and design flexibility make it a less optimal choice.

Concept B: Two propulsion fans and a U-Base design

Concept B increases the component count to 11 with dual propulsion fans and servos for increased control. Added complexity brings in wiring challenges and failure points. The base U-shaped design compromises the efficiency of airflow, hence higher fan RPMs are needed to make the hover consistent. The coding will be complex, with synchronized thrust vectors and obstacle avoidance logic; this increases development time and error probability. Due to three fans and two servos, it has higher power consumption. Moreover, hovering at 3–4 cm takes a lot of energy. Having a weight of 618 g further strains the efficiency of the unit, making Concept B less viable practically, though it had additional features.

3.4-Selection of a concept, decision matrix

This is a combination of the simplicity of Concept A with enhanced efficiency and functionality, making it the best choice. With nine components and a rectangular base, it has a better layout and optimized weight distribution, ensuring uniform lift, easy component placement, and stable hovering at 4–5 cm with reduced power consumption of 50–80 W.

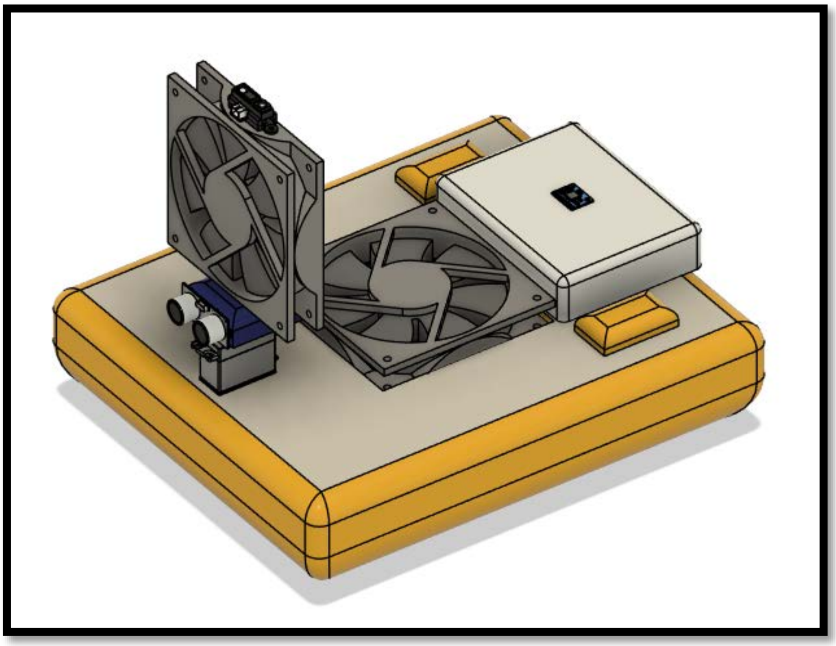


Figure-4: Rectangular Base Design

The coding includes a simplified PID for IMU-based yaw correction, while sensors efficiently perform obstacle detection and path clearing. Weighing only 509 g, it is lighter, more power-efficient, and gives better performance with least complexity. This chosen design (Figure 4) is optimized for simplicity, reliability, and maintainability. Centrally located, a lift fan (~50 g) provides even airflow for stable lift, while a front-mounted propulsion fan (~50 g), positioned 4 cm from the edge, provides optimal thrust-to-weight ratio for precise control. A servo motor (~46 g) directly attached to the fan enables accurate steering.

The ultrasonic sensor (~19 g) on a servo arm, 4 cm from the front, scans for obstacles while the IR sensor (~8 g) atop the propulsion fan detects overhead barriers. The IMU (~6 g) on the control board monitors yaw and tilt. This has a slightly rearward offset of the control board (~155 g) and symmetrically positioned batteries at the base corners (~100 g each) to maintain a low, central center of mass. Such a balance will provide stability, efficiency, and reliable operation, thus making it the best general choice.

Evaluation criteria	Weight	Concept A		Concept B		Concept C	
		Val.1	Wt* Val.1	Val.2	Wt*Val.2	Val.3	Wt*Val.3
1.Base shape	0.2	9	1.8	6.5	1.3	10	2
2.Code implementation	0.25	10	2.5	5	1.25	10	2.5
3.simplicity	0.1	8.5	0.85	6	0.6	10	1
4.power consumption	0.1	9	0.9	5	0.5	9	0.9
5. Propulsion Fan Thrust	0.1	9	0.9	10	1	9	0.9
6.Energy Efficiency	0.15	8	1.2	6	0.9	9.5	1.425
7. Total Weight (less better)	0.1	8	0.8	6	0.6	9	0.9
Total	1		8.95		6.15		9.625

Figure 5: Decision Matrix

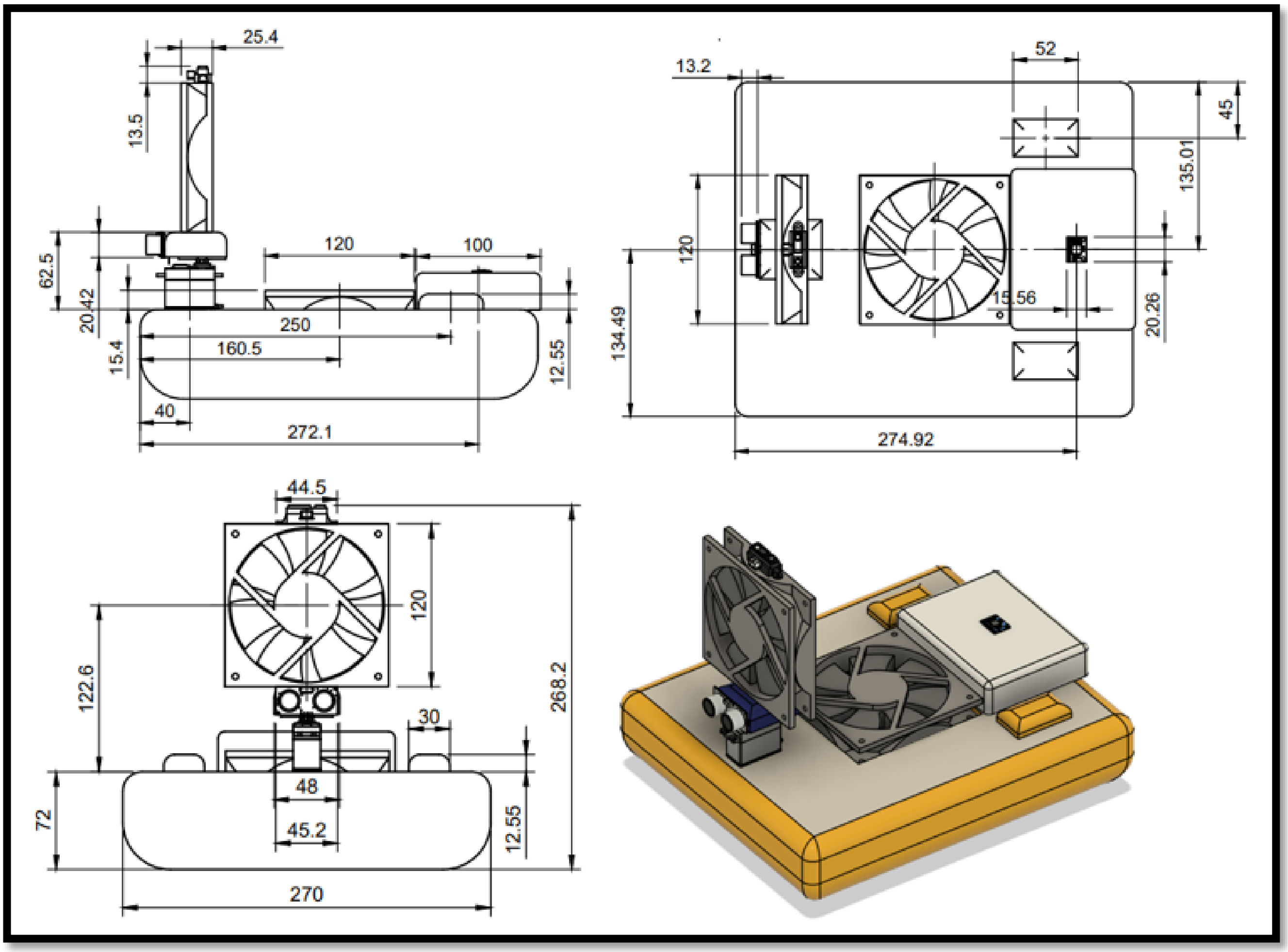


Figure 6: Technical Design of the Selected Concept

3.5-Design calculations, Simulations

Power Consumption

Concept A :

$6.36w + (1.08w) + 0.15(w) + 5.5w + 0.01353w + 0.1w$

$= 13.20353\ (w)$

Concept B :

$(0.15w \times 2) + (1.08w \times 2) + 6.36(w) + (5.5w \times 2)$
$+ 0.01353(w) + 0.1w$

$= 19.93353(w)$

Concept C :

$6.36w + (1.08w) + 0.15(w) + 5.5w + 0.01353w + 0.1w$

$= 13.20353\ (w)$

Propulsion Fan Thrust

① Concept A :

Fan Thrust = Airflow × Air density × Fan speed

* Air density = $1.2\ kg/m^3$

* Airflow = $108.2\ CFM \times 0.000471947 = 0.05105\ m^3/s$

* $F_{thrust} = 0.05105\ m^3/s \times 1.2\ kg/m^3 \times 19.48\ m/s = 1.191\ N$

② Concept B :

$F_{thrust} = 1.191\ N \times 2 = 2.382\ (N)$

③ Concept C :

* $F_{thrust} = 0.05105\ m^3/s \times 1.2\ kg/m^3 \times 19.48\ m/s = 1.191\ N$

Energy Efficiency

Concept A: Weigt (N) = $\frac{658.76}{1000} \times 9.81 = 6.46\ (N)$

Useful Work (J) = $6.46N \times \underbrace{0.040}_{\text{hover height}} = 0.2585\ J$

Input Energy (J) = Power consumption (W) × Time (S)

from previous section = $\boxed{13.20353\ (W)} \times 1$

$= 13.20353\ (J)$

Efficiency (%) = $\frac{\text{Useful Work (J)}}{\text{Input Energy (J)}} \times 100$

↓

$= \frac{0.2585\ J}{13.20353\ J} \times 100$

$= 1.95779\ \%$

Concept: B Weigt (N) = $\frac{819.552}{1000} \times 9.81 = 8.03986\ (N)$

Useful Work (J) = $8.03986 \times \underbrace{0.040}_{\text{hover height}} = 0.32159\ (J)$

Input Energy (J) = Power consumption (W) × Time (S)

from previous section = $\boxed{19.93353(W)} \times 1$

$= 19.93353\ (J)$

Efficiency (%) = $\frac{\text{Useful Work (J)}}{\text{Input Energy (J)}} \times 100$

↓

$= \frac{0.32159\ (J)}{19.93353\ (J)} \times 100$

$= 1.61333\ \%$

Concept: C Weigt (N) = $\frac{638.505}{1000} \times 9.81 = 6.264\ (N)$

the concept we chosed

Useful Work (J) = $6.264 \times \underbrace{0.045}_{\text{hover height}} = 0.28187\ (J)$

Input Energy (J) = Power consumption (W) × Time (S)

from previous section = $\boxed{13.20353\ (W)} \times 1$

$= 13.20353\ (J)$

Efficiency (%) = $\frac{\text{Useful Work (J)}}{\text{Input Energy (J)}} \times 100$

↓

$= \frac{0.28187\ (J)}{13.20353\ (J)} \times 100$

$= 2.13479\ \%$

Total Weight

Styrofoam: 0.035g/cm^3

① Concept A: $5g + 43g + 198g + 4g + (28.5g \times 2) + 161.9g$
$+ 34.36g + 155.5g = 658.76g$

② Concept B: $(5g \times 2) + 43g + 198g + 4g + (161.9g \times 2) + (28.5g \times 2)$
$+ 155.5g = 819.5582g$

③ Concept C: $5g + 43g + 198g + 4g + (28.5g \times 2) + 161.9g$
$+ 14.105g + 155.5 = 638.505g$

Consider the centre of the lifting fan to be the centre of mass.

Use the Datasheet links in the reference section to get the variables for our calculations.

After building the hovercraft with the final design concept and placing all the components in their respective positions, we did several tests before going into the simulations. The hovercraft passed various tests, which included balance while hovering, change of direction, use of minimal components, transmission of data to the control board from sensors, and battery-operated.

Simulation-1

In the first simulation, we implemented the IMU functionality to enable straight-path movement using a servo motor and propulsion fan. While the hovercraft was able to maintain a straight trajectory, its ability to change direction based on longer-distance sensing by the ultrasonic sensor at a track corner proved to be inaccurate.

Simulation-2

In the second simulation, we simulated the hovercraft to move towards the direction of the area with the highest distance detected by the ultrasonic sensor attached to the propulsion fan and servo motor. With this, we were able to obtain readings from three sections of the track: left-0°, straight-90°, and right-180°. However, without the IMU, the hovercraft was able to pass through two sections of the track before getting stuck on a straight path.

4-Detailed design

4.1-Main features and how they work

The hovercraft integrates several critical components, each optimized to facilitate its seamless navigation over a predefined track. Together, these components allow the hovercraft to detect obstacles, adjust its movement dynamically, and maintain stability, ensuring reliable and autonomous operation.

Sensors:

IR Analog Rangefinder (GP2Y0A21):

Purpose: The endpoint should be detected by measuring the distance to a flat bar above the track, signalling the hovercraft to stop.

How It Works: The rangefinder detects the bar at the track's endpoint by emitting infrared light and capturing the reflected signal. For the hovercraft, the microcontroller reads the analog voltage output, which decreases as the distance to the bar increases. Once the voltage falls below a pre-defined threshold, the system shuts down both the lifting and propulsion fans, effectively halting the hovercraft at the exact endpoint.

Function in Navigation: Acts as a precise stopping mechanism, ensuring the hovercraft halts at the exact endpoint autonomously.

Ultrasonic Sensor (HC-SR04):

Purpose: Detects obstacles and calculates distances in real-time (2–400 cm) with up to 3 mm accuracy.

How It Works: The sensor emits ultrasonic pulses, which bounce off obstacles and return to the receiver. For the hovercraft, the microcontroller measures the echo time to calculate the obstacle's distance. Based on this data, the hovercraft dynamically adjusts its servo motor direction enabling it to avoid collisions by changing its trajectory in real-time.

Function in Navigation: Enables obstacle detection and avoidance by dynamically redirecting the hovercraft with the help of servo motor and the propulsion fan.

IMU (MPU-6050 Gyroscope & Accelerometer):

Purpose: Stabilizes the hovercraft during turns and ensures smooth trajectory adjustments.

How It Works: The IMU provides real-time feedback on the hovercraft's orientation by measuring yaw. In the hovercraft, this data is used to stabilize movement by adjusting the thrust direction of the propulsion fan. For instance, during a turn, the IMU ensures the yaw remains controlled, preventing spinning and maintaining smooth, precise navigation around corners or tight spaces.

Function in Navigation: Prevents spinning and facilitates controlled turning, even in tight spaces.

Fans:

Lifting Fan (AFB1212SH):

Purpose: Generates the necessary lift to allow the hovercraft to glide over the surface.

How It Works: Positioned at the centre of mass, it creates a cushion of air underneath the base with the help of a plastic bag, ensuring stable hovering without tilting.

Function in Navigation: Enables smooth movement over track surfaces and obstacles by minimizing friction.

Propulsion Fan (Model MEC0251V1-0000-A99):

Purpose: Provides forward thrust and precise directional control.

How It Works: Coupled with a servo motor, it adjusts thrust direction dynamically in response to IMU and ultrasonic sensor feedback.

Function in Navigation: Works with the IMU to make fine directional adjustments and ultrasonic sensor to avoid colliding with obstacles, ensuring precise navigation around corners and obstacles.

Battery:

Rhino 460 2S 20 C Series:

Purpose: Powers all components efficiently while maintaining a lightweight and compact design.

How It Works: Provides a high-discharge rate to support energy-intensive components like fans and sensors without voltage drops.

Function in Navigation: Ensures continuous operation throughout the track while maintaining proper weight distribution for stability.

Shape and Dimensions:

Purpose: Optimized to enhance manoeuvrability and stability.

How It Works: A rectangular body minimizes drag and ensures the hovercraft can fit through narrow passages without collisions.

Balanced weight distribution, aided by the central placement of critical components, prevents tilting.

Function in Navigation: The aerodynamic design ensures consistent and predictable behaviour on the track.

The hovercraft's functionality is powered by its integration of advanced components. Sensors like the IR Analog Rangefinder and Ultrasonic Sensor enable precise endpoint detection and obstacle avoidance, while the IMU ensures stability and smooth navigation. The lifting fan provides stable hover capability, and the propulsion fan delivers precise directional control. A lightweight, high-capacity battery powers these systems, while the aerodynamic rectangular design ensures manoeuvrability and stability. Together, these elements allow the hovercraft to autonomously navigate the track with efficiency and reliability.

4.2-Results of analysis, experiments, and models

Analysis

The success of the hovercraft project depended greatly on the application of mathematical and computational models to predict performance. Calculations ranged from power requirements for fans and servo motors, weight-to-thrust ratios for stable hovering, to gear ratios and airflow dynamics for lift and propulsion. Decision matrices were used to analyze several design options by assigning weight to the criteria of power consumption, stability, and simplicity. This ensured that the chosen design was the most effective and robust for a given set of constraints.

Experiments

Physical experimentation was crucial in verifying theoretical predictions and in determining unforeseen issues. Early hover tests showed instability in lift, which led to refinements in the material of the skirt and placement of vents for better distribution of airflow. Experiments in sensor alignment optimized obstacle detection and accuracy of stops. Simulated track runs allowed further integration of IMU feedback and real-time adjustments for yaw correction. These iterative tests helped ensure that the hovercraft met its design specifications while minimizing the risks of failure during operation.

Models

Scaled physical models and simulations were developed to help facilitate the design process and save costs. For example, a lightweight prototype of the hovercraft base could be used to experiment with weight distribution and component placement. Digital simulations modeled airflow dynamics, fan thrust, and power efficiency to refine the design before full-scale implementation. In this way, the models enabled rapid iteration and troubleshooting, saving time and resources in both the detailed design and manufacturing phases.

4.3-Manufacturing results

Using the port identification for the pin connector in Control Board (Figure A) and Arduino Nano (Figure B), we used this information to connect and code the IR (Infrared sensor), US (Ultrasonic sensor), IMU (Accelerometer and Gyroscope), servo motor, two fans, and batteries as shown in Figure C.

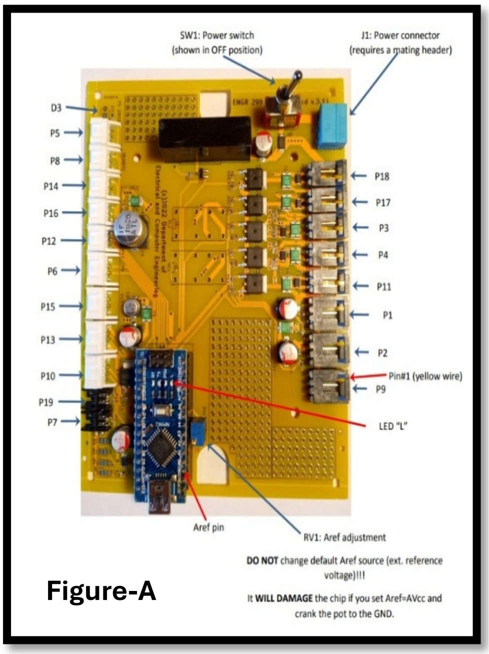


Figure-A

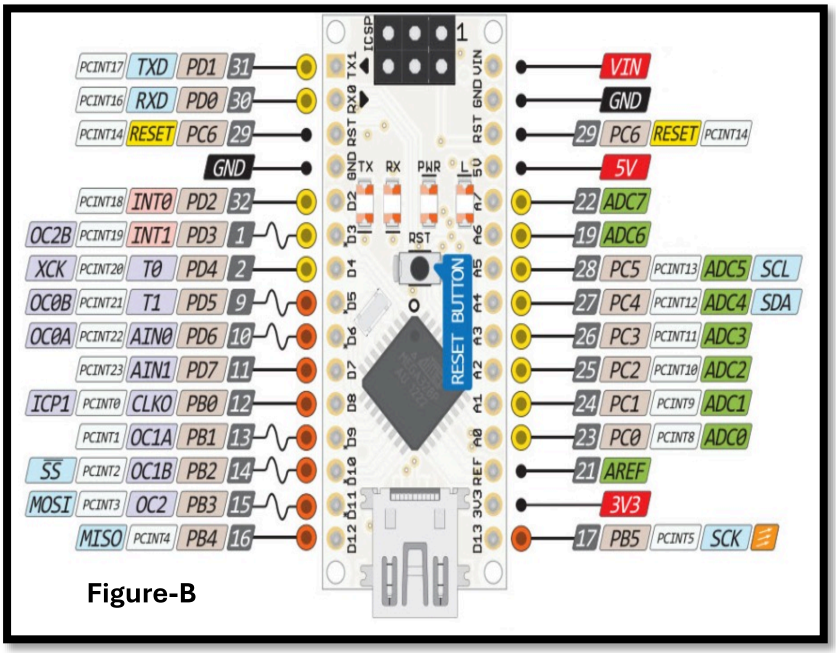


Figure-B

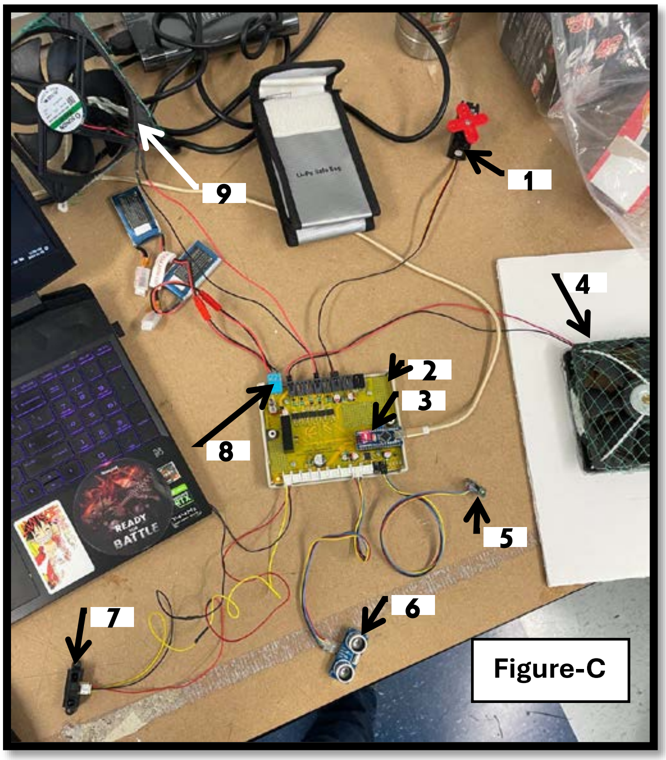


Figure-C

1-Servo Motor (HS-311)

2- Control Board

3-Arduino Nano

4- Lifting fan

5- IMU sensor

6-Ultra-sonic Sensor

7- Infrared Sensor

8-Battery connection

9-Propulsion fan

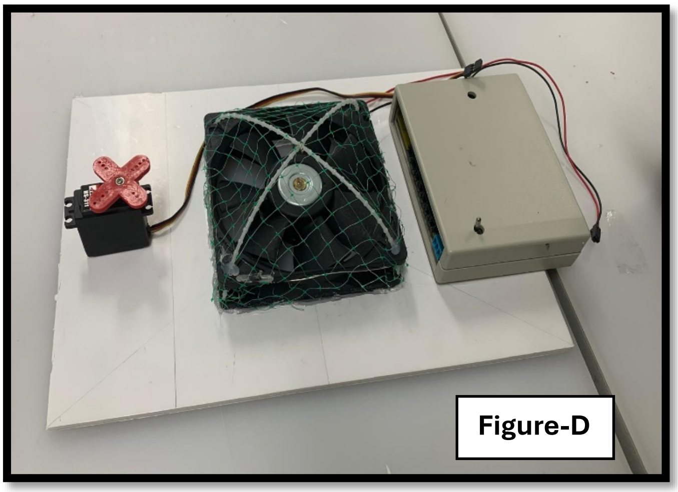
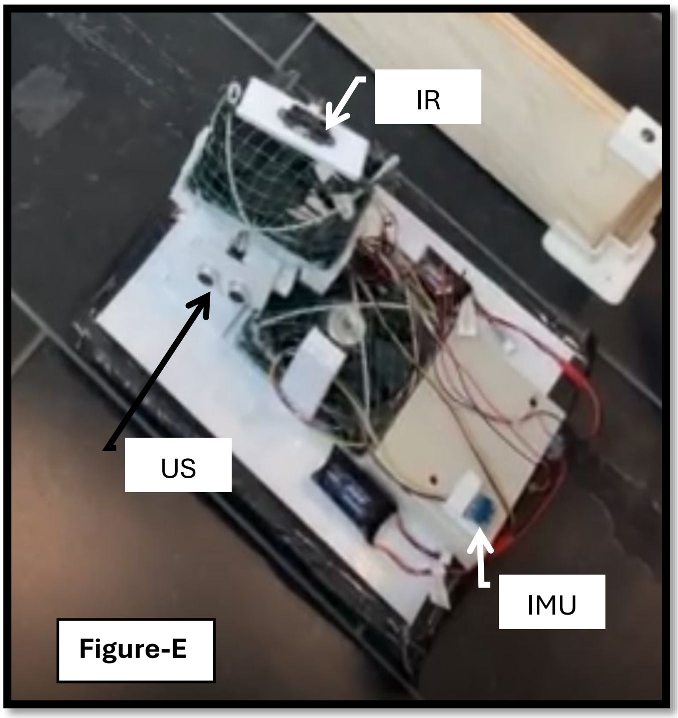


Figure D shows the location of the major components of the hovercraft that were glued in place. The other components were not glued down until their exact placement for balancing the hovercraft was determined.

In Figure E, all the parts are fixed using hot glue. The propulsion fan is attached atop of the servo motor at a 90° angle in such a way that its movement is straight while it allows the servo motor to turn between 0°-left to 180°-right. Attached to the servo motor in front of the propulsion fan is the ultrasonic sensor that will measure the walls within a 20-cm range. When an obstacle is detected, the servo motor rotates to 0°, 90°, and 180° to help the US sensor measure and identify the direction with the longest distance.

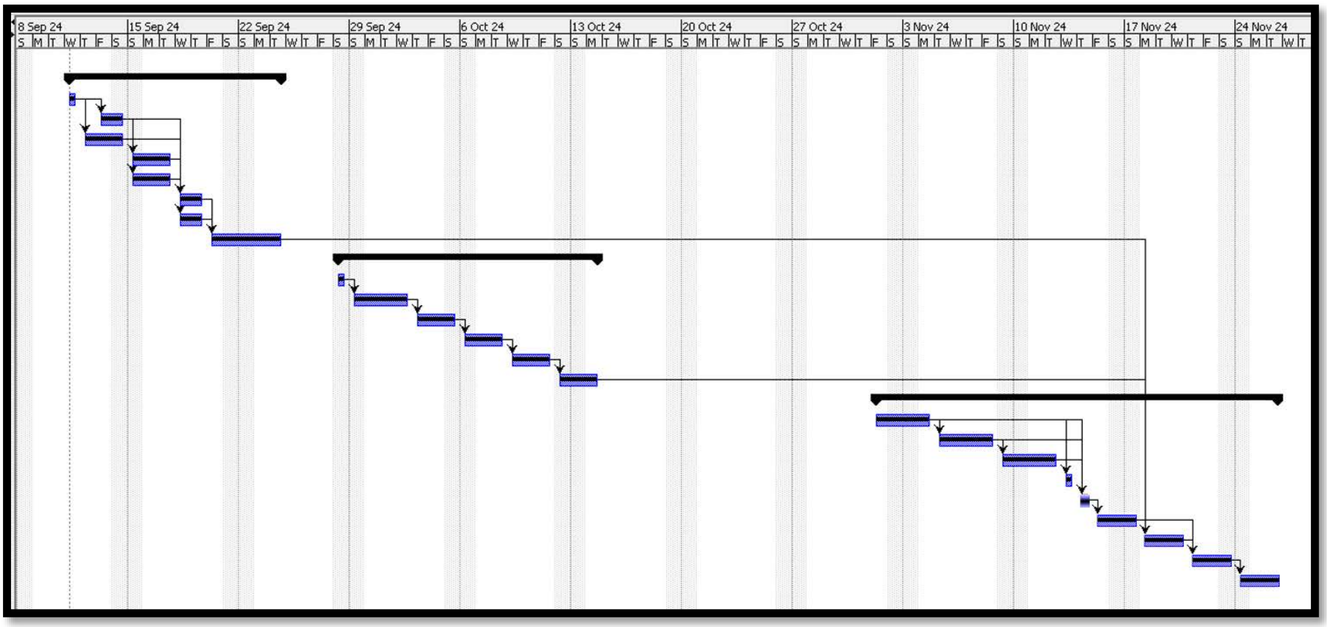


An IR sensor has been mounted on top of the propulsion fan for extra height, so that it is able to detect an overhead bar along the track. If the hovercraft detects the bar above it, it will make the hovercraft stop with both the fans off. The IMU is on top of the control board. Once the IMU is powered it will record its initial position, and since the IMU is considered the center in virtual space, the physical placement of the IMU is inconsequential for accurate orientation.

This configuration was chosen as it minimizes the number of components used and balancing the hovercraft but also keeps the functionality and efficiency high.

4.4-Gantt chart

1	⊟ **Techinical assignment-1 (Phase-1)**
2	Get familiar with Arduino IDE, Microcontroller features, IR, and US Sensors
3	Write code for US sensor to measure and display distance on Serial Monitor
4	Write code for IR sensor to measure and display distance on Serial Monitor
5	Write code for LED D3 Brightness Control for US sensor
6	Write code for LED D3 Brightness Control for IR sensor
7	Write code for LED L Flashes when outside (d1,d2) range for US sensor
8	Write code for LED L Flashes when outside (d1,d2) range for IR sensor
9	Run three trials for both US, IR sensors and improving code when required
10	⊟ **Techinical assignment-2 (Phase-2)**
11	Get familiar with IMU and Servo motor
12	Write code for IMU to output Roll, Pitch, Yaw & XYZ acceleration
13	Write code for Servo-Motor to replicate Yaw of IMU
14	Write code for LED L to turn ON when outside ±85°
15	Write code for LED D3 Brightness Control for ±1.00g in X-axis
16	Run Gyroscope,Accelerometer, Sample rate adjustments, Distance Calibration and Angular position tests
17	⊟ **Desigining & Implementation (Phase-3)**
18	Sketches, Concepts, Final Concept Design
19	Detailed design
20	Design calculations
21	Presentation run through
22	Construct the Hovercraft
23	Write code for turning on fans (propulsion & lift) when required
24	Write code to control the fan propulsion direction by integrating it with sensor inputs.
25	Create & run tests for lift, propulsion & direction change propulsion
26	Improve code to Complete the Hovercraft



5-Performance evaluation

Distance testing with both US and IR sensors was conducted; due to the capability for longer-range detection, much better readings were found when the US sensor was applied. To test the accuracy of the distance, a measuring tape and a wall-like object were used, where the wall was moved in at specified intervals toward and away from the sensor to compare readings. Also, we tested the IMU's yaw by rotating it about the Z-axis and then replicated that movement successfully with a servo motor. The experiments above represent the parts of Technical Assignments 1 and 2.

We then ported those functionalities developed in Pure C and AVR during the assignments to our final concept. We then build the skirt for the hovercraft. We used a garbage bag as the skirt material, keeping it 7 cm wide around the perimeter of the hovercraft and cutting out the shape. A central hole cut was made to provide passage for air from the lifting fan; it was made both big enough and centrally located. We attached 2 cm of the skirt's perimeter to the hovercraft and was able to hover at a height of 4-5 cm. This allowed the hovercraft to overcome obstacles at least 3 cm in height and hover until the battery was drained.

However, during the competition, there were some challenges in implementation. Thus, the hovercraft was only able to pass through the second part of the track.

6-Conclusions and lessons learned

The hovercraft project was one big learning curve wherein every problem introduced new areas for further improvement and enhancement. What started as a very simple idea flourished into an intricate system where every part of the system became quite necessary. We've encountered some technical roadblocks, found innovative solutions, and taken some lessons valuable enough to lead us through our future projects.

What Worked Well:

Making Trade-Offs Count

The rectangular base simplified airflow dynamics, ensuring uniform lift and easier component placement for stability. Time saved on structural complexity allowed us to refine the balance of lift and propulsion.

Turning Sensors into a Team

First, the IR and Ultrasonic sensors had to be aligned in their output range and response time. We exploited the long-range accuracy of the Ultrasonic sensor and precision at close range of the IR sensor to provide a useful, layered detection for reliable obstacle avoidance.

Weight Distribution Fine-Tuning

Strategic placement of components, including placing the batteries at opposite corners and the lifting fan center, helped to minimize tilting and keep it balanced and smooth when hovering over obstacles.

Maximizing the IMU's Capabilities

This allowed for very precise yaw correction, especially in tight turns. The servo motor was connected into a feedback loop to make live adjustments, ensuring that accurate navigation and the hovercraft did not veer off the path.

What Surprised Us:

The Power of Small Changes

Small changes, such as the adjustment of the propulsion fan angle and the IR sensor being slightly raised, made a huge difference in airflow, detection of obstacles, and balance of the hovercraft.

Failures resulted in better solutions.

Early lift inconsistencies led to a redesigned skirt with thinner material and optimized vent sizes. Sensor misalignments highlighted the need for recalibration, improving navigation accuracy.

Systemic Interactions Were Everything

Component interactions revealed critical dependencies. For example, damping pads under the propulsion fan minimized vibrations that interfered with sensor readings, enhancing system reliability.

What We'd Do Differently:

Modular testing could have saved time by identifying issues early, while technologies like LIDAR could enhance future navigation. Improved cable routing would simplify debugging. The project highlighted persistence and innovation, with key lessons in sensor data synchronization, weight distribution, and yaw correction shaping future work.

7-References

The following are the references we used to help us do the calculation.

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8-Appendix

8.1: Documentation of Workshop time and Person-Hours

Date (2024)	Time	Task Category	Team Member	Person-Hours Spent	Details	Workshop Total time
10th Oct & 17th Oct	6PM-12AM & 4PM-12AM	**Conceptual Design**	Sarvesh Sai Rajesh	15	Participated in brainstorming, decision matrix, and feasibility analysis.	42
			Fabio Binu Koshy	15	Evaluated alternative designs, decision matrix, and initial simulations.	
			Abhishek Thakur	12	Worked on block diagram, coding feasibility analysis, and decision matrix.	
5th Nov & 12th Nov	6PM - 1AM & 4PM-12AM	**Assembly and Integration**	Sarvesh Sai Rajesh	15	Assembled components and refined balance.	75
			Fabio Binu Koshy	15	Integrated lifting fan, propulsion fans, and sensors.	
			Abhishek Thakur	13	Assisted with wiring, stability tests, and integration.	
			Xinran Hu, Youssef Tassine	16 16	Wired hardware components and ensured stability.	
19th Nov & 26th Nov	6PM - 2AM & 6PM - 1AM	**Testing and Debugging**	Sarvesh Sai Rajesh	15	Conducted balance tests and debugged obstacle detection logic.	75
			Fabio Binu Koshy	15	Debugged Pure C code and optimized IMU functionality.	
			Abhishek Thakur	15	Tested IMU yaw correction, sensors, and overall stability.	
			Xinran Hu, Youssef Tassine	15 15	Conducted initial tests and monitored hardware behaviours.	
13th Dec		**Documentation (**All contributed to technical assignment 1,2 documentation as well)	Sarvesh Sai Rajesh	3	Worked on the Problem, requirements, specifications and main features	NIL
			Fabio Binu Koshy	3	Drafted final report sections, gantt chart, final concept and ensured completeness.	
			Abhishek Thakur	3	Appendix, conclusions and performance evaluation	
			Youssef Tassine	7	Evaluations of alternate designs, calculations and results of analysis	
			Xinran Hu	7		

8.2: Meeting Minutes:

<table>
<tr><th>Meeting 1</th><th>Agenda</th><th>Discussions</th><th>Outcomes</th></tr>
<tr><td>Date: October 10th, 2024</td><td rowspan="3">Define project goals and initial design ideas.</td><td>- Reviewed project requirements and constraints.</td><td>- Selected a rectangular base design for better stability.</td></tr>
<tr><td>Time: 1hr</td><td>- Discussed initial base designs (circular, U-shaped, rectangular).</td><td rowspan="2">- Defined key design goals.</td></tr>
<tr><td>Attendees: Sarvesh, Fabio, Abhishek, Xinran, Youssef</td><td>- Highlighted challenges like stability and weight distribution.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Meeting 2</th><th>Agenda</th><th>Discussions</th><th>Outcomes</th></tr>
<tr><td>Date: October 17th, 2024</td><td rowspan="3">Finalize components and materials.</td><td>- Evaluated sensors: IR vs. Ultrasonic for detection.</td><td>- Selected IR and Ultrasonic sensors, IMU, and fans.</td></tr>
<tr><td>Time: 1hr</td><td>- Discussed IMU integration for stability and yaw correction.</td><td rowspan="2">- Finalized component list.</td></tr>
<tr><td>Attendees: Sarvesh, Fabio, Abhishek</td><td>- Analysed weight and power constraints.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Meeting 3</th><th>Agenda</th><th>Discussions</th><th>Outcomes</th></tr>
<tr><td>Date: November 5th, 2024</td><td rowspan="3">Create assembly plan and assign roles.</td><td>- Created timeline for component assembly.</td><td>- Finalized assembly plan.</td></tr>
<tr><td>Time: 1hr</td><td>- Assigned tasks: wiring, balancing, fan integration.</td><td rowspan="2">- Scheduled preliminary tests for stability and synchronization.</td></tr>
<tr><td>Attendees: Sarvesh, Fabio, Abhishek, Xinran</td><td>- Discussed weight distribution challenges.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Meeting 4</th><th>Agenda</th><th>Discussions</th><th>Outcomes</th></tr>
<tr><td>Date: November 12th, 2024</td><td rowspan="3">Refine assembly and start initial tests.</td><td>- Addressed weight distribution and placement issues.</td><td>- Adjusted component placement.</td></tr>
<tr><td>Time: 1hr</td><td>- Debugged IMU yaw correction and propulsion fan interactions.</td><td rowspan="2">- Initiated balance and obstacle detection testing.</td></tr>
<tr><td>Attendees: Sarvesh, Fabio, Xinran, Youssef</td><td>- Reviewed lift test results.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Meeting 5</th><th>Agenda</th><th>Discussions</th><th>Outcomes</th></tr>
<tr><td>Date: November 19th , 2024</td><td rowspan="3">Debugging and testing.</td><td>- Tested IMU yaw correction and servo motor movement.</td><td>- Resolved IMU and sensor synchronization issues.</td></tr>
<tr><td>Time: 1hr</td><td>- Addressed sensor synchronization issues.</td><td rowspan="2">- Stabilized hovercraft during turns.</td></tr>
<tr><td>Attendees: Sarvesh, Fabio, Abhishek, Youssef</td><td>- Reviewed stability during turns.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><th>Meeting 6</th><th>Agenda</th><th>Discussions</th><th>Outcomes</th></tr>
<tr><td>Date: November 26th, 2024</td><td rowspan="3">Final testing</td><td>- Conducted final tests on lift, stability, and detection.</td><td rowspan="3">- Successfully completed final tests.</td></tr>
<tr><td>Time: 1hr</td><td>- Reviewed compliance with project requirements.</td></tr>
<tr><td>Attendees: Sarvesh, Fabio, Abhishek</td><td>- Prepared for evaluation.</td></tr>
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