MCI Spicy Killa Bytes - Milestone 03
(Modules and Sensor Interfacing)

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1 Overview

The primary objective of this milestone was to develop a wireless remote interface for controlling our Robot. There is a need to communicate with the robot remotely in order to regulate its movement and transmit critical information in both directions. In addition to the microcontroller, which serves as the main controlling module of this project, we also employed two important modules to implement the Bluetooth Controlled Movements. These are the HC-05 Bluetooth Module and two L298N Motor Driver Modules. The HC-05 Bluetooth Module is in charge of enabling Bluetooth communication between the TM4C123GH6PM and an Android phone, while the L298N Motor Driver Module is in charge of providing the necessary drive current to the motors of the robot. We may issue specific commands to the robot using an Android app installed on the phone. At the receiving end, the Bluetooth transceiver module receives the commands and forwards them to the TivaC, allowing the robot to be controlled. Furthermore, we have used 4 keys: Forward, Reverse, Left, and Right in the Android app. When a key is pressed, the Bluetooth module sends the corresponding data from the phone to the robot over Bluetooth communication.

Our proposed design has the advantage that our robot may operate on any kind of surface. As a result, it is more cost efficient and simple than other design approaches in use. Another objective of this milestone was to ensure that the robot, whilst moving, could identify obstacles in its path and change direction where any obstacles were present without the aid of any form of external force. This was achieved using an ultrasonic wave sensor, which measures distance by sending pulses, and the design also utilizes both manual and auto control via the infrared (IR) sensor. The movement of the servo motor (for sensor movement) and the DC motors (for wheel movement) are controlled by the motor driver shield in order to enable the obstacle avoidance function. The commands are relayed to the TM4C123GH6PM micro-controller chip, which serves as the main controller of the robot car, controlling both the sensor and robot movement.

2 Description of Hardware required

2.1 HC-05 Bluetooth Module

The HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. It uses serial communication to communicate with the electronics (a controller or PC), which makes interacting with them quite simple. The HC-05 is a 6-pin module that has two operating modes: data mode and command mode. Additionally, it offers a switching mode between master and slave mode, which means that it is unable to use either receiving or transmitting data. The module is used to connect small devices such as Android mobile phones using a short-range wireless connection to exchange files. It uses a 2.45GHz frequency band and requires a supply between 4V and 6V to operate (the module has an onboard 5 to 3.3V regulator). The transfer rate of the data can vary up to 1Mbps and is in a range of 10 meters. Furthermore, it is capable of supporting a baud rate of 9600, 19200, 38400, 57600, etc.

Figure 1: HC 05 Bluetooth module

The HC-05 module features a red LED that indicates whether or not the Bluetooth is connected. Prior to connecting any device to the HC-05 module, this red LED continuously flashes in a periodic way. Its blinking slows down to two seconds when it is connected to any Bluetooth device. The HC-05 module features a red LED that indicates whether or not the Bluetooth is connected. Prior to connecting any device to the HC-05 module, this red LED continuously flashes in a periodic way. Its blinking slows down to two seconds when it is connected to any Bluetooth device. Since the HC-05 Bluetooth module's RX/TX levels are rated at 3.3V and the microcontroller can detect these levels, there is no need to shift the transmit level of the module. The transmit voltage level from the microcontroller to the RX of the HC-05 module, however, may need to be adjusted. In our solution, the Bluetooth module's TX and RX pins are directly linked to the TX and RX of the TivaC. Additionally, the vcc and ground pins of the module are wired to ground on the TivaC and +5 volts respectively. The circuit has been powered by a volt battery via the Tiva's Vin pin.

2.1.1 UART Communication Protocol

HC-05 uses serial UART protocol to make it easier to send and receive data wirelessly. UART stands for Universal Asynchronous Receiver/Transmitter. It is not a communication protocol like SPI and I2C, but a physical circuit in a microcontroller, or a stand-alone IC. The main purpose of a UART is to transmit and receive serial data using just two wires, TX and RX.

As previously stated, HC-05 is a two-way full-duplex Bluetooth to serial module. This Bluetooth device operates on UART communication. In other words, it uses serial communication to transmit and receive data serially over standard Bluetooth radio frequency. UART communication port of the TM4C123GH6PM microcontroller is used with HC-05. The microcontroller in use has on-chip 5 UART ports such as UART0 to UART5. We can use any one of these UART ports to interface TM4C123 with the BT device.

2.2 L293D Motor Driver Shield Overview

The L293D is a high voltage, high current Integrated circuit which is used to drive DC motors with a power supply of up to 36V. This chip is able to supply a maximum of 600mA per channel. This chip is also known as a type of H-Bridge as it enables a voltage to be applied across a load in either direction to an output, such as a motor.

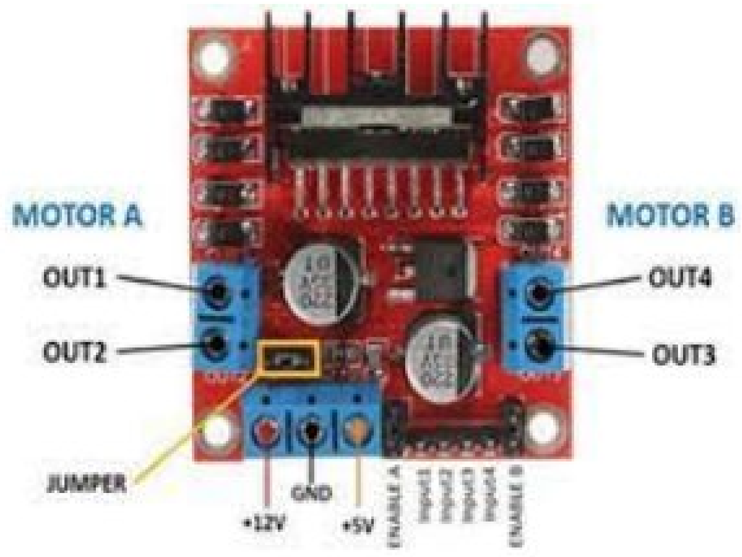

Figure 2: Motor Driver

2.3 Ultrasonic Sensor

Obstacle avoidance is one of the most important aspects of our robot implementation. It has an intelligence built in it such that it directs itself whenever an obstacle or the opponent robot comes in its path so as to protect the robot from any physical damage. The module includes ultrasonic transmitters which emit a 40kHz wave, receiver and control circuit. These sensors can identify a distance within a range of 2-400 cm and they require a current consumption of 2 mA and a 5V power supply to operate. The ultrasonic sensor employed sends out a high-frequency sound pulse and then times how long it takes for the echo of the sound to reflect back. The speed of sound is approximately 341 meters per second in air. The ultrasonic sensor uses this information along with the time difference between sending and receiving the sound pulse to determine the distance from an object.

The implementation was carried out using two HC-SR04 ultrasonic sensors in each of the two directions of the robot, one at the front and one at the back. The two sensors were programmed to function as follows:

1. The Ultrasonic sensor in the front would detect the enemy ROV and would initiate attack protocol, i.e. the servo motor would swing the hammer down on the enemy ROV.
2. The Ultrasonic sensor at the back would turn 180 degree at detection of the enemy. Such that now the front sensor would be able to detect the ROV and hence initiate the attack protocol.

Figure 3: HC SR04 Sensor

2.4 Infrared Sensor

The IR sensor is a 3 three wired sensor, in which the brown and the black wire are used to connect the sensor to the power supply, whereas, the red wire is connected to the load, or TivaC, in our circuit. The module has an onboard potentiometer that allows the user to adjust the detection range. Because there is a semiconductor/chip inside the sensor, it must be powered with 3-5V to function and it consumes about 20mA even during idle state. The UART and IR interfaces are compatible with a baud rate of 9600Hz.

Before going into the implementation of the ROV it is important to note the rationale behind using the IR sensors. In the arena it was important to distinguish between the enemy ROV and the boundary wall. The arena was made such that 10 cm before the boundaries black tape had been placed on the arena floor. Black tape being a bad reflector of light would be unable to send the light signal back to the IR sensor. Hence, once the IR sensor was on the tape, it would show that no object was detected. Using this knowledge we would be able to detect the incoming wall and subsequently backtrack the ROV. The way the IR sensor were implemented in the ROV was as follows:

1. Two IR sensors were used in the front and the back.
2. If the front IR sensor detected the black tape (detected no object) the ROV would reverse.
3. If the back IR sensor detected the black tape (detected no object) the ROV would move forward.
4. If black tape was detected the ultrasonic sensor would be disabled so that there was no confusion between boundary wall and enemy ROV.

Figure 4: Infra-red Sensor

2.4.1 MG-995 Servo Motor

Figure 5: MG-995 Servo Motor

MG-995 servo motor was chosen as it was more powerful than the one used in labs. It was mounted on the top of the ROV using L-shaped metal holders (Please refer to image (9)). This was used to swing the hammer (attack) mechanism. The specification of the servo motor are listed below:

1. Weight: 55 g
2. Dimension: 40.7 x 19.7 x 42.9 mm approx.
3. Stall torque: 8.5 kgf·cm (4.8 V), 10 kgf·cm (6 V)
4. Temperature range: 0 ºC – 55 ºC
5. Operating speed: 0.2 s/60º (4.8 V), 0.16 s/60º (6 V)
6. Operating voltage: 4.8 V a 7.2 V
7. Dead band width: 5 µs
8. Stable and shock proof double ball bearing design

3 Pictures of the Model

Following are the upgraded images of our robot after having implemented the attack and defence mechanisms, as well as interfacing the robot with a Bluetooth module and sensors to regulate its movement.

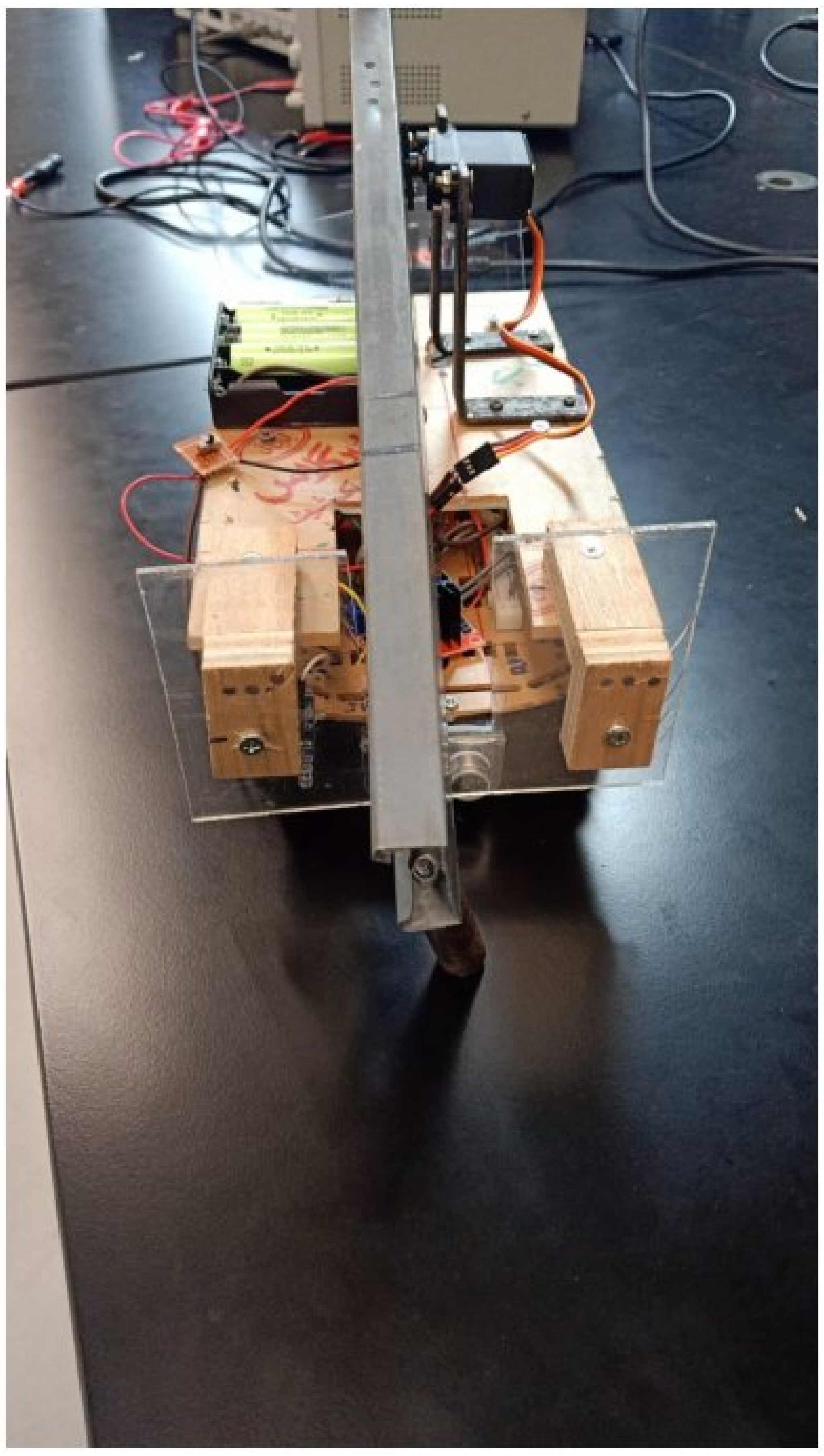

Figure 6: Front part of the robot showing shield, attack hammer, and batteries

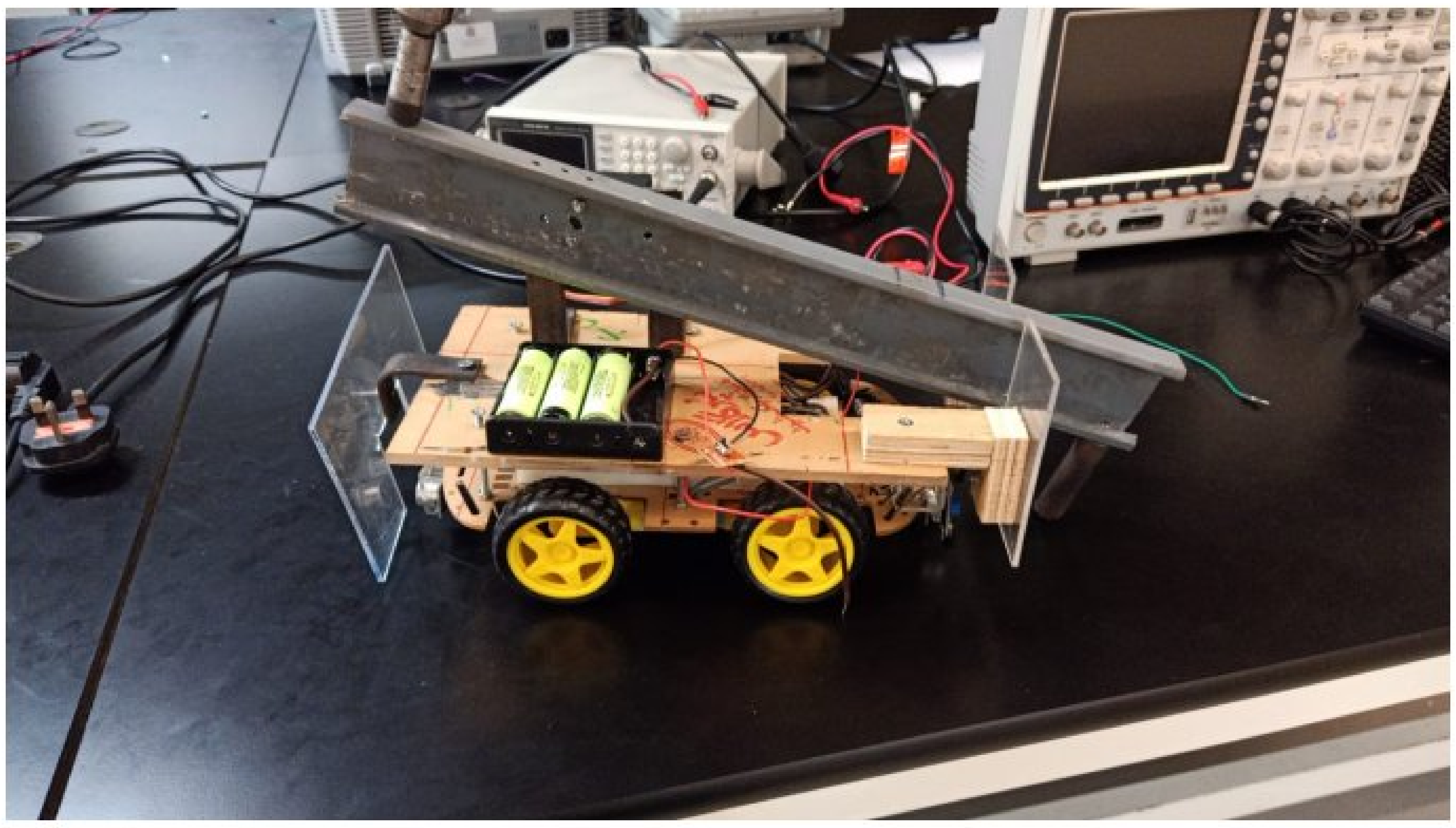

Figure 7: Sideways picture of the ROV

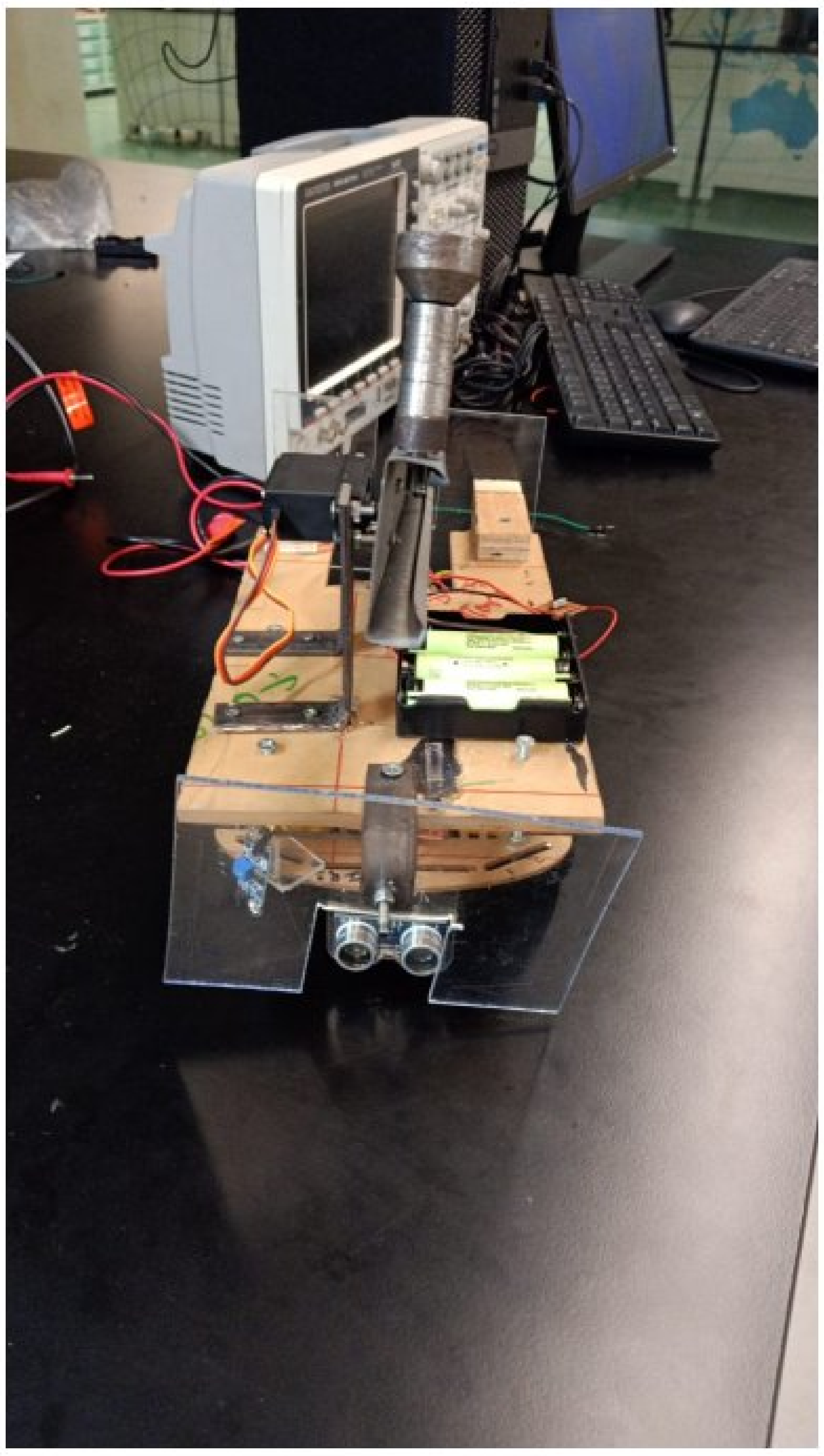

Figure 8: Back-angle of ROV showing counter weight for hammer, back shield, batteries, and sensors

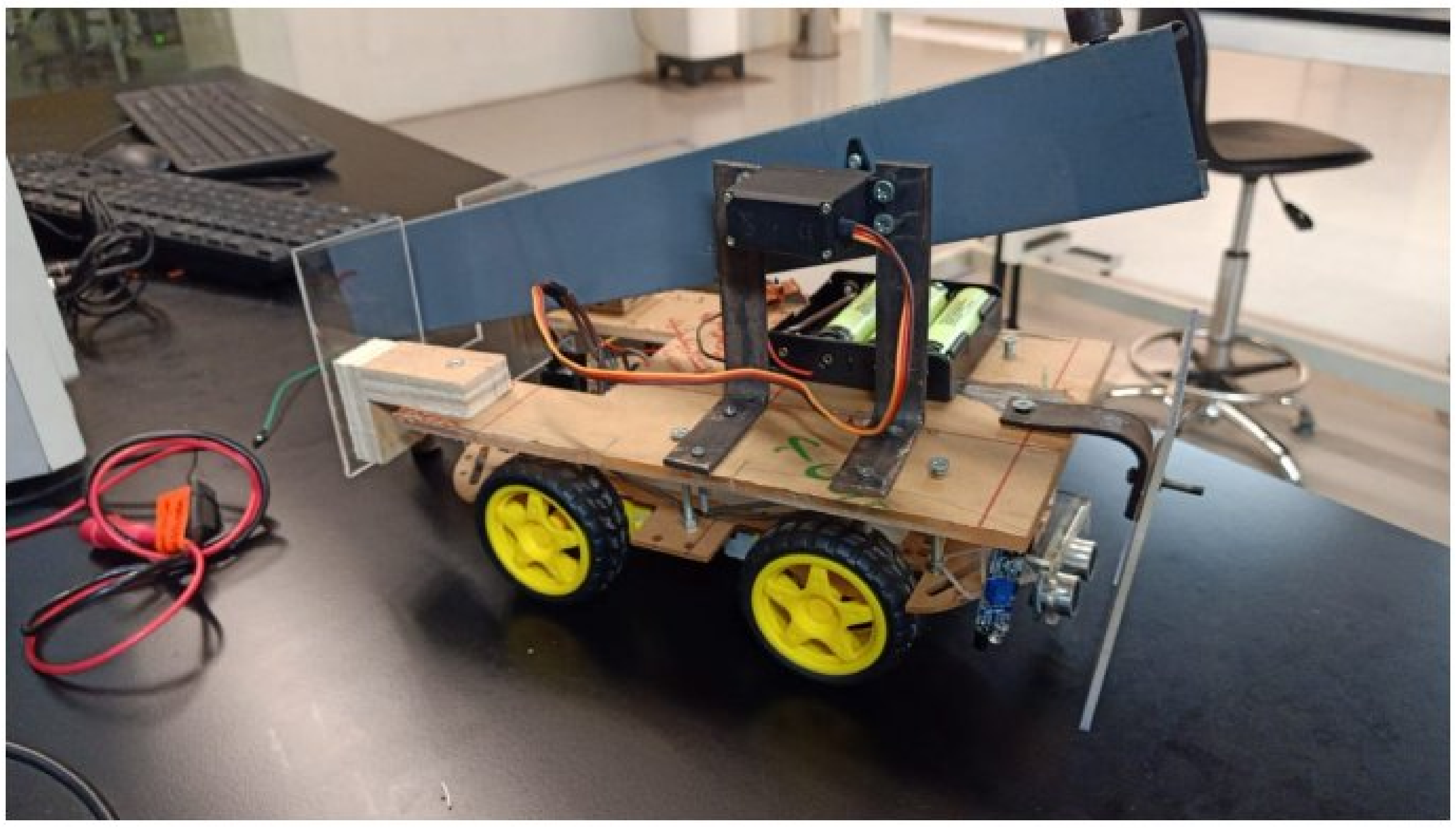

Figure 9: Other Side of ROV

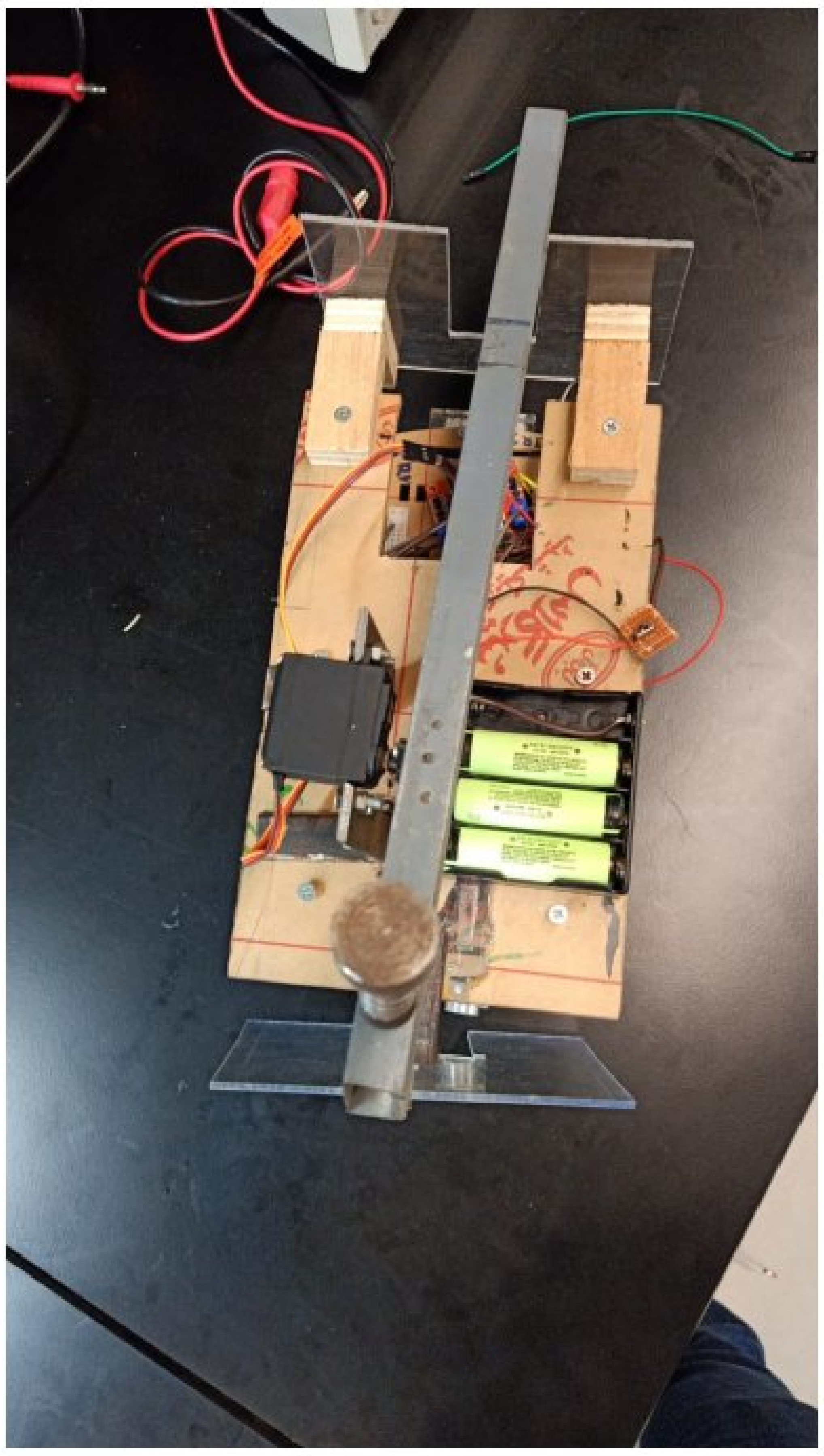

Figure 10: Birds-eye view of ROV

4 Pin Configurations

Function	**Pin**	**Pin Number**
Infrared Sensors		
IR1	PE_0	18
IR2	PA_7	10
Interrupt Pins		
interrupt_pin_backward	PD7	32
interrupt_pin_forward	PF4	31
Servo		
Servo Write	PF1	30
motor driver 1		
ENA1	PB5	2
ENB1	PB4	7
IN1	PA6	9
IN2	PA5	8
IN3	PE5	6
IN4	PE4	4
motor driver 2		
ENA2	PB2	19
ENB2	PF0	17
IN1	PB6	14
IN2	PA4	13
IN3	PA3	12
IN4	PA2	11
For Ultrasonic In Front		
Trig	PB3	38
Echo	PC4	37
For Ultrasonic At Back		
Trig	PE1	27
Echo	PE2	28
Attack Servo		
PWM	PD0	23

Table 1: Pin Mapping

5 Top Level Flow Diagram

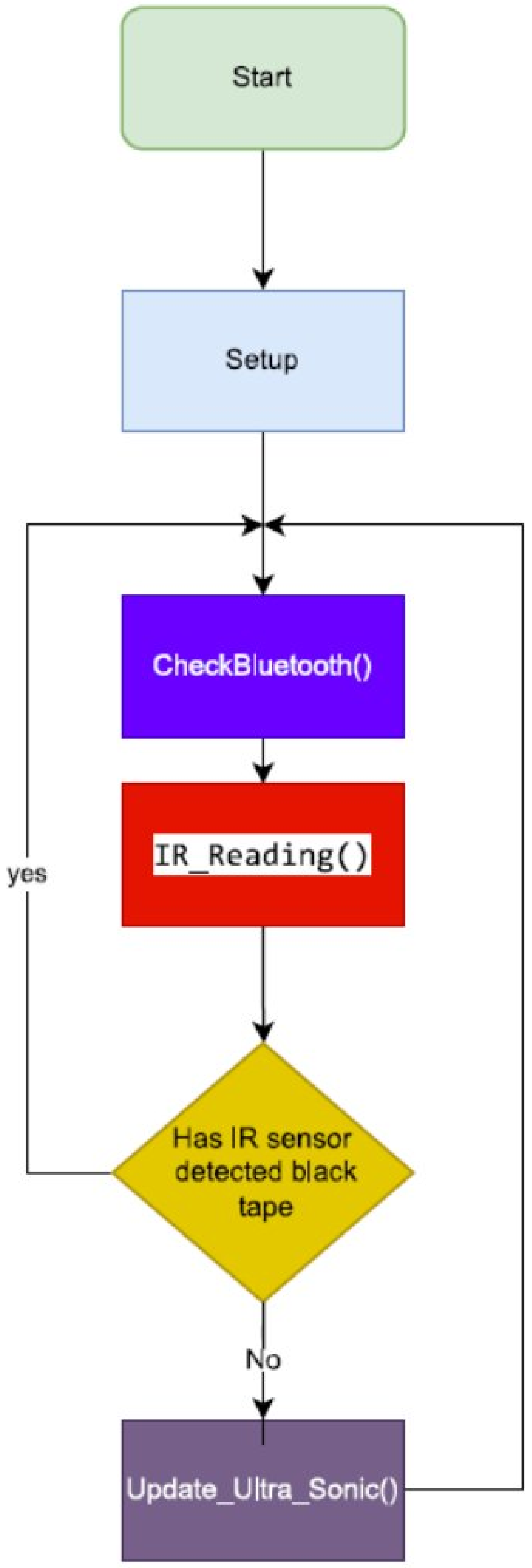

Figure 11: Top level flow diagram