ACS6502 Group Project (GP) Final Report

Maze Runner

Group 12, Task 3A

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1 COMPONENT LIST & PURCHASED ITEMS

See Table 1 and Table 2 (Appendix).

2 OUTSOURCED DESIGN/LIBRARY/SOFTWARE

No outsourced materials were used.

3 MECHANICAL DESIGN AND FABRICATION

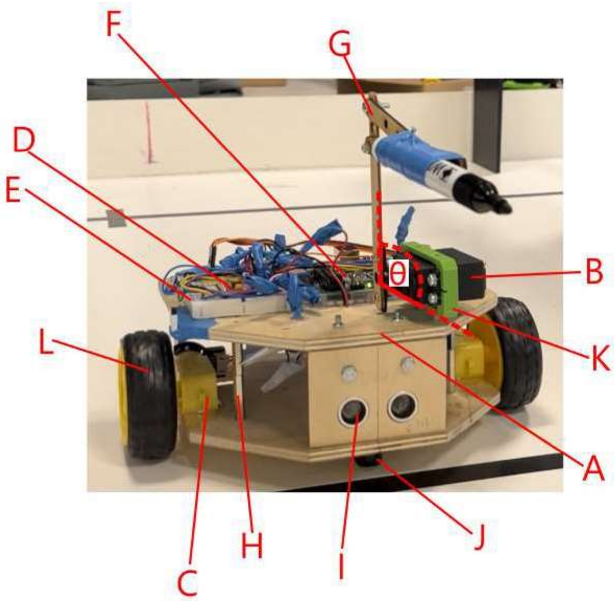

Fig. 1 The final robot design. B: Servo. F: Arduino. E: Breadboard. C: DC motor. I: Ultrasonic distance sensor. θ: Servo control angle. See Table 1 and Table 2 for all label definitions.

The robot utilises two dc motors with fixed wheels, on opposite sides of the robot along a line going centrally through the robot body. The body consists of two main plywood panels separated by spacers. To the lower panel is attached the driving motors and two spherical castors to the front and rear to ensure a stable base. The upper panel has the main electronic circuitry, batteries and servo motor attached to it. Further, a small panel is mounted to the top half of the robot at 90° downwards using brackets. This panel has cut-outs through which the single front-facing ultrasonic distance sensor is mounted. (Fig. 1).

The robot was designed using these separate mounting panels in order to allow parallel working during construction and troubleshooting. This proved to be a sound decision when the reliability of the main circuitry and drive motor mounting were both at issue at a late stage leading up to the physical demonstration of Task 3A.

Drive motors where adhesively attached in the final design. Experimentation with several mechanical motor mountings resulted in substantial wheel wobble and unreliable robot movement. Adhesive attachment provided ample rigidity, enabling a dependable control approach. Adhesive was also used to firm-up the motor shaft within the wheels, which was manufactures to a loose tolerance. Drilling a central hole, and threading into the shaft was considered, however this posed the risk of imperfect centring that could result in further wheel wobble and by extension less precise robot control.

Spacers were used on both caster wheels to ensure the main wheels (L, Fig.1) made contact with the ground without excessive rocking of the body. An additional spacer was placed on the front caster to implement a very slight upward angle on the front of the robot. This reduces the chance of interference from ground reflections for the ultrasonic sensor.

Plywood was selected as the body material due to the low cost and easy workability. No members of the group were experienced with laser cutting or 3D printing, thus the chance of making errors with such methods and wasting material was judged to be high. As a result, using a material that can easily be modified with subtractive hand tools and simple machine tools (e.g. scroll saw, drill press), something all group members were familiar with, was considered a better approach. Though the precision of manufacture is not high using these methods, it is sufficient to ensure the components interacting with the environment are square to each other, by using vernier callipers and set squares to draw out the design before cutting and drilling.
The body spacer size selection was made to ensure sufficient space for the motors between the panels as well as the battery pack.

MDF and acrylic were also considered as the primary body material. MDF was decided against due to the experience of some group members which suggested a susceptibility to weakening and fraying of edges when worked with repeatedly, something necessary as the design was validated. Acrylic was not used because the cutting methods chosen, for the reasons described above, have a risk of shattering acrylic.

The robot arm has one degree of freedom, using a linkage mounted at the centre of the servo and a second linkage perpendicular to the first, with the marker pen attached. The arm rotates on an axis parallel to the face of the whiteboard, meaning the pen can only make a vertical line on the board. This was chosen as it provided the simplest implementation of the task requirements. The arm is initially positioned at 90 degrees.

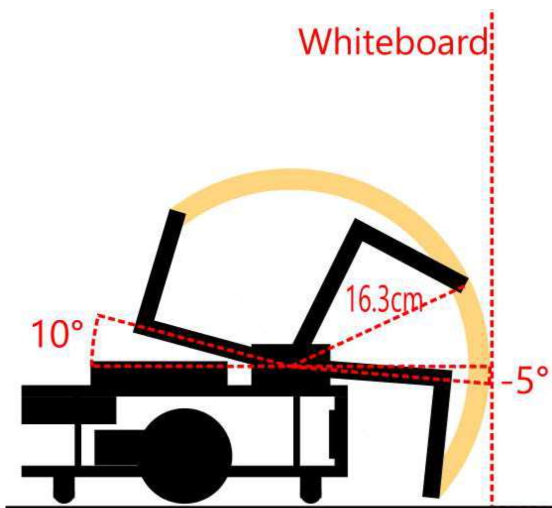

Fig. 2. The workspace of pen tip on the end of the servo arm (yellow). Side view.

A very light weight arm design was used, consisting of three thin plywood linkages. Two were mounted perpendicular to one another, using a single plastic rivet connection. A third linkage provided bracing against rotation about the rivet, by being offset slightly along the length of the first linkage while connecting to the same point on the end-effector section. While the servomotor has a stall torque of 9.4kg/cm, well in excess of what is required for the movement of the light weight marker pen, there was no mission-incentivised advantage to further complicating the arm mechanism because it performed as required.

Each wheel has a single degree of freedom, providing two degrees of freedom of motion around the arena. One linear degree of freedom perpendicular to the central axis in the frame of reference of the robot, and one angular degree of freedom about the vertical axis at the centre between the two wheels.

The centre of mass of the robot is deliberately positioned slightly to the rear of the robot, by placing the battery pack behind the main wheels. This serves the same purpose as the additional spacer placed on the front caster wheel, reducing the probability of ultrasound reflections from the floor of the task area. The centre of mass is well within the support polygon, as demonstrated by a complete lack of balance issues during testing and demonstration, because of the presence of the rear caster wheel. All wheels are on the ground at all times, thus in any designed configuration the centre of mass remains within the support polygon.

4 ELECTRONICS

The main electronic components are shown in Fig. 3. A 9V power pack of 6x 1.5v AA batteries directly supplies the Arduino UNO microcontroller, and the Vm input of the motor driver. The sensor and servo, as well as the Vcc of the driver, are supplied from the 5V outlet of the Arduino. All components share a common ground, in practice implemented through a rail of the breadboard used to build the schematic in Fig.3. A single pole, single throw, switch is used to control power supply to the entire circuitry.

The Arduino Uno microcontroller was utilised due to the existing familiarity of group members with its use, in addition to it having sufficient inputs and outputs for the sensors and controls required to construct the designed robot. Moreover, the computations required were well within the capabilities of this microcontroller.

A single ultrasonic distance sensor was used in the final design. The accurate range (2cm-400cm) and precision (3mm) of the sensor made it usable at all positions within the arena, without requiring further sensors to create overlapping intervals of accurate measurement. Initial designs utilised a second, side mounted, ultrasonic sensor to correct for motor speed variation at fixed speed signals. However, the second sensor was damaged due to a short circuit during construction. Careful calibration of PWM values was sufficient to ensure reliable motor speeds when battery capacity was high.

While the both of the servomotors available within the kit provided were sufficient to carry the basic arm and pen design, the larger MG996 model was chosen in favour of the SG90. The SG90 has a stall torque of just 1.8kg/cm, which may have issues with the resistance of the whiteboard in situations where the stopping distance of the robot at the whiteboard was imperfect.

Since the battery was an integral part of the circuit it was at first suggested to use multiple battery section to support different sections of the bot. Two servo motors were to be controlled by three batteries and the Arduino board and the servo controlling the arm was controlled by the another set of three batteries. It was later that finalized that the all six motors will be connected in parallel to support all the components. The batteries used were 1.2V rechargeable batteries.

Initial designs utilised a soldered protoboard, after finalising the prototype with a breadboard, justified on the basis of resilience to movement and reduced likelihood of accidental disconnects. Significant electrical problems were encountered in the course of manufacturing, however, and as a result a change was made to utilise a breadboard for the final product. Though this increased the chance of disconnections, circuit problems were continuously possible to troubleshoot which was a substantial advantage. Moreover, the overall circuit current is just at the maximum recommended for breadboard use and caused no issues.

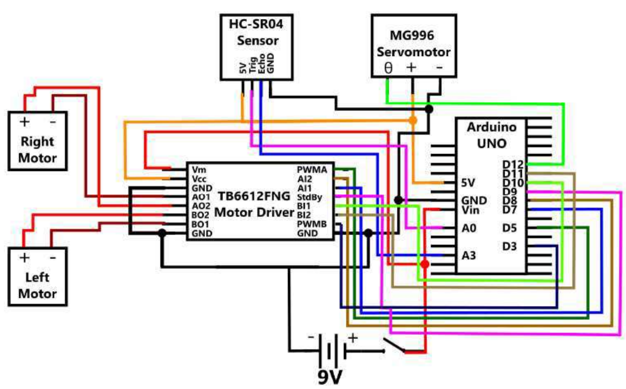

Fig. 3 Schematic of robot electronics.

5 CONTROL

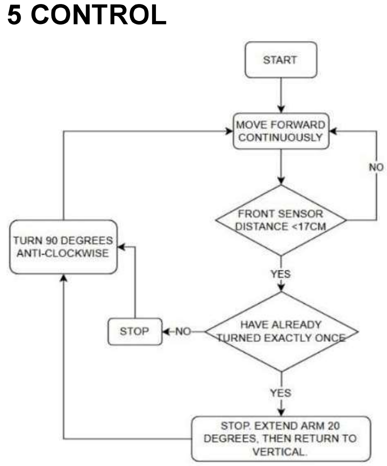

Fig.4 Operational logic utilised for the task strategy.

The conclusion was to simplify the task. So, basic use of structured algorithm was used. Initially the bot is supposed to move forward until the US sensor detects the range of obstacle to be under 17cm. Once the bot reaches within the vicinity, it was calibrated to achieve turn towards left 90 degrees. Again, the bot moves forward. Now if the bot has already turned exactly once. It would stop and perform the task of moving the servo on the top of second panel. With this, the bot achieves the target and finally returns back to original and keeps the loop continuously running.

6 APPENDIX

Table 1: Component list.

Label	Component
F	Arduino UNO
E	Breadboard
-	Connecting wires
-	Battery box
C	2x DFRobot Micro DC Motor with Encoder
B	MG996 RC servomotor
-	M2x8mm Phillips Head Flange Screws
D	TB6612FNG Motor Driver Board
G	2x Wooden Robot Arm Linkage, "Type A"
K	Bracket for mounting MG996 RC servomotor
H	Panel mounting spacer

Table 2: Purchased Items.

Label	Item
I	3x Ultrasonic sensor
J	2x Castor wheels
L	2x Wheels for DC motor
-	6x 3 AA Battery
A	Plywood
-	Marker