Stair Climbing Robot

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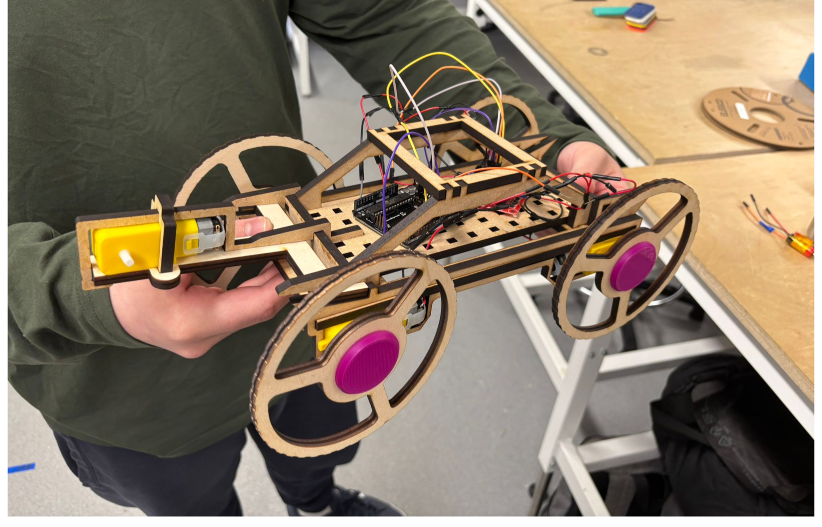
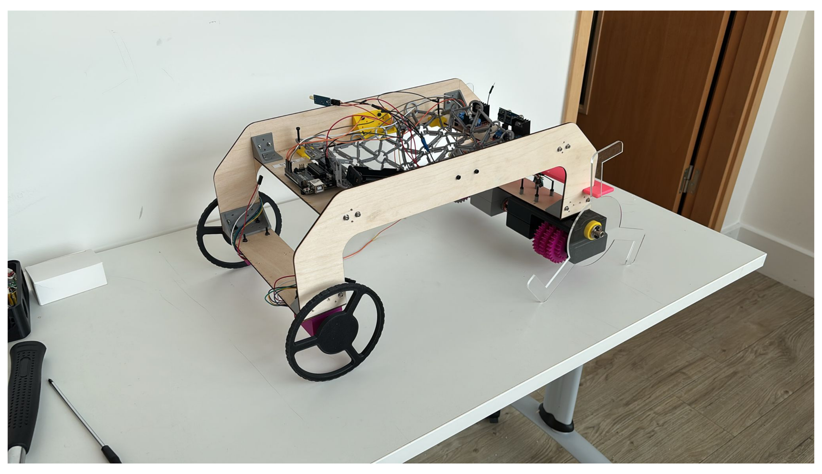
https://github.falmouth.ac.uk/GA-Undergrad-Student-Work-24-25/COMP208-GROUP-SCALING

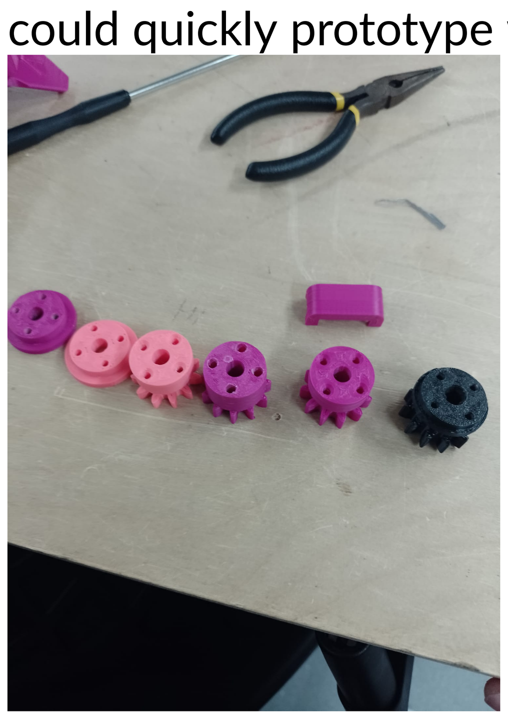
Falmouth Uni-Robotics

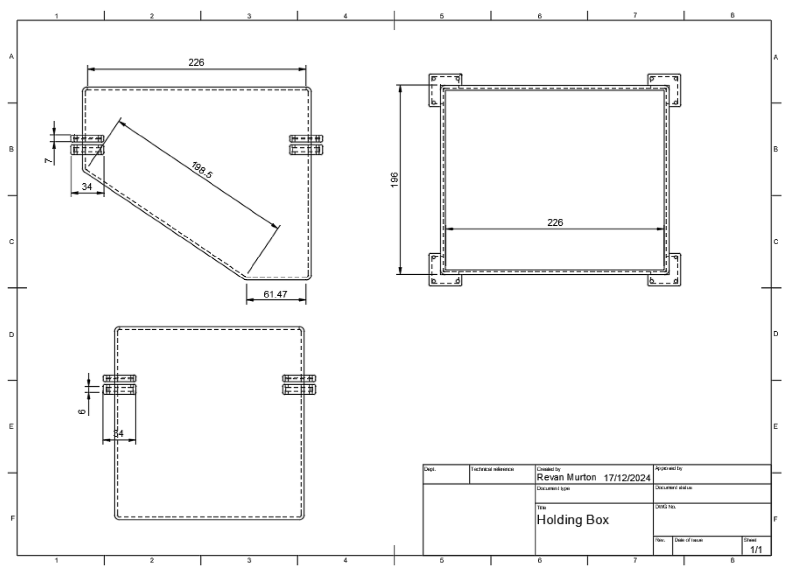




Introduction

- For this project my team was assigned the scaling contract. This entailed making a robot that could climb/jump up 2 flights of stairs, with a minimum of 20 steps and a 90◦ turn. In addition to having to climb these stairs it also needed to be load-bearing for a weight of 1kg. Dropping this weight would result in the task being failed.
- We decided upon creating a 1:3 scale version of the robot to ensure we could quickly prototype with the components and materials we had on hand.





Electronic Usage

1. Originally I thought to use a laser rangefinder [5] that was on a rotatory actuator that would differentiate between the stairs and walls, next I thought to use a magnetometer, this would use the pitch of the robot to determine if it was on a tilt. However a tilt sensor would achieve the same result as either however with far less code, 3D modeling, and wiring required.
2. We used:
   - 2x Motor Shield (l298n)
   - M-M, M-F Jumper Wires
   - 1x Arduino Uno
   - 4x Motors (JGA25-370)
   - 1x Ultrasonic Sensor
   - 1x Tilt Sensor
3. Throughout this process I used various tools in the lab to help reposition and secure different components in different configurations. The use of wood for the chassis allowed me to easily drill and reposition components for more effective design.

Scaling Robot Code

- At the start of the project I wrote code that tested the movement forwards and backwards, I've added and modified this test code along with creating test code for both motor driving and utilizing tilt sensors. Additionally I used functions to quickly use the required elements without repetition.
  The state machine architecture evolved as the project progressed, going from a system that would use a laser rangefinder and 6 states to a much simpler and efficient 4 states and tilt sensor. To make debugging quicker the PWM movement of the wheels was made into function that could be called.

Materials and physical design elements

The plastic components I created were; a concept for a rotary actuator (laser rangefinder), prototype compound gear box, parts of the final improved compound gear box, crossbar and a holding box.

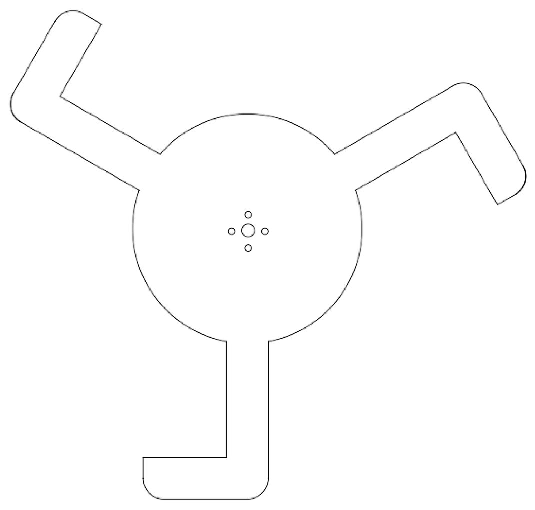
The rotatory actuator prototype and gearbox highlighted multiple errors in my fusion design:

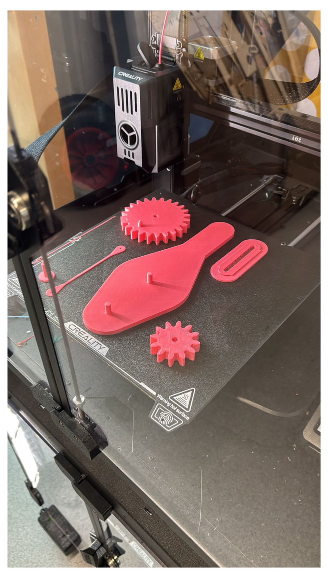
1. Plastic Axles are especially weak when freestanding, in both this caused them to break at the joint after only a small amount of force.
2. Holes may shrink when 3D printed and this should be taken into account when designing.
3. Having gears that are too thin will prevent gear meshing as they will slip out of place often.
4. Ensure that the 3D print can be easily assembled and disassembled or else construction and modification becomes nearly impossible.

Taking into account these problems I helped Luke design the final gearbox by assisting in avoiding these mistakes, as well as designing the wheel gear. Here are some of the steps we took to avoid these:

1. The plastic axles were replaced by metal rods, these were secured on both ends.
2. The gears were thicker and secured significantly better to prevent wobbling/improper gear meshing.
3. The entire print could be disassembled and reassembled which helped massively in diagnosing and debugging problems.
4. The bore holes were made slightly bigger than the metal axles to account for the shrinking caused by 3D printing.

I laser cut multiple wheels from both acrylic and wood that were used to test various designs quickly. Allowing quick prototyping and debugging.





Results

Unfortunately despite the amount of effort and work put into this project we couldn't get the robot to climb more than a single step, ultimately our critical mistake was how late we realised that gearing would be vital to achieve any part of this project. We had the robot wheels all spinning but it didn't have the torque to pull itself up each step consisitently.

Research

- The weight and size required for this task immediately pushed any ideas of bio-mimicry from my mind, as most examples are tick/locust [1] [7] inspired robots that are able to launch themselves more easily upwards due to their small stature, a luxury we didn't have.
- Next I looked at varying designs ranging from a robot that uses suction in order to cling to walls or "star" [4] [3] wheels that are used in wheelchairs. We settled on a hook design, this was because of the relative simplicity compared to other options as well as the ability to more easily change wheel placement, shape and configuration in order to discover the most effective option.
- I watched the tutorial mentioned in the mechanism Workshop in order to make the rotatory actuator.
- This robot uses a track design [2] that we hoped to replicate but after discovering the difficulty invoked in creating a tracked robot decided against this to better manage our time.

Forthcoming Research

Although a smaller robot this kickstater is of a robot vacuum [6] that they claim will be able to climb stairs to vacuum the usually impossible to reach spots for a robot of this kind.

References

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