Reconfigurable Mobile Platform

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Abstract

Unmanned ground vehicles (UGVs) are used by warehouses to move millions of packages every day. The *warehouse problem* has largely been solved by mapping out warehouses and using UGVs of standardized sizes to fit under standardized carts. This makes it easy for these autonomous robots to operate at scale as more and more robots are added to the warehouse floor. One limitation to this design is that the robots are limited to carrying only objects that fit on the standardized carts. Another limitation is, the robots do not communicate amongst each other or collaborate with one another. Our project focuses on building scale models of UGVs that can operate individually but also have the capacity to lock together to create UGVs of varying dimensions with increased surface area and load bearing ability.

Problem Definition

Design and implement multiple reconfigurable mobile platforms that are able to move autonomously and work as a team in order to reshape and maximize applications of usage.

Goals

1. Build platforms/ UGV bodies that can lock together
2. Add a microcontroller and motors so that the platforms can move around autonomously
3. Add sensors to the platforms so that they can lock together autonomously
4. Program the robots so that they can move as a single robot when locked together

Materials

- 5V Stepper Motor
- ULN2003 Driver Board
- Self-Designed Lock and Hold
- Self-Designed Motor Holders
- Self-Designed Turret
- Self-Designed IR Diode Holder
- 5/8-inch Roller Casters, 22lb Load
- Breadboards
- Infrared Diode Emitter and Receiver
- Ultrasonic Module HC-SR04 Distance Sensor
- 9V Alkaline Batteries
- ARDUINO MEGA 2560 REV3
- H-Bridge DC Stepper Motor Drive Controller Board
- 9.6Volt Battery Pack 2200mA per hour
- Piezoelectric sensor
- Zinc Plated Utility Hinges 1" with 1/6 in screws
- Custom Made Juliet Board from ENGR 120
- 6V DC Motor 6000RPM,90mA
- Aluminum Unthreaded Spacer, 3/16" OD, 1" Long, for Number 4 Screw
- Compression Springs-#75 Zinc-Plated Steel
  - For Motor Holders: D(9/32")L(3/2")
  - For forces on Locks: D(3/8")L(63/100") (k=37.019)

Figure 1: Program used to code UGV

Figure 2: Program used to create 3D models

Key Mechanical Components

Sensor Turret

Connects stepper motor to the sensor turret design and rotates IR receiver within it to search for the IR Diode

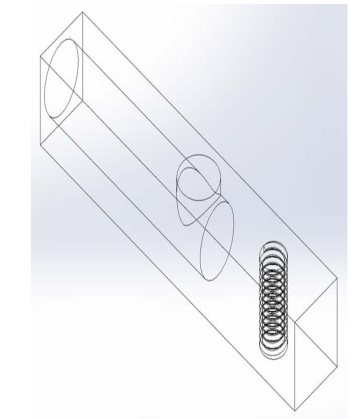


Figure 3: 3D print design to hold IR Diode and attach to rod

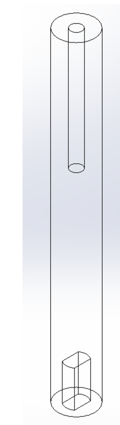


Figure 4: 3D design to connect stepper motor to rod

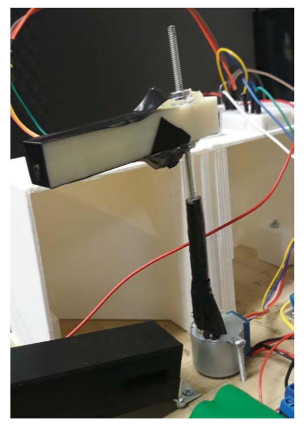


Figure 5: Final product of sensor turret design

IR Diode Hold

3D print designed to host the IR Diode and focus the IR beacon emitted

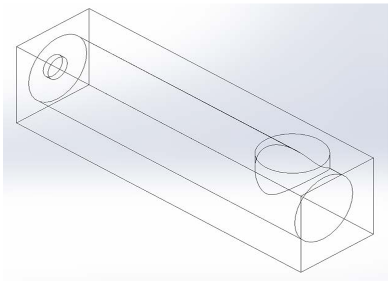


Figure 6: 3D print design to host IR Diode

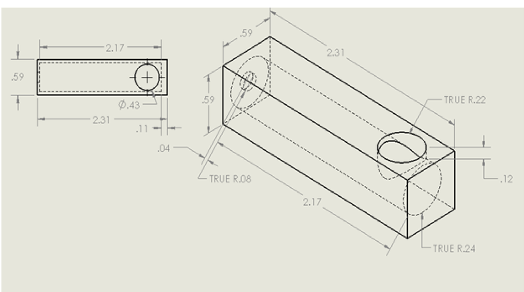


Figure 7: Dimensions of 3D print in mm

Locking Mechanism

Allows the Platforms to lock together

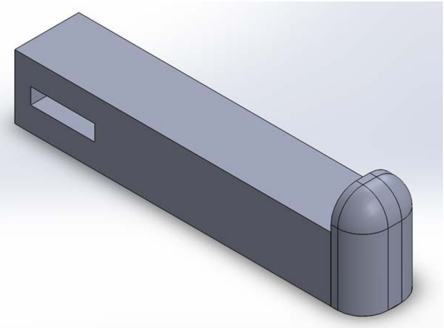


Figure 8: Lock designed to connect platforms

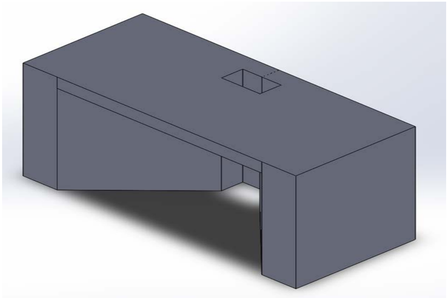


Figure 9: Concave structure designed to guide lock into a cavity and hold it

Spring for Lock (k=37.0190)

Provides the force for the platforms to stay locked

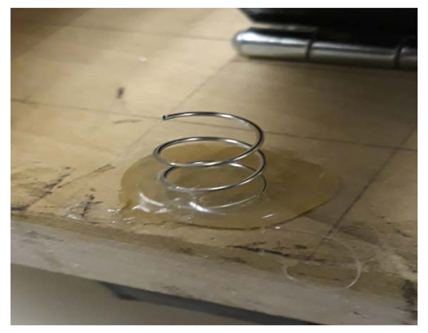


Figure 10: Spring held in place by glue from a glue gun


Figure 11: Spring applying upwards force to allow mechanisms to lock

Motor Holds

Holds motors in place to be attached to wheels and to the platform

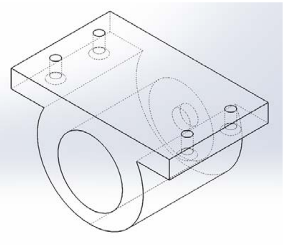


Figure 12: 3D design of motor hold

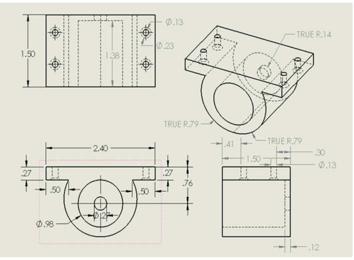


Figure 13: Dimensions in in. of 3D design

Suspension System

Allows platform to adjust to terrain and weight to match height of casters


Figure 14: Suspension system compressed fully

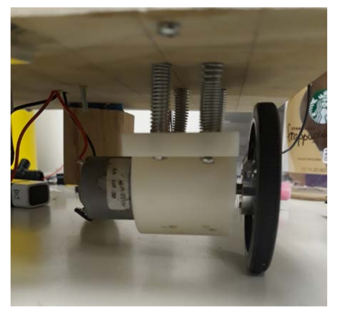


Figure 15: Suspensions system with no compression

Key Electrical Components

Arduino Mega

One board was used in each of the robots as the primary microcontroller.

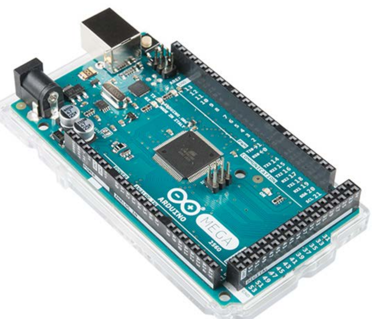


Figure 16: Arduino Mega Board

Infrared (IR) Communication

For IR communication a three legged infrared receiver module and a infrared emitter LED were used.

H Bridge Motor Driver

Allowed the motors and wheels to be controlled by the arduino using polarity and a PWM signal.

Ultrasonic Sensor

Used to detect the proximity from one robot to the other and send a different signal.

DC Motors

Contributed in the movement and rotation of the robots.

Stepper motor

Used to rotate the turret and keep track of the number of steps taken which can be converted to radians.

Technical Approach

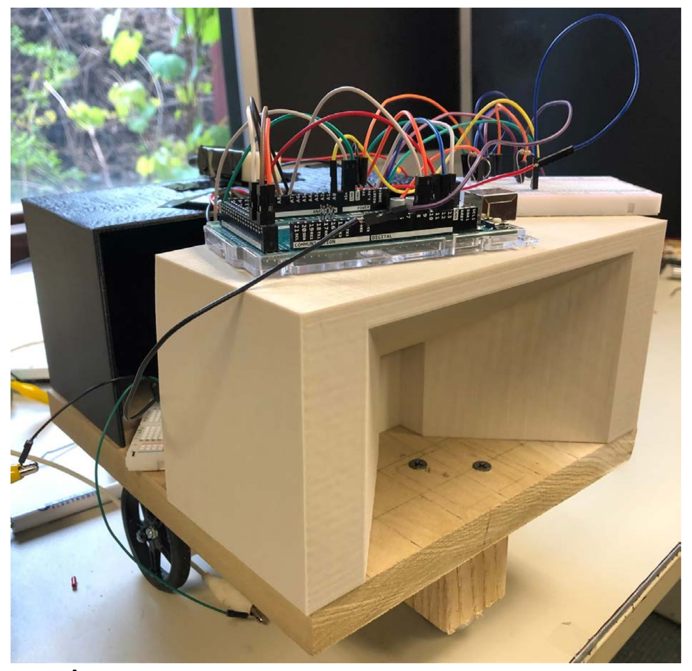
The finalized lock-in design was constructed using SolidWorks and a 3D printer. The structure consisted of a rod with a custom shape that worked as a lock, and a concave structure with a cavity that acted as the lock hold. The rod was pushed upwards into the cavity thanks to a spring system that allowed both platforms to stay locked.

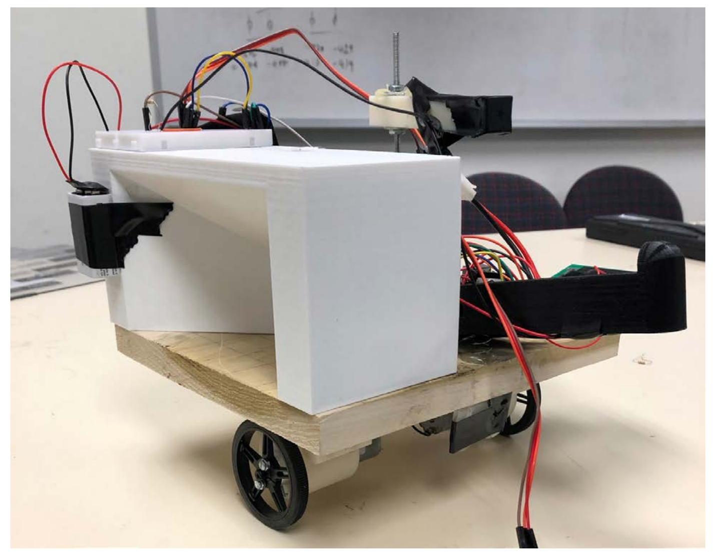
For movement, a two wheel drive system with a caster was used to simplify the movements and control of the motors. A suspension system was developed and implemented using custom made motor holders and other physical components.

Regarding communication and detection, an infrared LED was used to send a digital signal of pulses of IR light which are unique for a specific IR code. The receiver then decodes the pulses and identifies the unique code that has been sent. This helped to account for false positives and noise. An ultrasonic sensor was also used so that when the emitting board identified the receiving board within a certain distance, the code sent would change to modify the command. Due to the wide angle of emittance of the IR LED and the receiving angle of the receiver, it was decided to use an IR beam and a turret that would find at which angle was the signal being received. To implement this, it was decided to use SolidWorks and create a hold for both the emitter and receiver.

The emitting platform was stationary while the receiving platform followed a loop of three independent processes: movement with no signal found, rotation of the turret, and movement if the signal is found.

Results


Robot A


Robot B

Conclusion

The final design consisted of a successful system of locking but unfortunately due to the multiple processes, high angle of emittance from the LED, and time limitations, not all the goals were met. There were several things to account for and even though some of the processes worked independently it was extremely difficult to get them to work together. Communication once lock-in was successful and would have been interesting to explore but unfortunately we did not reach that point.

Future Work

- Increase range of IR communication.
- Make platforms work together and communicate after lock-in.
- Develop more than two boards.
- Increase angle of successful lock-in.
- Have multiple emitters and receivers
- Implement multi directional movement.

Acknowledgements

Trinity College Engineering Department

Dr. Taikang Ning

Dr. John Mertens and Dr. Harry Blaise

Andrew Muslin

Trinity College Center for Education Technology