Design of an All-terrain Unmanned Ground Vehicle

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ABSTRACT

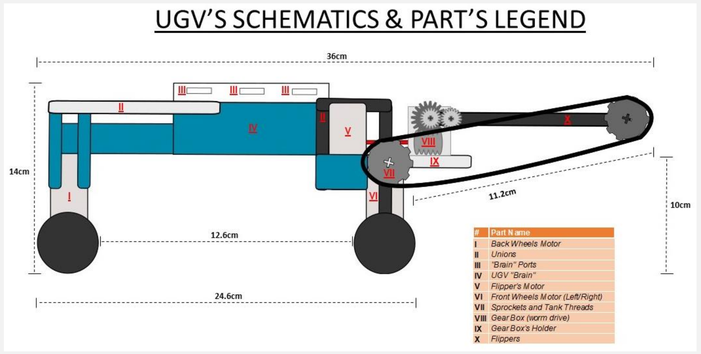
Unmanned Ground Vehicles (UGV's) are invaluable for public safety tasks such as Explosive Ordnance Disposal (EOD). In collaboration with L3Harris Technologies, we are exploring alternative designs to the traditional "treaded" robot design in favor of designs more capable of reliable stair-climbing. We designed and built a motorized Lego device for testing to evaluate a promising alternative "articulated" design combining wheels and legs since if it is possible to create it using Lego pieces, it should be possible to build it with more complex equipment. The current model can be moved using a game controller, and it can both spin its wheels and rotate its legs about an offset axis. Currently, the current prototype is capable of climbing 17-cm tall obstacles. The future for this project will aim to create a robot that can easily climb stairs while being sturdy enough to allow other tasks like bomb defusing. Ongoing work will systematically test control strategies for climbing over obstacles and upstairs, automatic movement, and other additional features.

UGV CONCEPT

INTRODUCTION

- ❑ Based on a previous report written two years ago by the Aero-Propulsion, Mechatronics, and Energy Building in collaboration with L3Harris, this project aims to one of the proposed robot models from this report.
- ❑ The robot model we used is based on a simulation created by our team at the Aero-Propulsion, Mechatronics, and Energy Building.
- ❑ After creating several UGV prototypes, we decided to test out a promising model of around 14-cm high.
- ❑ The robot's test consisted of how successful the UGV is at climbing obstacles of different heights.
- ❑ Ultimately, the prototype demonstrates that it can climb obstacles up to 3 cm higher than its original height using the "Flipper" system.
- ❑ We will optimize future models to perform more challenging tasks.

UGV'S SCHEMATICS & PART'S LEGEND



UGV's Sketch with Measurements & Highlighted Important parts

METHODS

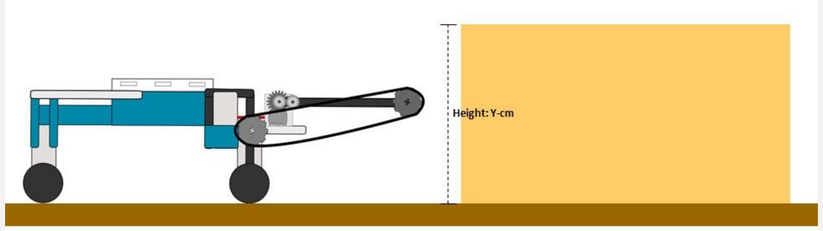
Materials

- LEGO® MINDSTORMS® Robot Inventor (51515)A
- Programming Interface - LEGO® MINDSTORMS® Robot Inventor

Procedures

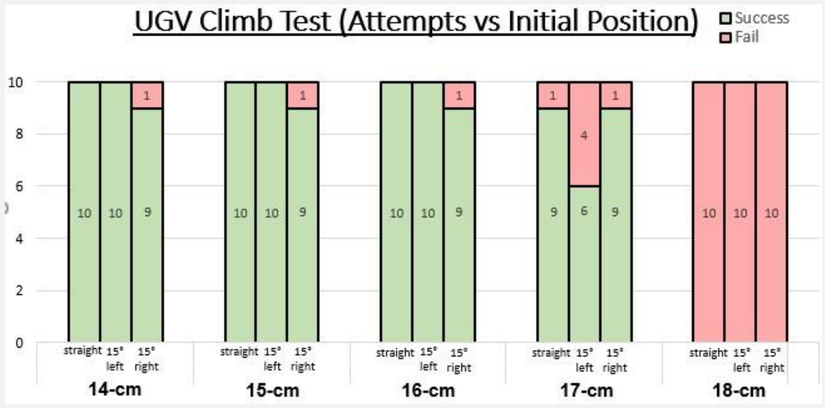
- Create UGV using the 51515 LEGO Kit
- Set the environment to test out a climbing task that includes:
  - ➢ Long rulers that are positioned through the length and height of the track
  - ➢ Multiple obstacles with different heights ranging from 14cm to 18cm. The upper base of the block must be at least 40cmx27cm.
  - ➢ Recording device centered on filming the prototype doing the task
- Start the pre-test of the final prototype by climbing the second-highest obstacle (17 cm) at least ten times.
- Test the UGV by measuring how long it takes to climb obstacles with different heights (14cm, 15cm, 16cm, 17cm, and 18cm) in three different initial directions from the obstacle (straight, 15° left, and 15° right.)
- Repeat this procedure ten times and record the data.

Testing Method Schematics



UGV Testing: Climbing an y-cm tall obstacle from three different initial positions

RESULTS



Success & Fail ratio out of 10 attempts in different positions and heights

DISCUSSION

- ➢ **Accomplishments**
  - The UGV climbed with a high success rate in all test variations in obstacles from 14cm to 16cm height.
  - Overall, the forward position test was had the highest rate of success out of all three variations regardless of the obstacle's height.
  - In most tests, the robot accomplishes climbing regardless of breaking some parts in the process
- ➢ **Setbacks**
  - Climbing of an 18cm tall obstacle couldn't be accomplished.
  - Angle climbing is more challenging to accomplish than straight climbing.
  - Falling wheels, flipper system unalignment, and lost balance often occurred during testing.
- ➢ **Possible solutions**
  - Reinforcement of joints and wheels can reduce the rate of pieces falling apart.
  - Using two motors to replace the single back wheel motor can improve both the UGV movement and its control while climbing an obstacle, reducing the chances of losing balance
  - Improving the placement of the Gearbox can help in straightening the flipper system.
  - Placing the sprockets on the same axis can erase the pressure on the flipper's axis, making it have a smoother rotation of threads and accelerating the climbing process.

CONCLUSION

- ➢ **Summary**
  - The UGV climbed obstacles from 14cm to 17cm with a reasonable success rate in each different category.
  - The flipper system allowed the UGV to climb obstacles up 3-cm higher than its original height.
- ➢ **Relevance:**
  - The project proves the potential of legged-wheel UGVs at obstacle climbing. Additionally, overall potential improvement will open the door for more investigations on this model.
  - Documentation on the UGV's hardware and software will be stored and provided to future similar projects that may need it.

REFERENCES

Clark, J., Hubicki, C., Austin, M., Adwait, M., Van Stratum, B., & White, J. (2019). *L3Harris High Mobility UGV Study*. Scansorial and Terrestrial Robotics and Integrated Design Lab & Optimal Robotics Lab. *https://www.optimalroboticslab.com/*

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