Creation and Optimization of a Mechanical Obstacle Avoidance Sensor for Autonomous Exploration of Venus

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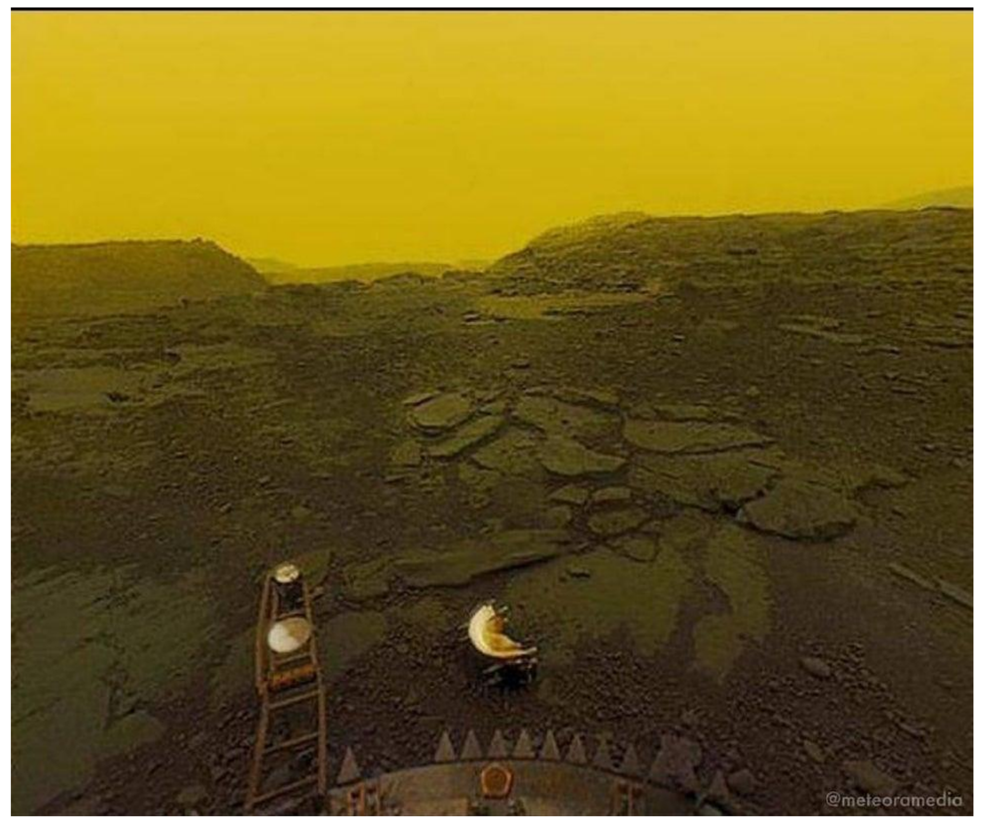
BACKGROUND

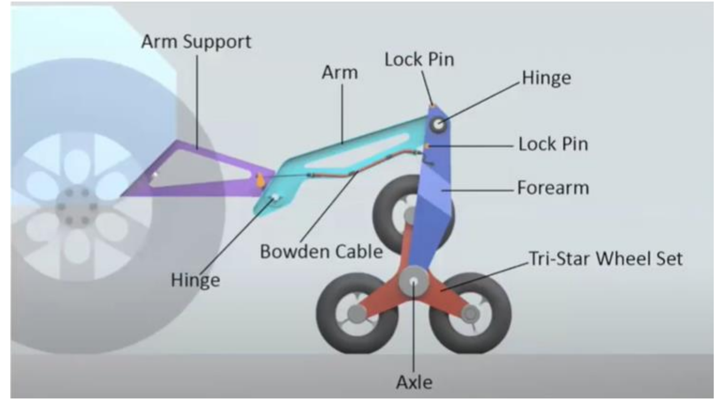
Exploration of the surface of Venus is currently one of the most lacking areas of planetary research in our solar system today. This is because the surface of Venus is an extremely hostile environment, especially when considering the use of conventional Mars-type rovers. With temperatures exceeding 400 degrees Celsius, pressures 90 times that of Earth, and a sulfuric acid atmosphere, traditional electronics would quickly fail.



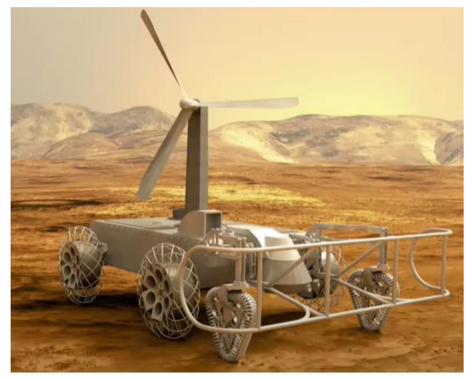
Surface of Venus - Credit: Roscosmos

HAR-V - Credit: NASA/JPL

WINNING DESIGNS



Credit: Youssef Ghali



Credit: KOB Art

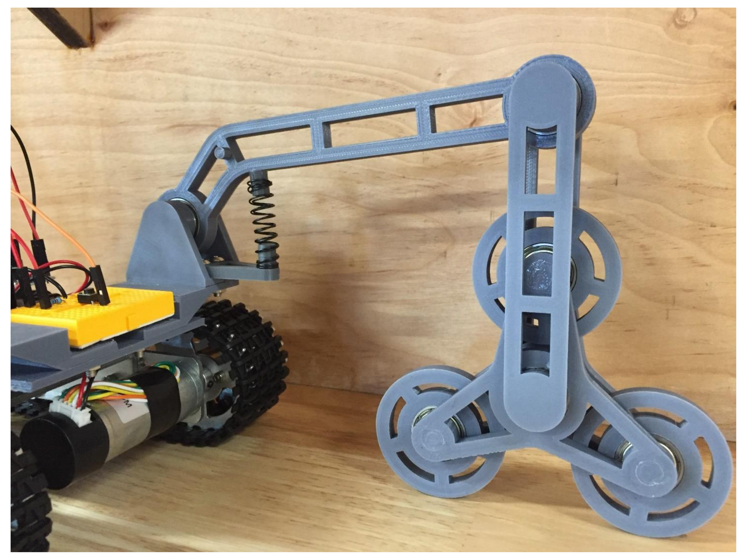
"EXPLORING HELL" COMPETITION

One solution to this problem is to make a rover less reliant on electrical components by designing mechanical replacements. The Automaton Rover for Extreme Environments (AREE), also known as the Hybrid Automaton Rover-Venus (HAR-V), does just that. In NASA's "Exploring Hell" challenge in 2020, teams designed mechanical obstacle avoidance sensors to be used on HAR-V. The main feature of these designs is the ability to detect steep drops and/or rocks directly in front of the rover, while ignoring less severe obstacles. Once detected, a mechanical signal could be sent via cables to the rover's drive system, triggering an avoidance maneuver.

PROJECT

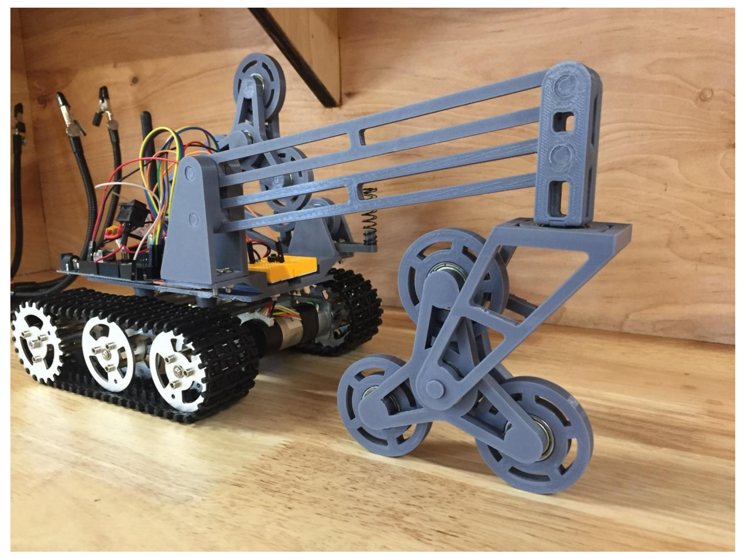
The purpose of this project is to build and assess a functional prototype based on the winning design from the competition. The poster illustrates that the obstacle avoidance sensor is feasible, but several critical aspects of the design were missing from the initial design to make a functional sensor. The project shows multiple solutions to these missing elements in order to create a working prototype that incorporates all of the required elements from the competition. Additional work can further optimize the design, and this project illustrates potential future paths to improve the sensor.

PROTOTYPE I



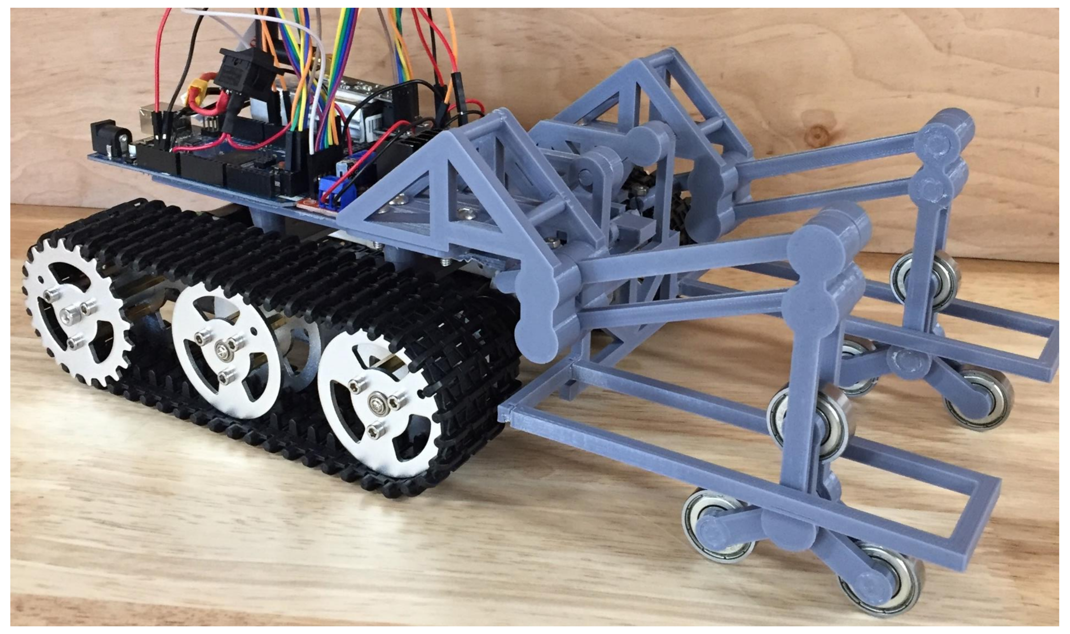
- Recreation of Youssef Ghali's winning design from the "Exploring Hell" competition.
- Requires springs to maintain structure.
- More difficult to tune.

PROTOTYPE II



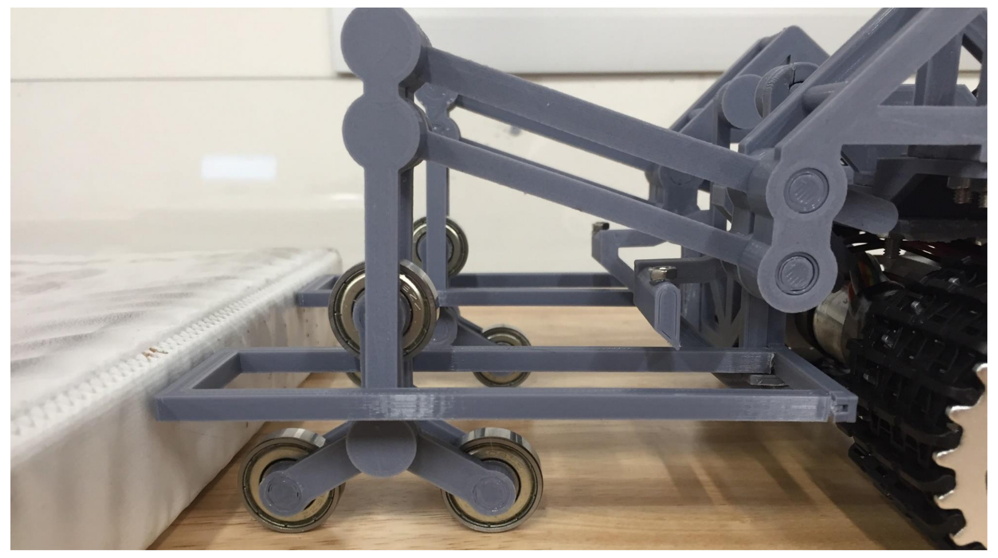
- Four bar linkage eliminates the need for springs.
- Wheel pivot improves mobility in tight turns.
- Pivot introduces the risk of getting stuck on an obstacle.

FINAL DESIGN

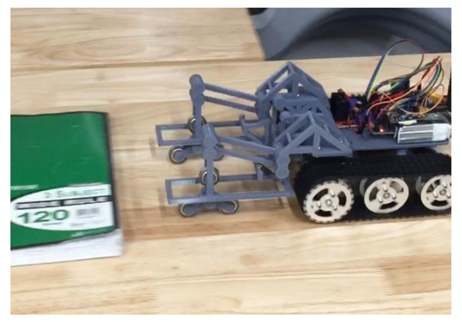


- Retained four bar linkage while eliminating pivot.
- Introduces large rock sensor.
- More compact, tunable, and robust.

ROCK AVOIDANCE

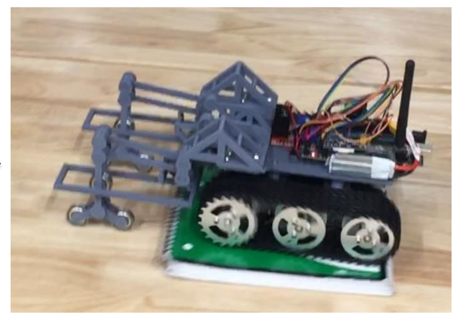


Objects too large to pass under the bumper bars are determined to be too large to drive over and trigger the avoidance maneuver.



The rover approaches a smaller obstacle.

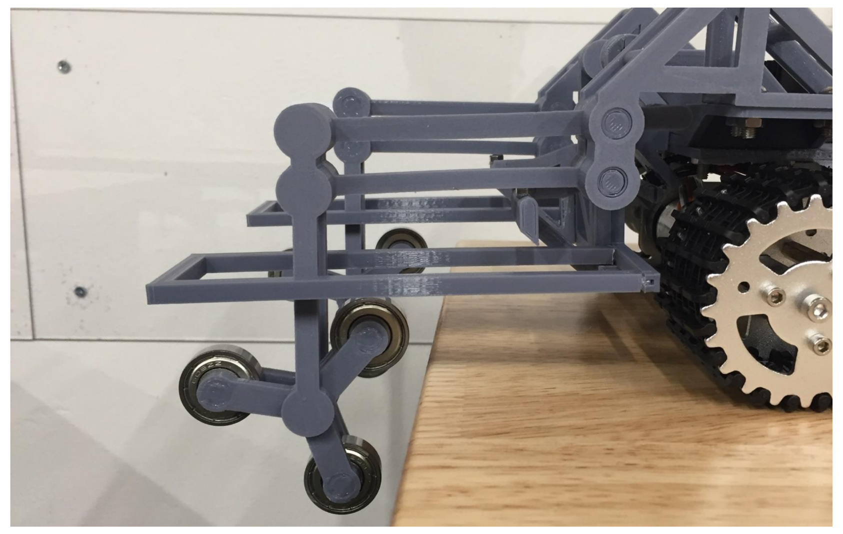
The "feelers" roll up and over the obstacle.

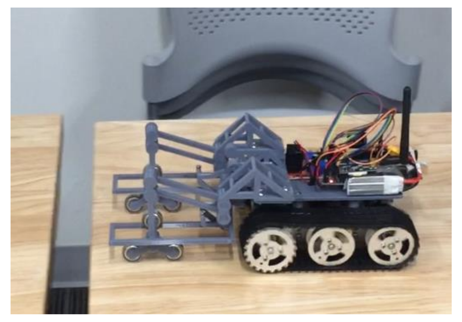


The rover can safely drive over the obstacle.

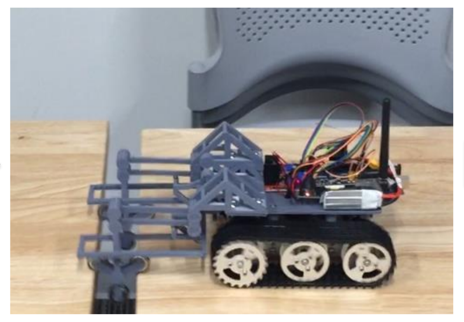
CLIFF AND STEEP DROP AVOIDANCE

When the "feelers" drop down too low, the hole is determined to be too large to safely traverse, and the avoidance maneuver is triggered.

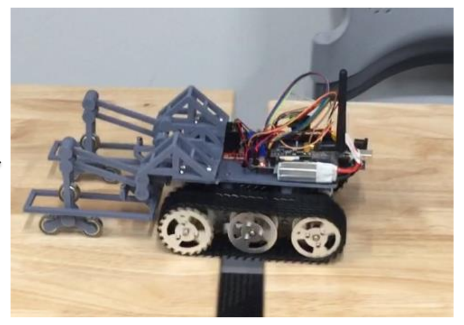




The rover approaches a smaller hole.



The "feelers" do not fully extend.



The rover can safely traverse the gap.

REFERENCES

- Sauder, J., et al (2017). Automaton rover for extreme environments.
- NASA Tournament Lab, HeroX (2020). Exploring Hell: Avoiding Obstacles on a Clockwork Rover

ACKNOWLEDGEMENTS

Dr. Jonathan Sauder NASA/JPL