Construction of Lunar Radio Astronomy Telescopes Leveraging Low-Latency VR/AR Teleoperation

NESS Network for Exploration and Space Science

University of Colorado Boulder

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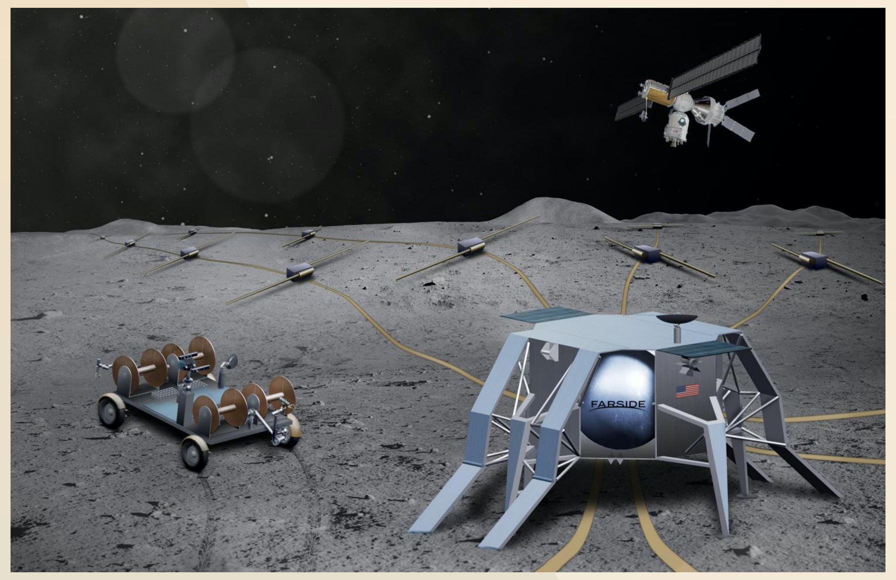
Introduction

FARSIDE, a NASA-funded concept mission, calls for the deployment of radio antennas over roughly 40km of lunar surface to build a low frequency radio array. All of this will be done through collaborative human-robot interactions. Low latency communication supported by the Lunar Gateway will allow for real-time rover teleoperation. In response, we propose a virtual reality (VR) recovery sandbox for human operator failure response. This sandbox acts as a risk free environment for solution development.



FARSIDE, a NASA-funded concept that would place a low radio frequency interferometric array on the far side of the Moon.

Research Objectives

- Simplify the process of planetary robotic failure recovery
  - Specifically assembly failure
- Create virtual recovery simulation
- Compare the effectiveness of problem solving in a virtual recovery sandox to traditional methods

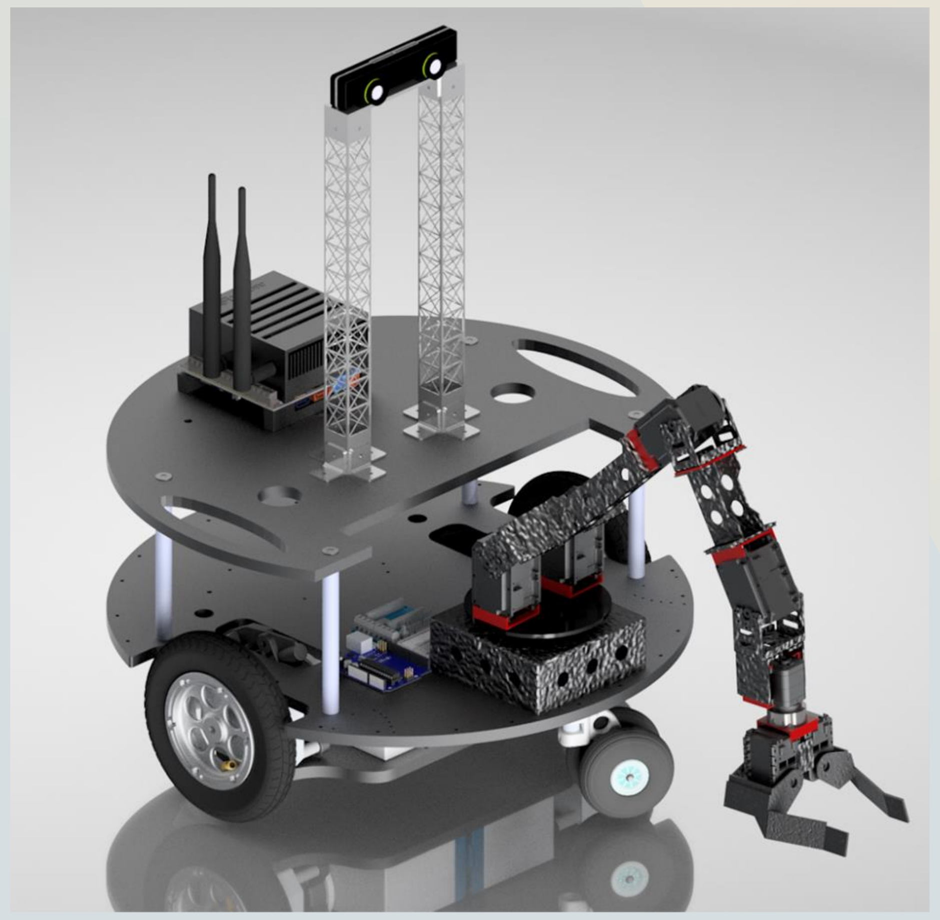
Our Robot

Armstrong Rover

- 6 DOF Crustcrawler Pro-series Robotic Arm
- Differential Drive Base
- Pan/Tilt ZED Mini (Stereoscopic Camera)
- Jetson Xavier (On-board Computing Unit)
- Arduino Microcontroller
- 30000mAh Power Bank

Control Interface

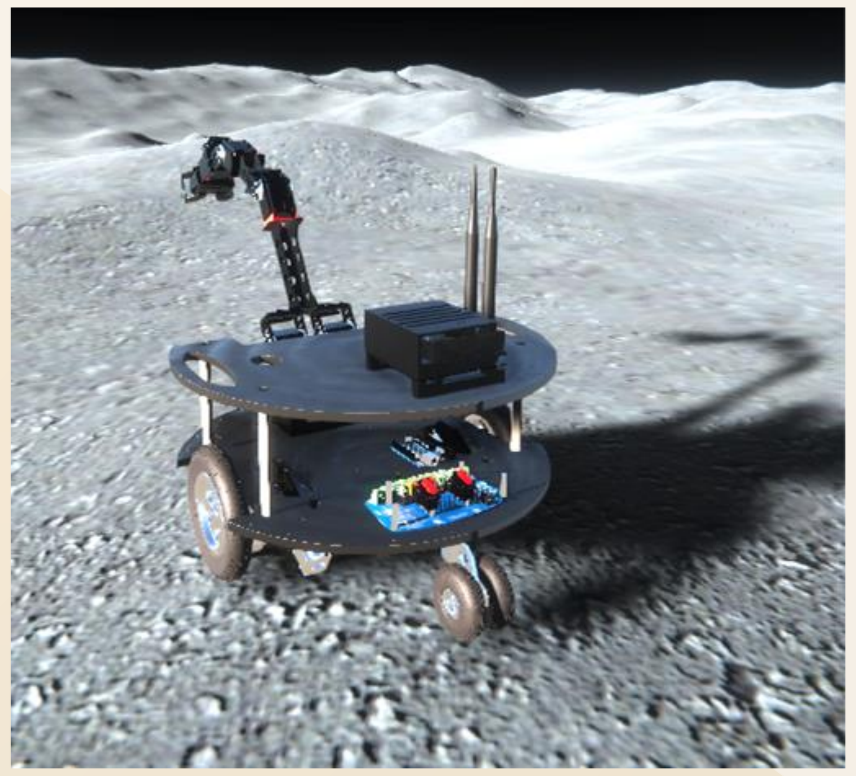
- Oculus Quest
- PC w/ RTX 2060
- Xbox Controller
- Virtual Simulation



Rendered image of the Armstrong Rover. Note that this model does not contain the pan/tilt mounting for the ZED Mini.

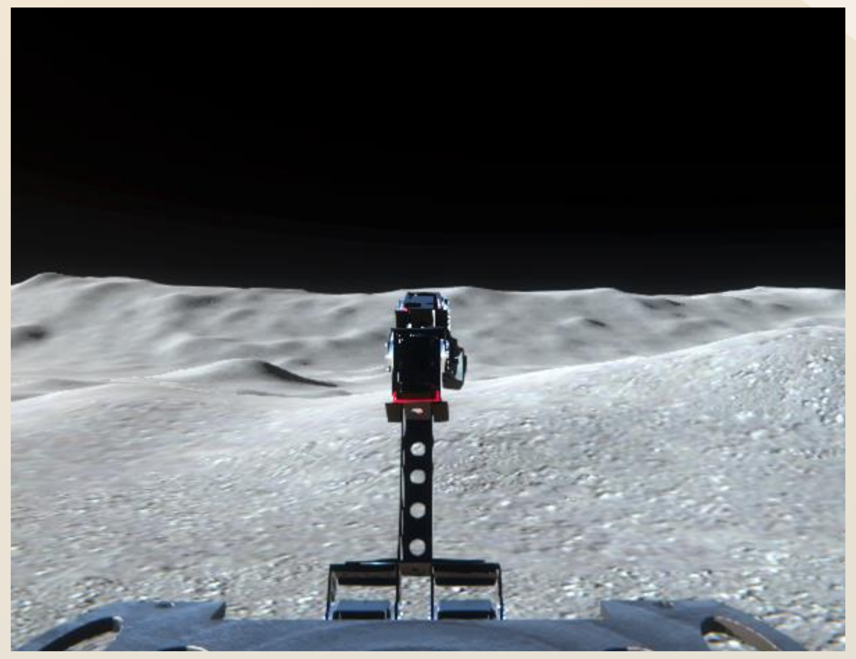
Virtual Recovery Sandbox

- Operator use for failure identification and solution development
- Use of CAD models of the rover for accurate simulation
- 3D scans can recreate environment/assembly space
- Ability to manipulate gravity and physics model
- Risk-free solution development sandbox
- Immersive VR perspectives



Exocentric Observation

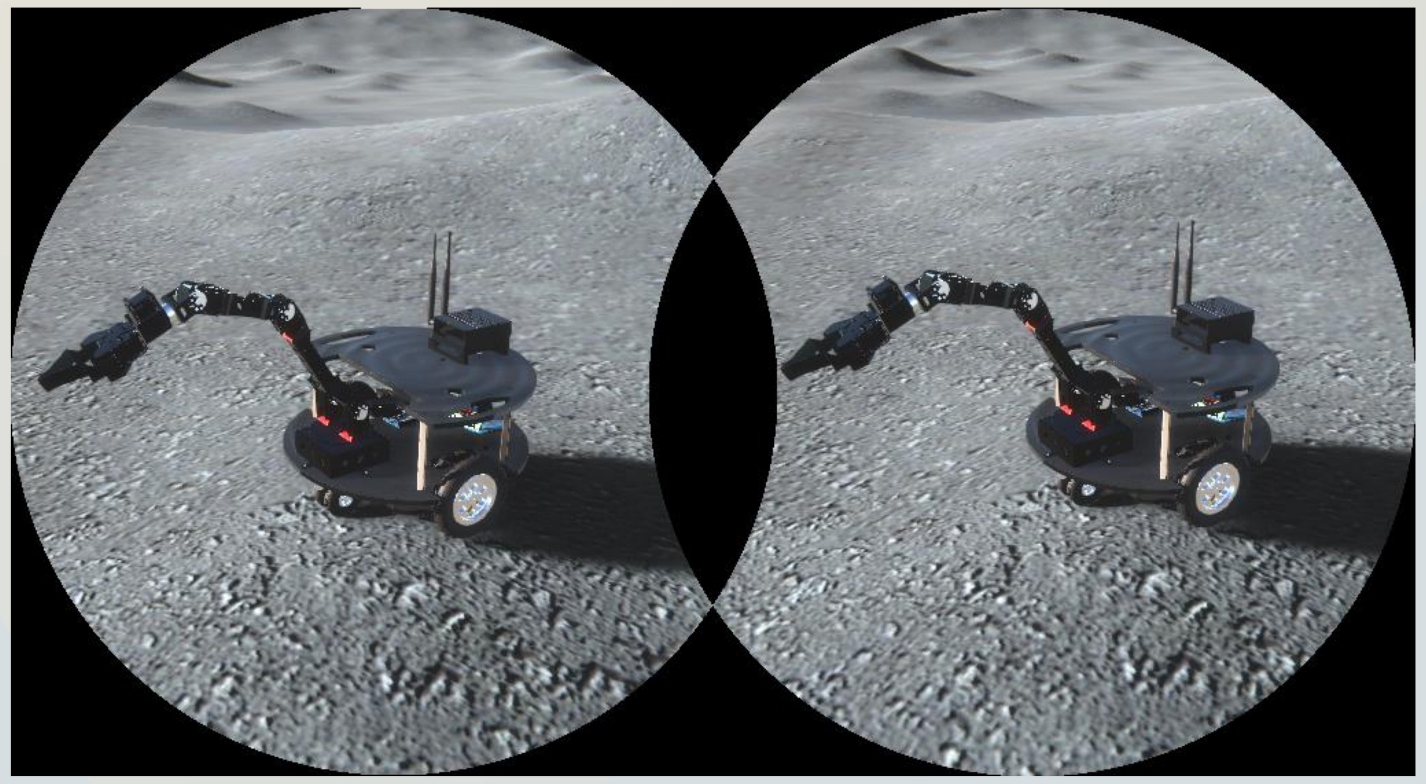
- Free-Moving 3rd Person Perspective
- Failure Assessment



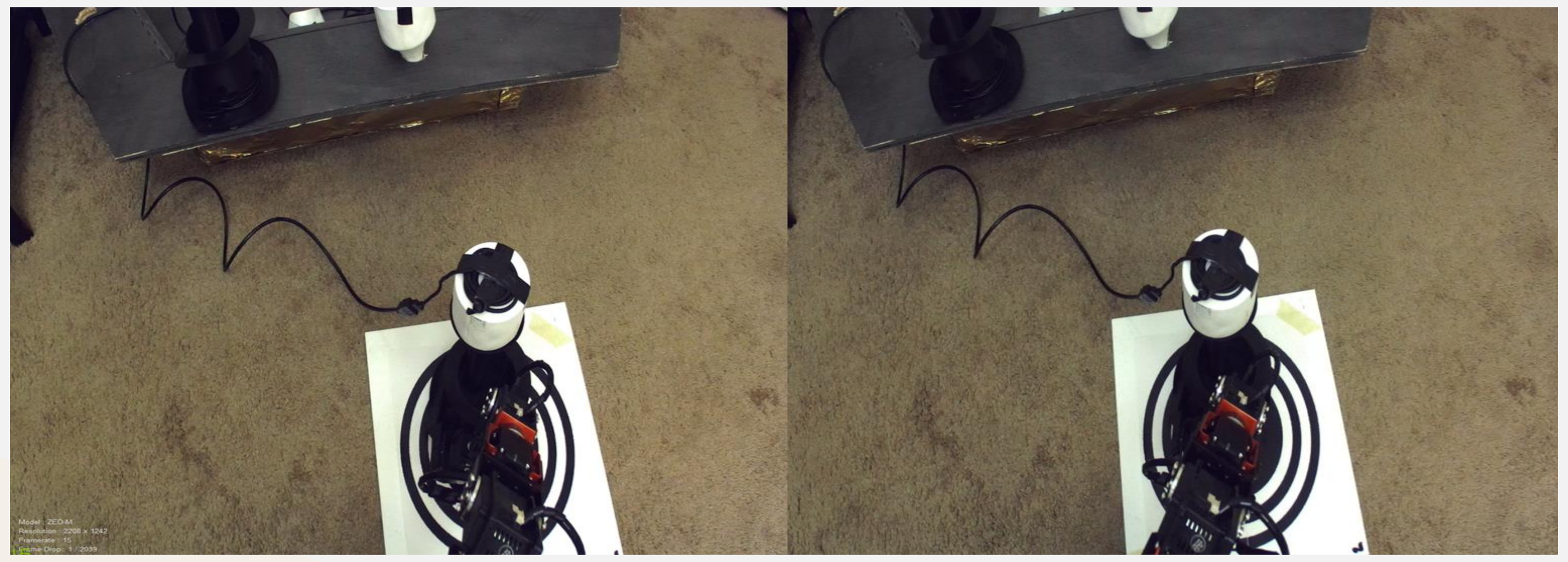
Egocentric Control

- VR Headset viewing through the “eyes” of the virtual rover
- Rover Manipulation

- Operator may switch between perspectives as desired
- Virtual rover control interface mirrors physical model
- Assembly objects and environment may be reset



Ocular view of the Armstrong rover in a virtual simulation space



Stereo viewpoint from the rover. Left and right images provide the operator depth within the HMD view.

AR/MR Teleoperation

- Stereo camera provides real time passthrough to HMD
- Physical camera movement mimics HMD movement
- Teleoperator controls rover using controller
- Platform used to experiments for validation of our virtual recovery sandbox

Stereo/HMD Control

- VR Headset viewing through the “eyes” of the physical rover
- HMD movement directly controls servos for smooth head tracking

Benefits of Virtual Recreation

- Fewer inaccuracies in recreation
- Ability to replicate gravity
- Cost efficient solution
- Accessible to anyone with a VR headset

Future Work

NASA has set a goal to return to the Moon to conduct lunar and space science while also preparing for future human exploration missions. Current failure response methods used by NASA for rovers consist mainly of using hardware duplicates which are costly and time consuming to assemble. Low latency capabilities call for a faster and more effective failure response model. After developing a virtual recovery simulation, we will compare it to traditional failure recovery methods. If effective, a virtual failure recovery method could save time and resources while providing more accurate information to the operator.

This work is directly supported by the NASA Solar System Exploration Virtual Institute cooperative agreement 80ARC017M0006.

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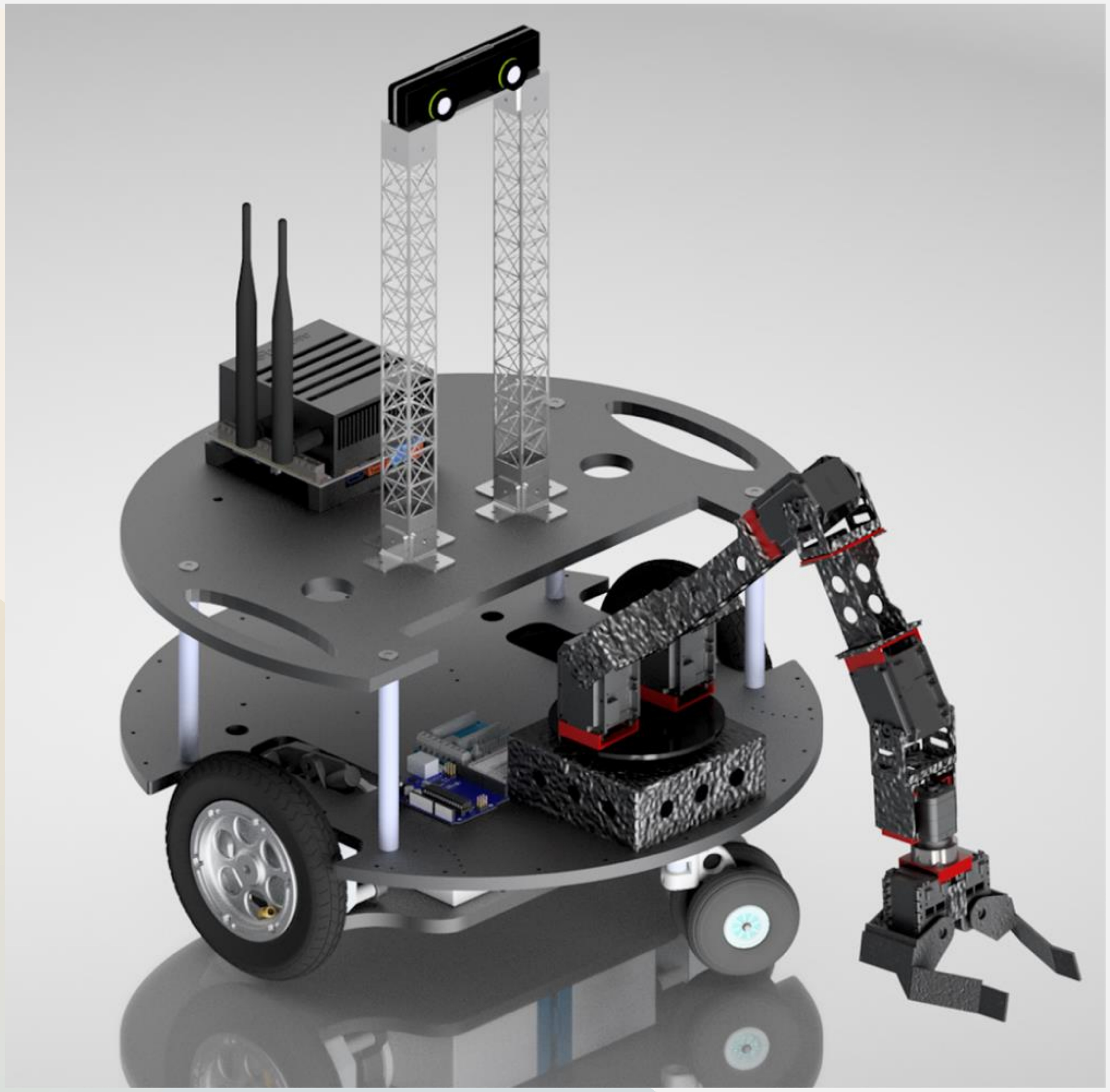

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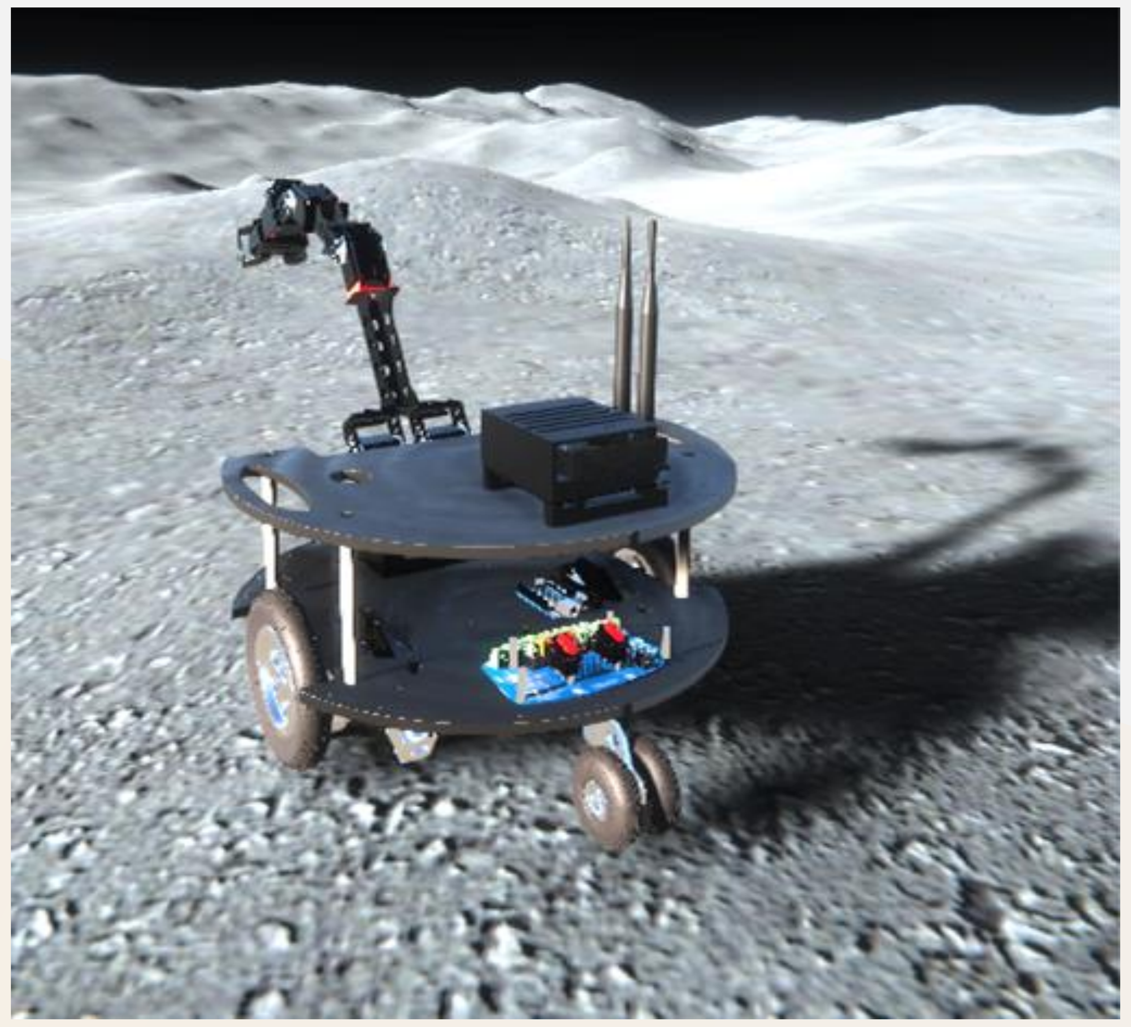

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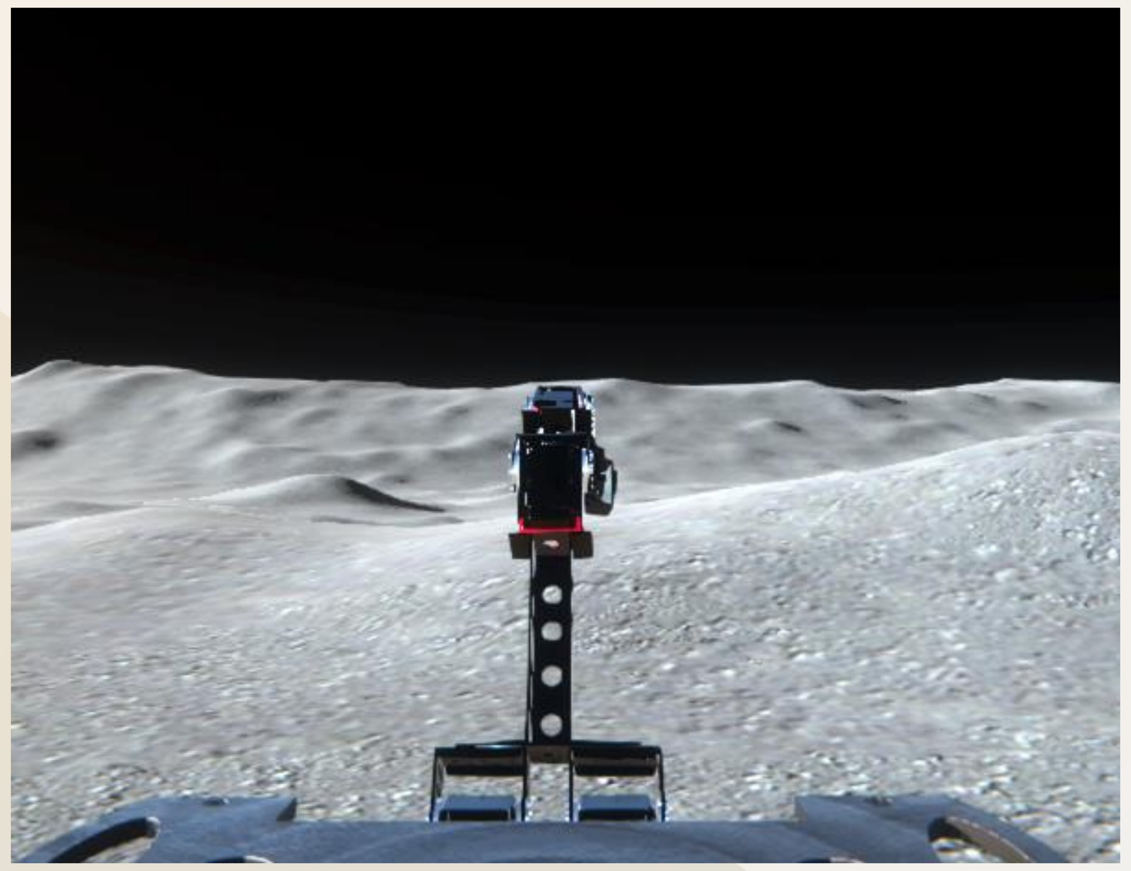

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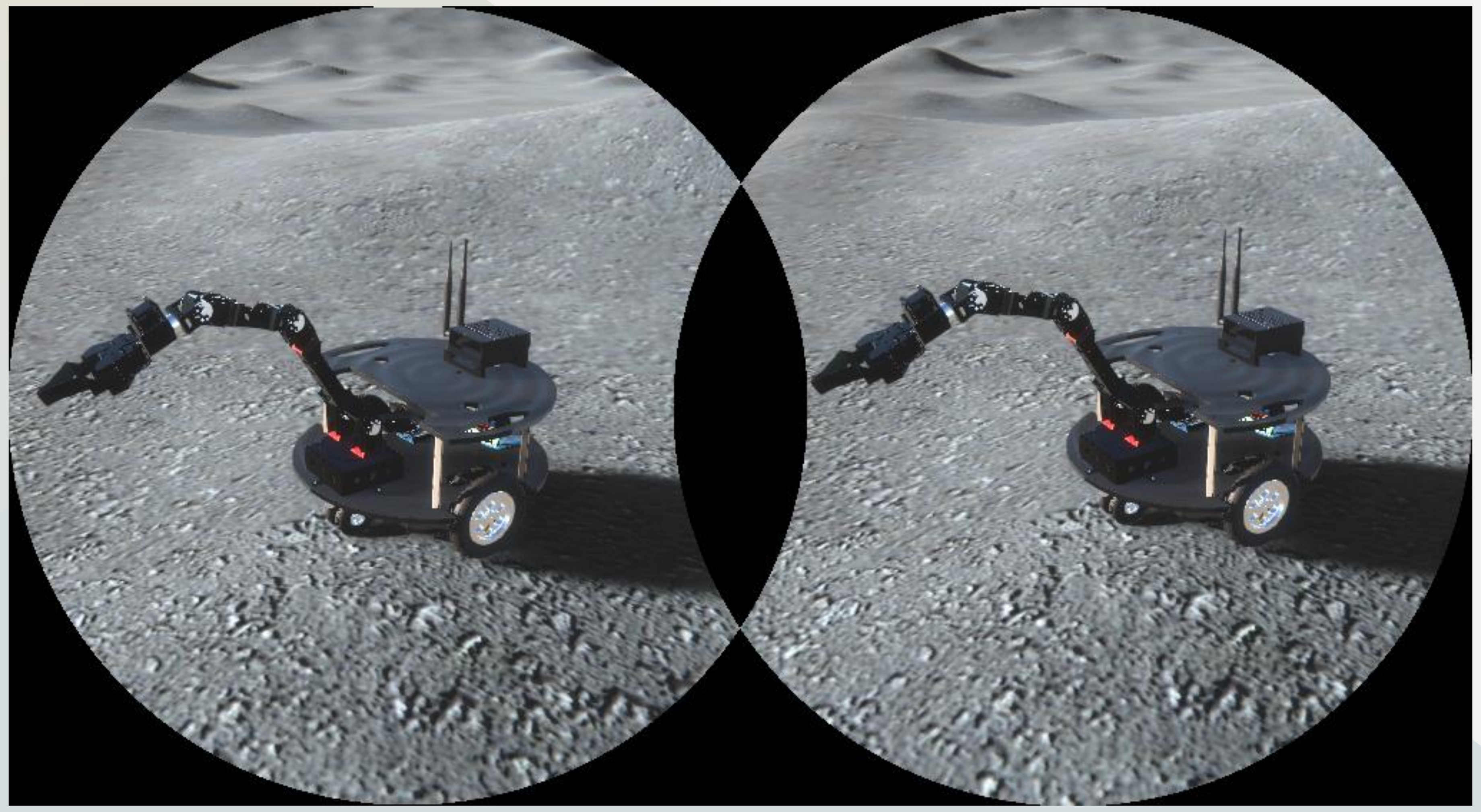

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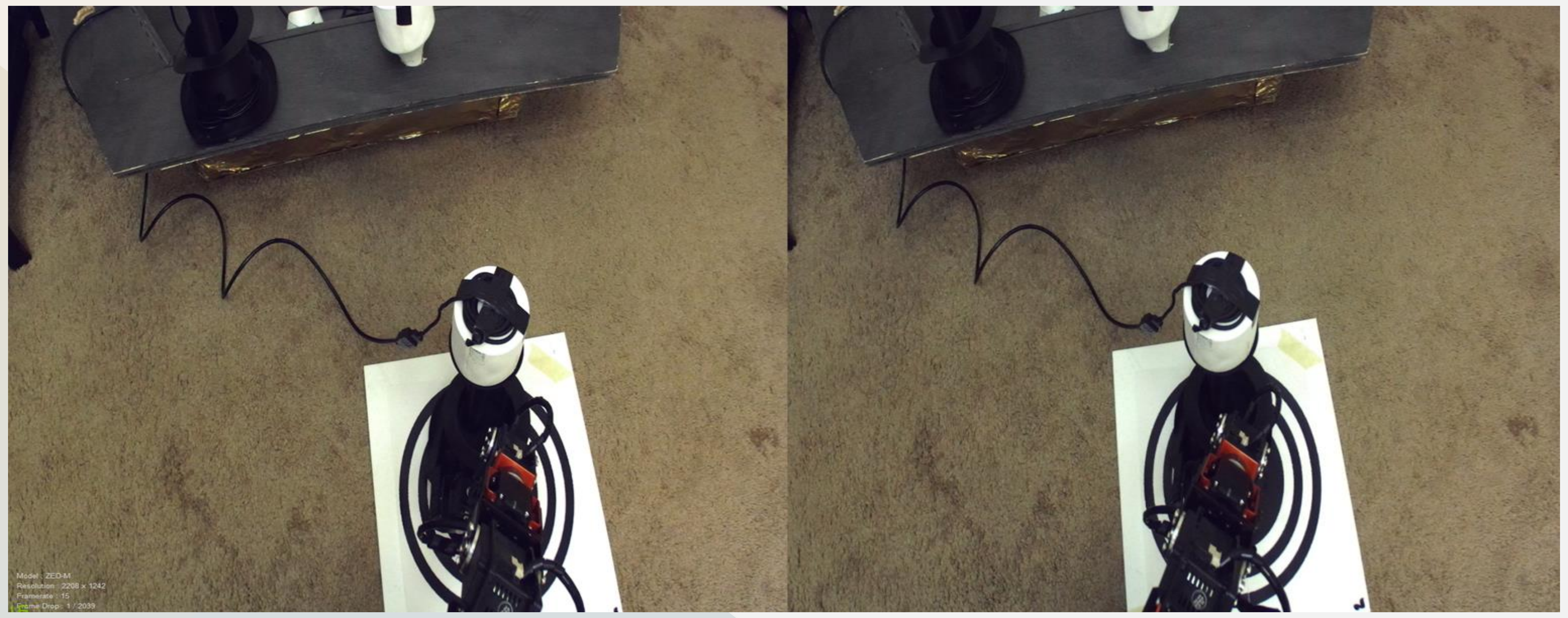

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