TDC-86 Integrated Camera and Lighting System

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Project Overview

Our project involves designing an integrated camera and lighting system for a lunar surface rover aimed at capturing high-quality images in dynamic environments.The static lighting array, controlled by a microprocessor, includes independently adjustable spotlights and floodlights for optimal illumination at varying distances. A lighting analysis camera captures snapshots, allowing the microprocessor to identify dark and bright areas for real-time lighting adjustments. Our high dynamic range camera captures and records high quality video for a mission specific purpose.

Our primary goal is to enhance image quality on the lunar surface through adaptive lighting and high dynamic range imaging. We have completed the design of a functional prototype in our second semester and have provided a foundation for future Texas State teams to create further innovations on our design. Future goals for this project include optimization of our existing system, hazard detection, and wireless control.

Outline of Design Objectives

- Develop an integrated camera and lighting system for a lunar surface rover, capable of capturing high-quality images in various lighting conditions.
- Utilize programmable spotlights and floodlights to dynamically adjust illumination based on environmental needs.
- Implement a lighting analysis camera to assess and adapt to real-time brightness levels, ensuring consistent lighting.
- Integrate an HDR camera to capture detailed images, accommodating high-contrast scenarios and reflective surfaces.
- Use a microprocessor to process images and control lighting adjustments for optimal visibility of the rover's surroundings.
- Design the system to operate effectively under extreme lunar conditions, including total darkness and direct sunlight.
- Ensure the system can produce clear imagery across a variety of material textures and reflective surfaces.
- Develop a statically mounted device to combat the lunar dust problem.
- Create a system that is fully autonmous to allow the rover operator to focus on mission critical tasks.

System Features

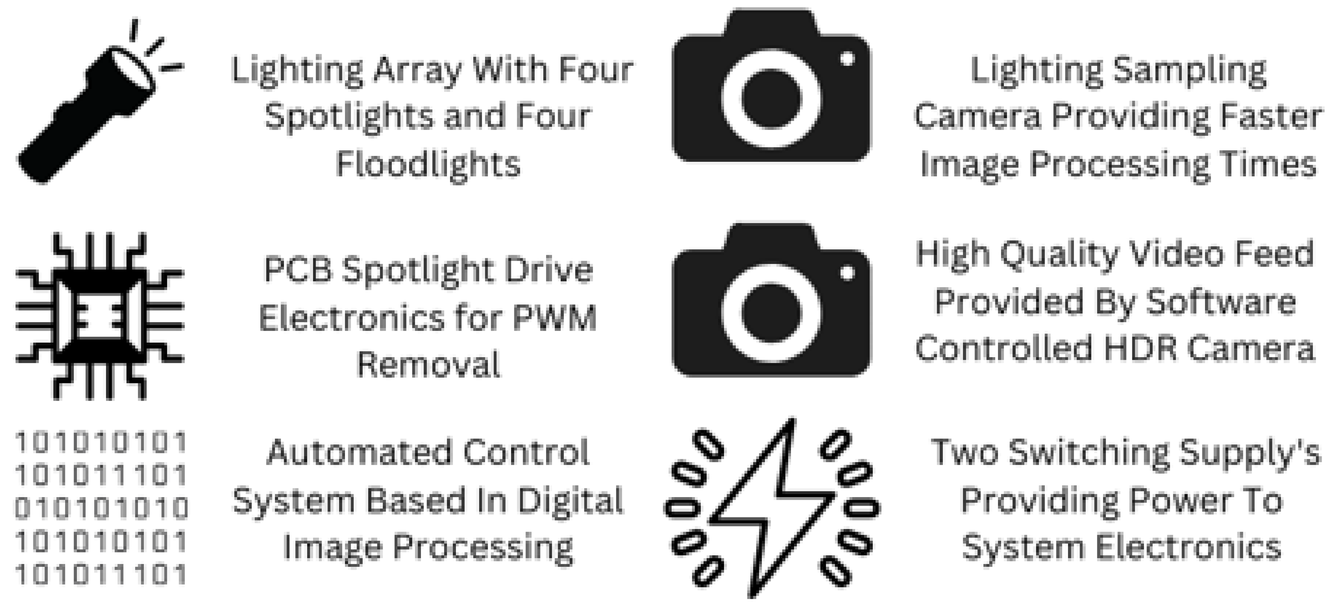

Fig. 1: Core Attributes

Image Processing Algorithm

Fig. 2: Original Image (Apollo 15 Moon Landing)

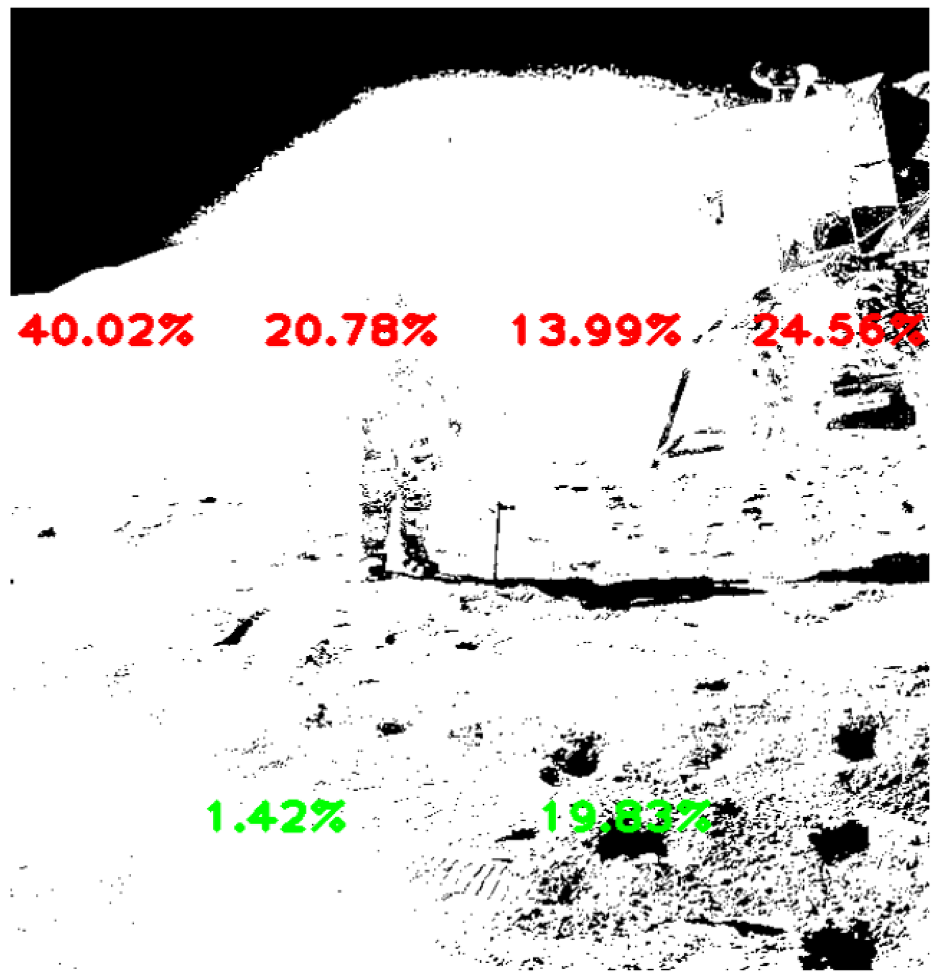

Fig. 3: Processed Image With Darkness Detection

Our image processing algorithm first converts a sample image to the HSV color space, where information relating to the brightness of each pixel can be extracted. Following this, calculations are preformed on each quadrant of the image to determine its level of relative brightness. The output of the lighting array is then adjusted to reflect the needs of the environment.

Lighting Array and Spotlight Drivers

Our lighting array is statically mounted in order to combat the lunar dust problem. This array is comprised of four spotlights to illuminate areas further away from the rover and four floodlights that provide illumination for near the front of the rover. During testing, we identified that our spotlights alone provide more illumination than the headlights of a car. Our PCB design is a voltage controlled current source that allows brightness variation in our spotlights via voltage inputs.

Fig. 4: Car Headlights

Fig. 5: Spotlights

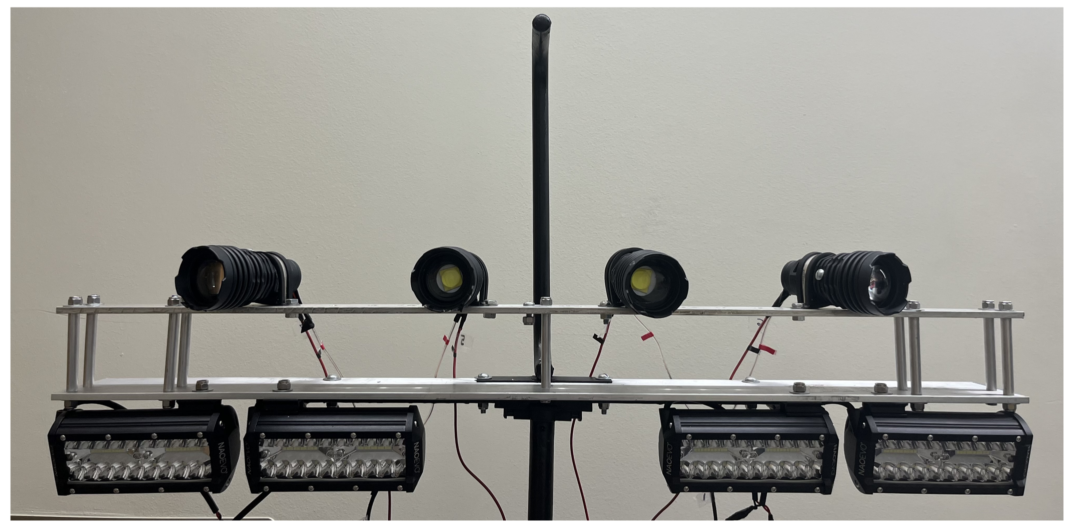

Fig. 6: Lighting Array

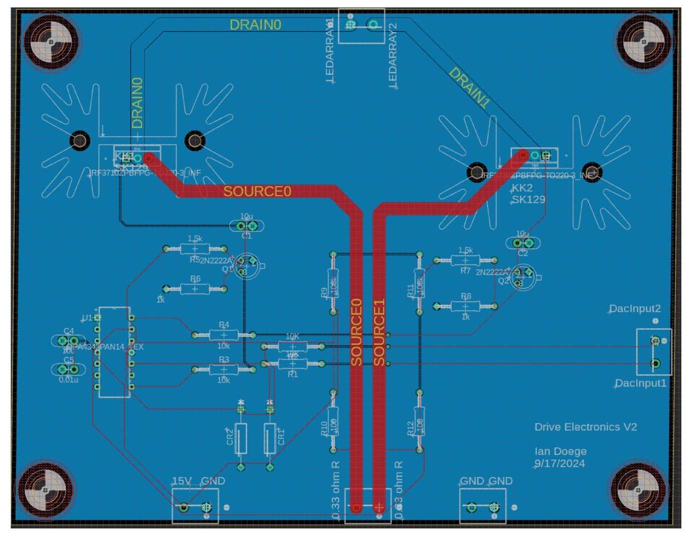

Fig. 7: Spotlight Driver PCB

HDR and Lighting Sampling Camera

Our system utilizes an HDR camera in order to capture high quality imagery and a lighting sampling camera to identify regions in front of the rover that need artificial lighting. The video captured by our HDR camera is stored on a 32GB SD card on the microprocessor. The image data captured by the lighting sampling camera is used in our image processing algorithm and deleted after it is used to adjust the lighting array to improve the lighting environment of the scene.

Fig. 8: HDR Camera

Fig. 9: Lighting Sampling Camera

Team Accomplishments and Acknowledgments

Over the course of the last two semesters our team has overcome many challenges and accomplished a great deal together. Some of our key accomplishments have been:

- **Image Processing Algorithm:** Our algorithm correctly identifies dark regions of an image that require artificial lighting.
- **Automated Control System:** Our control system allows the operator to focus on critical tasks with an improved lighting environment.
- **Drive Circuit Design:** Our drive circuits correctly remove PWM signals from our lights, allowing for clear images to be taken with the HDR camera.
- **Custom PCB:** Our custom PCB effectively implements our spotlight driver design.
- **Lighting Array:** Our lighting array contains both spotlights and floodlights to provide quality illumination to the scene.

We would like to give a special thanks to our NASA Sponsor, Mrs. Toni Clark, who's assistance has been invaluable in the completion of this project. Additionally, we would like to thank Dr. Tim Urban and the rest of TSGC for facilitating this challenge. We would also like to thank all of our Texas State Faculty, Mr. Mark Welker, Dr. Rich Compeau, and Dr. Jeff Stevens for there many contributions. Finally, we would like to thank our mentor team, Phonons and Photons, and our first semester team, Effectively Grounded.

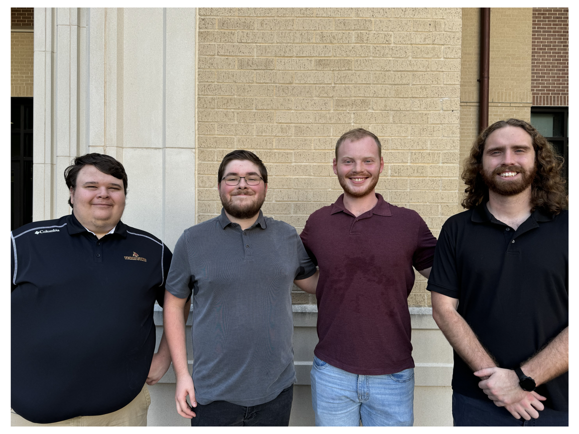

Fig. 10: Team Photo