HEC 4: LENS

INTEGRATED LIGHTING AND CAMERA SYSTEM

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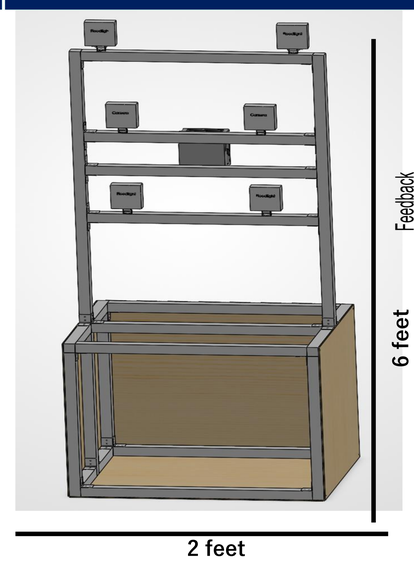
ABSTRACT

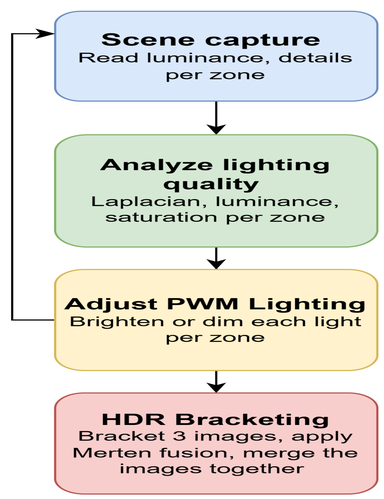
This project addresses extreme lunar lighting conditions that limit imaging performance. An integrated camera and lighting system was developed using real-time image processing and PWM-controlled LEDs to adapt to varying brightness levels. Testing showed significant reductions in dark pixels and improved image clarity. The system successfully enhances visibility in both low-light and high-contrast environments, demonstrating its suitability for lunar applications.

OBJECTIVES

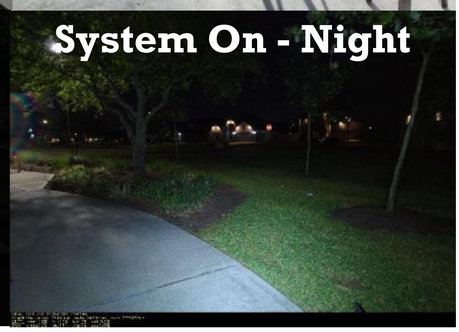
The objective is to develop an integrated camera and lighting system optimized for lunar imaging that can adapt to varying lighting conditions through an automated control module. The system processes real-time image data to adjust lighting and improve overall image quality while maintaining efficient operation.

HARDWARE AND SOFTWARE





TESTING RESULTS



SPECIFICATIONS

Specification	Target / Description
Camera system	IMX708 (color) + IMX477 (HDR)
Exposure performance	< 2% bright, < 5% dark pixels
Configuration	3 LEDs (2 fill + 1 navigation)
Control	Independent PWM per light
Illuminance output	50-500 lux across 6-30 feet range
Light placement	~6 ft (top) and ~2 ft (lower fill)
Camera height	~4 ft from ground
Consumption	≤ 85 W
Processor	Raspberry Pi 5
Stabilization time	≤ 15 seconds

KEY RESULTS AND ANALYSIS

Distance (ft)	Amount of light (lux)
6	500
10	340
20	208.4
30	59

Filename	Dark pixel %	Blown pixel %	sharpness	contrast	Analysis
BASELINE DARK	99.99	0	9.57	7.93	Dark pixels dropped from 99.99% to 20.35% and sharpness improved 3,397%, rescuing an otherwise unusable scene.
SYSTEM DARK	20.35	0.36	334.61	30.21	
BASELINE 1 ambient	7.07	0.41	84.41	28.78	System correctly dimmed in adequate lighting while improving sharpness 305% — prioritizing detail over brightness.
SYSTEM 1 ambient	19.5	0.29	342.03	31.26	
BASELINE all ambient	7.38	0.2	89	25.35	Usable pixels held at 83.67% and sharpness improved 284%, confirming smart dimming behavior under sufficient ambient light.
SYSTEM all	16.04	0.28	342.17	29.45	

- Dark pixels reduced from **99.99%** → **20.35%** in low-light conditions
- Sharpness increased from **9.57** → **334.61** (over **3000% improvement**)
- Bright pixel percentage maintained below **0.36%**, preventing overexposure
- Sharpness improved by over **300%** under ambient lighting

CONCLUSION

The system effectively improves image quality by reducing shadows and overexposure while increasing sharpness. Results confirm reliable performance across different lighting conditions, making it suitable for adaptive imaging in lunar environments.

ACKNOWLEDGEMENT

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