# E1.01 Integrated Camera and Lighting System

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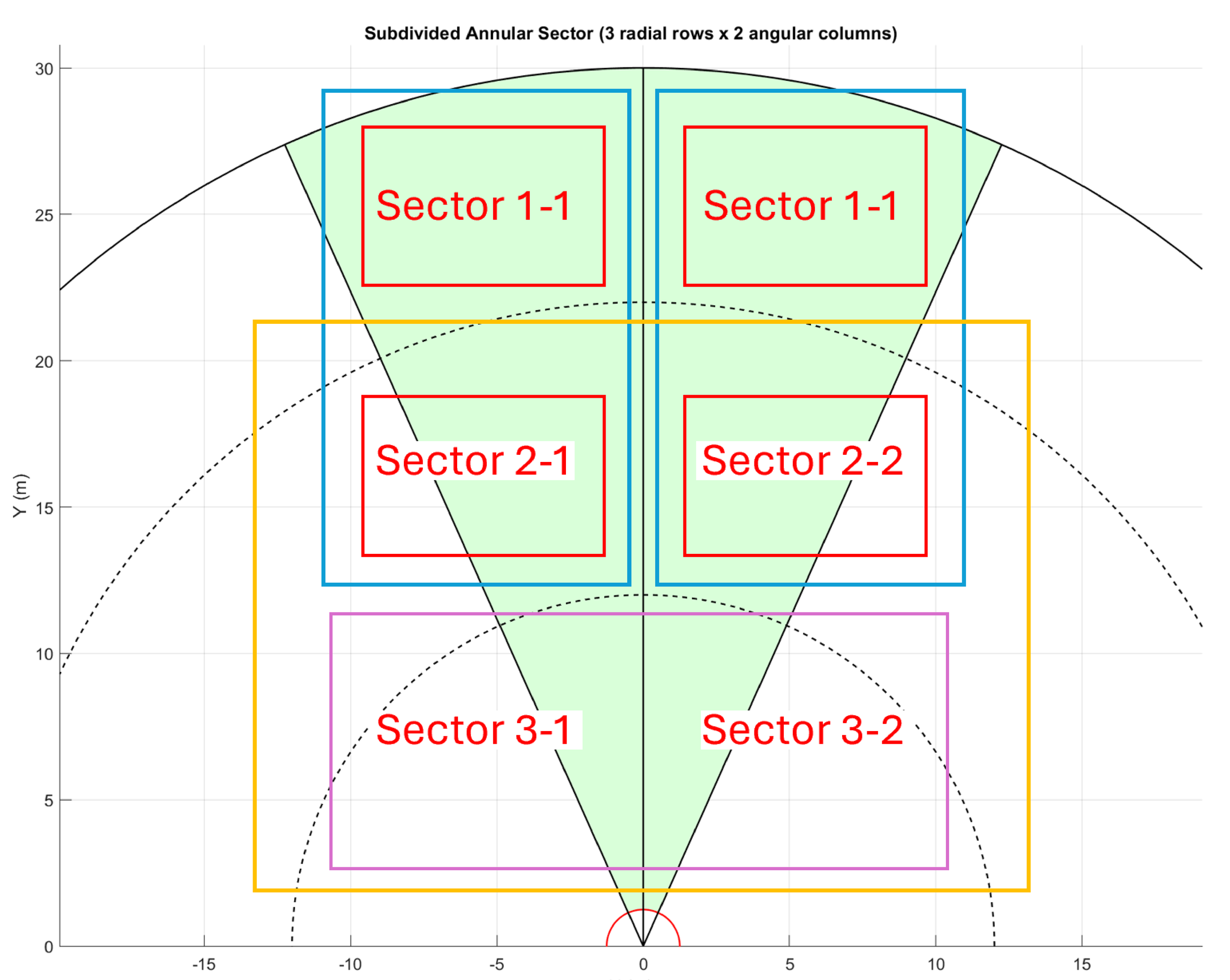
Texas State University - Lights, Camera, Bobcats!

## Problem Description

NASA's upcoming missions to the lunar surface present extreme contrast lighting conditions, from brilliant sunlight on the surface to the deep darkness of shadowed craters. Traditional lighting systems force a trade-off between underexposure and power efficiency while many existing Pulse Width Modulation systems used to drive LEDs are incompatible with video capture. Future exploration also demands real-time monitoring for both astronaut safety and mission efficiency.

## Our Solution

We developed the Integrated Camera and Lighting System (ICLS), which dynamically adjusts LED floodlights and spotlights in real time based on embedded vision processing. A Raspberry Pi 5 automatically detects low-light sectors, activating only the necessary lights to maintain uniform illumination. Manual override mode is provided for operators who need direct control. Power stability is ensured through an Uninterruptible Power Supply (UPS), with an emergency mode that conserves energy by disabling nonessential lights.

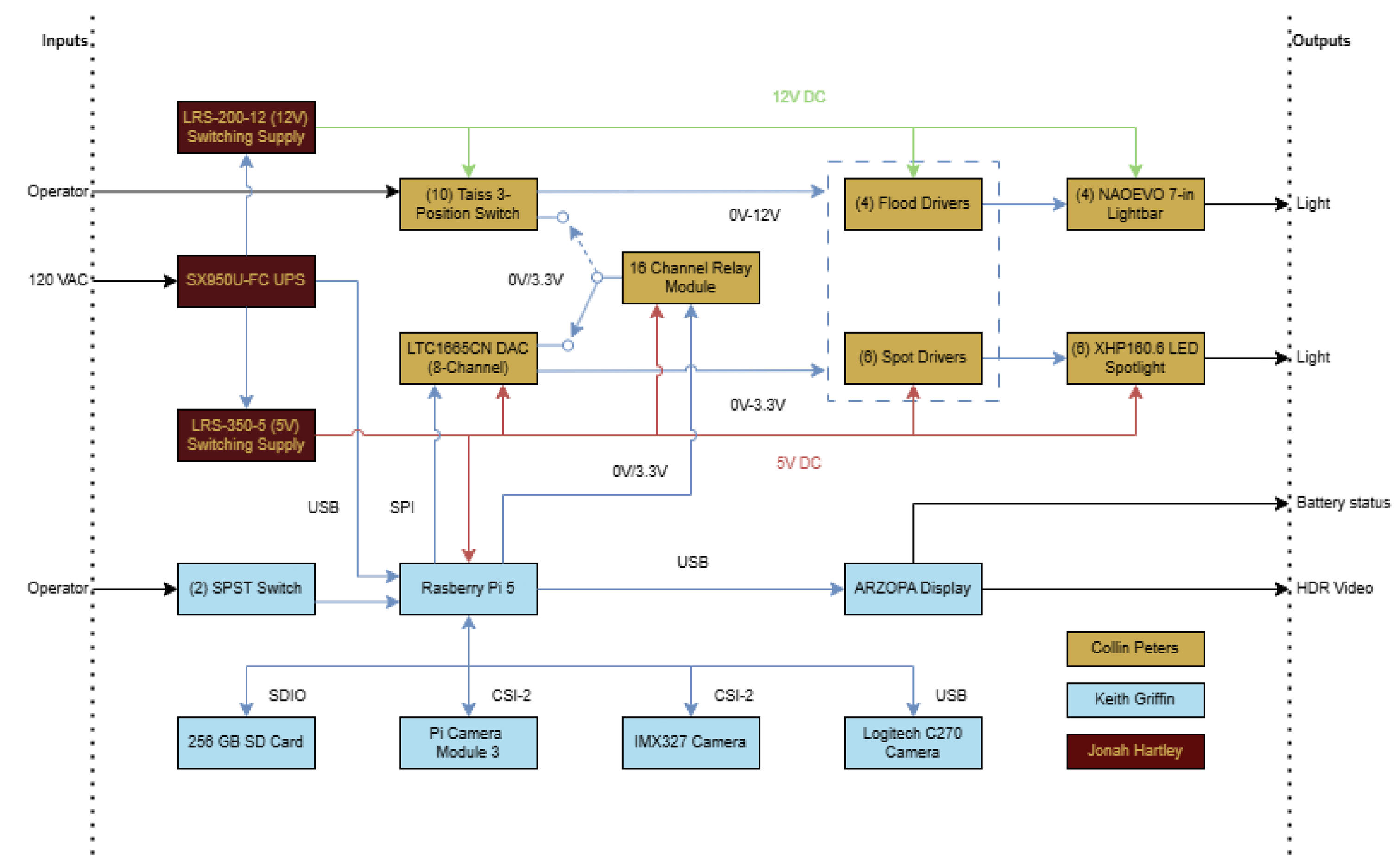



Sector map corresponding to lighting coverage. Different color boxes correspond to different light categories.

## Meet the Team

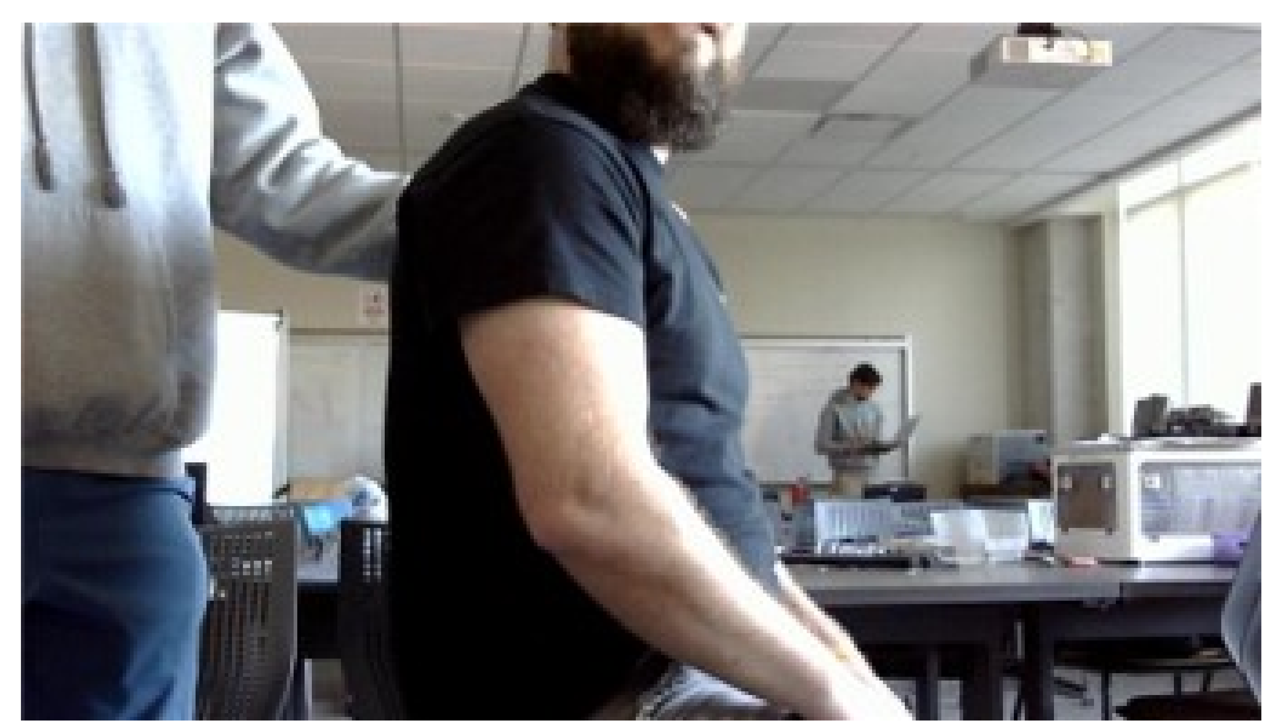
Left to Right: Collin Peters, Keith Griffin, and Jonah Hartley

## System Architecture & Top-Level Diagram

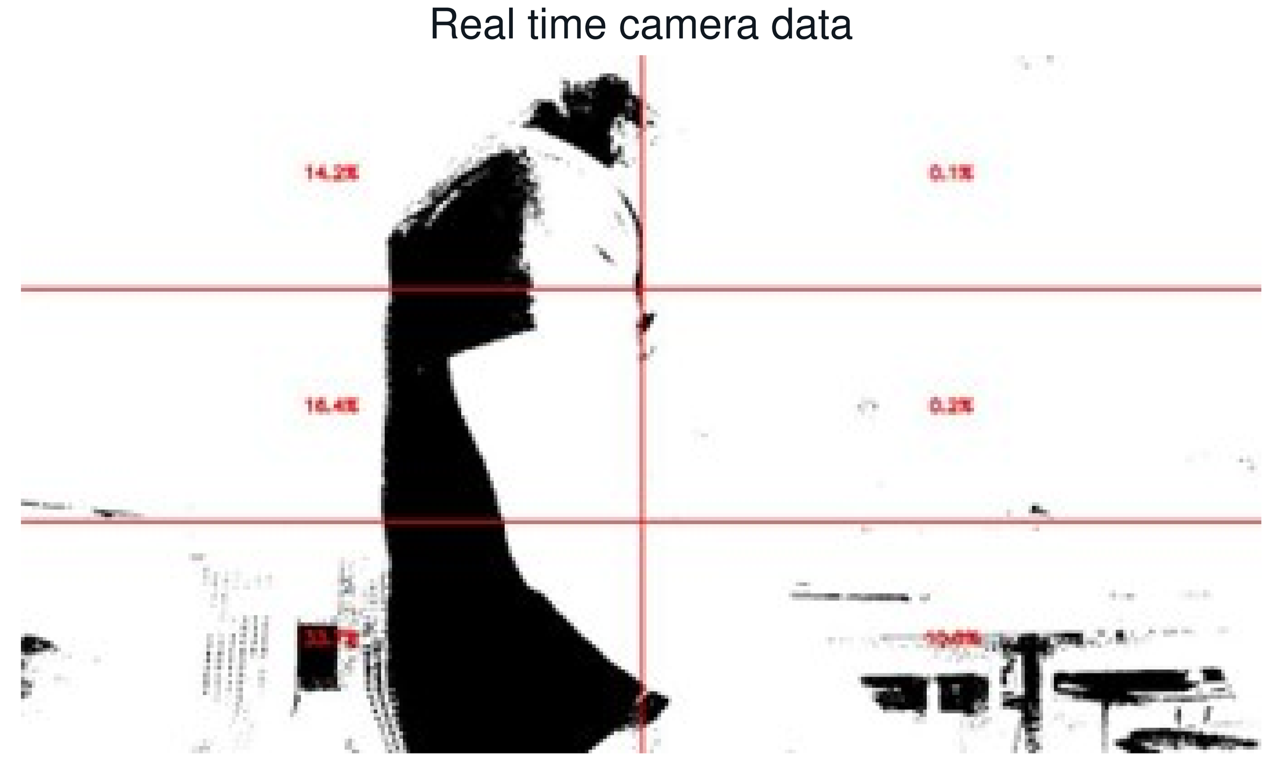



## Embedded Vision

Our embedded vision pipeline uses a Logitech C270 for brightness analysis, plus additional HDR and low-light cameras for day/night scenarios. Real-time image processing on the Pi 5 identifies underexposed sectors, activating the corresponding lights for uniform illumination. Manual input overrides these decisions, allowing the user to select discrete lighting levels.



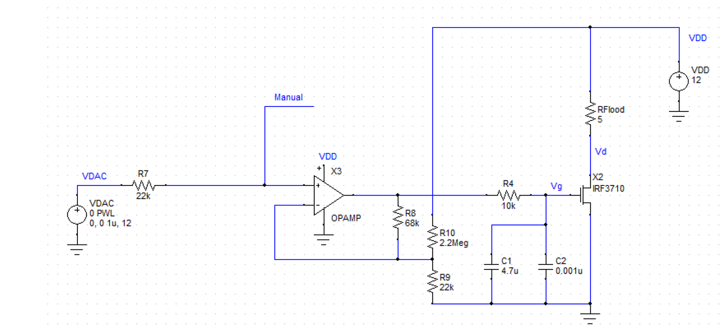
Real time camera data



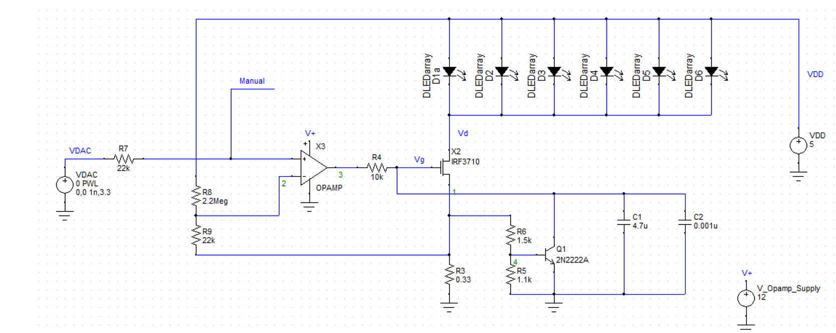
Camera image after HSV conversion

## Drive Electronics

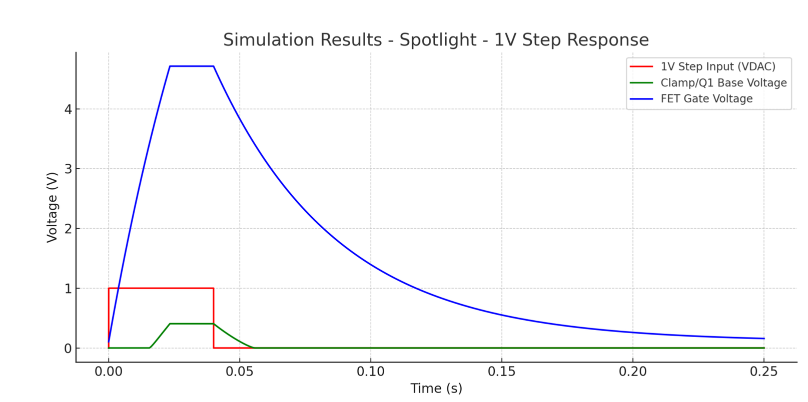
Each spotlight and floodlight channel is powered through linear drive circuits that use MOSFETs to sink current into the LEDs. Feedback signals regulate current to prevent LED damage. Below are simulation plots from the spotlight circuit compared to the captured circuit response:



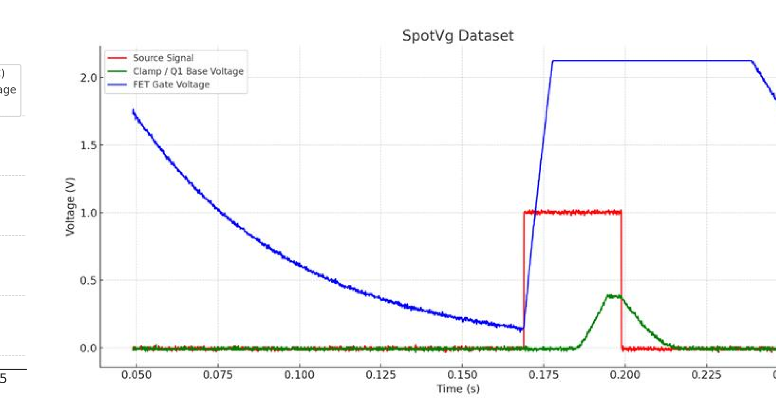
Floodlight Circuit Model



Spotlight Circuit Model




Simulation Results




Captured Data

## Power Supply & Emergency Power

To ensure continuous operation, the system requires a reliable power source at all times, with a backup available if the primary supply fails. It will include a reserve battery (UPS) that automatically switches to an emergency mode when the main supply is lost. In this mode, the UPS can sustain the system for approximately 73 minutes.

## Thermal Management

High-power LEDs and driver electronics require robust cooling. Each MOSFET will have its own heat sink, while the Pi 5 is housed in an actively cooled enclosure. Two internal fans circulate air through vented panels, preventing localized hotspots around power supplies.

## Optics

Beam focus is refined by adjustable mirrors mounted near select lights, redirecting stray rays into their target sectors. This approach enhances coverage in shadowed regions and improves lighting efficiency. Both floodlights and spotlights can be tilted or rotated on modular brackets, allowing operators to fine-tune illumination patterns.

## Acknowledgements

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Student mentors: John Gellerup, Tyler Nuckols.
Independent collaborators: Luke Scarpato.

Further documentation may be found here