# Polynomial Texture Mapping Dome for Digitally Preserving Our Past

ECE 445 Team 6 Project Proposal

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# Objective and Background:

Goals and Benefits:

- There are geographic limitations that restrict a broader audience from being able to view or study these artifacts.
- A way to effectively share these artifacts with scholars worldwide is to create high-quality digital models of the artifacts using a method called Polynomial Texture Mapping (PTM).
- It's made to digitally preserve the museum's large collection of artifacts and gain insight from scholars outside the Champaign area.
- It can limit the cost of travel and reduce the possibility of damage during the handling or transportation of artifacts.

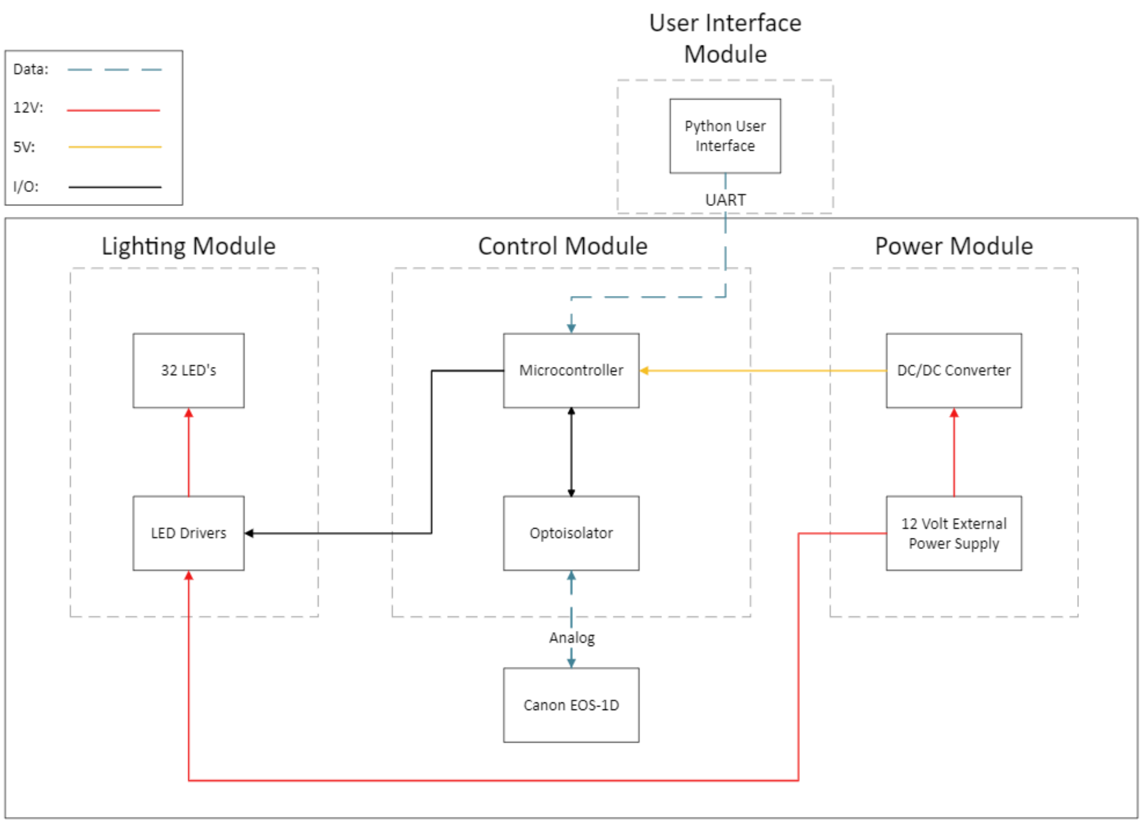
**Note: this project is based off of an existing project created by a previous senior design team**

High-Level Requirements:

- The PTM Dome System shall have 2 mode states, one to provide an output of 32 images, each corresponding to a unique LED light when prompted by the user, and one to provide a single image output corresponding to any specific LED light acting as the flash when prompted by the user.
- The PTM Dome System shall interface with the Canon EOS-1D camera, an external computer, the power supply, and the 32 LEDs to produce the output.
- The design of the PTM Dome System shall be modular, with components like the 32 LEDs being interchangeable, and the team shall provide a user-interface manual to document the modularity and how to fix common problems that may arise.

# Design:

System Level Block Diagram:




Our system consists of 3 main modules- the lighting, control, and power modules. The lighting module consists of 32 LED lights and LED drivers. The inputs to this module are 12V and 5V power from the power module and the data from the microcontroller. The control module consists of the microcontroller and the optoisolator, which safeguards the camera during communication from any unwanted electrical input/overload. The inputs to the control module are 5V power from the power module and communication signals from the Python computer interface, and the outputs are signals to the Canon EOS-1D and data to the LED drivers. Lastly, the power module consists of a DC/DC converter to step down voltage from 12V to 5V and a 12V external power supply. The power module outputs the stepped-down power to the microcontroller and other elements which require 5VDC power.

Lighting module:

- General description and i/o connections

- LEDs: Illuminate the dome's interior to photograph the artifact from 32 different angles. It's connected to and powered by the LED driver, which then ties back to the microcontroller for control of each LED.
    - Requirement 1: LED shall operate at 12V +/- .5V and 210mA +/- 10mA
    - Requirement 2: LED shall respond to signals from the microcontroller and shall be in sync with the duration of the shutter with an accuracy of +/- 1ms.
- LED drivers: Regulate and supply the ideal power to the LED, typically from high to low voltage. It's connected to the DC/DC converter through the microcontroller.
    - Requirement 1: Regulate LED voltage to 12V and support a 210mA current draw.

Control module:

- General description and i/o connections
    - Microcontroller: The microcontroller, chosen to be the ATMega640, handles input/output processing and communicates with the external PC, the camera, and the LEDs. It decides, based on user input, whether to operate the LEDs sequentially or to manually turn on specific user-selected LEDs, up to 5 lights at a time. The data transferred is through the Python user interface, which is connected via a USB-A to serial adapter, which feeds into the microcontroller via the PCB. Then, the microcontroller will contain code to determine which LED drivers to communicate with and therefore, which LEDs to turn on.
        - Requirement 1: 2 mode states, one for 32 LED sequence, and one for user-selected LED configuration output.
        - Requirement 2: Correctly time control signals to control the focus and shutter of the camera, and to flash the LED(s) at the correct times for each state/image capture.
    - Optoisolator: the optoisolator, selected to be the 4N35, consists of an infrared LED and a photoresistor and allows for signals to be sent without electrical interference or damage to sensitive circuit elements. We chose to include this part because we have an expensive camera that we do not want to damage. The data going into the optoisolator is from 2 GPIO pins in the microcontroller, producing a high or low output for the shutter and focus signals. The data goes through 2 traces on the PCB into 2 separate optoisolators and then into an audio jack port, which allows a connector to send the shutter and focus signals to the camera.
        - The optoisolator shall transmit signals between the microcontroller and the Canon EOS-1D while protecting the camera from unwanted electrical surges and contacts.

        - The optoisolator shall successfully drive the camera to take a picture if given a shutter signal from the microcontroller.

Power module:

- General description and i/o connections
    - 12V external power supply:
        - Requirement 1: Must convert a standard 120V 60Hz AC voltage source from a standard wall outlet into a 12V DC voltage source.
        - Requirement 2: Must supply power to the LEDs to turn on from the drivers.
    - DC/DC Converter:
        - Requirement 1: Must buck the 12V DC signal from the 12V External Power Supply to a 5V DC signal
        - Requirement 2: Must provide sufficient power to drive the microcontroller in the control module to run the program.

## Tolerance analysis:

One area of risk we saw from initial analysis was the power consumption. The power source that the previous group used was rated for 12W at 12VDC, and each LED draws .208A of current at 12V. The representatives from the Spurlock museum had requested that we expand the capabilities of the previous design by allowing for 1-5 lights to be turned on at a time. By performing quick mathematical analysis, it is clear that the power source would not have a high enough rating for the multiple LEDs as well as crucial components, such as the LED drivers and the microcontroller.

Analysis for new power supply:
Total amperage = 5 * .208A + 1*.2A + 4 * .010A = 1.28A
With safety buffer of 20%: 120% * 1.28A = 1.536A

We chose our new power supply to be rated for 2.5A at the same 12VDC to mitigate risk of overloading the power supply.

## Ethics and Safety:

We believe that there are only a couple ethical concerns that are pertinent for our project, and they are:

- Keeping the safety of the user in mind and avoiding any injury to the user due to faulty instructions or faulty equipment.

- Ensuring that the pulses of light are kept at an intensity level such that the artifacts being preserved/scanned are not damaged. This entails keeping the total light exposure to the artifacts under 100 lux for highly sensitive artifacts, like textiles, paper, photographs, etc, and under 200 lux for other artifacts that may be made of wood or undyed leather, for example.

Keeping this in mind, we are going to construct our project with the goal in mind to eliminate any chance of electrical injury to the user of our project by ensuring secure electrical connections, providing an instruction manual for how to use our project, using said instruction manual to explain how to replace any faulty equipment that could pop up through repeated use, and using this instruction manual to help the user troubleshoot any program errors that could arise as well. To ensure that the light intensity is kept at a safe level, we will confirm that the light bulbs used are not able to output a light intensity that is higher than this threshold and that the power being used by the LED’s is under their rated power consumption so as to not burn up any lights, create a light intensity higher than the ratings of the bulbs, or create a light intensity higher than the rated damage levels of the artifacts.