ECE 445 - Spring 2026
Paint Color and Gloss Classification Device
PROJECT PROPOSAL

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1. Introduction

- **Problem**: Homeowners, renters, and especially college students frequently face the challenge of matching existing wall paint and texture for touch up or repairs often without access to the original paint can. While it is possible to peel a physical chip off the wall to scan it, it is an inconvenient process. While mobile apps exist they rely on smartphone cameras which use auto white balance and are heavily infused by ambient lighting. These current solutions do not account for sheen such as matte vs eggshell meaning that even the best color match can look off once applied. This resulted in wasted time and materials and a poor result / color match.
- **Solution**: We propose a non-destructive "Paint/Surface Analysis Device" that accurately identifies both wall color and sheen without removing a physical paint chip. Our device utilizes a controlled lighting environment and a spectral color sensor to determine the precise color composition (hex code) of the wall. To address the gloss, the device integrates a secondary computer vision subsystem utilizing "raking light" (low-angle side lighting). This illumination technique reveals the paint finish (e.g., gloss vs. semi-gloss.)
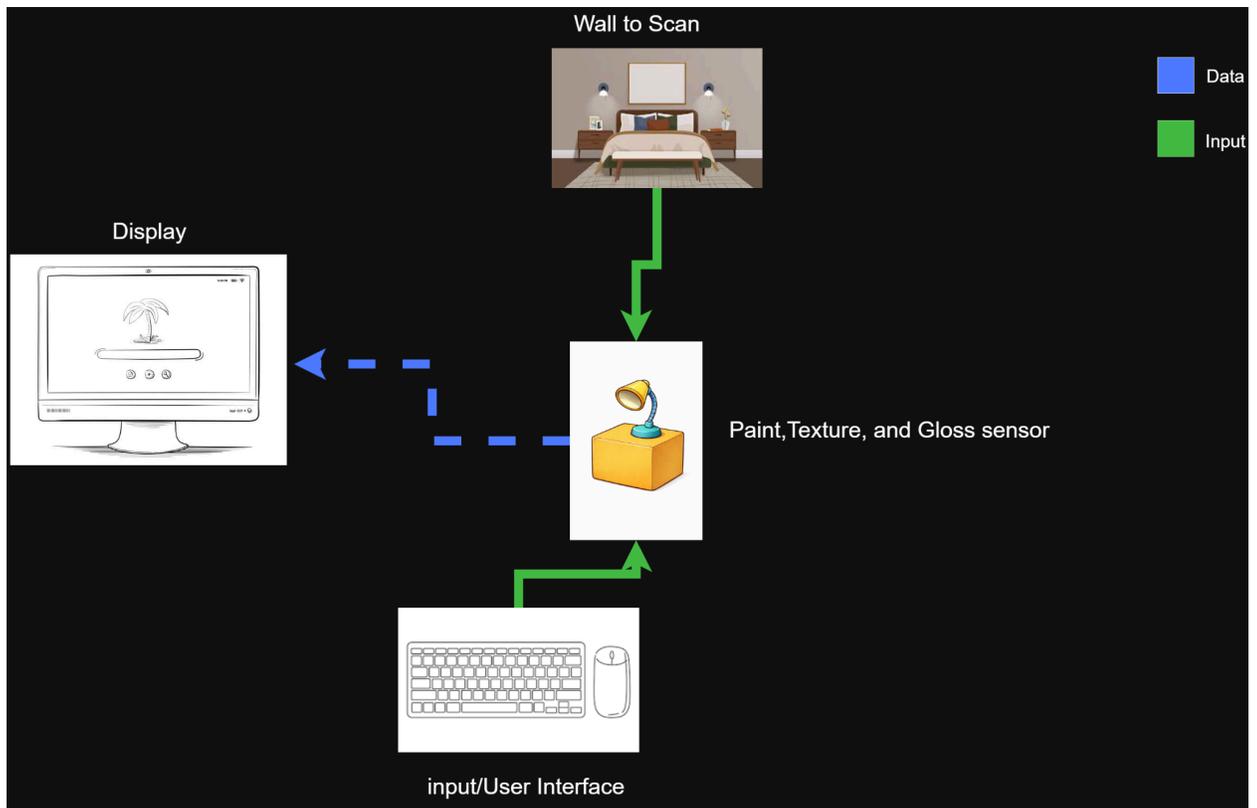- **Visual Aid:**

Figure 1: *Visual Aid*

- **High-level Requirements List**
  - Color accuracy within Delta E < 3

- Delta E (or ΔE) is the distance between two colors in the color space. We will be using the CIELAB space, which is the standard color space used for Delta E [1]
- Sheen classification of gloss, semi-gloss, and flat/matte within 80% accuracy across 10 different test samples
- The enclosure must provide light isolation such that the spectral sensor reading varies less than 2% when external ambient light changes from dark (0 lux) to bright lighting (500 lux).

2. Design:
- **Block Diagram:**

Figure 2*: Block Diagram*

- **Subsystem Overview: A brief description of the function of each subsystem in the block diagram and explain how it connects with the other subsystems. Every subsystem in the block diagram should have its own paragraph.**
  - **User Interface:** The user interface the user to gain real time feedback from the display monitor. It receives the output data from the microcontroller. Additionally, we'll have a button to restart/start the process as we can sequentially figure out what specifically the color, gloss type, and texture.
  - **Control System:** The control system includes the microcontroller, and it tells the sensing subsystem when to begin and receives the color data from it. Additionally, the microcontroller will consistently have a light blocking sensor to determine how effective the enclosure system is.
  - **Power Subsystem:** The power system is mainly connected through a battery 12V DC supply. We use the buck converter so we can maintain a constant 5 V voltage through our micro-controller as that is the recommended voltage for the microcontroller. For the LED and the photodiodes it is best to use a 3.3V load regulator as these will vary depending on the load as our load will vary depending on what sequence.

- ○ **Sensing Subsystem:** Includes the photodiodes/spectral sensor. The spectral sensor allows us to have a detailed analysis of the wall containing 8 photodiodes, using 8 different photodiodes at different angles. The spectral sensor feeds our microcontroller with spectral data. This ensures the accuracy making the standard deviation as low as possible.
  - ○ **Enclosure:** Creates standardized environment for our sensing subsystem. The enclosure will contain all of the other subsystems, other than User Interface, and will have an opening to connect to the wall. It will prevent outside lighting from affecting the sensors.
- ● **Subsystem Requirements:**
  - ○ Microcontroller : must process spectral to hex conversion and database lookup in under 1 second
  - ○ Sheen analysis: The LED for raking light must remain within 5 degrees of a 60 degree angle relative to the sensor place
  - ○ Spectral sensing: the neutral white LED must provide a stable color rendering index(CRI) of >90 to ensure accurate color measurement [2]
  - ○ User interface: displays sample of hex color, names the hex color, gloss type, and texture within 10 seconds
  - ○ Power management: the 3.3 LDO must maintain a ripple voltage of <50mV to prevent noise in analog photodiode readings
  - ○ Enclosure : light blocking seal must include minimal (hopefully 0) lux reaches the sensor when internal LEDs are off
- ● **Tolerance Analysis:** Identify an aspect of your design that poses a risk to successful completion of the project. Demonstrate the feasibility of this component through mathematical analysis or simulation.
  - ○ The goal
    - ■ The system must output a color match in < 1.5 seconds
  - ○ The Variables (worst case)
    - ■ Sensor Integration Time: The AS7341 spectral sensor needs to perform 2 readings one for channels F1-F4, one for F5-F8
      - ● $T_{sensor} = 2 \times 100$ ms $= 200$ms
    - ■ Number of Colors: Sherwin-Williams deck of colors
      - ● $N_{colors} = 1800$ colors
    - ■ Calculation Time per Color: The time it takes the MCU to calculate the Delta E color difference for one color
      - ● Estimate: $T_{calc} = .1$ ms per color
    - ■ Display time 100 ms (standard refresh time)
  - ○ Mathematical Proof
    - ■ $T_{total} = T_{sensor} + (N_{colors} * T_{calc}) + T_{Display}$
    - ■ Total $= 200$ms $+ 180$ ms $+ 100$ ms $= 480$ ms.

- ○ Conclusion
    - ■ We are planning on running a color match and a texture / gloss analysis separately. We have a goal of first finding the color within 1.5 seconds. Our approximate total processing time is about .48 seconds and is well within the 1.5 second requirement.
- **Ethics, safety, and social impact:**

Potential ethical issues include IEEE Code of Ethics Section 1.5 (Honesty & Realism).[3] This issue is that color matching is somewhat subjective when considered by the human eye and there is an ethical risk of over promising accuracy. If the device something with a delta E greater than 5 but still displays a perfect match: Sherman Williams Bee, that would be misleading a user causing them to ruin a wall and waste money. We could prevent this by displaying no close match found or low confidence rather than guessing if Delta E is greater than 3.

Another potential issue is IEEE Code of Ethics 1.2 avoiding harm. Economic harm is a potential issue if a controller uses our device for a client and the device fails. This causes the contractor to lose money as well as credibility. We could prevent this issue by labeling it as a prototype or reference tool as well as making sure that we warn results may vary for extremely textured surfaces

Power and Thermal Safety UL 60950-1: We are using a 12V DC wall adapter and while that is slow, electrical buck converters and LDOs can generate heat. If the 5v buck converter fails it could cause 12V to be sent to our 3.3 V microcontroller which could cause a thermal failure (fire/smoke). This could be prevented with using a UL-listed external wall adapter and including an over-current protection on the 12V input line on our PCB to prevent overheating in case of a short circuit.

In terms of positive social and environmental impacts our device is able to reduce chemical waste common when home, however or retenter buy test cans of paint that end up not matching leading to gallons of unused paint easier sitting in basements or improperly disposed of. Our decision increases the "first-time success rate" of paint purchasings matching specific hex code and sheen and reduces the volume of wasted paint and continues entering landfills. Additionally 1/12 men and 1/200 women supper with color vision deficient or blindness. For these indices it can be incredibly difficult to match paint without assistance. Our device can act as assistive technology and empower independent living and decision making for color blind or deficient individuals.

References:

[1] ViewSonic Corporation, "What Is Delta E? And Why Is It Important for Color Accuracy?,"
ViewSonic Library, web page. Available:
https://www.viewsonic.com/library/creative-work/what-is-delta-e-and-why-is-it-important-for-co
lor-accuracy/. [Accessed: Feb. 13, 2026].

[2] Waveform Lighting, "What is CRI? The ultimate guide to the Color Rendering Index,"
Waveform Lighting, web page. Available:
https://www.waveformlighting.com/tech/what-is-cri-color-rendering-index. [Accessed: Feb. 13,
2026].

[3] IEEE, "IEEE Code of Ethics," IEEE, web page. Available at:
https://www.ieee.org/about/corporate/governance/p7-8. Accessed Feb. 12, 2026