Department of Electrical and Computer Engineering

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EECE 401 SENIOR DESIGN

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GLOW GARMENTS

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ABSTRACT

The Glow Garments project explores the intersection of wearable technology, sustainable fashion, and cultural expression through the development of an LED-integrated jacket that responds to physical movement. By incorporating individually addressable LED technology into a thrifted garment featuring the symbolic Howard University bison, this project demonstrated the potential for combining engineering principles with fashion design while maintaining a commitment to environmental sustainability. The motion-activated lighting creates dynamic visual displays that enhance personal expression while honoring institutional identity. This project addresses the growing market demand for interactive fashion that balances technological innovation with cultural relevance and environmental responsibility.

PROBLEM STATEMENT

The fashion industry faces a pressing need to incorporate light art into costumes and clothing, facilitating explicit expression through message-delivering light patterns while enhancing consumer safety by merging technology with fashion. This approach involves the seamless integration of flexible LED arrays into fabric, maintaining comfort and wearability, alongside a small, rechargeable battery pack that is removable for washing, and a pre-programmed microcontroller for dynamic light displays. The innovation promises to elevate fashion to new creative heights, allow unique consumer self-expression in various projects, and open a new market at the intersection of technology and fashion.

DESIGN REQUIREMENTS

Our project goal is to design and develop sustainable garments incorporating LED technology to enhance visibility and aesthetic appeal. The Glow Garments project was guided by the following design requirements, intended to ensure the final product was functional, wearable, and aligned with both user needs and engineering standards:

1. **Motion-Based Activation**

   The garment must respond to user movement through an embedded sensor, automatically altering the visual output without the need for manual input.

2. **Dual-State Visual Output**

   At minimum, the lighting system must support two distinct display modes to reflect idle and active states. These states should be easily distinguishable to observers.

3. **Programmability and Flexibility**

   The microcontroller must support programmable lighting sequences, enabling potential expansion to new behaviors or designs without hardware changes.

4. **Power Compatibility**

   The system must be powered by a compact, rechargeable battery that supports several hours of operation and can be discreetly housed within the jacket.

5. **User Comfort and Safety**

   Electronic components must be integrated in a way that avoids discomfort, restricts movement minimally, and does not pose safety risks during regular wear.

6. **Minimal Visual Disruption**

   Technical elements—including wiring, LEDs, and sensors—must be embedded cleanly within the garment to preserve its aesthetic appeal.

7. **Secure Mounting and Durability**

   All hardware must be firmly mounted or sewn in to prevent detachment or failure due to regular body movement or handling.

8. **Washability Considerations**

   While full waterproofing is not required, the garment must allow for easy disconnection or protection of components to accommodate routine cleaning.

9. **Sustainable Material Use**

   The base garment must be sourced sustainably, with preference given to thrifted or repurposed materials, to reduce environmental impact.

AGILE WORKFLOW & WEEKLY PLAN

At the start of the semester, we developed an agile workflow plan to ensure steady progress throughout the project timeline. For our first sprint, the goal was to determine fabric material, resketch and finalize the sweatsuit design, allocate LED placements on the sweatsuit, purchase fabric and begin sewing, and start drafting the final report, including the abstract, problem statement, and design requirements. However, we were only able to finalize the jacket design and begin the writing process for our final report. Our progress was hindered when Dr. Kim informed us that the school had not yet placed the order for the technical components, which would not arrive until March.

For the second sprint, our objectives shifted to writing code for the Arduino and circuit system, implementing features such as color coordination and reactive lighting to enhance the garment's aesthetic appeal, programming the LED system to support various lighting patterns—including static, dynamic, color transitions, and user-customizable modes—and continuing the development of the final report by incorporating sections on the agile workflow, weekly plan, solution design, and project implementation process. However, it was only during this sprint that we were finally able to complete the design for both garments. We also designed the circuit layout for the LED connections, but without the actual components, we were unable to test the system for potential coding discrepancies.

A major setback arose when we discovered that our order for the technical components had not been placed due to a freeze on federal funding from the Trump administration. With our final presentation scheduled for April and it already being March, this unexpected issue left us without the necessary hardware to build and test our design—an incredibly frustrating and stressful situation.

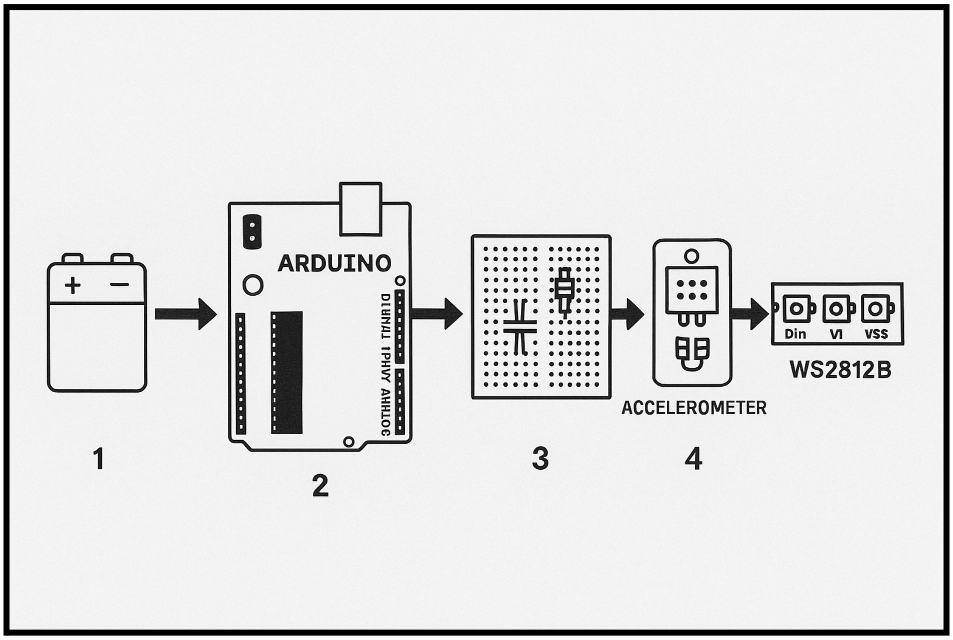
Despite this challenge, our team remained determined. We quickly reassessed our approach and focused on areas where we could continue making progress. We prioritized finalizing the physical garments and refining our technical report. This strategic pivot allowed us to maintain productivity while reinforcing key skills such as adaptability, time management, and resourcefulness—essential qualities for any engineer.

Sprint 3 served as a critical transition from concept to prototype, forcing the team to align scope with a tight three-week schedule. The initial ambition—integrating addressable RGB lighting into both jacket and pants—was pared down to a single focus: illuminating only the back panel of a varsity jacket. Because the fast-fashion shell originally purchased from UNIQLO failed to capture the desired vintage collegiate character, a wool-blend varsity jacket was thrifted at the Georgetown Flea Market and deconstructed with a seam ripper to provide flat panels for modification. Heritage branding elements were then heat-pressed: “HU” on the left chest to honor Howard University, “1867” on the left sleeve to mark its founding year, and “2025” on the right sleeve to signify the graduating class and build year.

Technical feasibility drove the next major pivot. Individually wired detachable RGB pixels were abandoned when the team calculated more than fifty solder joints, each a potential point of failure and a guaranteed schedule overrun. Addressable LED strips were selected instead; their sealed construction and consistent diode spacing reduced both installation time and risk. This change dictated a redesign of the back-panel lighting strategy: a horizontal array of LED strips was mounted beneath a diffusion layer, with a stencil-cut BISON appliqué exposing only the interior of each letter to the emitted light. An Arduino Uno served as the control platform, and two days were devoted to soldering fifty-four strip-to-wire connections. Although the first set of strips was irreparably damaged during initial power-on, a spare reel enabled rapid recovery without jeopardizing the timeline.

Given the time crunch, the LED array was bonded directly to the wool back panel using E6000 industrial adhesive, eliminating the need for additional stitch lines. The BISON appliqué itself was secured with a Singer domestic sewing machine, ensuring clean edges and durable attachment over the illuminated area. Final integration steps included hand-sewing low-profile pockets near the lower hem to house the lithium-ion battery pack and power button. The closing days of the sprint were dedicated to functional verification, including flex-cycle testing of solder joints, a thirty-minute continuous-illumination burn-in, and rehearsal of battery replacement procedures. The outcome was a fully wearable, heritage-inspired letterman jacket that met performance requirements and was delivered on schedule despite mid-sprint design pivots.

SOLUTION DESIGN



The Glow Garments system is powered by a 5V rechargeable battery [1], which supplies voltage to the Arduino Uno microcontroller [2], a compact breadboard [3], and the WS2812B LED strip [5]. The Arduino [2] controls the lighting logic and is programmed to respond to motion input from the MPU6050 accelerometer [4], which is mounted on the breadboard [3]. The breadboard [3] serves as the central wiring hub, distributing power from the battery [1] to the accelerometer [4] and the LEDs [5], while also housing a 1000µF capacitor for voltage stability. The accelerometer [4] communicates motion data to the Arduino [2] via I2C (SDA to A4, SCL to A5), and the Arduino outputs a digital signal from Pin D6 to the LED strip [5] through a 330Ω resistor. An additional 100µF capacitor is placed across the LED power input to prevent voltage dips. All components are embedded within the garment, with wiring routed through the fabric lining.

Glow Garments is a wearable tech prototype that combines expressive lighting with cultural significance. The focal point is a motion-responsive jacket designed using a repurposed varsity-style garment. The jacket integrates an LED display behind a bison-shaped cutout to symbolize Howard University pride, while promoting sustainability through thrifted materials.

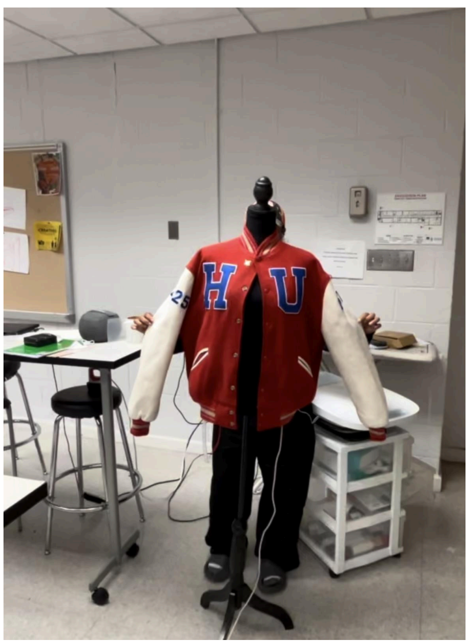
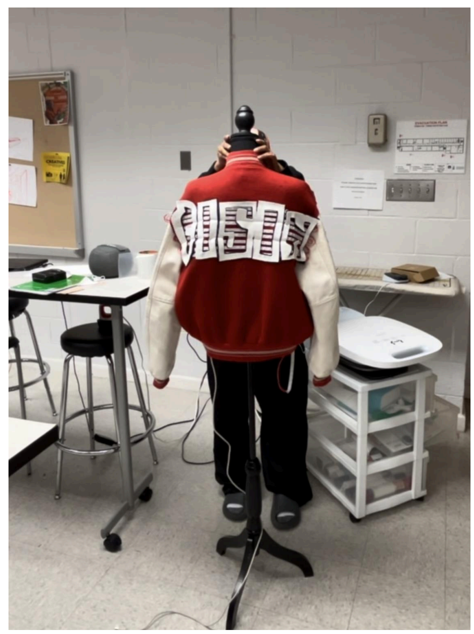
Core Components:

- **Microcontroller**: Arduino Uno
- **Sensor**: MPU6050 accelerometer/gyroscope, configured to detect motion above a 0.8g threshold
- **LEDs**: 270 WS2812B RGB LEDs
- **Power Source**: 5V rechargeable battery with USB charging, housed *inside* the jacket through a custom slit created for internal wiring
- **Wiring**: Flexible silicone wire reinforced with heat shrink tubing

Default Light Behavior:

- Jacket lights up white when powered on (idle state)
- Transitions to blue when motion is detected
- Code is written to allow future updates for alternate light sequences or animations

The internal placement of the battery maintains a clean external aesthetic while preserving garment functionality.

PROJECT IMPLEMENTATION PROCESS

The implementation process followed an agile workflow split into three sprints, allowing our team to adapt to delays and unexpected challenges while maintaining progress.

Sprint Highlights:

- Sprint 1:
  - Finalized jacket design
  - Determined LED placement and material feasibility
  - Began drafting sections of the final report
- Sprint 2:
  - Wrote Arduino code for LED sequences and sensor response
  - Programmed behavior for white idle lighting and blue motion-triggered lighting
  - Deconstructed the patches on the varsity jacket
  - Finalized bison-shaped cutout design
  - Ordered and received jacket components
  - Continued documentation updates
- Sprint 3:
  - Fully assembled the Glow Garments jacket
  - Wired the Arduino Uno, MPU6050 sensor, and WS2812B LEDs
  - Installed the 5V rechargeable battery inside the jacket through a custom wiring slit
  - Soldered and mounted the circuit on breadboard
  - Completed functional testing of the motion-triggered lighting sequence

The final product was verified to light up white when powered on, and shift to blue when motion is detected. Though our timeline was impacted by external delays, we successfully executed the integration of all components, completed the garment, and demonstrated a working prototype.

UPDATED SOLUTION DESIGN

While the original concept imagined full-jacket coverage with more complex animations, practical constraints led us to a streamlined, focused version:

- **Display Area**: Concentrated behind the bison logo to reduce wiring complexity and conserve power
- **Trigger Logic**: Simplified to two states (white = on, blue = motion detected)
- **User Interaction**: Code can be modified to switch between lighting effects or expand functionality
- **Battery Housing**: Power source placed inside the jacket via a carefully cut slit to allow clean routing of internal wiring and preserve garment aesthetics

This final iteration balances usability with functionality while achieving our core goal of a motion-reactive, culturally relevant design.

SCHEMATICS

The Glow Garments circuit centers around an Arduino Uno, which reads motion input from the MPU6050 sensor and controls the WS2812B LED array accordingly. The components are powered by a 5V rechargeable portable battery, housed discreetly *inside* the jacket through a slit created to route wiring internally.

Wiring Summary:

- **Power Supply**:
    - 5V rechargeable battery connected to:

        ○ Arduino VIN

        ○ LED power rail (with 1000µF capacitor across V+ and GND for voltage stability)

- **Sensor Interface (MPU6050)**:

    ○ VCC → 5V

    ○ GND → GND

    ○ SDA → A4

    ○ SCL → A5

    (Using I2C communication)

- **LED Interface (WS2812B LEDs)**:

    ○ Data In → Digital Pin D6 (with 330Ω resistor in series)

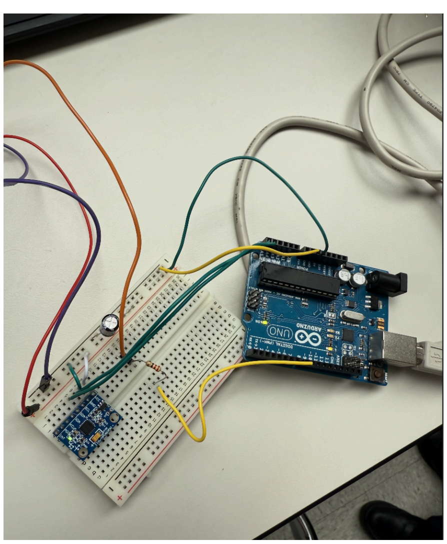
    ○ V+ and GND → Connected to battery and shared ground

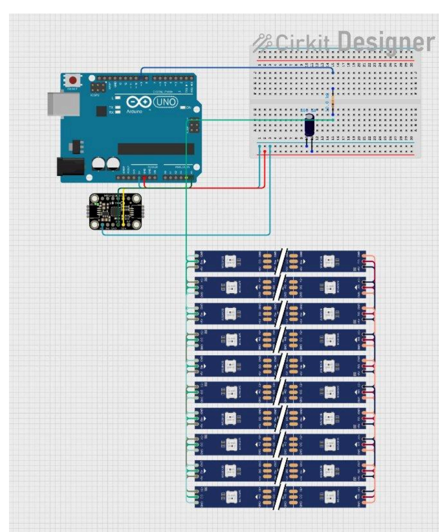
- **Stabilization Components**:

    ○ 100µF capacitor placed across LED power input to prevent voltage dips

    ○ All wiring secured using heat shrink tubing and sewn into the fabric lining

The entire circuit was assembled on a perfboard to maintain a compact and robust configuration. The layout was planned to ensure minimal movement of components while maintaining flexibility and wearer comfort.





CONCLUSION

Glow Garments merges fashion, function, and engineering to create a culturally significant, responsive garment. Through technical setbacks and limited resources, our team adapted to deliver a working, motion-responsive LED jacket that lights white by default and glows blue when motion is detected.

This project sharpened our skills in microcontroller programming, system integration, and agile development, while reminding us of the power of storytelling through engineering. Glow Garments offers a wearable narrative that represents innovation rooted in identity—and opens the door for future development in tech-integrated fashion.

-5

References.