

Executive Summary

IV insertion can be challenging, especially in fast-paced emergency settings where accuracy is critical. Multiple failed attempts can delay care and increase patient discomfort. Our project focuses on improving IV insertion success by developing a cost-effective, easy-to-use device for EMS personnel and nurses. Our system uses near-infrared (NIR) technology to enhance vein visibility. We have completed circuit integration and built a working prototype that projects vein patterns onto a screen mounted directly on top of the device for clear, real-time visualization. The design features like adjustable arm, allowing users to adjust position and direct the device over the patient's arm for optimal alignment and control. In future, we aim to project the vein map directly onto the patient's skin, making the device more intuitive and practical in real-world settings.

Background

- Intravenous (IV) access is a critical procedure in emergency medicine, yet obese and difficult-access patients often present significant challenges for healthcare providers, leading to repeated attempts, increased patient discomfort, and treatment delays.
- EMS providers frequently struggle with vascular access in obese patients, where veins are harder to visualize and palpate. We expect that this system will provide accurate, real-time vein visualization while remaining, and easy to use.
- Existing devices like handheld vein finders are bulky, costly, and disruptive to workflows. Develop a lightweight, wearable wristband that uses NIR imaging and side projection for hands-free vein visualization to improve IV insertion.

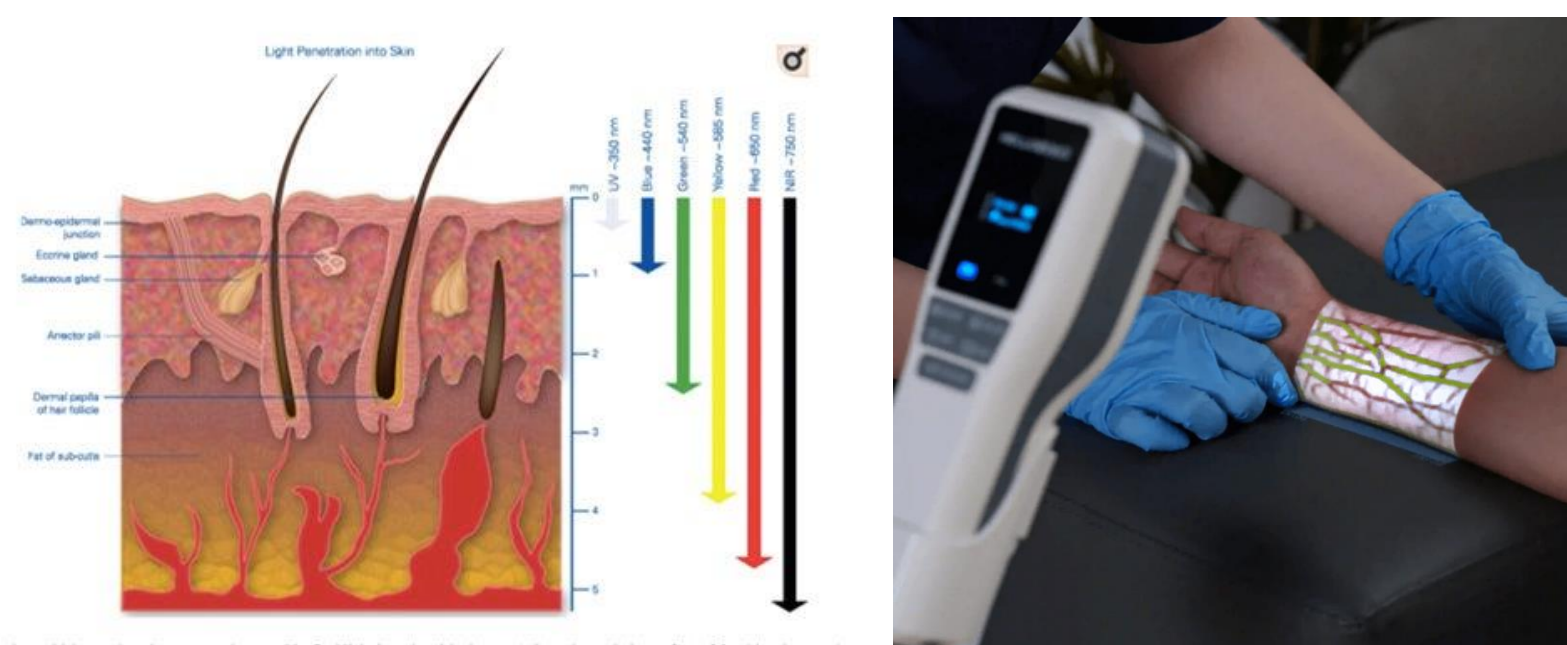


Figure 1 and 2. shows how NIR technology works underneath skin

Experimental Setup

The prototype was built using NIR LEDs, a camera module, Raspberry Pi, and a display screen mounted on top of the device. A lamp-like adjustable arm allows flexible positioning over the arm for better alignment. Testing was performed in a controlled indoor setting to evaluate visibility, positioning, and overall functionality.

Tests	What we did	What we observed
System Integration	Connected all components	Device powered and functioned smoothly
Vein Visualization	Placed device over arm	Vein patterns are visible
Display Output	Viewed results on top-mounted screen	Clear, real-time image display
Usability	Simulated real use	Simple and user-friendly design
Housing Fabrication	Designed and 3D printed housing i to hold all components.	Stable, organized, and portable design

Table 1:experimental setup and fabrication

Experimental Test Plan

- Our system is built around near-infrared (NIR) imaging technology, which enhances vein visibility by capturing differences in light absorption beneath the skin. The core components include NIR LEDs, a camera module, a Raspberry Pi for processing, and a display mounted on top of the device for real-time visualization. The device is supported by a lamp like adjustable arm, allowing flexible positioning over the patient's arm for accurate alignment.
- What makes our solution unique is unlike traditional vein finders that are often bulky and expensive, our design aims to be compact, portable, and easy to operate especially in fast-paced environments like EMS settings. The integration of a mounted display and adjustable structure improves user control without adding complexity.
- Key tradeoffs in our design include balancing cost vs. performance and portability vs. stability. While we prioritize a low-cost system using accessible components, we ensure sufficient image clarity and functionality for effective use. Similarly, the lightweight design improves mobility but requires careful structural support, achieved through the adjustable arm and housing.
- Our current prototype demonstrates successful system integration and real-time visualization. Future improvements focus on projecting the vein map directly onto the skin, enhancing usability and eliminating the need for an external display.

Experimental Results

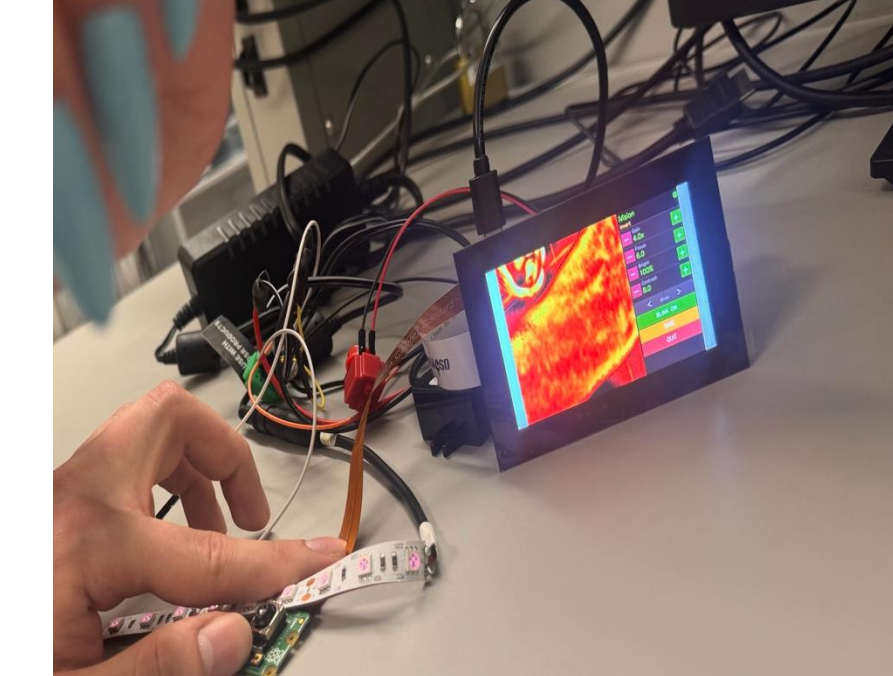


Figure 3:Prototype setup with Raspberry Pi, NIR LEDs, and real time display.

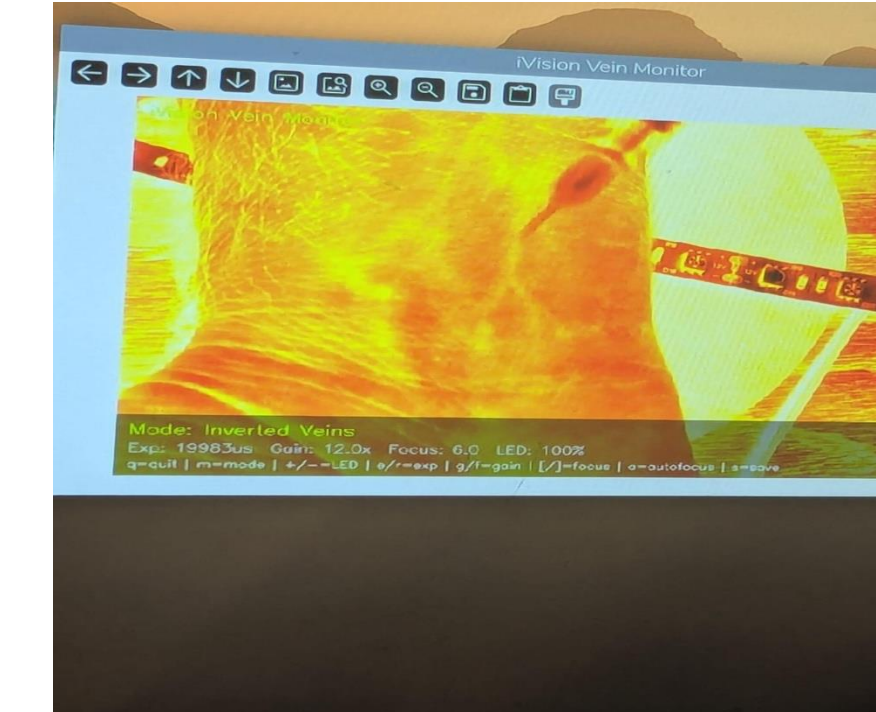


Figure 4:Real-time NIR imaging showing enhanced vein visibility

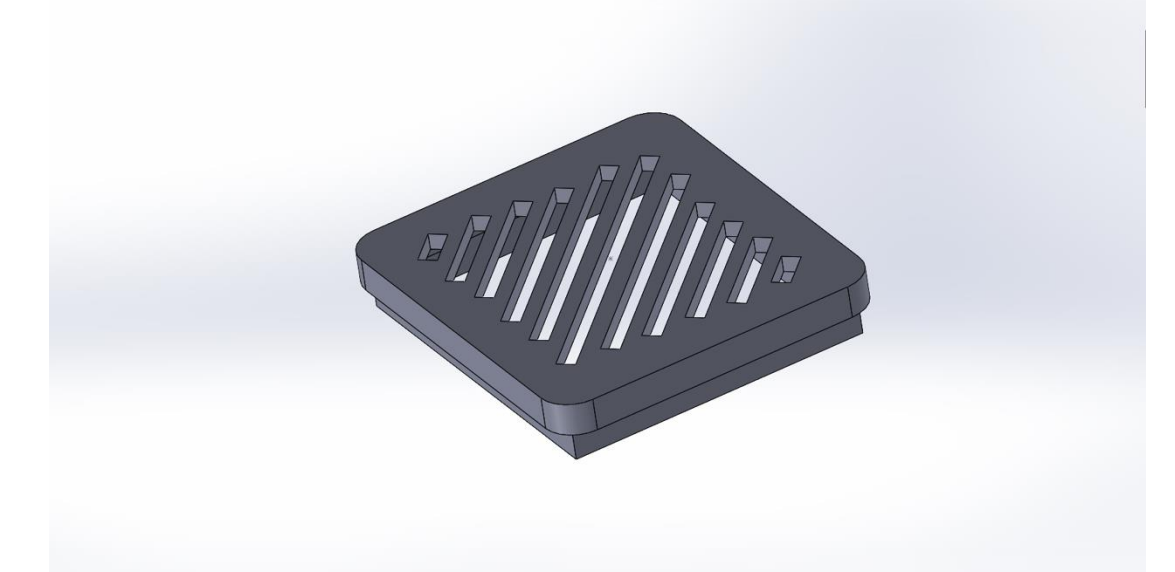


Figure 5:NIR LED illumination module for uniform vein visualization

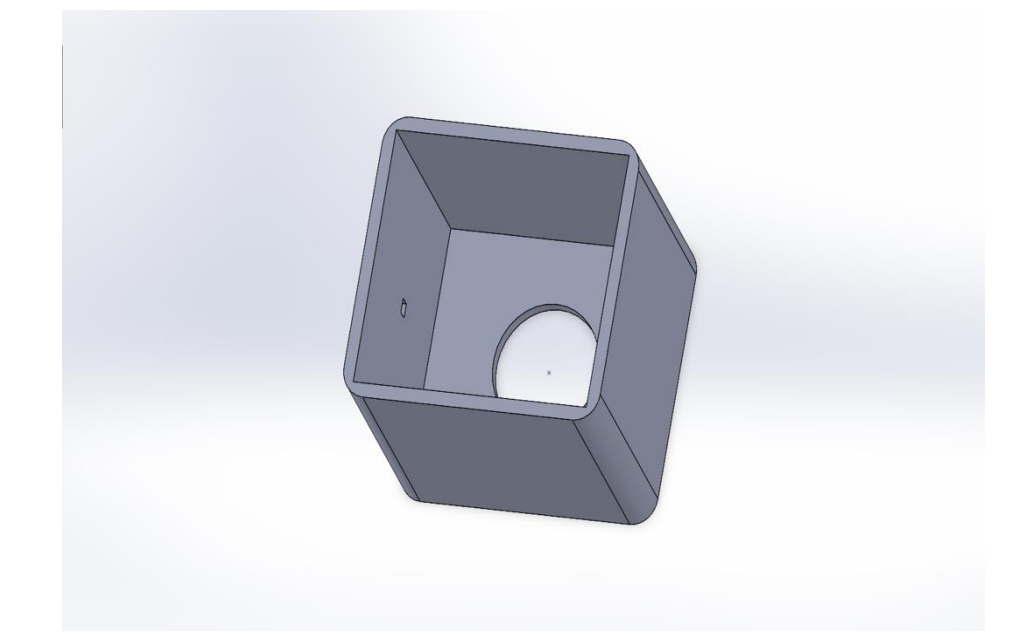


Figure 6:Proposed enclosure design for compact and portable use.

Conclusions

Our design aligns well with the original goal of creating a low-cost, portable, and easy-to-use solution to improve IV insertion success. The prototype successfully meets key specifications, including real-time vein visualization, compact integration of components, and user-friendly operation through a simple button-controlled interface. The lamp-like adjustable arm and top-mounted display further support usability and adaptability in fast-paced clinical environments. One of the main constraints was balancing cost with performance. While we prioritized affordability by using accessible components, we were still able to achieve visualization. Another challenge was maintaining portability while ensuring structural stability, which was addressed through the housing design and adjustable support system. Through this project, we learned the importance of careful circuit integration, stable power management, and ergonomic design for real-world applications. Iterative prototyping helped us refine both functionality and usability. Moving forward, we plan to improve image clarity, test the device under diverse real-world conditions, and transition from screen-based output to direct projection onto the skin for a more intuitive user experience. We would like to sincerely thank our mentors, instructors, and supporting organizations for their guidance, resources, and continuous support throughout this project.

References

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