Vein Finder Preliminary Design Report

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Survey of the State-of-the-Art:

During our survey of existing products we noticed several things. First, vein finders already on the market for medical applications. Although, what we have found is that they are typically inaccessible to buy online without contacting these medical companies directly. As a result, their prices are also not publicly listed making it difficult to gauge cost [1]. We did find some options online from sites like Ebay however, which go for around $1,200. There are also other options such as the Veinlite which range in price from $250 - $550 which do not project back onto the arm [2].

Products like the AccuVein and our design use near-infrared (NIR) to detect veins. This system works due to our veins carrying deoxygenated blood with hemoglobin [3]. The hemoglobin absorbs the infrared which gives it a dark contrast compared to the tissue around the veins. Since this difference is very visible with our eyes it should be possible to use machine learning to identify the veins.

Our model that we currently have goes for around $270 compared to the $1,200 of the AccuVein or $250 (pediatric version) of the veinlite. The largest cost by far is the projector which is $179. Our hope is that we will eventually be able to find a more cost effective method of projecting the veins back to the arm.

[1] Vein Visualization System | AccuVein, Inc.
[2] Clinically Proven Vein Finders for IV Access (veinlite.com)
[3] Competitive Real-Time Near Infrared (NIR) Vein Finder Imaging Device to Improve Peripheral Subcutaneous Vein Selection in Venipuncture for Clinical Laboratory Testing - PMC (nih.gov)

Imaging System:

For our preliminary system, we have a project previously worked on by another student at the University of Utah, Lance Delos Reyes. As part of his undergraduate research, he developed a system for vein finding to reduce cost over traditional systems used in the medical industry. As a result of his project, he managed to develop a system that could correctly image and display veins in the human body using near infrared LEDs, an infrared camera, and a simple projector. By shining the infrared LEDs on the skin, the hemoglobin in blood absorbs most of its light while the camera picks up everything that's reflected back off the skin. Then using a raspberry pi 2 and some simple python scripts, the system processes the images by applying tone curves and using image segmentation to make the veins more visible. Finally, once the image is prepared, it's displayed back on the skin to show the locations of the veins.

When we received the physical hardware from Lance, everything was already assembled and mostly working. When it came to imaging and displaying, the camera and projector worked, but it didn't appear to be displaying or "finding" any veins. While it was difficult to tell exactly why the vein detection itself wasn't working, we still have working electrical components, the raspberry pi, and his code repository itself so we could begin working on improvements in both hardware and software. In terms of other components included with the project, Lance was also using a 37Ah battery for power, and had the entire system secured in a 3D printed enclosure.

For our contributions to the project, we plan to update the design for the enclosure to make it more portable and robust. We also hope to improve the positioning of the LEDs and sensor in relation to the projector for more accurate placement of the image on the skin post processing. We hope that our solution will not only reduce noise produced by the projector, but also help with image focus and scaling depending on distance to the camera and projector. The rest of the improvements will then be done to the segmentation software, and we'll likely explore the implementation of machine learning to better detect the veins for clearer images and more accurate results overall.

Parts List for Vein finder project:

1. Pi camera 2
    - price : $23
    - Purpose: captures images for vein detection.
    - Quantity: 1

2. Raspberry pi 2 Model B
    - Price: $39
    - purpose : Serves as the central processing unit and machine learning unit for the vein finder.
    - quantity : 1

3. IR Emitter
    - Price: $3.06
    - Purpose: Provides infrared illumination to enhance vein visibility.
    - Quantity: 1

4. HDMI Ribbon cable (short)
    - Price: $14.08
    - purpose: connects the Raspberry pi board to mini projector for signal transmission. Here we used thin Ribbon type cable.
    - Quantity: 1
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5. DC-DC converter Module
    - Price: $4 each
    - Purpose: converts and regulates lithium-ion battery voltage to power components.
    - quantity : 2
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6. 3D print Materials
    - Price: $3 per 200g
    - Purpose: used for creating physical enclosure and mounting structures for the device
    - quantity : As required

7. Projector
    - Price: $179
    - Purpose: projects image of the veins onto the skin for easy visualization
    - Quantity: 1

Total: $269.14