NIR VeinFinder

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***Abstract* — Vein detection plays a crucial role in various medical procedures. It often becomes challenging for medical professionals to find options to help with veinfinding for patients with difficult to locate veins. This is because typical solutions can be expensive and large. We have created a vein finder which uses near infrared imaging with machine learning to find veins.**

***Keywords*— U-Net, Infrared Imaging, Veinfinding, Segmentation.**

I. A Survey of the State of the Art

During our survey of existing products we noticed several things. First, vein finders already exist 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 and image alteration techniques to identify the veins.

Our current model 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.

II. Our Physical Approach

Our goal with this project is to create a vein finder that will show where your veins are. We do this by taking an IR image of your arm and then segment the veins using a U-Net machine learning model. This works well considering that veins carry hemoglobin which absorbs the IR light being used on your arm. Therefore, when NIR imaging is used, the veins come out well defined.

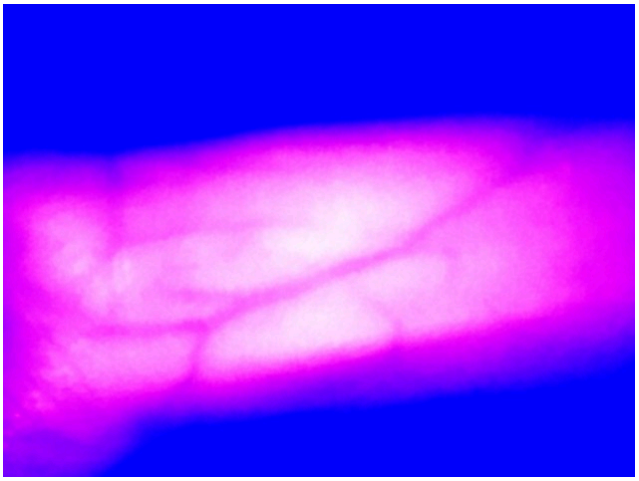

Fig. 1 An image from the camera of our vein finder showing well defined veins without the need of image processing..

Our setup involves a PiCam which is connected to a Raspberry Pi 2. The PiCam is in the middle of an IR emitting LED array. The PiCam is the NoIR version and we installed an IR pass filter onto it so that we could isolate the IR frequencies from visible light. The IR LEDs also use diffusers to spread out the IR for a clearer picture. We also have a projector which will be used in the future to project the veins back onto your arm.

All of this is enclosed in a custom 3D printed housing which is small and easy to carry. Using this setup we are able to capture very clear images which allows us to implement the machine learning portion much more efficiently.

III. Our Machine Learning Model Approach

Given that the nature of our veinfinding project is to locate veins in people's arms, the data collection process requires us to take pictures and work on data processing without a ground truth. This complicates our process of data collection as there is a manual segmentation step involved to pick the veins out of our images. Using these segmented images we can then train our UNet model. We started our data collection by taking a total of around 125 images of veins from 6 different people. From that we picked out the best images we had where you could see the veins clearly with the most contrast. That ended up giving us a total of 66 workable images which we then used to train our segmentation model. We ended up with a lot less photos than we initially took primarily because some veins were harder to find on certain people than others.

We then began to annotate our images for training the segmentation model. This was done by splitting the pictures we took between each team member and having each person individually highlight the veins in Photoshop. We drew over what we thought were veins with white then added a black background. This gives us the segmented veins while removing everything else. By the end, we then had 66 original images taken from our IR camera, and a matching annotation of the veins representing our ground truth that we could use to train a segmentation machine learning model.

The machine learning output from using our training set of 66 images was not usable so we decided to do data augmentation to increase the amount of training images we had. We did rotation, flipping, and various crops to create more images. This took us from our original set of 66 training images to 1,584. When we trained with this augmented dataset, the model worked much better producing very usable results.

We're definitely happy at the moment with the images our camera can take and the segmentation our U-net model performs for segmentation. Our next steps however will be to start working on making the model outline more of the subtle veins in each of the images. If we have time we will also start to see if we can get the alignment of the projector set up so that we can display the vein images back onto the arm. From some basic tests, we determined that this becomes quite complex as the distance from the camera to the arm can vary.

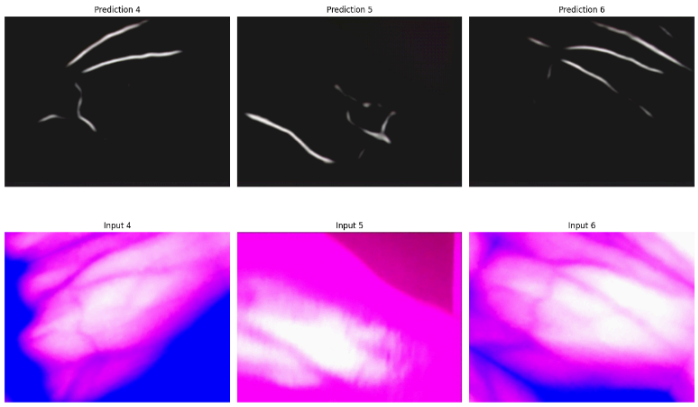

Fig. 2 Image showcasing the current segmentation ability of our model.

IV. Current Progress

Currently, we are more focused on training our model to give us better segmentation. We will do this by taking more images from additional users so that we can feed our model more varied data. Once we have an improved model we will connect it up to our program running on the Raspberry Pi. This will allow us to then feed live image data to the model so that we can segment in real time and use it to display the veins back on the user through the projector.

V. References

[1] "Vein Visualization System," AccuVein, Inc. https://www.accuvein.com/vein-visualization-system/

[2] "Clinically Proven Vein Finders for IV Access," www.veinlite.com. https://www.veinlite.com/

[3] M. D. Francisco et al., "Competitive Real-Time Near Infrared (NIR) Vein Finder Imaging Device to Improve Peripheral Subcutaneous Vein Selection in Venipuncture for Clinical Laboratory Testing," Micromachines, vol. 12, no. 4, p. 373, Mar. 2021, doi: https://doi.org/10.3390/mi12040373.