Vein Finder First Report of Results

이동기, 歐陽樂文, **Semrah Odobašić,** 정어진

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 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.

Objective and Experiment Plans

- Project Objectives

    - Lower cost.
    - Simplify use.
    - Reduce size.
    - Improve hardware for obtaining better images in camera.
    - Implement software to improve and alter images from the hardware.
    - Project improved vein image back onto a patient's arm.

- Experiments
    - Test various IR emitters to improve hardware image quality.
    - Test different lens filters to improve hardware image quality.
    - Try various room conditions such as lights on and off.
    - Implement various image alteration techniques to determine if the image can be further improved.
    - See if there are any computer vision programs that can help segment the veins for display back onto the arm.
    - Find methods to reduce the effect of the projector light on the received IR image in camera.

Experimental Results to Date

Throughout these last few weeks we have made various changes and improvements to the vein finder. The first advancements we made were to improve the hardware. This was because the quality of the images being collected prior was low and already limited the amount of work the software could have done to improve the vein finding.

We first experimented with the vein finder we received from Lance to see how it worked and performed. During this process we identified that the IR emitters were being driven by a 5V source but noticed the silkscreen on the PCB for power said 12V. From using a phone camera on the IR emitter, we noticed only one of the IR LEDs was powered on at 5V so we determined that we needed to increase the voltage to the IR emitter. The voltages on the device were 3.3V and

5V from USB. Since this wasn’t what we needed, we used a voltage stepper to get 12V from the 3.7V USB supply. After looking at the images from the veinfinder again we immediately noticed all the LEDs powered on resulting in more IR light which slightly improved the images.

The images were still not great however so we decided to start improving other aspects of the hardware. One of the first things we had issues with was the portability and the fragility of the vein finder. In order to fix this we decided to remake the case and rewire the electrical systems. We first removed the breadboard and made a 3D printed case that has dedicated slots built in for all of the components. We then removed the original battery pack and used some smaller batteries instead. This will give us less run time but lowers the space required for the vein finder substantially.

Fig 1: Image of the new vein finder case.

After improving the portability we then focused on getting a better image from in the camera. The first change we tried was using a different IR emitter that had more IR LEDs on it. When we used it with our camera however, we found that it did not improve the IR image we were receiving. After some discussion and research we found that the larger emitter produces IR at 950nm while the original emitter was producing IR at 800nm. After looking up the details for the Picam2 we found that there is a substantial drop in IR detection past 850nm which is why we didn't see an improvement despite having more LEDs.

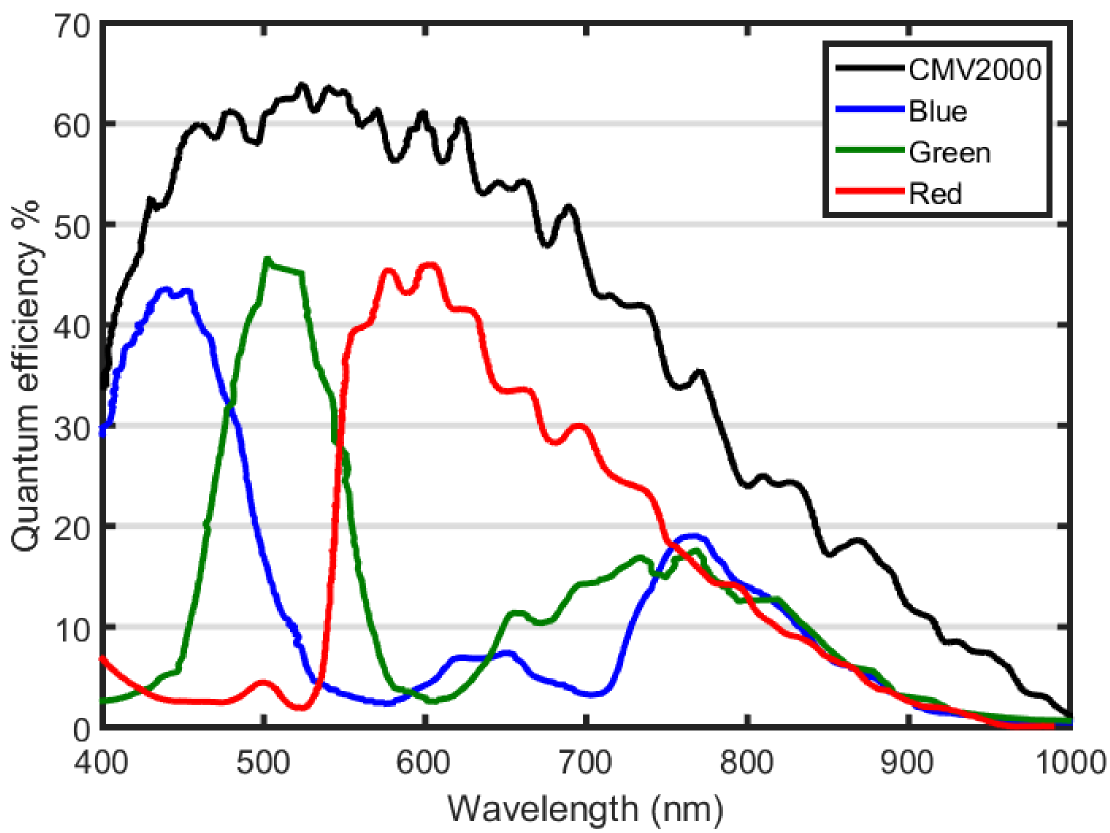

Fig 2: Wavelengths of the Sony IMX219.

From there, we chose to continue using the original emitter at 850nm. During our imaging tests however we found that visible light was also a slight complication. With the lights on in the room or the projector shining on an arm we found that we had too much visible light reflection to see anything in the NIR range. To fix that, we ordered an IR-Pass filter that allows light in wavelengths above 780nm.

While that was shipping we started looking at the software. The difficulty we had was with editing files since there was no PiOS desktop to go to. After attempting to get into the PiOS desktop from the SD card we had, we eventually gave up and started from scratch using our own image since we have the veinfinder code on Lance's GitHub repository. During this process there were a number of dependencies we needed to install. The one we had the biggest issue with was OpenCV. After installing for about 3 hours it would crash with an error message. We read various forums on the internet and after about a week we managed to troubleshoot and get it working. We then installed the rest of the dependencies we needed and were able to get the program running from the PiOS desktop. With the help of Rich we were also able to download all of the existing files from the old SD card to our new environment.

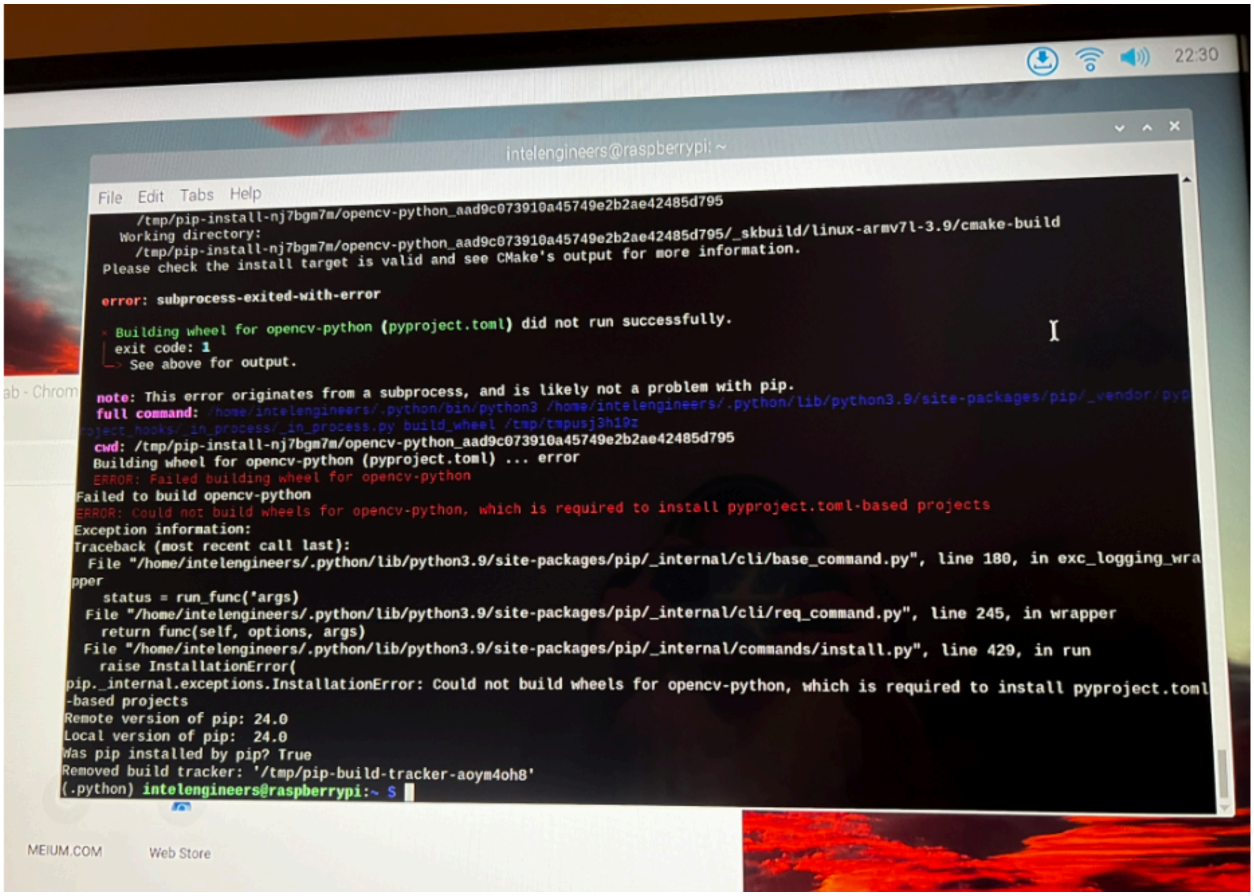

Fig 3: OpenCV error we were stuck on.

Once we had all of this we were able to make a simple program that just displays the image the camera is receiving. As before though the IR image quality was poor. We attempted to use tint for car windows from a recommendation online which did not work well in our case. Luckily, during this time the IR-pass filter eventually arrived so we could test that instead. After putting it over the lens we immediately had much better images coming directly from in camera with no software image processing or alterations. At this point, we are very happy with our progress as this now gives us a substantially better base image to begin altering in software.

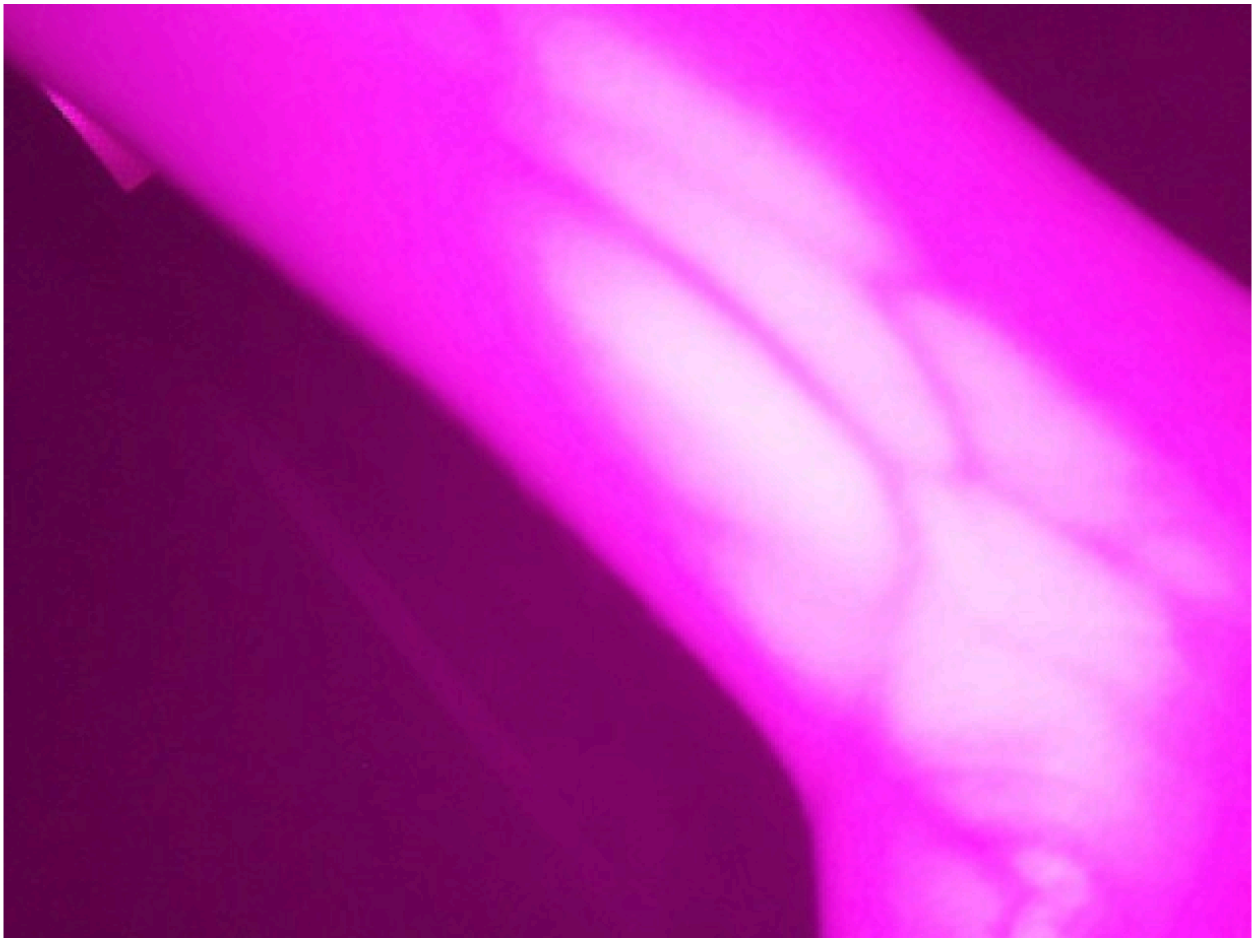

Fig 3: Initial results from implementing new hardware and the IR-Pass filter without software alterations.

Semester Plans

- **Current Objectives**
    - Develop an image processing algorithm to better highlight and accentuate veins from the camera's filtered image.
    - Take the image from the program and use the projector to display it back onto the arm.

- Implement a hardware system to be able to align the projector image in place on the arm.

Credits

[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)