

Infrared Endoscopy and its Practicality for Surgery

Phys 173
June 2014
Kevin Kohler
A09320836

Abstract

The focus of this experiment was to see if there was a wavelength of light that would allow for surgeons to “see through” blood. White light was used to illuminate the blood but the camera had a filter of wavelength 675nm. This paper will detail the results of the experiment and a discussion of further experimentation.

Introduction

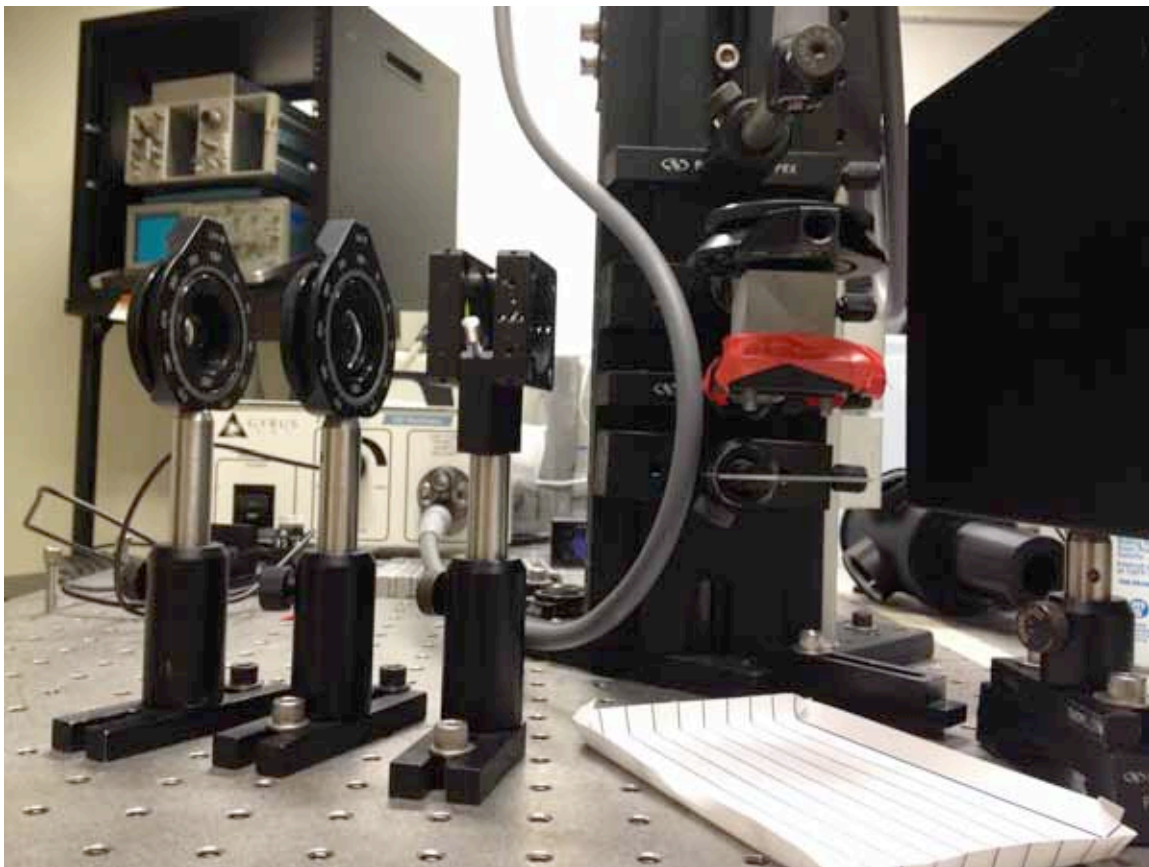
While conducting any surgery, there will undoubtedly be blood. As human beings, we are extremely visually dependant and as a result, we typically require visual stimuli to make decisions. Blood is a very thick substance, typically associated with a very deep-red hue.

Scott Prahl of the Oregon Medical Laser Center created a spectrum of both oxygenated and broken-down hemoglobin and found the lowest absorbance of oxygenated hemoglobin to be at the wavelength 686nm, where the absorbance is 0.634 and the absorption coefficient is 1.461. The data was collected from 250-1,000nm, signifying that there may be better options lying outside of this range.

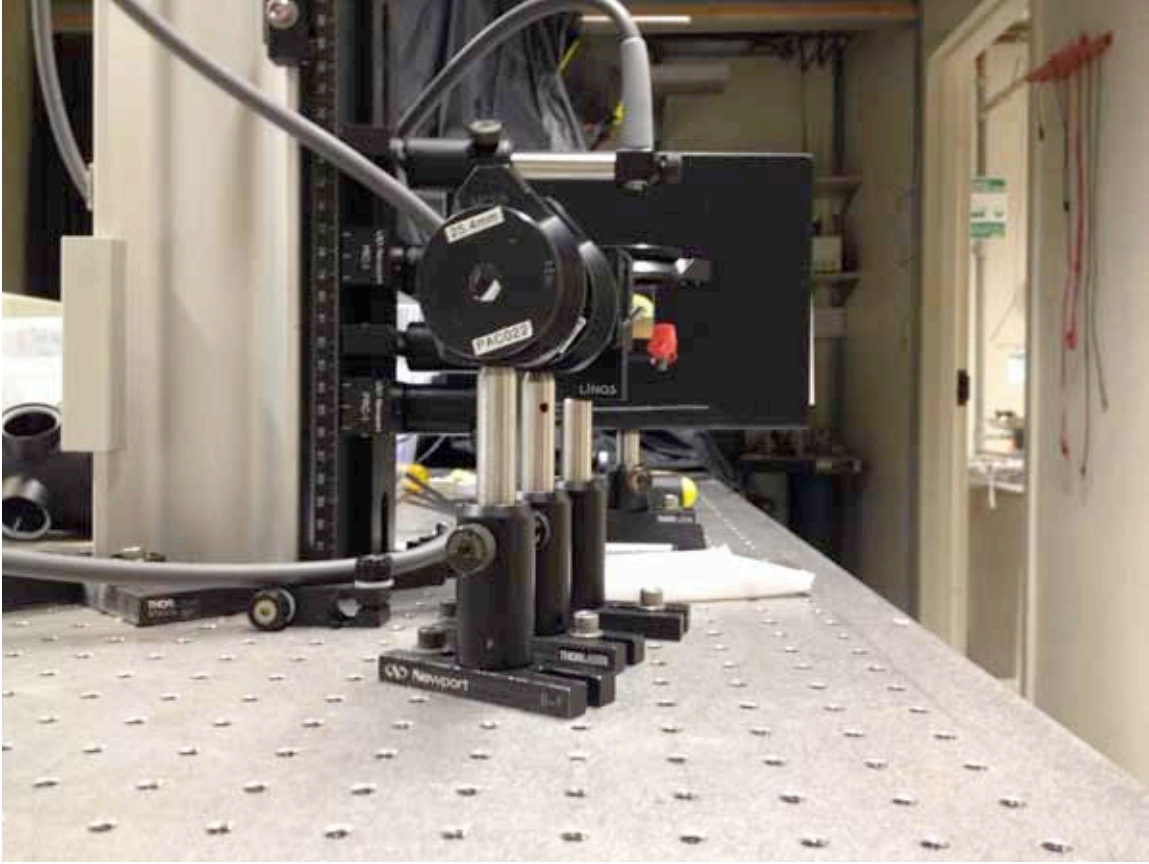
Materials and Methods



In an ideal world, we would be able to procure the exact materials relevant to this experiment, but instead we were forced to make due with what we already have. Instead of a 686nm light, we instead used a white light source which passed through a 675nm filter with a bandwidth of 25nm. In order to focus the light, we used a 25.4mm lens to form columnated light as best as possible. A standard web cam was used to capture images, but with the inability to manually focus the image, an additional two 25.4mm lenses were used to focus the image for it. To hold blood of varying depths, slide wells were constructed using a number of #1 cover slips glued together on a slide. The thicknesses of the three wells were 0.17, 0.34, and 1.02 mm (or 1, 2, and 6 slips respectively). The slides also had a laminated label with the text “AAA” on it as our objective. In order to replicate the visual process of observing reflected light, we also utilized a 50/50 dichroic mirror.



The set-up had a light source pass through a convex mirror of focal length 25mm from a distance of 30mm then through the 50/50 dichroic. Below that, was the blood well. Once the light reflected off the text, it would come back up and reflect off the mirror and to the side, where it would then pass through the filter, then the corrective lenses, then finally the camera.



An important thing to note is that the back half of the set-up needs to be offset. If all the material is on the same axis as the columnated light, the camera will be unable to see anything, as the circle of light will dominate the camera. As a result, it must be set-up with a slight angle off the axis. However, if the angle is too large, then the camera will not be able to see the slide through the dichroic at all. The angle I used was about 14° .

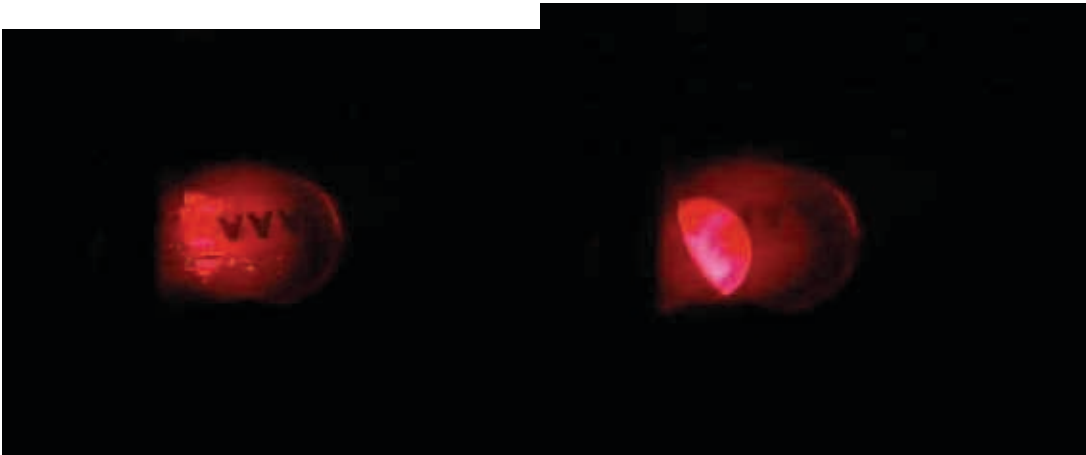


The actual experiment consisted of filling the blood wells with oxygenated hemoglobin from a rat. Once the well was full, another coverslip was placed on top to ensure that the depth was correct. Once the filled well was in place, the light was turned on, and the webcam was used to take images of the blood wells with and without the filter.

Results and Data Analysis



The first well (of depth 0.17mm) showed promise. The images don't truly exhibit what was seen with the naked eye. With one coverslip, I was easily able to see the text with perfect clarity. This includes both through the filter and without the filter. As such, we can conclude that a thickness of 0.17mm is a good control, since the text was visible in either situation.



The second well (of depth 0.34mm) was not as successful. Once again, the images don't really give a sense of what was going on. While looking at the slide with naked eye, I was able to see the text below the blood, but it was a little blurred around the edges. With a depth of only 0.34mm, this was not a good sign at all for the direction of the experiment. It was a little easier to distinguish the text through the filter compared to with no filter, but that may have had more to do with the intense reflection off the surface of the blood being dimmed down through the filter.



The final well (of depth 1.02mm) was way too thick to make anything off. It may sound strange since it was only a tenth of a centimeter, but even that much blood made it impossible to discern the underlying text. Regardless of whether I used my naked eye or the camera, the filter or not, all outcomes were the same: the text was not visible in the slightest. However, the blood, being a perfectly flat surface, reflected the light pretty well, making the results unreliable.



Discussion, Sources of Error, and Further Experimentation

The results were not favorable, but they were somewhat expected. The next step would be to use diluted blood samples and scale the results. In this way, we can determine how much of a role the intensity of the inbound light plays in this experiment and if, perhaps, that is the only issue holding me back. Another possibility is to test other filters of bandwidth 25nm and compare their results with the 675nm filter.

I feel as if the filter should be placed before the light hits the blood sample. This way, we can hopefully limit any scattering that occurred. Also, the columnated light proved to be problematic since the narrow beam of light was so dominant when looking

through the webcam. Finally, the coverslip that was laid on top may have contributed to that reflected light since it ensured that the light would hit a perfectly flat surface.

References

Prahl, Scott 1999. Optical Absorption of Hemoglobin. Oregon Medical Laser Center

Cuper et al. 2012. The use of near-infrared light for safe and effective visualization of subsurface blood vessels to facilitate blood withdrawal in children. *Medical Engineering & Physics*

Clay, Omar et al. 2006. Large Two-Photon Absorptivity of Hemoglobin in the Infrared Range of 780-880nm. *The Journal of Chemical Physics* 126