Schlieren Optics and Photoacoustic Imaging Development

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Research Question

Can the photoacoustic effect be detected using schlieren optics to provide real time image reconstruction?

The current method for image reconstruction of the photoacoustic effect is by using transducers to detect the pressure waves generated. To generate an image multiple scans are needed and the data from all scans must be complied resulting in slow imaging times.

Optics & Acoustics

Schlieren Optics is highly sensitive to changes in the refractive index allowing for the real time reconstruction of the photoacoustic effect.

The **Photoacoustic effect** produces pressure waves through the absorption of light in a target. This approach enables improved depth of imaging in biological tissue compared to optical microscopy approaches.

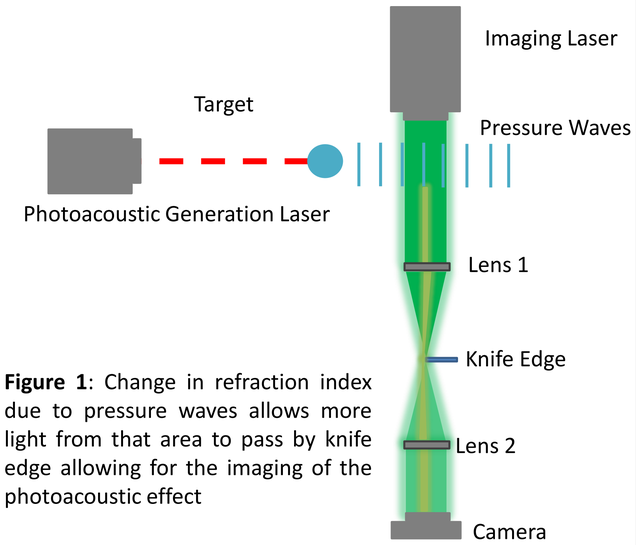
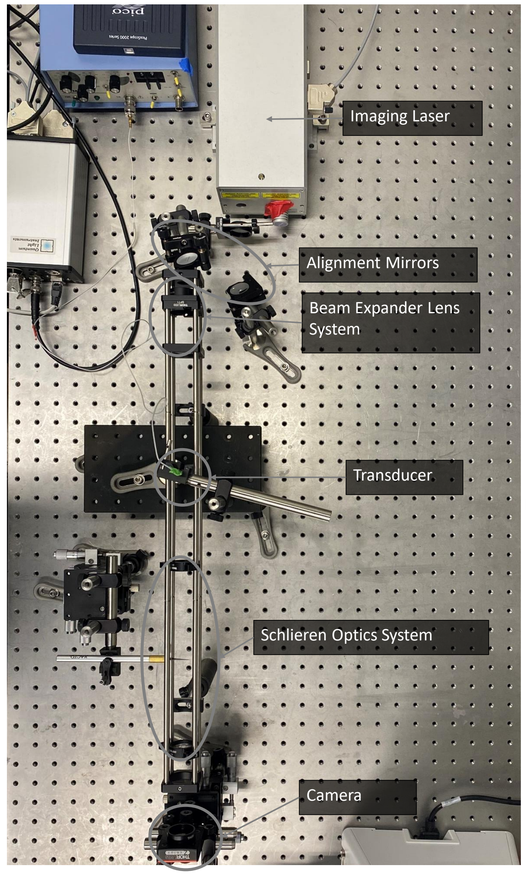
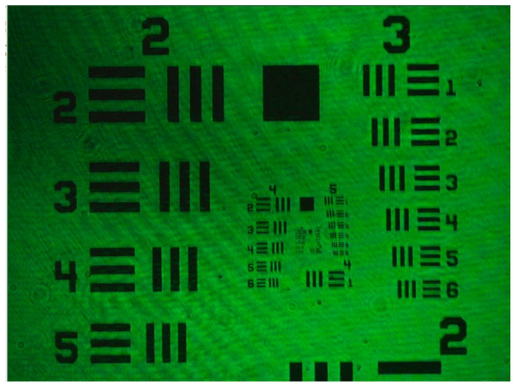


Figure 1: Change in refraction index due to pressure waves allows more light from that area to pass by knife edge allowing for the imaging of the photoacoustic effect

Results





```
meang=mean(meanGreenLevels);
i=1;     %creates vector of the frames to extract
for frame = 1 : numberOfFrames
    if meanGreenLevels(frame)>meang
        x(i)=frame;
        i=i+1;
    end
end
ReadObj = VideoReader(z);
CurFrame = 0;
GetFrame = x;
l=1;
```

```
clc
clear all
f=dir('frame*.jpg');
files={f.name};
Y=imread('unpluged.jpg');
for k=1:numel(files)
  Im{k}=imread(files{k});
  Z{k}=imsubtract(Im{k},Y);
  imwrite(Z{k},sprintf('sub%d.jpg', k))
end
```

Figure 2: Top Left: Diagram of current imaging system in use.

Figure 3: Top Right: Right: Image of Airforce target used to determine resolution of optical system. Current system resolution is approximately 17.5 µm.

Figure 4: Bottom Right: MATLAB code used to first extract frames of interest from video, then code used for image analysis. [1],[2]

Conclusion

Overall, the results of the research thus far have shown that the system has an acceptable resolution, but that not all research objectives were achieved. The current image analysis techniques have not resulted in the detection of pressure waves within the system. This could be due to multiple potential sources of error within the system, stemming from possible alignment errors, inadequate image processing completed, and a potential for the imaging system to be out of sync with the transducer.

Future Goals

Currently there are several opportunities for improvement through additional research. The next step of is to explore additional image processing techniques focusing on k space image analysis for pressure wave detection. After that the alignment of the system should be improved ensuring the optimal environment for detection. Then the timing of the laser pulses and triggering of the transducer should be verified. Finally, the transducer should be replaced with a photoacoustic generation setup with imaging of the photoacoustic effect taking place.

Acknowledgements

I would like to thank Dr. Barbara Smith for all her help on this project, as well as all the members of the Smith Lab for their help and collaboration on this research. I would especially like to thank Christopher Miranda and Derek Semetanick for their contributions.

References

[1] MathWorks. (2021). How to extract frames of a video. Retrieved April 07, 2021, from https://www.mathworks.com/matlabcentral/answers/48797-how-to-extract-frames-of-a-video

[2] MathWorks. (2021). Imsubtract. Retrieved April 07, 2021, from https://www.mathworks.com/help/images/ref/imsubtract.html

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