



Incubator with DPC Microscope for Cancer Growth Measurement and DPC + Darkfield
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Light slows down or shifts in phase as it passes through a sample of increased density. QPI (quantitative phase imaging) can be used to an image of how the phase shift in cells occurs¹. The phase shift can be correlated to the density of the cytoplasm of the imaged cells¹. One method of QPI is DPC (differential phase contrast). This method uses 4 angles of sample illumination, with an LED, to determine the phase shift in the sample².

The first part of my UROP project has been to assist in developing a DPC microscope capable of fitting within an incubator. In pursuit of this goal, I worked on various projects. The first was optimizing the stepper motor to decrease time between images. I conducted tests on the speed at which the stepper motor, camera and LED could cycle in between different illumination patterns. I also developed a program for centering the LED within the view of the camera. This required comparing average intensities of 4 images of varying half circle illumination, as shown in Fig 1.

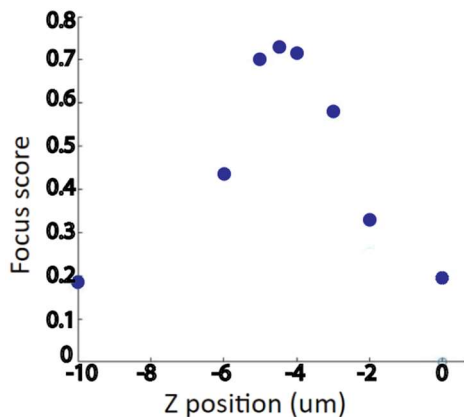


Figure 1: Focus algorithm test, best focus at -4 microns

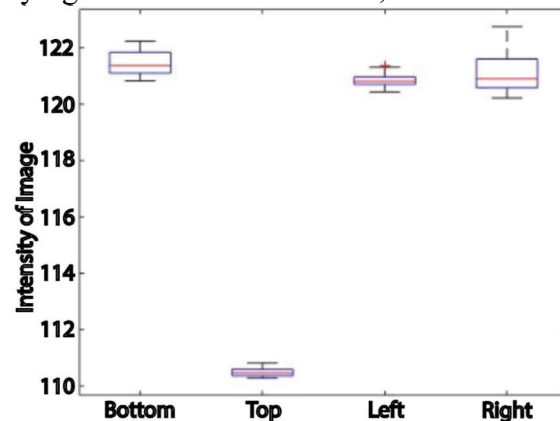


Figure 2: Figure 3 (Right): Boxplot of intensities of each half circle image showing that the LED is

To automate the system an autofocus procedure was developed, Fig 2. This required finding a focus score based on the contrast of an image and comparing that score over different z-axis distances.

I have additionally, worked to develop a DPC microscope that also collects Darkfield images. The design of this microscope is shown in Fig 3 and 4. This microscope was able to collect, not only darkfield images, but darkfield images as well. Images of polystyrene beads in quantitative phase and darkfield as well as an image of algae are shown in Figures 5 and 6. This device could prove useful in imaging and measuring absorption of light in tandem with the QPI mass data.

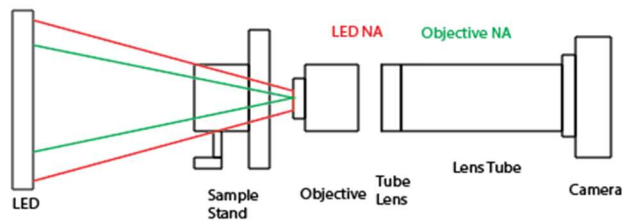


Figure 3: Diagram of microscope design

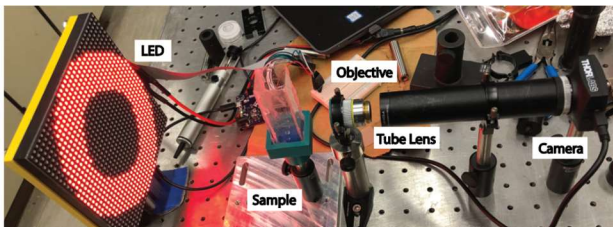


Figure 4: Image of DPC Darkfield Microscope

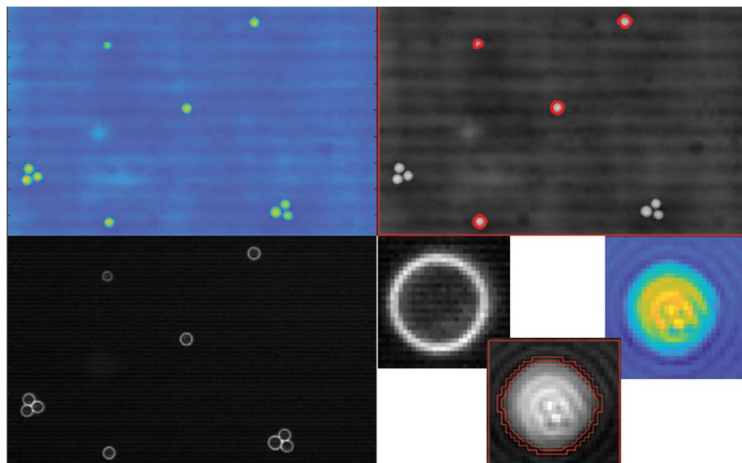


Fig 5 (Left): Top Left: DPC Image of Beads
Right: Segmented DPC Image.
Bottom Left: Darkfield Image.
Bottom Right: Darkfield, Segmented DPC, and DPC Images

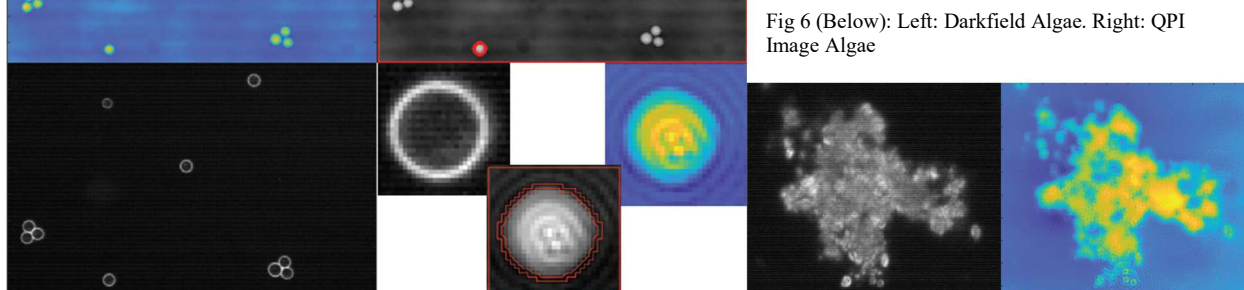


Fig 6 (Below): Left: Darkfield Algae. Right: QPI Image Algae

Research on the incubator DPC has shown promising results in chemotherapy efficacy trials. The images of the algae cluster indicate that there is immense potential for further applications of the DPC and darkfield system in the future. Additional research projects on both systems are being conducted in the Zangle Lab to discover and refine applications.

References

1. Liu, Z., Tian, L., Liu, S., & Waller, L. (2014). Real-time brightfield, darkfield, and phase contrast imaging in a light-emitting diode array microscope. *Journal of Biomedical Optics*, 19(10), 1. <https://doi.org/10.1117/1.jbo.19.10.106002>
2. Tian, L., & Waller, L. (2015). Quantitative differential phase contrast imaging in an LED array microscope. *Optics Express*, 23(9), 11394. <https://doi.org/10.1364/oe.23.011394>