Projector Based Microrobots

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Abstract: A system of controlling microscopic bubbles in a thin film was designed using heat from a projector on an absorbing substrate on the underside of the film. These bubbles attracted to the heat sources could be use to carry smaller microscopic objects that could be used to build microstructures.

Introduction:

Micro-robots hold great potential as tools for every field of study. From medical applications, to the manufacturing of small objects, and as technology advances, reliance on micro-robots will continue to grow. The projector-based micro-robots created by Hu, Ishii, and Ohta at the University of Hawaii at Manoa [1] use microscopic bubbles to push and pull smaller microscopic objects, giving these bubbles the capability to build microstructures. This is accomplished by creating an optically absorbing substrate of amorphous silicon between two glass slides, light patterns are then projected onto the substrate [1]. The substrate converts these projected light patterns into heat; The differences of temperature caused by this, along with the surface tension of the amorphous silicon give the bubble a horizontal fluid motion. By adjusting the position of the light patterns, the circulation of the fluid in the substrate can be used to give the bubble movement, along with the ability to push or pull smaller objects [1].

The goal of our project was to complement the existing micro-robotics design by adding the ability to adjust the size and speed of the projected images used to control the bubbles as well as adding collision detection systems to prevent bubbles from getting within a certain distance to each other.

The ability to adjust the size of the projected image allowed users to control the size of the heated area in the substrate and thus control the size of the bubble that would be attracted to the area. If bubbles in the substrate came into close contact with each other, there was the possibility that the bubbles would merge into a larger bubble. This could create bubbles that were too large to be manipulated or work closely with other bubbles. The collision avoidance system was thus useful in preventing this kind of unexpected behavior.

Design and Fabrication:

Fig.1: Light from a projector is directed towards the film containing the fluid in which the bubbles form and move through. Below is the reflecting mirror setup for redirecting the projector image beam towards the film. A focusing lense is placed on the cube to focus the image onto the substrate.

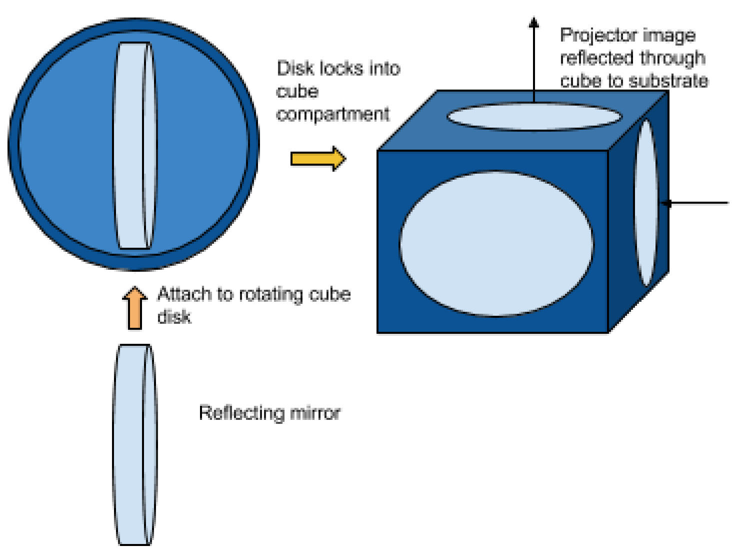


Fig.2: The film is fixed on a platelet that can be adjusted in the x-, y-, and z-directions. This allows the position of the film to be adjusted to so that the camera can properly focus on the microscopic bubbles in the film.

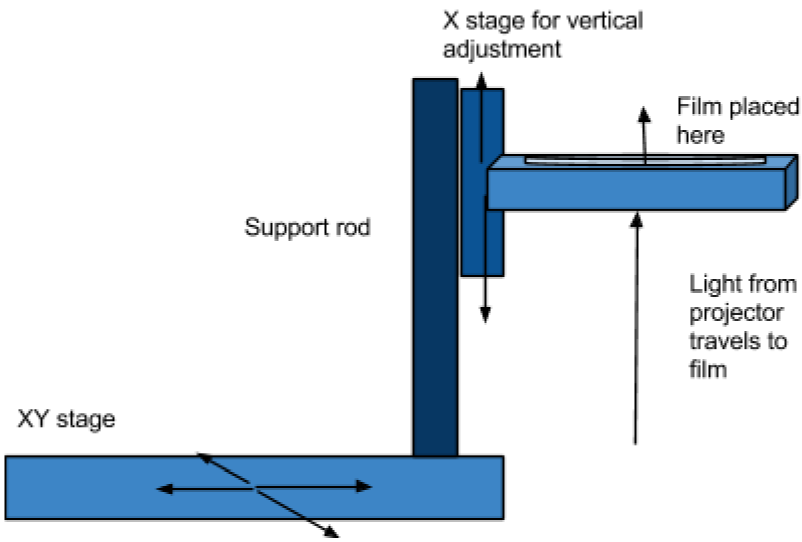


Fig.3: The camera is attached to a stage capable of moving vertically to allow for further adjustments for focusing the image. The camera requires a microscopic focusing lense to clearly view the bubbles in the film.

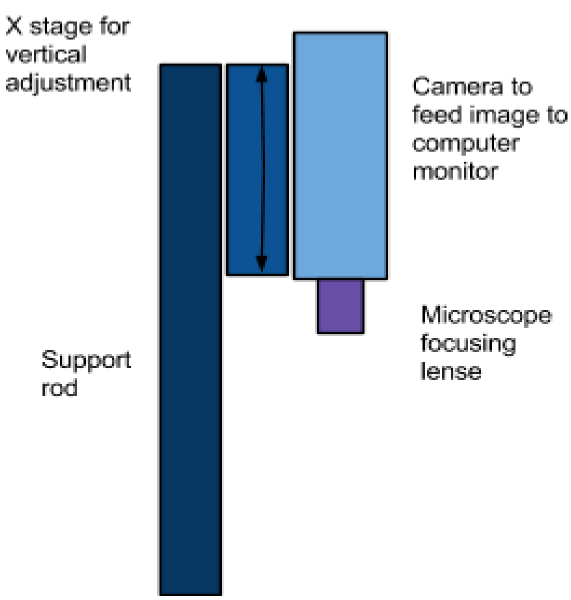
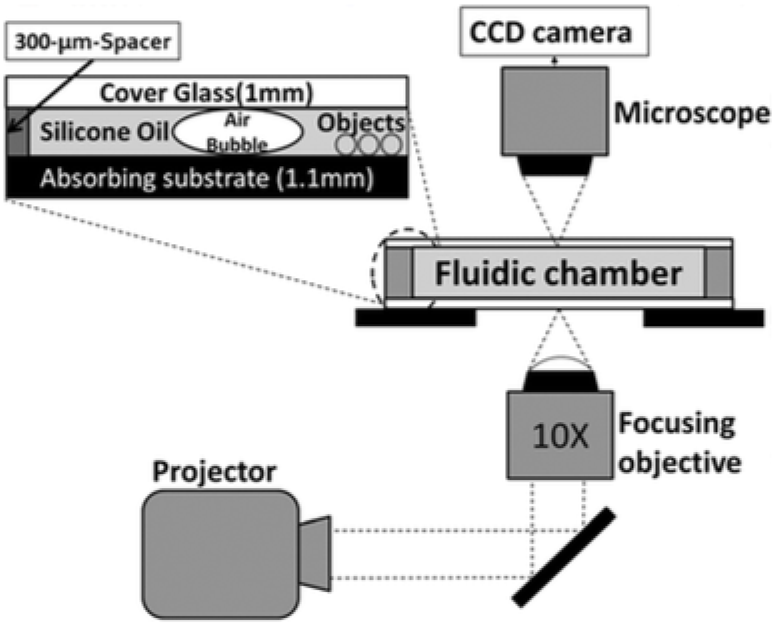


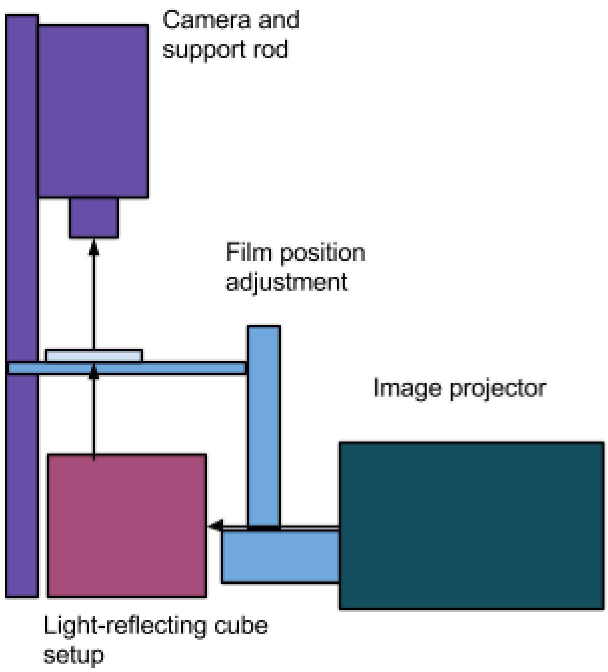
Fig.4: Overall design setup [1].



The program that controls the spotlights on the film allows users to move using game controllers. These controllers provide a simple interface for the user to adjust the size, speed, and direction of the spotlight and, in turn, the bubbles. The output of this program is a black field on a computer monitor with white circles, each controlled by a user. This image is then projected to the underside of the substrate.

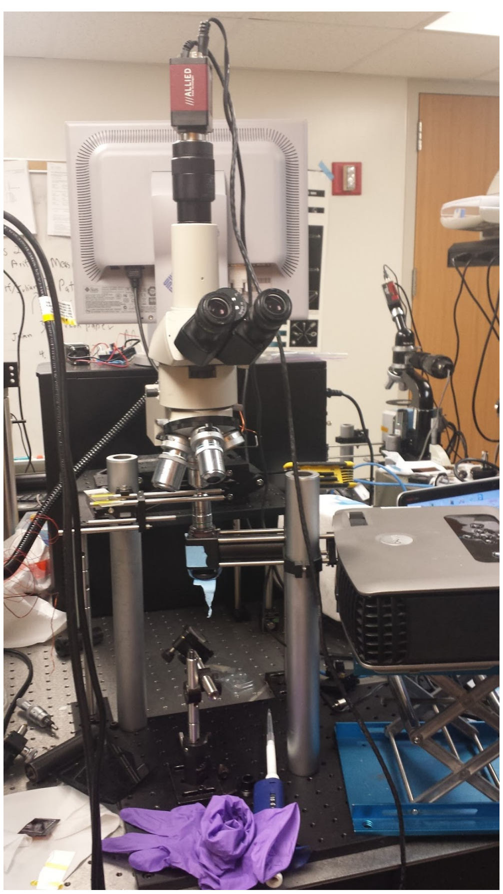
Experimental Results:

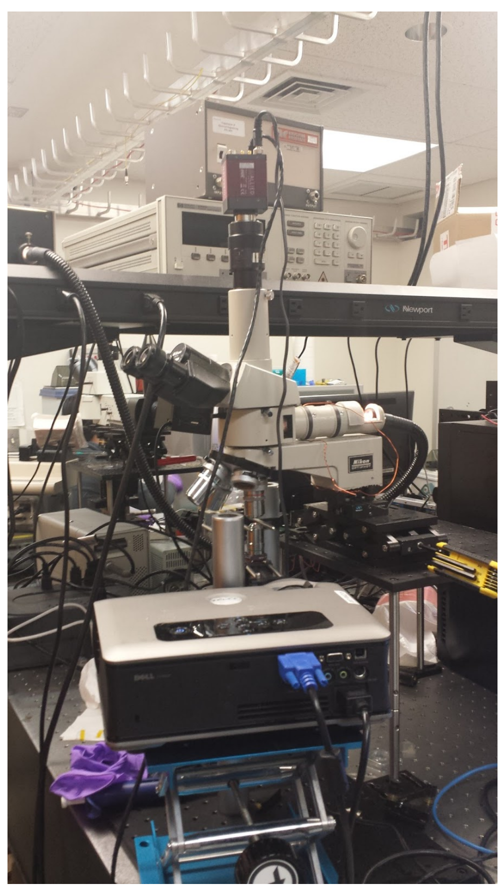
<u>Fig.5</u>: Concept of final setup.



- Final setup

<u>Fig.6</u>: The parts for our final setup were not available during testing and an older setup was used.





During testing, we found that slight variations in the orientation of the glass film increased the chance that any bubbles formed in the oil would slide in the direction of this slope. A slope could be caused by such factors as the platelet on which the film was mounted not being precisely balanced or by the table on which the setup was built not being perfectly level. The sliding of the bubbles due to inclines was sometimes enough to overcome the attractive force of the heated areas of the substrate.

Bubbles sometimes had difficulties moving due to slight imperfections in the glass or particles of dirt between the slides, each of which can cause the bubble to stick to the top or bottom of the inside of the film.

Fig.7: Below, we see a bubble moving towards the center of the heated area (top left) as well as two bubbles that have merged into a larger bubble, drifting due to an slight incline (center).

The bubbles were successfully attracted to lighted areas of sufficient size; larger bubbles moved slower towards heated sources than smaller bubbles. We found that it was easy for the users to move faster than the bubbles could follow when the control program allowed for fluid motion. This was addressed by having the movement of the users done by tapping the control sticks rather than holding them down.

Discussion:

Micro-robots are already being designed to perform micro-manipulation and microassembly tasks that cannot be done by humans. One such example is an alternative means to diagnose or treat certain types of cancer [2]. Due to their small size, microrobots can decrease the trauma experienced by the patient and have the ability to reach areas of the body that would otherwise be inaccessible to surgeons. Some questions that scientists and engineers still need to consider are how they plan to power their robot, how they plan to move/control it, and how to insert and remove it; a common problem of untethered micro-robot designs is storing energy at such small scales as well as the fact that at such small scales, viscous effect start to dominate the inertial effects in fluids [3]. Most of the answers to these questions are expensive and do not fully address these design issues [2].

The projector-based microrobot system offers an alternative to these concerns; the components of the system are cheap and can be easily replaced. The design also has the advantage that the objects used for micro-manipulation, the bubbles, are naturally occuring within the medium in which they travel, this eliminates the problems of insertion and extraction of the micro-robot. Since the bubbles are attracted to heat from an outside source, we also avoid the problem of storing sufficient energy at small scales.

The system itself is customizable and with the improvements that we have implemented, it allows teamwork between multiple micro-robots. While this system may not yet have the ability to be used for surgery as other microrobots are being designed for, it still has great potential in micro-assembly and -manipulation tasks. The design is highly programmable, straightforward, and simple, which gives it flexibility and allows that users need not know the internals of how it works in order to use it effectively and without concern of breaking the design. The simple and highly programmable design also has educational applications as it can serve as a tool to introduce new users to concepts of micro-robots and micro-manipulation in an interactive and easily understood way.

Conclusion:

To conclude, a projector-based controller is not efficient but has other qualities that make it viable. The white circles produced by the projector are not guaranteed to influence bubbles. The bubbles controlled will have a degree of lag. The design of the experiment has important functions isolated to specific equipment like the projector and the computer making assembling a setup relatively simple compared to other microbot control setups. The simple setup also creates possible customization for users to control the light on the screen with just the keyboard or game controllers of their choosing. Due to the use of external heat applied to the medium in the which the bubbles travel, this design is more suited for non-medical micro-manipulation and assembly tasks as well as educational purposes.

Acknowledgements:

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References:

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