CONTROL AND NAVIGATION OF MICROSWIMMERS

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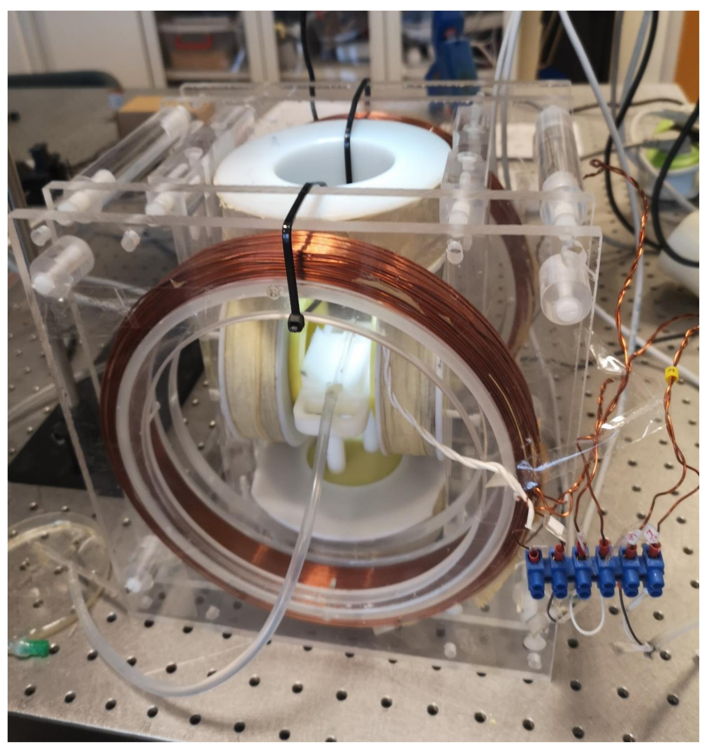
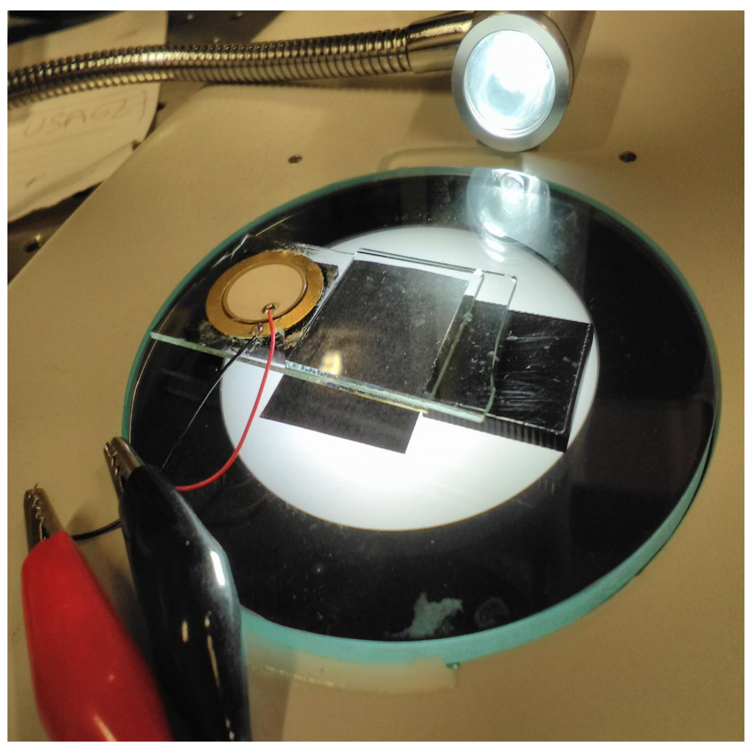
ABSTRACT



Experimentation Setup
Rotating magnetic field is achieved with the help of two pairs of orthogonal Helmholtz coils



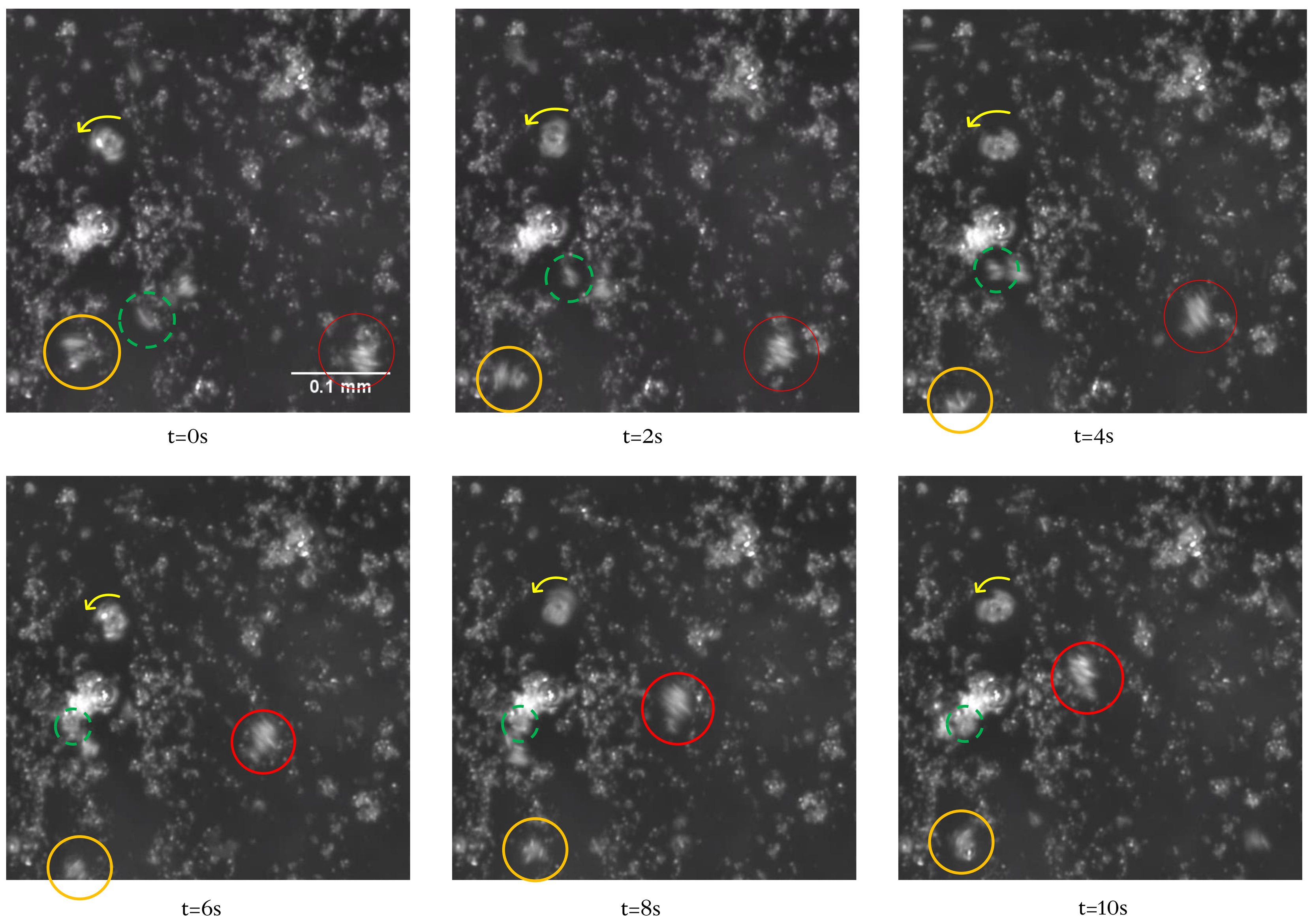
Experimentation Setup
Acoustic waves are generated with the help of piezoelectric transducers

Swimming microrobots which are inspired by natural swimmers such as E. Coli, R. Lupini and Salmonella have a huge potential in medical and biological applications. However, many challenges and difficulties must be overcome for the realization of the technology. In manufacturing part, we have tried to minimize the presure that when we place the magnet in the head of micro swimmer. 3D printing technology(Form Labs Form 2), which is the most advanced and usable method in micro manufacturing , is used in micro swimmer design. On the other hand, we used external magnetic field to rotate micro/milli magnetic particles and the external magnetic field can be manipulated to obtain a controllable trajectory. While rotating magnetic field is used for propulsion, sound waves can be used for swimmer navigation. We also investigated the motion of the glass spheres under the influence of acoustic actuation.

OBJECTIVES

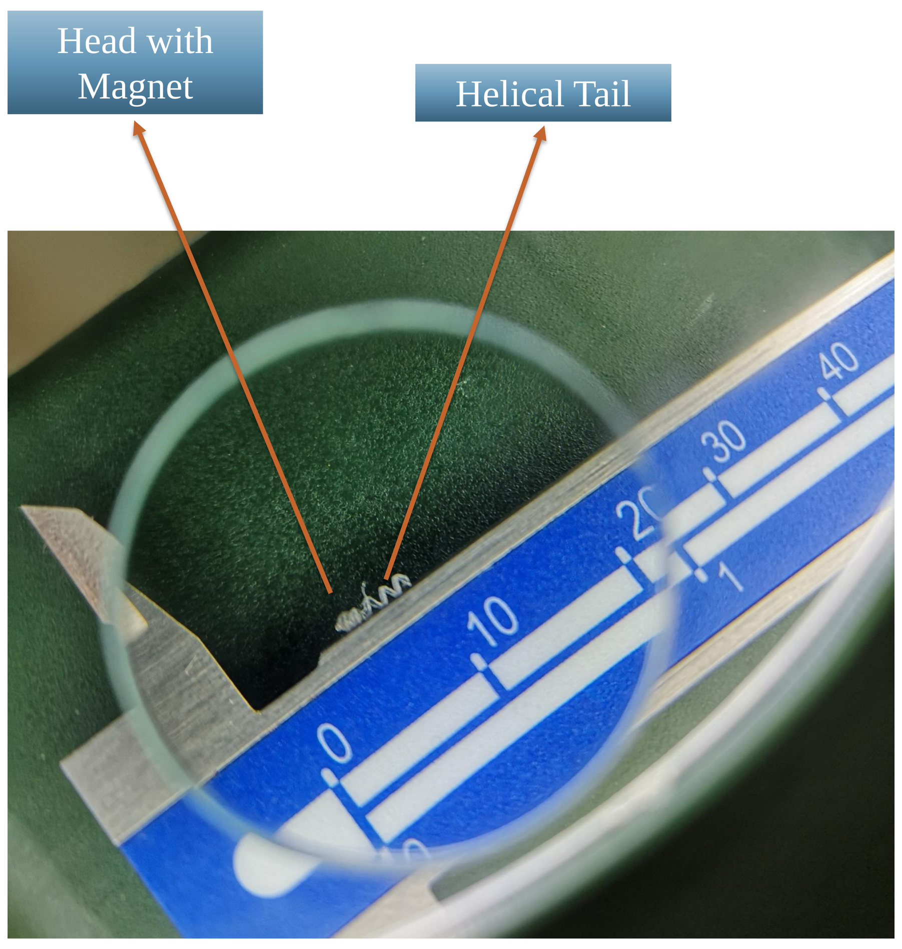
In manufacturing part of this project, our object is to reach lightest micro swimmer with thinnest helix diameter. On the other hand, in the terms of actuation, our goal is generating standing surface acoustic waves and observing how tiny glass particles behave in a closed microfluidic chamber. Also, investigating the influence of different fluids on the motion of particles.

PROJECT DETAILS IN ACOUSTIC ACTUATION EXPERIMENTS



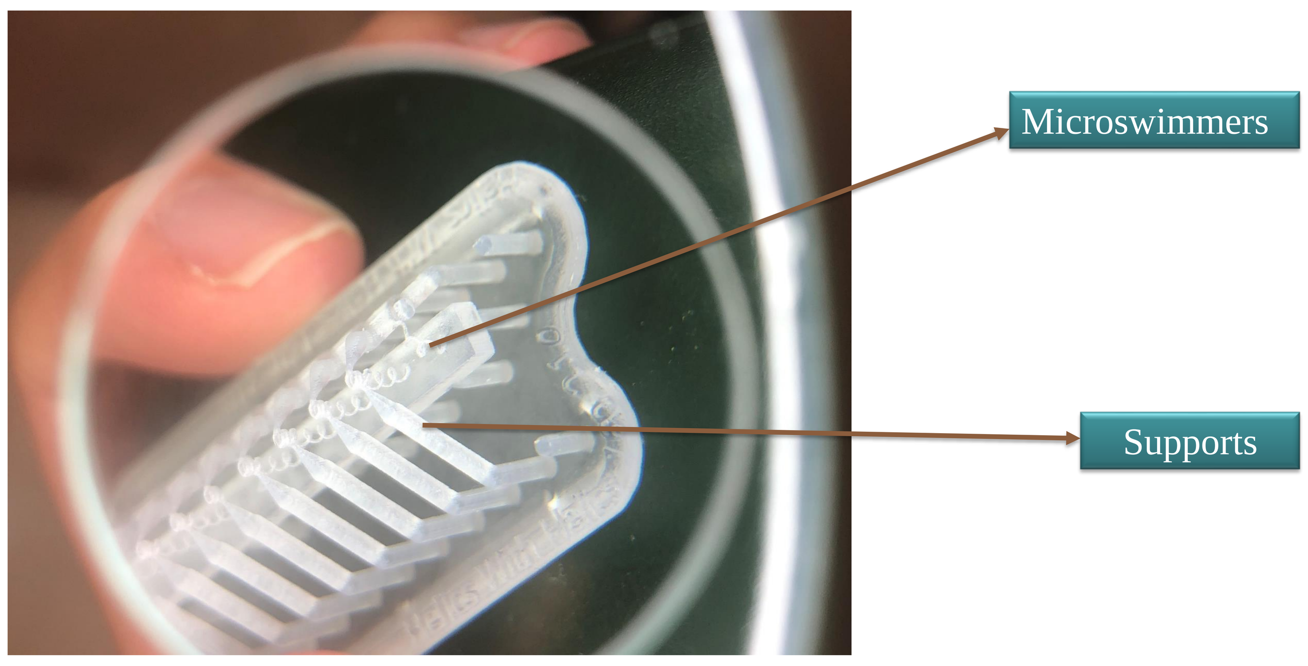
We used different experimental setups for acoustic actuation to get better results. Last version of our setup consists of water droplet with small particles between two glass slides and the droplet is sandwiched between glass slides. Acoustic waves are generated by piezoelectric transducer. We operated the piezoelectric transducer(PZT) at different frequencies to activate the motion of particles and observe their responses. The voltage at which PZT operating is 20 V.

PROJECT DETAILS IN MANUFACTURING



Our research group is concentrated on microswimmers manufacturing with helical structural tails. These microswimmers have two parts: helical tail and head which has a micro scaled magnet. In micro manufacturing, 3D printing technology is not easy as other manufacturing methods. So that, first we were trying to understand how micro scaled helical structure are printed. Therefore, we have printed helical structures from 200um to 300um diameter.

From this effort, we understand that it is impossible to manufacture these helical structures without supports and then, we tried to minimize the touchpoint area and number of supports because we want to reach the lightest micro swimmer with the thinnest diameter so, we focus on head. We want to minimize the pressure that we make to the helical tail when we put the magnet to the head.



CONCLUSION

In our final microswimmer design, the helical tail consists of 4 revolution with 1mm pitch and head consists of 2 revolution with 0.4mm pitch. We made our designs in SolidWorks. Then, we printed our designs in 3D printer and we placed the magnet to the head. After that, we conduct old experiment which uses external magnetic fields with our designed micro swimmers to understand our design is appropriate or not. Finally, we figured out that our micro swimmers were applicable for experiments and we started to took videos of our experiments. Then, we image processed the videos in MATLAB to observe the progress of microswimmers in 10cm tube which is filled with glycerin. Now, we are trying to reach more clear videos for MATLAB with gold-plated. On the other hand, in our first acoustic actuation experiments the chamber thickness was 2 mm and the chamber was made of acrylic. We operated PZT(piezoelectric transducer) over the range of 0-3 MHz and observed no motion. Then, we changed the thickness of the chamber to the 1 mm and start to observe motion. We get the best result with droplet sandwiched between glass slides. We concluded that acoustic effects are more pronounced in the chamber with less thickness. We also get better results using glass slides rather than using plexiglass slides owing to low attenuation of acoustic waves.

We observed the motion of particles at certain frequency ranges. According to our experiments the frequency range at which particles start to move are profoundly dependent on the type of the PZT. In our last experimental setup, which is described in the project details, we observed motion of particles in the frequency range of 6-9 kHz and the peak was at 8.1 kHz.

REFERENCES

1- Ahmed, Daniel & Baasch, Thierry & Jang, Bumjin & Pané, Salvador & Dual, Jurg & Nelson, Brad. (2016). Artificial Swimmers Propelled by Acoustically Activated Flagella. Nano Letters. 16. 10.1021/acs.nanolett.6b01601.

2- Liu, Bin, Kenneth S. Breuer, and Thomas R. Powers. "Propulsion by a Helical Flagellum in a Capillary Tube." *Physics of Fluids*26, no. 1 (January 8, 2014): 011701. doi:10.1063/1.4861026.