CPS: Medium: CyberOrganoids: Microrobotics-enabled differentiation control loops for cyber physical organoid formation

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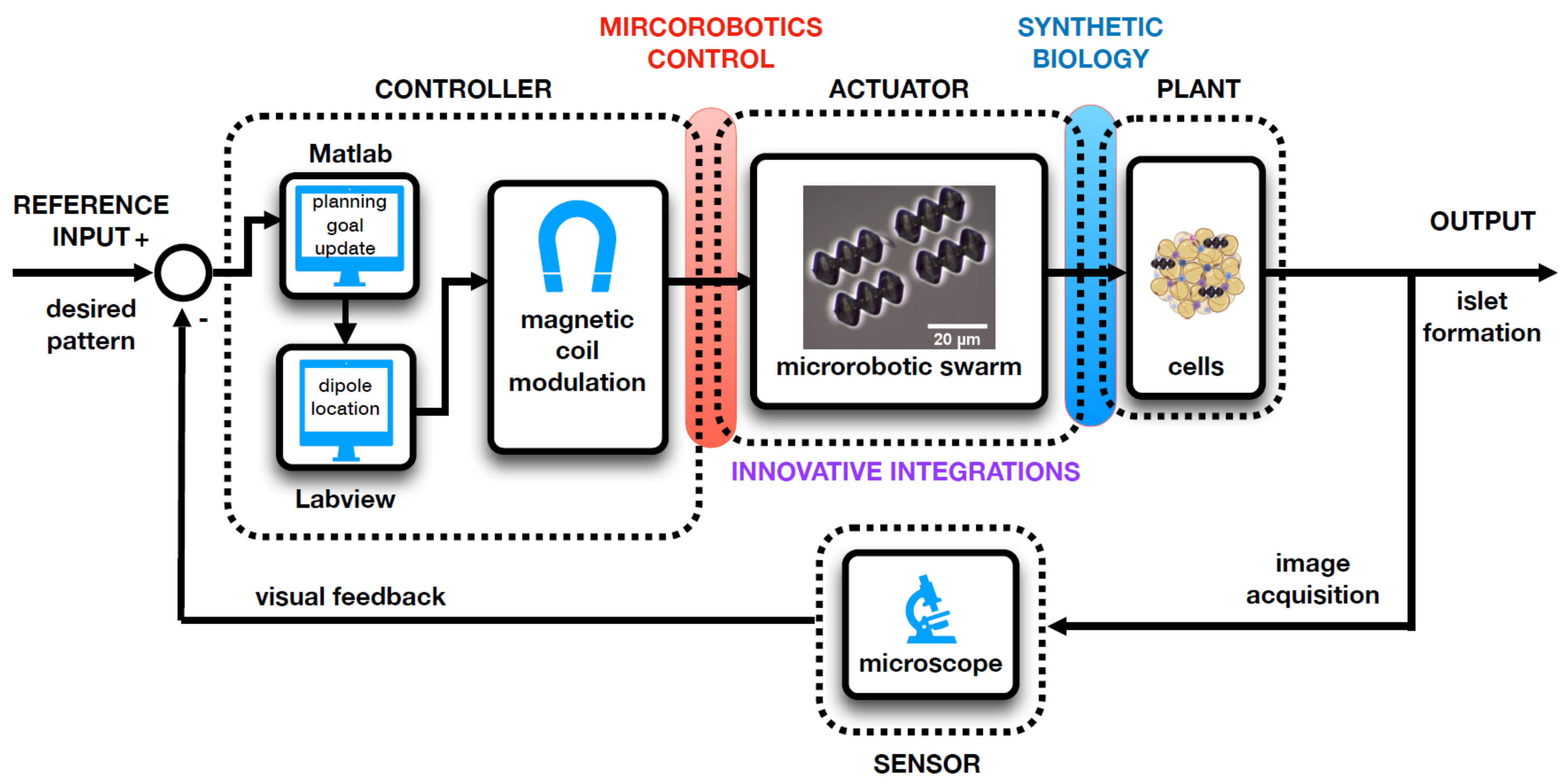


Microrobot-in-the-loop approach where physical signaling among cells is substituted with microrobot-controlled inputs to afford excellent spatiotemporal precision and feedback control in directing cell behavior

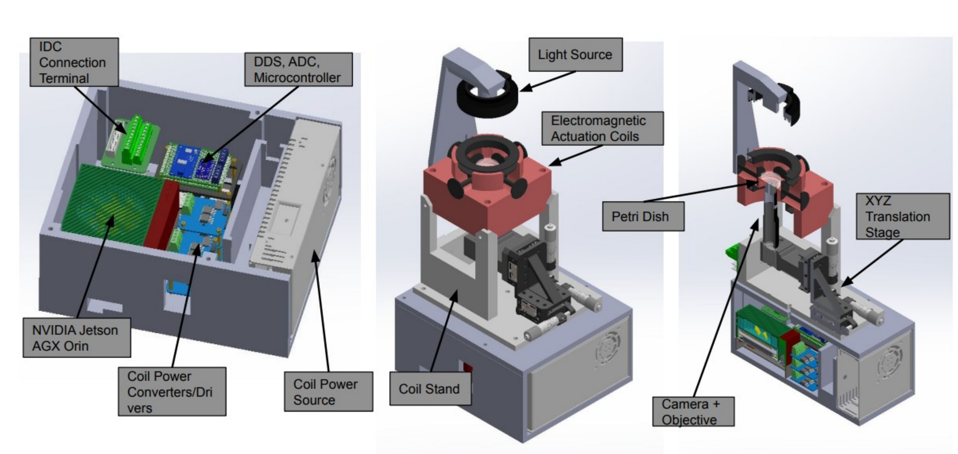
Goals and Impact

This project will address a pressing need in biological CPS to enable feedback control of cellular processes and will be validated using a complex, hard-to-control biological system like pancreatic organoids. The key scientific question that this proposal tackles is how to develop a closed-loop vision-based control system capable of actuating multiple microrobots simultaneously and positioning them in an organoid system to control and correct cellular behavior. We pursue the project's goal via the following Aims:

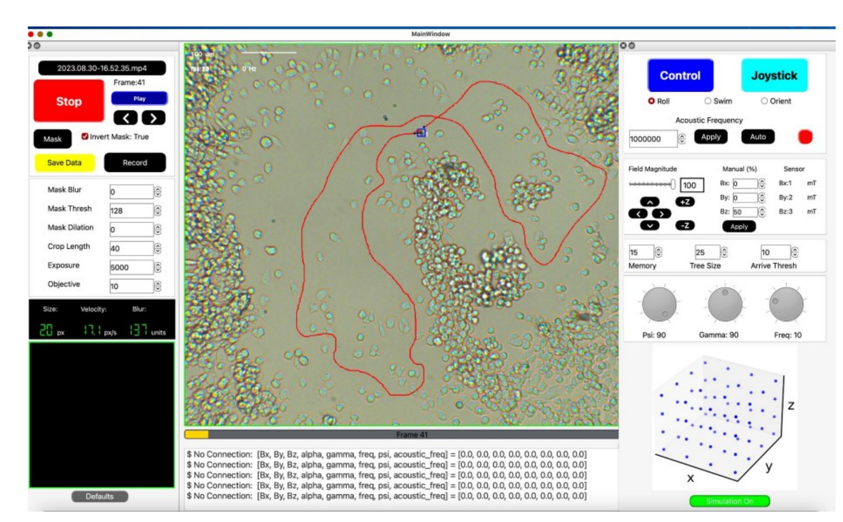
1: Design a physical platform for robo-cell cyber physical system
2: Develop a closed loop control system for swarms of robo-cells
3:Multistep vascularized pancreatic organoid formation using robo-cell CPS system

Experimental Results

MagScope: an all-in-one microrobotic control and imaging device that is flexible, robust, user friendly, portable, and compact.

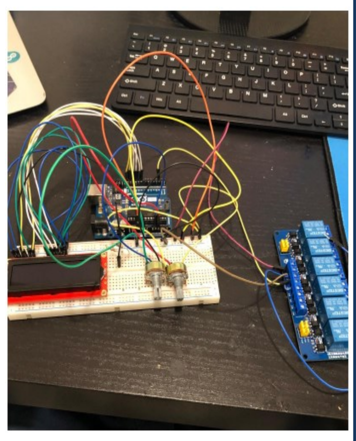


3D rendition of the MagScope device

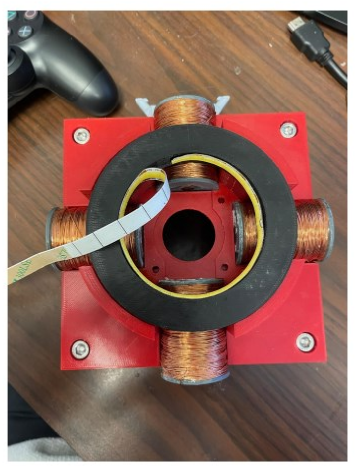


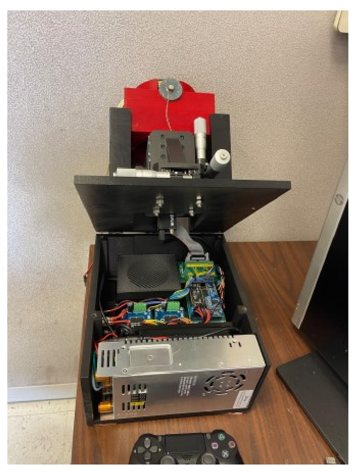
MagScope software

Original System

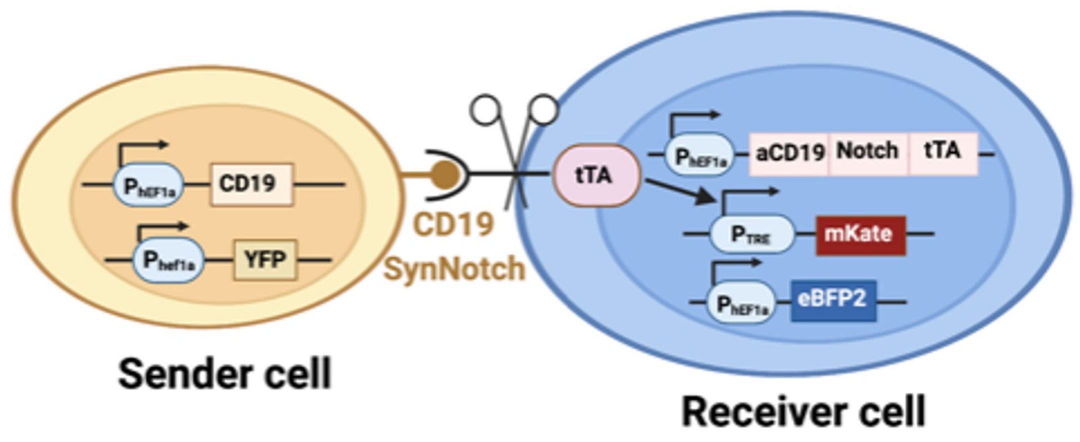


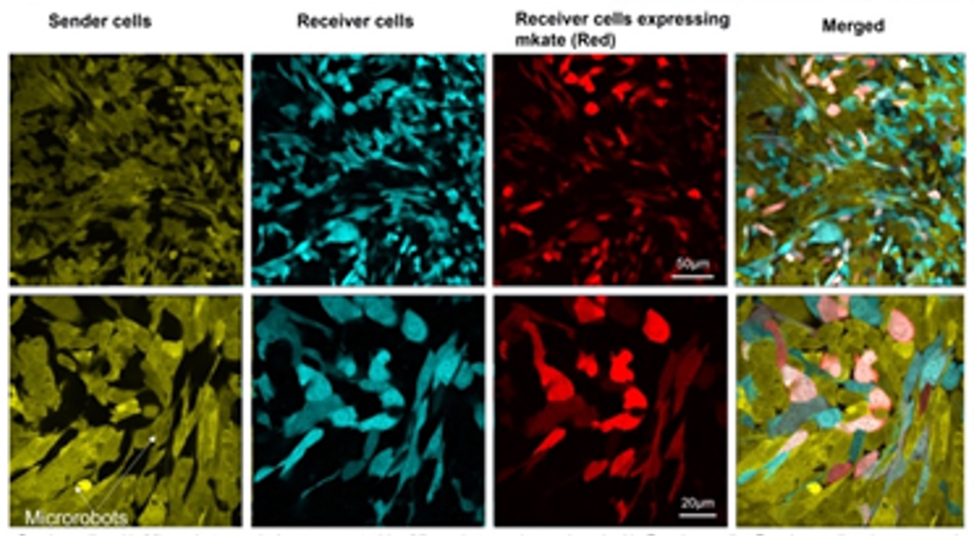
First Portable Prototype





MagScope latest version and Control Box





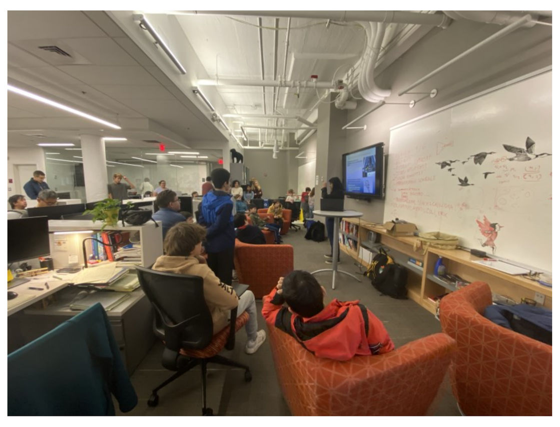
Synthetic Notch genetic circuit in Chinese Hamster Ovary (CHO) cells

Sender cells with microrobots are transported by microrobots and cocultured with receiver cells. Receiver cells when they come in contact with sender cells, the synNotch signals are being received by the receiver cells and downstream signaling leads to the expression of mKate (Red)

Broader Impacts and BPE

Societal Benefits: Approximately 114,000 people in the U.S. alone are currently waiting for a transplant, while the price of insulin has increased dramatically. A process for developing patient-compatible pancreas tissue can have significant public health and economic societal benefits.

Advancing CPS Education: We organized a hands-on workshop for middle school students in the Boston area introducing them to concepts of robotics and synthetic biology. We did some demonstrations for the students using the robots in the lab, some presentations about the science behind them, an introduction to robotics at the cellular scale, and a demonstration of a prototype device that we have that can use micro robots to move cells around in a culture.



References

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MAGSCOPE

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