Final Report for Period: 07/2010 - 06/2011
Submitted on: 07/29/2011
Principal Investigator: Lu, Hang .
Award ID: 0649833
Organization: Georgia Tech Research Corp
Submitted By:
Lu, Hang - Principal Investigator
Title:
IDBR: An Automated, High-Throughput Micro System for Precision Imaging and Ablation of Cells

Project Participants

Senior Personnel

Name: Lu, Hang
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Chung, Kwanghun
Worked for more than 160 Hours: Yes
Contribution to Project:
Kwanghun Chung has worked on designing, fabricating, and automating the microfluidic systems for imaging C. elegans.

Name: Lee, Hyewon
Worked for more than 160 Hours: Yes
Contribution to Project:
graduate student being trained on the research project

Name: Caceres, Ivan
Worked for more than 160 Hours: Yes
Contribution to Project:
graduate student being trained on the research project

Name: Krajniak, Jan
Worked for more than 160 Hours: Yes
Contribution to Project:
Graduate student being trained on the research project

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

California State University, East Bay
We collaborate with Maria Gallegos' lab and supplied Dr. Gallegos with microfluidic devices and hardware to test in her genetics lab.

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities:

We designed and tested several generations of microchips that route, trap and immobilize C. elegans without having to use anesthetics. The novel design in our devices is the use of local temperature control to immobilize worms for imaging and laser ablation. We demonstrated all the individual steps for manipulating animals on chip with great efficiency and success rate. The animals can be cooled and immobilized on chip in less than 1 second, and resume threshing immediately once released into environment at room temperature. We have also shown that the microchip allows 100% viability for the animals it manipulated, as compared to lower viability in commercially available high-throughput worm sorters. In preliminary experiments, we demonstrated that the complete cycle of on-chip manipulation of individual worms can allow a throughput of at least 500 animals per hour and that it is possible operate for many hours continuously. We have automated all components for high-through imaging of animals including worm delivery, loading, fluid flow control, worm immobilization, imaging, simple decision-making (such as target recognition and coordinate extraction) based on morphology, and collection of samples. The computer code (written in Matlab) is currently modularized, commented, and upgraded for robust and user-friendly usage.

This project involves multiple graduate and undergraduate students. The students are learning microfabrication, numerical simulation, system integration, genetics, and neurobiology in the progress of doing their thesis work.

In terms of outreach activities, we have hosted multiple undergraduate/visiting students over the summer to perform behavioral genetics research in the context of ecology. We also hosted minority undergraduate students (through the SURE program at Georgia Tech) during the summers; these students are Josue Cordero, Michael Warner, John Nahabedian, Francine Smith, and Varun Charupadi. In addition, we have formed a formal collaboration with Dr. Maria Gallegos of Cal State East Bay (an undergraduate institution with large Hispanic student population) to transform the research to usable chips for her genetics class at CSEB. Dr. Gallegos and a student have traveled to Georgia Tech to learn about using the microfluidic chips, and we have sent a graduate student to her lab to help set up the system, which is currently running.

Findings:

We demonstrated that it is possible through engineering design to perform microscopy on C. elegans with a throughput already exceeding manual throughput. We have been improving the device for high-through imaging and the system now works very robustly. In addition, we have designed additional systems for laser ablation and demonstrated its utility.

Training and Development:

This project provided research experiences for both the graduate students directly involved and the undergraduate student whom they mentor. Working with the undergraduate student also provided teaching experience for the graduate students.

Outreach Activities:

We have hosted multiple summer students working on small projects (see earlier section). We have also hosted two high school teachers from the Atlanta Public School system to conduct research in our lab through the GIFT program. In addition, we have formed a formal collaboration with Dr. Maria Gallegos of Cal State East Bay (an undergraduate institution with large Hispanic student population) to transform the research to usable chips for her genetics class at CSEB.

Journal Publications

Kwanghun Chung, Matthew M. Crane, Hang Lu, "Automated on-Chip Rapid Microscopy, Phenotyping, and Sorting of C. elegans", Nature Methods, p. 637, vol. 5, (2008). Published, 10.1038/nmeth.1227

Matthew M. Crane, Kwanghun Chung, and Hang Lu, "Computer-enhanced high-throughput genetic screens of C. elegans in a microfluidic system", Lab on a Chip, p. 38, vol. 9, (2009). Published, 10.1039/B813730G

Kwanghun Chung, Jaekyu Cho, Edward Park, Victor Breedveld, and Hang Lu, "Three-dimensional In Situ Temperature Measurement in Microfluidic System Using Brownian Motion of Nanoparticles", Analytical Chemistry, p. 210, vol. 81, (2009). Published, 10.1021/ac802031j

Chung, Kwanghun; Lu, Hang, "Automated laser ablation of neurons in microfluidic system", Lab on a Chip, p. 2764, vol. 9, (2009). Published, 10.1039/B910703G

Chung, Kwanghun; Lee, Hyewon; Lu, Hang, "Multiplex pressure measurement in microsystems using volume displacement of particle suspensions", Lab on a Chip, p. 3345, vol. 9, (2009). Published, 10.1039/b911480g

Adela Ben-Yakar, Nikos Chronis, Hang Lu, "Microfluidic tools for the analysis of behavior and neural cell physiology in worms", Current Opinion in Neurobiology, p. 561, vol. 19, (2009). Published, 10.1016/j.conb.2009.10.010

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Product Type:

Software (or netware)

Product Description:

We have developed Matlab modules to automate our microfluidic chips and to perform image acquisition and image processing.

Sharing Information:

Once organized and thoroughly tested, the code will be freely available to any researcher who can request through hour website or email the PI.

Product Type:

Instruments or equipment developed

Product Description:

We have designed a few microfluidic devices for imaging and sorting of C. elegans.

Sharing Information:

Currently it is limited to our group, but the technology will be useful for many other C. elegans (and potentially drosophila/zebra fish) researchers.

Contributions

Contributions within Discipline:

We have developed a methodology that dramatically improves the throughput of classical visual screen for genetic studies. Based on this technology, we also made a system to automatically ablate cells in C. elegans with high throughput compared to manual operation. These two techniques have both made significant contributions to the biological communities. The microchips we developed and the nanoparticle motion based temperature sensing scheme and also pressure sensing contribute to the engineering field by adding to the tools and types of applications to the microfluidics community and beyond.

Contributions to Other Disciplines:

Our contribution to the biological field include discovering new genes using our automated screening microfluidic system.

Contributions to Human Resource Development:

The project trains students in an interdiscliplinary environment, preparing students to embrace the nature of this type of research.

Contributions to Resources for Research and Education:

We have designed and fabricated these relatively easy to use systems for genetics laboratory courses. This is done in collaboration with Dr. Gallegos at CSEB. Dr. Gallegos' lab now has one such system to run genetic screens.

Contributions Beyond Science and Engineering:

A patent is pending on our technologies and companies are interested in commercializing the system for wider applications.

Conference Proceedings

Categories for which nothing is reported:

Any Book
Any Web/Internet Site
Any Conference