Development of machine-learning algorithms for non-invasive single-cell manipulation

Keywords:

Artificial intelligence, machine learning, graphical user interface, optical tweezers, single-cell manipulation

Challenge:

Single-cell manipulation and analysis is playing an ever-increasing role in research and industry. In research, single-cell studies are providing an unprecedented level of resolution in our understanding of biological responses; in particular, they permit to explore the influence of cell heterogeneity, which is masked when analyzing entire cell populations. In industry, the emergence of the so-called omics fields (e.g., genomics, transcriptomics, proteomics) requires efficient single-cell micromanipulation tools to ensure that studies are sufficiently reliable and reproducible, and is expected to significantly decrease the development time and cost of new drugs as well as to enable new point-of-care diagnostics for personalized medicine. Among these, in vitro fertilization (IVF) is an area that still suffers from low success rates (<30%), where non-invasive single cell manipulation can bring tremendous improvements.

Motorized and non-contact manipulation requires intensive expert handling and high instrument costs, which are significant limitations hampering technology spread and market growth. Therefore, there is a need for a cost-efficient solution for single-cell manipulation and analysis that efficiently isolates cells, ensures their viability, and operates without requiring continuous expert supervision.

Goal:

Lucero is committed to provide an automated solution for single-cell manipulation and analysis to tackle all the challenges described above. Lucero wants to develop a solution based on machine-learning algorithms, as they have already shown great promise for cell tracking[1], as well as for reducing user input and the required expertise as much as possible to carry out these kinds of tasks.

A schematic of the Lucero single-cell micromanipulation platform is shown in Fig. 1. The solution will be based on the integration of three technologies:

1. A plug-n-play Holographic Optical Tweezers (HOT) module that can be installed on any commercial inverted microscope via the conventional camera port (C-port). The

HOT will be generated from an infrared laser beam to minimize cell damage. It can be used to trap, transport and sort living cells without harming their physical integrity.[2]

2. A microfluidic chip reader to be mounted on the microscope stage with custom-designed microfluidic chips, where suspended cells can be isolated for on-chip studies using user-defined protocols.
3. A machine-learning software based on digital video microscopy to automate the micromanipulation tasks that require autonomous decision making.

A prototype of the optical setup has already been developed in 2019. The student(s), however, will have to find out the best-suited programming language and the best approach to integrate seamlessly with the different components already present in the prototype (laser, camera, piezoelectric stages, spatial light modulator…) and the machine-learning algorithms that he/she will develop him/herself. Since most of the related programming has been done in Python, this programming language is preferred, although others should be considered.

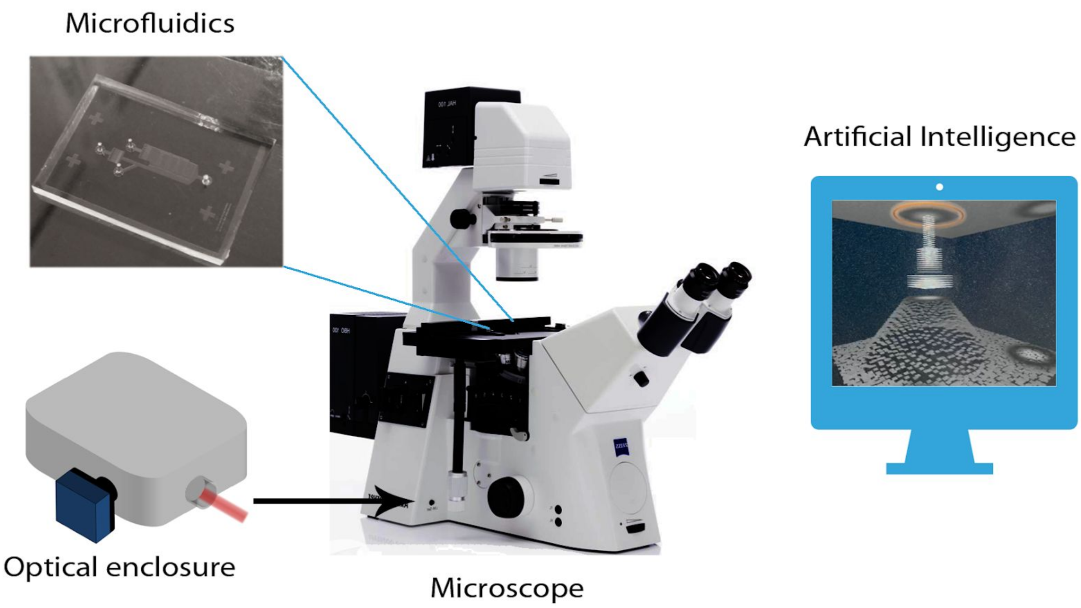

Fig. 1 | Lucero's single-cell micromanipulation platform. Lucero's solution is based on an enclosure with the necessary components to provide Holographic Optical Tweezers (HOT module) to any inverted microscope through the camera port. In combination with application-specific microfluidic chips and a user-friendly software based on Artificial Intelligence (AI).

The tasks that the student(s) will have to carry out during this project are:

- Review the literature on this topic and come up with the best machine learning algorithm to implement different functions within the microfluidic platform, e.g., cell capture, sorting and release.
- Design and simulation of the chosen algorithms.
- Experimental tests in the research laboratory optical setup with the chosen algorithms.
- Data processing and analysis of the results.

The student(s) will be exposed to a state-of-the-art research environment and will be in close contact with the development team of the recently funded spinoff Lucero. These student(s) will have an academic supervisor and will be working in close collaboration with an industrial advisor (company supervisor) from Lucero.

Skills required

- Motivation to work in a research environment and to develop new machine-learning algorithms
- Motivation to work in close collaboration with the development team of Lucero
- Knowledge and experience with Python graphical interfaces
- Knowledge of machine-learning libraries in Python

About Lucero

Lucero was founded in March 2020 upon deep research in physics and microbiology.
It is located in the Nordic life-science hub of Gothenburg, Sweden. Through cross-disciplinary work between micro and systems biologists from local universities, our team uncovered a need for better tools to work with single cells.

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References

1. Helgadottir, Argun & Volpe. Digital video microscopy enhanced by deep learning. Optica 6, 506, 2019.
2. Jones, Maragò & Volpe. Optical Tweezers: Principles and Applications. Cambridge University Press, 2015.