MSc Student project proposal: Development of a 2D cell tracking algorithm for cancer cell migration

Introduction

In the study of cancer migration, three-dimensional (3D) models have become indispensable tools for mimicking the complex tumour microenvironment more realistically than traditional 2D methods. These cell models allow for the study of cell behaviour, including migration, proliferation, and interaction with the extracellular matrix [1]. However, the complexity of 3D cell culture presents significant challenges for data analysis, particularly when it comes to monitoring and quantifying dynamic cellular processes like migration [2]. This is where advanced image analysis plays a critical role.

Objective

The main objective of this project is to develop a MATLAB-based 2D cell tracking algorithm that accurately follows the movement of individual tumour cells across multiple frames of time-lapse images (see Figure 1). We aim to quantify the migration of individual cells over time. The aim of this model is to analyse cell migration parameters, such as displacement, velocity, and persistence. These key metrics characterize tumour cell invasion, and are crucial for understanding how cancer invaded the body.

Your role in this project

This master student project offers an opportunity to contribute to the development of innovative tools for cancer research. Your goal will be the development of a cell tracking script to quantifying cancer cell migration via image analysis. You will be working on a MATLAB-based algorithm that can efficiently link cell positions across series of time-lapse images. You will focus on centroid-based tracking methods initially, with potential integration of more advanced algorithms depending on the data complexity. The project may also involve the integration of artificial intelligence (AI) techniques to enhance tracking performance and handle complex scenarios, such as overlapping cells or irregular movements.

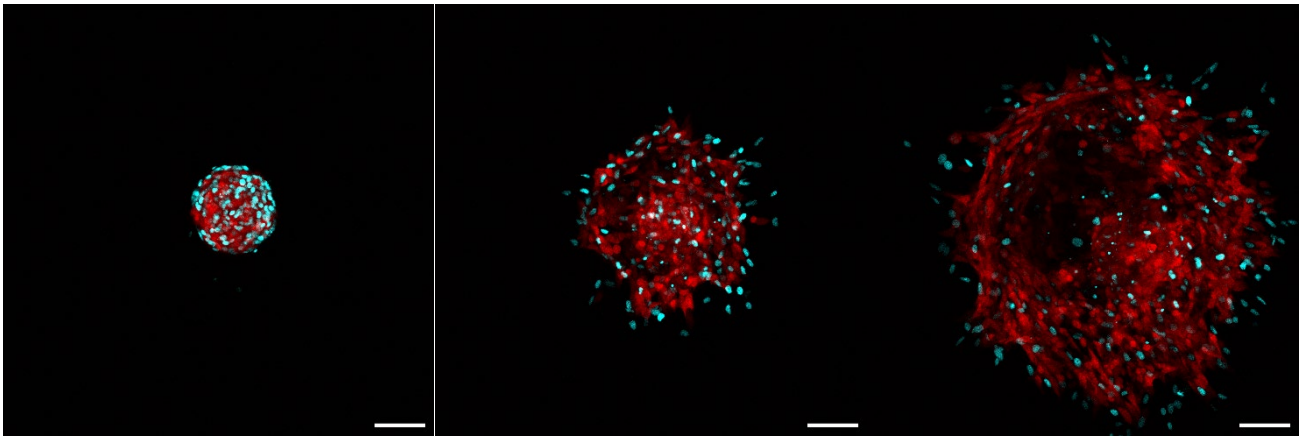

Figure 1. Images of cancer cells spreading. The cancer cells (red) and fibroblasts (blue), suspended in a fibrin hydrogel. The images were obtained via confocal fluorescence microscopy, and were taken as a z-stack and represented here in a max intensity projection. At t=0, the cells clustered together (A), after which they migrated outwards, imaged here at t=20h (B) and t=40h (C). Scalebar is 100 µm.

For inspiration, see the following links

- Ultrack: pushing the limits of cell tracking across biological scales (Github)
- LIM Tracker: a software package for cell tracking and analysis with advanced interactivity
- Interstitial flow potentiates TGF-β/Smad-signaling activity in lung cancer spheroids in a 3D-microfluidic chip†

Required experience

- Coding (Matlab/Python)

Duration of the project

- 4-6 months

Contact information

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References

[1] C. Jubelin *et al.*, "Three-dimensional in vitro culture models in oncology research," *Cell Biosci*, vol. 12, no. 1, Dec. 2022, doi: 10.1186/S13578-022-00887-3.

[2] Y. H. V. Ma, K. Middleton, L. You, and Y. Sun, "A review of microfluidic approaches for investigating cancer extravasation during metastasis," *Microsystems & Nanoengineering 2018 4:1*, vol. 4, no. 1, pp. 1–13, Apr. 2018, doi: 10.1038/micronano.2017.104.