Development of mathematical tools for metastatic cancer diagnosis and therapy using micro-robots

Many bowel cancers may, in fact, spread very soon after the original malignant transformation has occurred, which could be some years before the disease is diagnosed. For metastases to occur, malignant cells must acquire the ability to invade adjacent capillaries or lymphatics and then spread via the circulation to other parts of the body. These cells can then grow and form other tumours, which may be readily apparent on investigative scans. However, early metastases may be too small to be reliably detected by current modalities, and, for most cancers, there is no available blood test to detect malignant cells within the circulation. This PhD project aims to develop novel mathematical techniques for analysing the sensing capability of micro-robots to aid the detection of hard-to-visualise cancer cells.

In order to achieve this goal, the objectives of this PhD project are: (1) To build a mathematical model of robot's locomotion in the capillaries through a full understanding of the capillary anatomy, including its friction and resistance mechanisms. (2) To understand the dynamic characteristics of the robot numerically, particularly focusing on friction-, grazing- and delay-induced multi-stabilities, to learn three essential aspects: (a) emergence mechanisms, (b) stability, and (c) robustness. (3) To develop a control strategy for the micro-robot for cancer cell detection. (4) To verify the mathematical tools (including the mathematical model and the proposed control strategy) experimentally in collaboration with the experimenters (PDRA and PhD students) at Prof. Liu's laboratory.