**Mathematical construction of patient-specific vascular network based on clinical images, global optimization and physical calculations**

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Metastasis involves the dissemination of cancer cell from the primary tumor to the surrounding tissue and distant organs. To metastasize, the cancer cells must detach from the primary tumor, intravasate into the blood stream or lymphatic system, avoid immune protection, extravasate from the blood, finally migrate to distant organs, and proliferate to a secondary tumor. It has been long theorized that blood flow plays a vital role in metastasis and more than two-thirds of metastatic sites could be explained by the blood flow links between the primary and secondary sites.

To study circulating tumor cells in metastasis and the location of secondary tumor sites detailed geometry of vascular network is needed. Aim of this project is to develop a computational framework for constructing vascular networks with two applications: (1) for modelling tumor growth and its vascularization, and (2) for geometrical reconstruction of vascular networks in clinical images of vessels with incomplete information due to non-ideal filling of the contrast agent or image resolution. The students will work on developing an algorithm that will use the 3-D geometry of organs as well as skeletons of detectable vessel segments in the clinical image stacks and will reconstruct the missing vessel segments and microvasculature. The team will experiment with a combination of the constrained constructive optimization algorithm, global constructive optimization, simulated annealing and simplified fluid equations to develop the algorithm.

The team will start with reviewing the existing algorithms for in-silico construction of vessel networks and models of angiogenesis. The students will develop an algorithm that uses the patient priors from the incomplete vascular network data to construct the patient specific network. Based on the existing tools, the code is expected to be most easily prototyped in Python. The result of simulations will be validated against an ex-vivo vascular networks dataset obtained experimentally.

Students are expected to know and be interested in coding, optimization methods, image processing and basics of fluid dynamics. Knowledge of the finite-element and finite volume methods is a plus.

Cancer, metastasis, computational fluid dynamics, optimization, unsupervised vascular segmentation, angiogenesis, computational geometry