Optically guided intraoperative assessment of surgical margins in cancer

One in every three people will develop cancer in their lifetime, meaning almost every person in the world has been affected either directly or indirectly by the disease. In 90% of cancer cases, solid tumors are responsible, for which the most common method of treatment is surgical excision. Unfortunately, however, it is estimated that up to 20% of these procedures do not result in full removal of the tumor, leaving the cancer free to continue to grow and lowering the odds of survival for the patient. In this challenge, we would like to **imagine what could happen if the surgeon was able to leave the operating room confident that they had removed the entirety of the tumor, every time.**

We propose to build a multimodal polarization-sensitive optical coherence tomography (PS-OCT) system with microscope-level resolution, specifically for the purpose of intraoperative cancer cell detection. The system will be cart-based, capable of sitting within the operating theater so that specimens can be imaged immediately following excision. If the surface of the excised tissue still contains cancer, the surgeon can then go on to excise further until negative margins are found. In the long term, we envision that this method of intraoperative imaging will replace the current gold standard of post-operative histopathology, where patients must currently wait a week on average for the results.

While optical imaging more broadly is increasingly demonstrating its power in diagnostics, we believe that our solution addresses the issue in a manner which is reliable, fast, and inexpensive:

Superior resolution. Axial resolution in PS-OCT is proportional to the square of the central wavelength of the light source. By bringing the wavelength down into the visible light range, we will improve the axial resolution by an order of magnitude. The lateral resolution on the other hand is dictated by the imaging optics like in traditional microscopy. By using visible light, we can share the same objective lens kits as microscopy uses, resulting in cellular-scale imaging across wide fields of view.

Speed and simplicity. There is currently no optical method of intraoperative margin assessment that has made it past the research phase. We believe that this is, in part, due to the high complexity of the systems that are typically developed for this purpose. Our solution will be built to reduce all complexity of operation, with automated scanning and classification, so the only input required from the user is to place the tissue to be investigated face-down on the scanner and press a “go” button.

Lower cost. The blue light SLED used as the primary light source in this work is an order of magnitude cheaper than the visible-light sources (supercontinua) that have been proposed for microscopy-like OCT resolution in the past. This will make the device cheaper to roll out in the future – not only to the tertiary-care-providing institutions. Also, since this optical imaging technique requires very little manual input, it will reduce the cost of human resources required to perform routine histopathology.

This study is intended to be a proof-of-concept demonstration of the ability of a blue light OCT system and its extensions to provide cellular level histopathology-like analysis of an excised tumor surface. If successful, it will be the first in a fleet of intraoperative OCT-based imaging techniques developed in the lab, all serving the goal of removing every last cancer cell.

This application falls under the “Health” subcategory of the Optica Foundation Challenge.