VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Pooria Iranian**

The public defense will take place on **Friday 16th May 2025 at 4pm** in room **I.0.01** (Building I, VUB Main Campus)

To join the digital defense, please click here
Meeting ID: 396 354 711 373
Passcode: mK7gn2d8

FLUORESCENCE-LIFETIME ENDOSCOPY WITH A TIME-GATED CAMERA

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Abstract of the PhD research

The diagnosis and treatment of cancer remain complex and challenging, particularly during surgical procedures where accurately distinguishing between malignant and healthy tissue is critical. Conventional imaging modalities such as MRI and CT often fail to provide the real-time, high-contrast visualization necessary for precise tumour removal.

Fluorescence imaging has emerged as a valuable technique, offering real-time, high-sensitivity visualization of tissues. However, traditional fluorescence-intensity imaging is limited by the fluorophore's intensity and differentiating between fluorophores with overlapping emission spectra. In contrast, Fluorescence Lifetime Imaging (FLT) provides a more reliable alternative. FLT is less susceptible to variations in fluorophore concentration and offers a more accurate representation of the tissue environment.

To enhance the accuracy of tumour resection during image-guided surgeries, our research team is developing an innovative imaging system based on the Current-Assisted Photonic Sampler (CAPS). This advanced camera enables real-time FLT imaging in the near-infrared (NIR) spectrum, specifically between 700-900 nm, which is particularly effective for deep tissue imaging.

By integrating this FLT technology into an endoscopic system incorporating standard white light imaging, we aim to provide surgeons with enhanced visual information. This dualimaging capability enables better differentiation between malignant and benign tissues, which traditional white light endoscopy imaging systems cannot adequately achieve. Current systems often require separate RGB and FLT imaging cameras, leading to alignment issues and bulky configurations.

To address these limitations, we have developed a comprehensive endoscopy system that combines a rigid Hopkins endoscope with a state-of-the-art time-gated camera utilizing the CAPS sensor (tauCAM). This system capitalizes on the strengths of FLT to improve intraoperative imaging. Additionally, we have introduced a novel deep learning-based algorithm, FLTCNN, which accurately estimates fluorescence lifetimes without requiring the system's intrinsic parameters. The algorithm significantly reduces computational demands using a few data points, making real-time FLT imaging feasible.

Moreover, we have introduced a technique known as time-sequential RGB imaging. In this method, the surgical scene is sequentially illuminated with red, green, blue, and NIR light pulses, enabling the simultaneous acquisition of both RGB and FLT images. These images can be overlaid to give surgeons comprehensive real-time visual feedback.

Our research addresses the critical need for efficient recording of IRFs and dramatically reduces the time points required for lifetime estimation. By combining time-sequential RGB imaging with FLT in a single-camera system, we overcome challenges related to image alignment and equipment bulkiness. This development promises an advancement in surgical imaging technology, offering improved precision and better outcomes for cancer patients.