GPU implementation of bi-exponential decay in FLIM for real time assistance in cancer cell localization

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The concept of Fluorophore Lifetime Imaging Microscopy (FLIM) is widely used nowadays. It enables doctors to use minimal invasive methods to detect cancer and potentially, to operate surgeries in early stages. FLIM uses the lifetime response of fluorophores, which are excited with a laser with known wavelength and have a response in a fluorophore specific wavelength. Carcinogenic cells absorb the fluorophore and upon light excitation, they emit light with a different wavelength with a certain exponential decay, showing the location of the carcinogenic cells. Furthermore, Fluorescence Resonance Energy Transfer (FRET) phenomenon occurs when certain fluorophores are used, resulting in a double exponential decay.

At AQUA lab state-of-art Single Photon Avalanche Diode (SPAD) sensors are developed. Such is SwissSPAD2, a gated binary frame imager. This chip has a resolution of 512x512 and a frame rfate of up to 97kHz. Having a gated architecture makes it ideal to be used together with a picosecond pulsed laser. For FRET FLIM application, this sensor is used to capture the bi-exponential decay and extract the lifetime values. A neural network application has been developed to extract the lifetime and to achieve real time application, a GPU target is considered. The neural network is based on Gated Recurrent Unit (GRU).

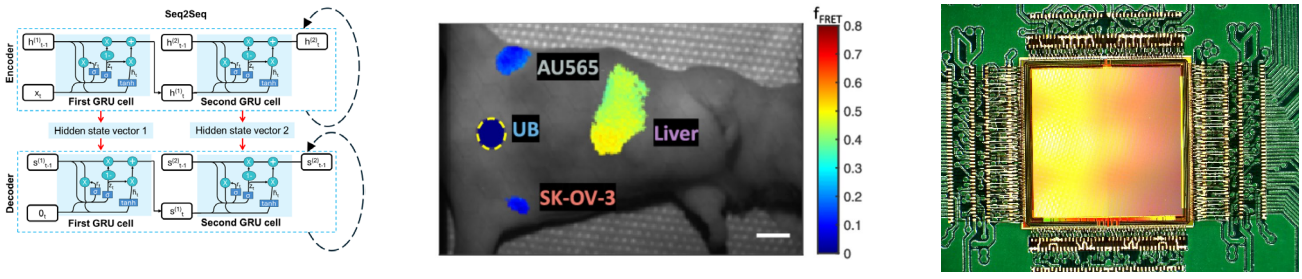

Figure 1. *Left GRU blocks used for encoder and decoder [1]. Center: Mouse image with superimposed lifetime image showing the cancer cells. [2] Right: SwissSPAD2 sensor wire-bonded to a PCB [3].*

The student will learn about FRET FLIM concept, GRU and GPU programming, SPAD technology, and FPGA design.

References

[1] Erbas, I., Amarnath, A., Pandey, V., Swaminathan, K., Wang, N., & Intes, X. (2024). Unlocking real-time fluorescence lifetime imaging: multi-pixel parallelism for FPGA-accelerated processing. arXiv preprint arXiv:2410.07364.

[2] Jason T. Smith, Alena Rudkouskaya, Shan Gao, Juhi M. Gupta, Arin Ulku, Claudio Bruschini, Edoardo Charbon, Shimon Weiss, Margarida Barroso, Xavier Intes, and Xavier Michalet, "In vitro and in vivo NIR fluorescence lifetime imaging with a time-gated SPAD camera," Optica 9, 532-544 (2022)

[3] A. Ulku, C. Bruschini, I. M. Antolovic, E. Charbon, Y. Kuo, R. Ankri, S. Weiss, and X. Michalet., "A 512 × 512 SPAD Image Sensor with Integrated Gating for Widefield FLIM," IEEE J. Sel. Top. Quantum Electron., vol. 25, no. 1, pp. 1–12, 2019. DOI: 10.1109/JSTQE.2018.2867439