Towards real time monitoring of blood oxygenation in human body through Time Domain Diffuse Correlations Spectroscopy

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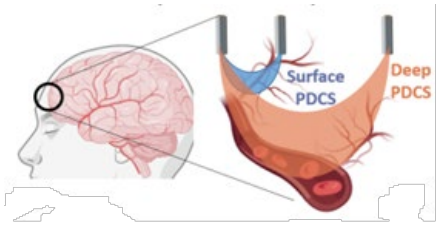
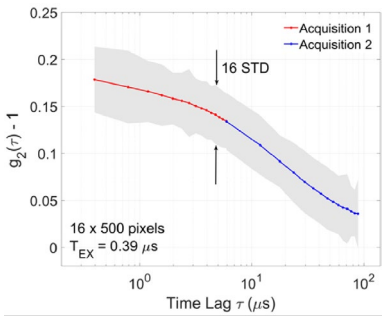
Official Start Date: *Anytime*
Submission of Final Report: *TBD*
Presentations at Group Meeting: *TBD*

Single Photon Avalanche Diode (SPAD) cameras are widely used in LIDAR-based applications. Diffuse Correlation Spectroscopy has already been used in monitoring the cerebral blood flow with a separation of laser to optical probe of up to 4cm. Through the addition of time domain, higher signal to noise ratio is expected.

At AQUA lab state-of-art sensors SPAD sensors are developed. One such sensor is Piccolo Gated, a Time Correlated Single Photon Counting (TCSPC) SPAD sensor with 32 x 32 pixels and a Time to Digital Converter (TDC) resolution of 50ps. These sensors have a very promising future in close-in LIDAR applications as they form the histogram of the detected light. Characterization of phantoms mimicking the human skull and the blood flow, followed by the monitoring of human subjects is the step forward in the cerebral blood flow monitoring.



a)



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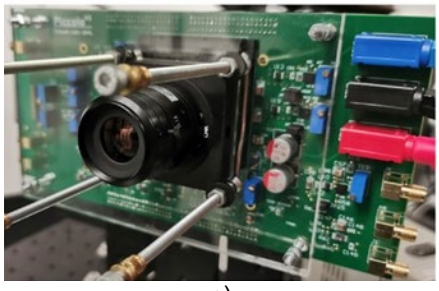

c)

Figure 1. *Left : Illustration of the banana shape that the light scatters in the human brain [1] Center: Decorrelation curve resulted from the g2 algorithm [2] Right: Piccolo Gated, a gated 32x32 TCSPC CMOS SPAD image sensor [3]*

The student will update an existing FPGA design to enable the real time computation of g2 algorithm used in TD-DCS. Furthermore, the student will implement the optical setup and conduct the experiments on a phantom mimicking the blood flow of the human brain.

Through this project, the student will be familiarized with FPGA firmware design, laser operation and safety, light behavior in diffusive environments, and TD-DCS.

[1] L Kreiss, M Wu, M Wayne, S Xu, P McKee, D Dwamena… - arXiv preprint arXiv:2403.03968, 2024
[2] Michael A. Wayne, Edbert J. Sie, Arin C. Ulku, Paul Mos, Andrei Ardelean, Francesco Marsili, Claudio Bruschini, and Edoardo Charbon, "Massively parallel, real-time multispeckle diffuse correlation spectroscopy using a 500 × 500 SPAD camera," Biomed. Opt. Express 14, 703-713 (2023)
[3] Paul Mos, Scott Lindner, Chao Zhang, Michael A. Wayne, Tommaso Milanese, Claudio Bruschini, and Edoardo Charbon "Piccolo gated: a CMOS 32x32 SPAD camera with all-solid-state nanosecond time gating and PCIe readout for single-photon time-domain DCS and near-infrared optical tomography", Proc. SPIE 12895, Quantum Sensing and Nano Electronics and Photonics XX, 1289507 (8 March 2024); https://doi.org/10.1117/12.2692934