Towards real time monitoring of brain oxygenation for premature born infants

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Project Type: *Master Project* *Section:* *Microengineering*
Official Start Date: *Anytime*
Submission of Final Report: *TBD*
Presentations at Group Meeting: *TBD*

Single Photon Avalanche Diode (SPAD) cameras are widely used in biomedical applications with a clear direction in breaking the ice of clinical measurements. Together with our collaborators from UZH, we are working on bringing the SPAD technology in real time monitoring of the brain oxygenation of premature born babies. Their skull allows more light to travel and therefore is easier to scan an image their brain blood vessels.

At AQUA lab state-of-art sensors SPAD sensors are developed. One such sensor is Piccolo Gated, a gated 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. Future improvements include overcoming the issues introduced by the non-linear nature of a TCSPC system, such as DNL and INL errors, after-pulsing, and high dynamic range. Further steps include improving the acquisition method on phantom targets that mimic the infant's skull.

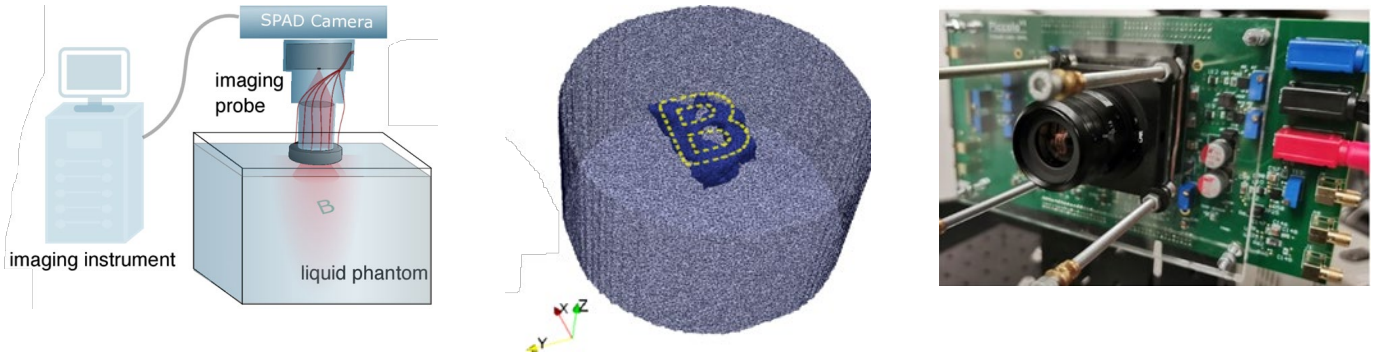

Figure 1. *Left: Illustration of the camera, phantom and optical setup [1]. Center: reconstruction of the target shown in the left image Right: Piccolo Gated, 32x32 TCSPC CMOS SPAD image sensor [2]*

The student will update an existing FPGA design to enable the use DNL correction, after-pulse reduction, and HDR enhancement. The student will apply existing algorithms on obtained data to reconstruct the objects hidden beneath the phantom. The implementation of these algorithms is in collaboration with UZH with a final target of achieving real time computation, if possible, within the timeline of the project.

Through this project, the student will be familiarized FPGA firmware design, laser operation and safety, light behavior in diffusive environments, and reconstruction algorithms for TCSPC systems.

[1] Jingjing Jiang, Meret Ackermann, Emanuele Russomanno, Aldo Di Costanzo Mata, Edoardo Charbon, Martin Wolf, and Alexander Kalyanov, "Resolution and penetration depth of reflection-mode time-domain near infrared optical tomography using a ToF SPAD camera," Biomed. Opt. Express 13, 6711-6723 (2022)
[2] 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