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Multi-Probe Time-Stretch Optical Coherence Tomography

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A Photonic Time-Stretch system allows to implement Optical Coherence Tomography (OCT) at A-scan rates of up to 1 GHz. The method is based on combining time-stretch dispersive Fourier transform (TS-DFT) and spectral interferometry. When an optical signal passes through a highly dispersive medium, optical spectrum is mapped to the time domain, this means optical signal at the output in the time domain looks like the input optical spectrum. At the same time, the signal is stretched and slowed down in the time domain so it can be captured using conventional oscilloscopes. By using dispersion in a highly dispersive medium, optical signal spectrum can be captured in real-time and single-shot. This concept is called TS-DFT or simply "Optical Time-Stretch". Conventional time-stretch OCT system uses only one probe to capture tomography images.

In this work, we propose and experimentally demonstrate that time-stretch OCT system has the potential to work with multiple OCT probes with very small increased complexity in the physical setup. The proposed method for multi-probe time-stretch imaging system is based on using a Wave Division Multiplexing (WDM) module to divide the bandwidth of the laser to different wavelength bands. These wavelength bands are used for imaging using different OCT probes. The reflection signals from different probes are combined using the same WDM module and pass through the rest of system (i.e. dispersion, photo-receiver, and digitizer) in a common path. The information from different probes are separated digitally in the computer that receives digitizer data. Adding multiple probes to time-stretch OCT system allows to cover larger areas for imaging or to operate at faster speeds. Here we demonstrate the example of using time-stretch OCT with 2 probes to double the imaging coverage area. The proposed method can be easily scaled up to use more than two probes for imaging.