Faster and efficient in-vivo measurements using a new time-domain diffuse correlation spectroscopy system

A team of researchers presents in Scientific Reports time-domain diffuse correlation spectroscopy system based on a superconducting nanowire single-photon detector, that allo s faster high-efficiency measurements in adults

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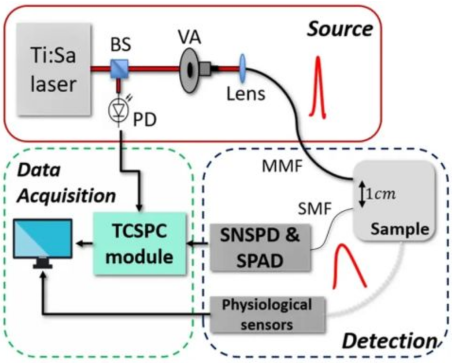
Time-domain diffuse correlation spectroscopy is a non-invasive imaging technique used to measure blood flow, which provides valuable information about the tissue's microvascular perfusion. Using pulsed laser sources, light is emitted in short pulses that scatter after passing through the biological tissues, creating a speckles pattern on a detector, and measuring the intensity auto-correlation function of the detected light. This method offers depth resolution and also allows to obtain the optical properties of the measured medium. However, there are two main limitations to this technique. First, it requires a pulsed laser with high temporal coherence. Second, it is considered a photon-starved technique because it relies on detecting a relatively small number of photons, due to the low scattering and absorption properties.

Now, a team of researchers describes in Scientific Reports a novel system that addresses conventional limitations, made in collaboration between ICFO researchers Veronika Parfentyeva and Marco Pagliazzi, led by Prof. ICREA at ICFO Turgut Durduran, Politecnico di Milano researchers Lorenzo Colombo, Pranav Lanka, Alberto Dalla Mora, Rebecca Re, Davide Contini, Alessandro Torricelli and Antonio Pifferi, researchers Annalisa Brodu and Niels Noordzij from Single Quantum BV and Swabian Instruments GmbH researcher Mirco Kolarczik.?

Faster and more accurate measurements of blood flow dynamics

The reported system utilizes a superconducting nanowire single-photon detector. This photo-detector offers enhanced performance when compared to conventional detectors. It has a higher efficiency in detecting the photons; lower dark count noise, making the measurements more reliable; fast after-pulsing decay time, allowing for a quick recovery and faster measurements, and more precise timing of detected photons.

In order to test and characterize the system researchers used phantoms, which mimicked the tissues and then performed several in vivo experiments in adult volunteers. Researchers placed the probe in the forehead of the subjects to do the measurements. They first performed a ï¿½Resting-state protocolï¿½, where subjects were asked to lay down fa ing upwards, to keep breathing at their normal breathing rate and depth and to close their yes for seven minutes. Then, they test a second protocol where participants were asked to b ow, three times, into an empty straw which was closed at the far nd. Overall, the system provided faster and more accurate measurements of blood low dynamics in vivo. It had better photon detection, less background noise, recovered quic ly, and offered more precise timing, obtaining faster measurements and providing cleaner and more accurate results. These, improvements in sensitivity and speed offer promi ing potential for various medical applications, including monitoring cerebral hemodynam cs. The reported studies have led to the start of FastMOT, a funded European project where six partners will join forces to develop an ultra-high performance light sensor in diffe ent imaging techniques, aiming to radically improve the performance of deep imaging ith diffuse optics.



Experimental system schematically divided in source, detection and data acquisition units (red, grey and green boxes respectively)