Humans are among the most advanced and complex biological systems on Earth. Our brains possess computational abilities capable of processing millions of tasks simultaneously, enabling the body to function under highly variable conditions. The human eye, our organ of vision, has evolved over millions of years into one of the most sophisticated systems for capturing and analyzing visual information. Notably, the eye contains the most accessible part of the brain's neural network—the human retina—which can be examined using relatively compact and non-invasive optical methods. The visual system has well-defined inputs, in the form of millions of photoreceptors, and outputs via nerve fibers that connect the eye to the brain. Each of these nerve fibers is linked to retinal ganglion cells (RGCs), which are distinct nodes that gather information processed by the retina from specific, spatially restricted groups of photoreceptors (receptive fields).

Additionally, the structure and function of retinal neuronal circuits are relatively well understood, and optical methods already allow us to observe neuronal activity during photoreceptor stimulation in genetically modified animals. With minor adjustments, these techniques could effectively serve as a bridge between computers and the neural network of the human retina in vivo—without requiring modifications to the human body. Such an interface could be further developed into an autonomous communication system with the brain, capable of performing preliminary computational tasks at the retinal level. However, the fundamental question that must first be answered is whether it is possible to obtain information about the functional state of the retina's neuronal circuitry—both inputs and outputs—using non-invasive optical methods.

Could we harness at least a portion of the brain's immense computational capabilities for the tasks we perform daily, whether for work or entertainment? Could we develop a brain-computer interface that transfers some of the computation from modern computers to biological computing systems, which have been shaped by millions of years of evolution? What would happen if we could use even a small part of the human brain's neural network to perform computations like those handled by computers, or to make inferences similar to artificial neural networks? Would we be able to leverage the natural similarities in the way we process data to create a distributed computing network composed of millions of biological neural systems in human bodies, synchronized by a central control computer? Could this increase both the speed and energy efficiency of processing? Perhaps we could take it a step further and learn from this network a new way of processing information, one that would enable us to acquire knowledge or skills more quickly and efficiently. So, why not utilize biological neural networks for inference and explore individual similarities that could make this kind of processing transferable across different people? But how do we achieve this?

The first step is to develop appropriate tools that will enable us to read neuronal cell activity in a non-invasive and non-contact manner. To develop such tools, we need to answer the fundamental question of whether it is possible to retrieve information about the functional state of retinal neurons using optical methods. In our work, we will develop a suitable methodology to answer this question.