EXECUTIVE SUMMARY of "C-SMART: a wearable solution to cataracts"

Cataracts is one of the leading causes of preventable blindness worldwide, resulting in an increased level of intraocular light scattering (see Fig. 1), reducing the contrast of retinal images impairing vision. Cataracts can develop at any age due to variety of causes such as falls, UV exposure, or smoking, and they can also be present from birth. However, most cataract cases are linked to the natural aging process of the crystalline lens. According to Statista, a trusted global statistics portal, about 70% of individuals over the age of 65 suffer from cataracts, **affecting approximately 700 million people worldwide**. Left untreated, cataracts are responsible for approximately 51% of the cases of blindness globally, according to the latest study by the World Health Organization. Furthermore, this number is projected to rise in the coming years as life expectancy continues to increase, which makes **ocular cataracts a major health issue**.

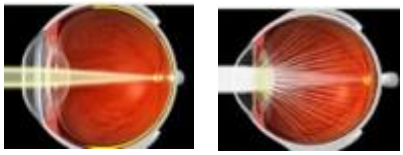

Figure 1: *Schematic of light propagation in a healthy eye (left) and cataractous eye (right). Credit: www.corkeyeclinic.com*

The ONLY treatment for eye cataracts is surgery, where the cataract-affected lens is removed, and then replaced with an intraocular lens. Currently, cataract surgery is typically a safe surgery, with a remarkable 97-98% success rate. However, **it is the only, and invasive, solution.** Due to this invasive nature, despite its effectiveness and ability to restore vision, **cataract surgery is not universally recommended or available for all patients**. This is particularly the case for infants with congenital cataracts, where surgery complications are common, being at a higher risk of blindness. It is not suitable either for patients with other ocular pathologies as corneal or retinal diseases, people with certain chronic diseases or medication, etc. Additionally, **cataract surgery is not equally accessible to the world's population**. Especially in low and middle-income countries (88% of world's population according to The World Bank), people might not have access to a surgeon who can operate cataracts or the financial means to do so. However, being the only existing solution means that people who cannot undergo surgery, will certainly become blind in the coming years.

Figure 2*: Idea sketch on corrector glasses based on Augmented Reality platform.*

The goal of this proposal is the development of the technology and first prototype of the Cataract's smart glasses (C-SMART), a wearable device capable of correcting vision for cataracts patients in an all-optical approach, thus avoiding surgery. This approach will be based on a similar concept to the Augmented Reality (AR) glasses. Here, the AR screen will display a real-time video of the exterior (as shown in Fig.2), wavefront-corrected for vision through cataracts by a miniaturized optical system on the glasses side, enabling a small form-factor for a definitive wearable solution for cataractous vision. If cataracts were corrected by smart glasses, it could revolutionize the lives of not only the community unable to undergo surgery but also of everyone who would prefer to avoid the surgery. Similar to the situation with myopia, where the success rate of surgery is quite high (around 98%), a significant majority of myopic individuals (approximately 80%) opt for non-invasive options like glasses or contact lenses over surgical procedures. The **intended outcomes of this project** are the development of the first prototype of the Cataracts smart glasses, a wearable device for the optical correction of cataracts. A wavefront measurement desktop device will also be developed, for the high-speed measurement of the cataract correction profile and glasses calibration.

The feasibility of this approach is supported by previous proof-of-concept experiments detailed in the full proposal, where we examined light scattering in ex-vivo human cataractous lenses and performed the wavefront correction through such lenses, forming wide-angular images through cataracts. The signal-to-noise-ratio of the focus spot through the cataractous crystalline lens was improved by 80-fold, demonstrating the potential of this technique for controlling light in real human cataractous lenses. We also demonstrated that the wavefront measurement and correction can be done non-invasively, using light reflected from the eye as feedback. In parallel, we have successfully miniaturized the technology required for the wavefront correction, in the form of wearable devices. These proofs of concept demonstrate that there is no physical limitation to the non-invasive (all-optical) correction of cataracts. **Now the open question is: Can Optics and Photonics with the existing technology handle this challenge to make it a practical solution?** I am convinced that, if granted, this project will make this optical solution to cataracts a reality, becoming a global change of paradigm.