# LuminEye

GAZING INT● THE FUTURE

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Our eyes speak volumes, whether it's a disapproving glance from your boss or a deep gaze of affection from your partner. However, our eyes can communicate more than just emotions; they can also serve a groundbreaking purpose through eye-tracking technology. In the blink of an eye, this technology can be revolutionary for those with physical disabilities. ❯
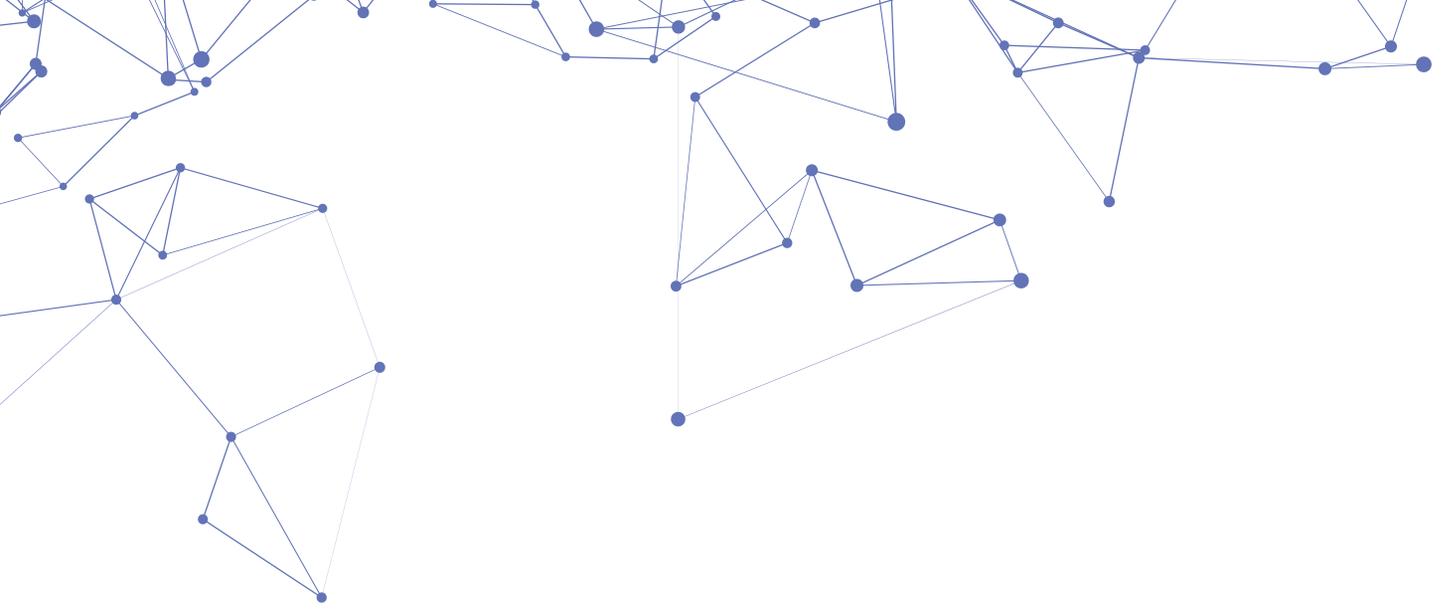
When I was a young boy, my mother had an ingenious way of stopping me from using the computer when I should be studying. She would simply unplug and take away the keyboard or mouse. Without either of these devices, there was simply no way for me to interact with the computer (and play video games).

For some individuals, such as those with physical impairments, using a mouse or a keyboard is simply not an option. However, some alternatives can allow users to interact with their computers without such devices. One way to improve accessibility is through eye-tracking technology. Essentially, your eyes function as a mouse. If your eyes are looking at the bottom right of the screen, the cursor moves to that part. Look long enough, and you click. In principle, it's fairly straightforward; however, actually designing the technology is a different issue entirely.

'Current eye-gaze trackers available on the market are active,' explains Dr Ing. Stefania Cristina, senior lecturer at the Faculty of Engineering at UM. 'This means they actively shine infrared light on a patient's face and eyes. The idea is to create a "red eye effect" or glints on the cornea. These allow the technology to estimate where the user is looking.

The downside is that if you have other infrared sources, such as the sun, that creates interference.' Furthermore, to shine the infrared light, you need specific equipment: the eye tracker that attaches to the computer, which can be quite expensive. Users are also limited in their movement, and the hardware needs to be regularly calibrated to work effectively.

The LuminEye Project aims to create an eye tracker that doesn't require such a controlled environment and only uses visible light and a webcam. This would allow users to circumvent the need for expensive technology, as the program would detect and capture a user's eye movements just through their webcam. 'To do so, we're using passive and pervasive eye-gaze tracking,' says Cristina. But what does that actually mean?

'With pervasive eye-gaze tracking, the idea is to have technology that can be implemented in flexible conditions, for example at longer distances and not just sitting in front of a monitor or constraining users to a stationary position,' explains Cristina. 'Passive technology doesn't actively shine a light on the user. The goal is to drop infrared technology completely and allow users to simply use their webcams.' Of course, developing something so user-friendly creates its own set of challenges.

LOCATING THE IRIS

Throughout their research, the team was able to create an eye-tracker that allowed users to control a keyboard on the screen with a degree of accuracy. However, one persistent problem was the identification, or localisation, of the iris centre. For example, changes in light, a different environment, or shadows, would mean that the software would lose the user's iris.

Way back in 2007, when Cristina was still an undergraduate studying with Prof. Ing. Kenneth Camilleri (Director of the Centre for Biomedical Cybernetics), they were using geometric models to model the eye-in-head movement. This would model how the face changes based on head movement. Since then, neural networks have rapidly developed, and the team decided to incorporate them into their technology. The neural network would be trained using varied and challenging image datasets to help it better identify the user's iris under difficult lighting conditions. 'Results were promising; however, there are other challenges that come with using neural networks,' says Cristina.

'Neural networks are computationally expensive, so most commercial computers might struggle to run the programme. Our goal is to make the code as lightweight as possible,' says

The LuminEye team (from left to right): Dr Ing. Stefania Cristina,
Mr Nipun Sandamal Ranasekara Pathiranage, and Prof. Ing. Kenneth Camilleri
Photo by James Moffett

Cristina. The other challenge is that neural networks are trained models, which means they need vast amounts of data to be trained effectively. 'We either capture our own data or use publicly available data sets. Since we're looking at different eye types, the data needs to be as varied as possible.' For example, using sample data exclusively with brown-eyed users to train the algorithm means that it would struggle with blue-eyed users.

GAZE INTO THE FUTURE

While the LuminEye project enables users to navigate the digital realm using just the subtle movements of their eyes, a visionary student in their final year aims to push the boundaries even further. Imagine a user, seated comfortably across the room, able to control other devices besides their computer, such as their television, using just their sight.

The main challenge is expanding the reach of eye-tracking capabilities, allowing the software to track a user's eye movements from a considerable distance away. To do so, Erik Micallef is investigating a way to superresolve sample images. The algorithm's training process relies heavily on vast sets of sample images. While images of users close to the screen distinctly capture their gaze, those seated at a distance present a murkier scenario. Nevertheless, through the process of superresolution, these images gain clarity, empowering the algorithm to recognise and interpret eye movements. This development represents a significant stride towards a more inclusive and user-friendly future, catering to the diverse needs of individuals who seek both convenience and accessibility in their technological interactions.

The LuminEye project not only pioneers a new frontier in user interface, but also makes this technology more accessible to the people who need it most. By perfecting LuminEye, the team would be able to offer an alternative to current cumbersome infrared technology and instead offer something more intuitive and versatile. Truly, we can see the future unfolding right before our eyes! 🇹