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Reimagining vision with infinity mirrors

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Abstract. This paper studies the possibility of interfacing motion control of an infinity mirror by using viewer eye tracking and the advantages and drawbacks of such an interface.

1 INTRODUCTION

A short general briefing of the terms: eye-tracking and infinity mirrors.

1.1 Eye-tracking

Eye tracking refers to the process of measuring where we look, also known as our point of gaze. These measurements are carried out by an eye tracker, that records the position of the eyes and the movements they make. Eye tracking records our point of gaze and our eye movements in relation to the environment and is typically based on the optical tracking of corneal reflections, known as pupil centre corneal reflection (PCCR).

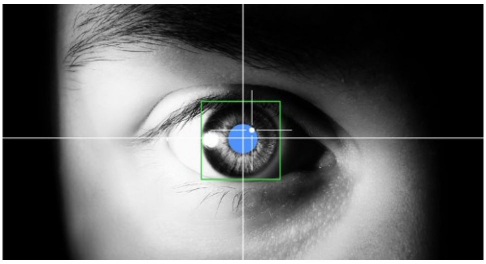

Fig. 1. Eye Tracking – a concept of what the eye tracking system acquires from the user.

Near-infrared light is directed towards the centre of the eyes (pupil), causing visible reflections in the cornea (outer-most optical element of the eye). These reflections – the vector between the cornea and the pupil – are tracked by an infrared camera.

Nowadays (currently), eye tracking applications are using more common hardware, like mobile telephone cameras, or USB cameras [1-5].

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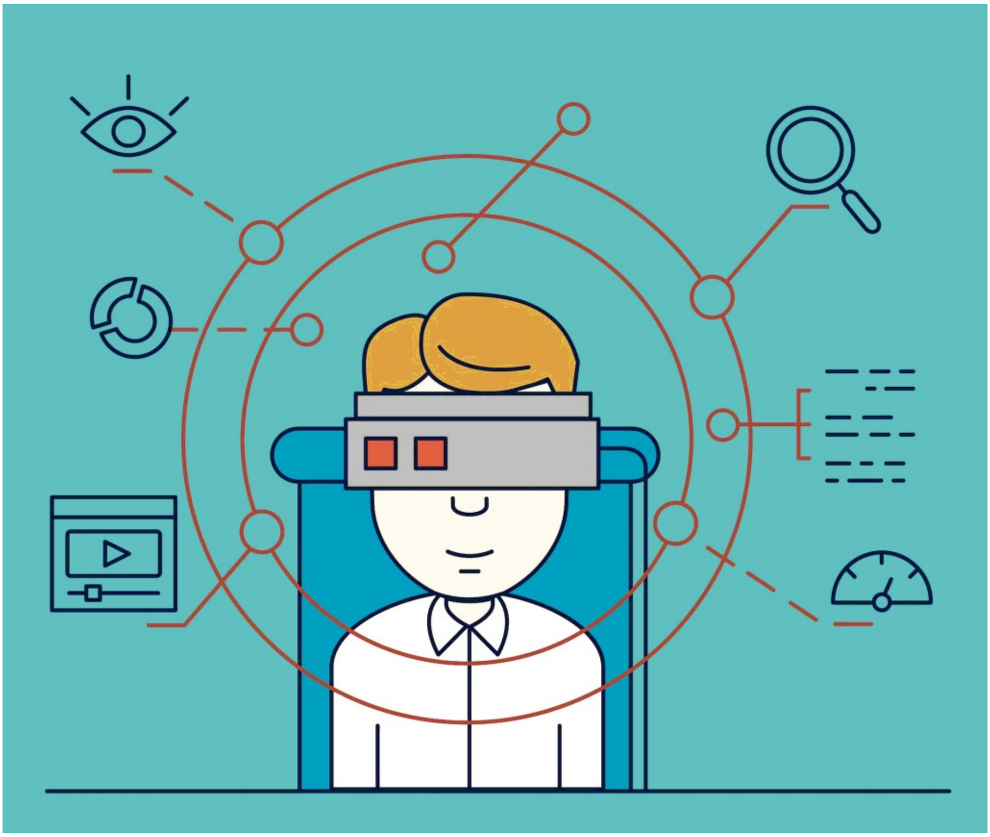

Fig. 2. Eye Tracking – a concept of what the user sees.

1.2 Infinity mirrors

Infinity mirrors have developed as a form of art, and haven't been used as anything else, yet. They are very attractive objects. Rather said, infinity mirrors are one of the greatest and easiest optical illusions, to create using three simple things: two mirrors and one, or more light sources, when combined, they make the illusion that the lights are trailing off to infinity, by placing the lights between two mirrors (a standard mirror with a high reflection rate and a semi-transparent "two way" mirror with a lower reflection rate, and medium light transmission rate).

1.3 The infinity cube (a future approach)

The way it's built involves another mirror that's placed in a diagonal position across the cube's internal structure, and has another smaller cube, placed at the centre of the host cube, placed in the same position as the host cube. When in motion, it would give the viewer the impression that it would be a cube that's floating inside the host cube, without anything visible, that's holding it in place, regardless of the motion's direction.

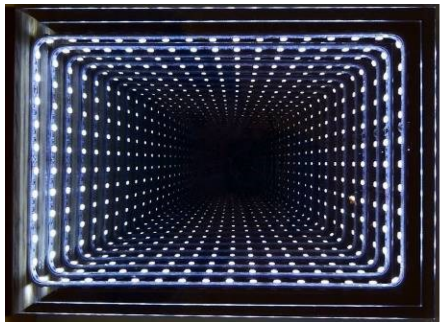

Fig. 3. A classic build of the infinity mirror, seen with a functional LED frame.

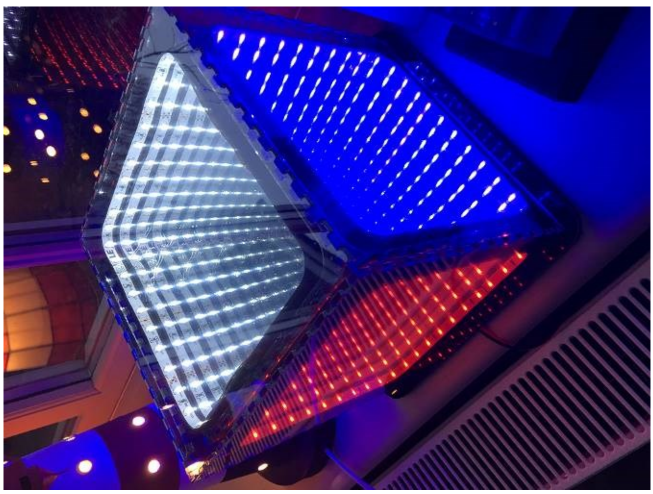

Fig. 4. A classic build of an infinity cube, seen with functional LED frames.

2 Eye tracking technology, methodology and current state

Eye tracking [1] is today, one of the most accessible research matters, ever growing, not only in popularity, but also in user experience, as for researchers, it can be developed alongside a vast field with an ever-growing number of disciplines.

The number of eye tracker users has rapidly grown ever since it became commercial, yet developments can always be made, either if development involves projects that are very useful, less useful for today's technology or market, or even odd projects, that may or may not ever be in use.

The process of investigation using eye tracking will in fact involve encountering issues that have a solution, or not. If the solution exists, development can involve improving or even simplifying the solution, or finding a solution where there isn't one.

2.1 Fixations (latencies) in eye tracking equipment

Most users trust the default configuration on the system, [9] because they are mostly dependent on it. Although, as their level of understanding ascends, they always discover more and more particularities. As an example, they get a first setup time that easily becomes too different from setup times found to be reported in the classic literature, and they cannot find out why: some possibilities include sampling frequencies, resolution, or even software glitches. The settings, algorithm, the study procedures can also take credit for the differences that occur.

Also, there are uncommon fixations for only 1-2 milliseconds in the data. [12] What does that situation represent, and why is it not mentioned in the literature? The manuals say that these fixations should be removed or sorted, but can the event in which these fixations have the initial ones as a cause? The manufacturers themselves might not have an answer. If they give an explanation, it would be that the system's architecture and the algorithms may not be in sync, but the algorithm they implemented was a rudimentary translation from an idea that was either drawn, [10] or written on paper and of course the paper doesn't exactly fit real life, most of the time, in other words they got close to establishing a functional system, but didn't really know how well their idea would manifest in the material world, [8] due to the lack of experimental data.

In the Petri Net [3] simulation, the by-stable circuit is designed with a set of quadrants that function in a certain manner, yet another area of the circuit needs to be used by the programs, but ignored by the user unless it's being supervised for function verification, in order to understand the time lapse of the bi-stable circuit.

As you can see, when there is a token in the active area of the saccade circuit, there is also a token in the inactive area of the fixation circuit, and vice-versa, but both tokens are in the transition area at the same time, one token is in the transition area of either state, and, the other transition will undoubtedly host both tokens, simultaneously.

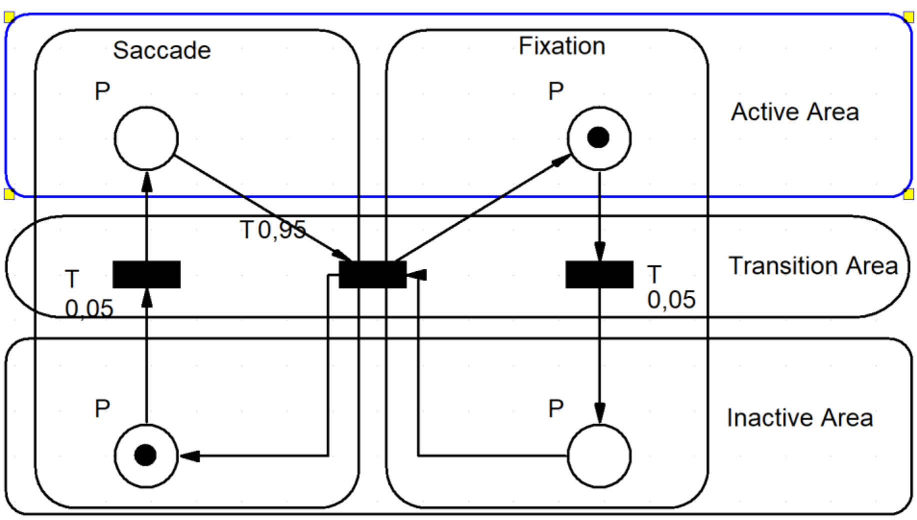

Fig. 5. The bi-stable circuit's Petri Net simulation, illustrating how tokens move from one area to the other, and can be analysed to determine how the toggle between saccade and fixation can take place.

2.2 Unspecified problems

The eye tracking methodology has a wide range of real problems that haven't been written down, published, or even kept in a public access online medium, or any other data source, for unknown reasons. For instance, the fixation durations from gaze overlaid videos. The camera-to-eye angles that allow the user to record data for the entire monitor, participants with contact lenses and what that affects the data recording process, ways and means to verify and repair poor quality data, after the recording, or identifying, and possibly eliminating the latencies from the eye tracking data.

2.3 Application domains where Eye-tracking is successful

Eye tracking [2] related research is not only hard work with a lot of confusing data and information, but when the whole system works, and the methods are correct, quite the lot of interesting findings can be obtained. Here are some fascinating examples of how eye tracking made a clear difference.

2.3.1 Clinical neuropsychology

The use of eye tracking to study schizophrenia started only 10 years after the first eye-trackers were constructed (Diefendorf & Dodge, 1908). Today we know that eye movements - specifically smooth pursuit gain and anti-saccades, allow medics to diagnose the illness in passive state, as well as in relatives who carry the genes, but are not directly affected.

2.3.2 Reading

Reading studies were first conducted very early in the eye tracking related research. Erdman and Dodge (1898) conducted a systematic inquiry into reading, showing that we do not look at all the letters in the words we read, and investigated saccade amplitudes and fixation durations during typical reading. Since then, thousands of eye movement studies have been conducted and published.

2.3.3 Controlling computers by gaze

This idea stated at least in the 1960s and states that if somehow the astronauts could control their telescopes and manoeuvring units with their gaze, then they could use their hands to control other parts of the aircraft (Merchant, 1967). Although this experience couldn't be achieved until the 1980s. The first working system was presented by Bolt (1981), where he controlled multiple windows with gaze. The research area within human computer interfaces that it became, could be studied theoretically and empirically (Jacob, 1990).

Thanks to the fact that eyes can be moved even if other skeletal muscles can't be moved, due to illness, the most used application of gaze was typing, and controlling computers. The ERICA (Eye-gaze Response Interface Computer Aid) system, which allowed gaze control over electrical machines (Lights, music, TV), in addition to writing texts and playing games by gazing at them, was an important early player.

Art was created and books were written by people who couldn't move more than their eyes. Eye-tracker control interfaces are now a commercial product that can be used with computers or even mobile phones.

2.4 Understanding eye movement control

In the early 20th century, the exploration was not about what drives eye movement. [11] The research started in two directions: one was about the psychological determinants of eye movement. This group conducted experiments that would reveal a selection system for the fixation targets based on peripheral vision. They discovered that saccades are launched by a timing mechanism that considers attentional processing demands.

The other group were conducting research that would use electrical probes to observe whether the same saccades were coming from the brain, measuring the electrical activity of the brain and stimulating the brain regions that would launch the saccades into execution. Today, a lot is known about the fact that a large amount of the visual and eye movement circuitry is in the brain.

2.5 The current state and immediate predictions regarding eye tracking technology

Eye tracking technology is expected to be one of the most profitable markets [4] in the immediate future, also predicted by marketing analysts to be an ever-growing success, but technology wise, eye tracking is now most commonly used as a virtual and augmented reality client resource for human computer interfacing. Eye tracking has been segmented on the basis of type to eye tracker device, which is further segmented into remote eye tracker and mobile eye tracker.

The mobile eye tracking system is expected to grow at a faster rate because of the technological advancements such as helping record the real time natural gaze behaviour which can be used over wide applications such as market research and medical applications. The new mobile devices are also enhanced to control real-time data access and study control through wireless connections.

3 The infinity mirror simulation approach

An application that uses eye tracking in the movement of the simulated infinity mirror. The main approach is to move the generated mirrors, in the direction that the eyes are gazing, in the way that changes the viewing angle, so that the user can change the direction that points towards "infinity".

This project can also be updated or upgraded (hardware) for example the LEDs that are used for the mirror’s infinity effect, could be upgraded to displays, which would inevitably create much better visual effects, and also the (software) algorithms [7] can be upgraded, as well as the camera, for better accuracy.

4 The basic application approach of the infinity mirror

This application was built to transmit the basic concept of the infinity mirror, as a reaction to mouse movement. The user would see the infinity path (the end of the tunnel), following the mouse pointer, on the computer screen, as seen in the image below.

Luckily, free, open source eye tracking software that uses the webcam [6], had been developed (Gaze Pointer). This software application allows the user to control the mouse pointer, by gazing at the computer screen. After a brief calibration in an imposed position for the user, the mouse pointer will follow the user's gazing points (locations on the screen). However, the saccades and fixations could not be solved by the software developer for the eye tracking application, and there are minor setbacks in the infinity mirror movements.

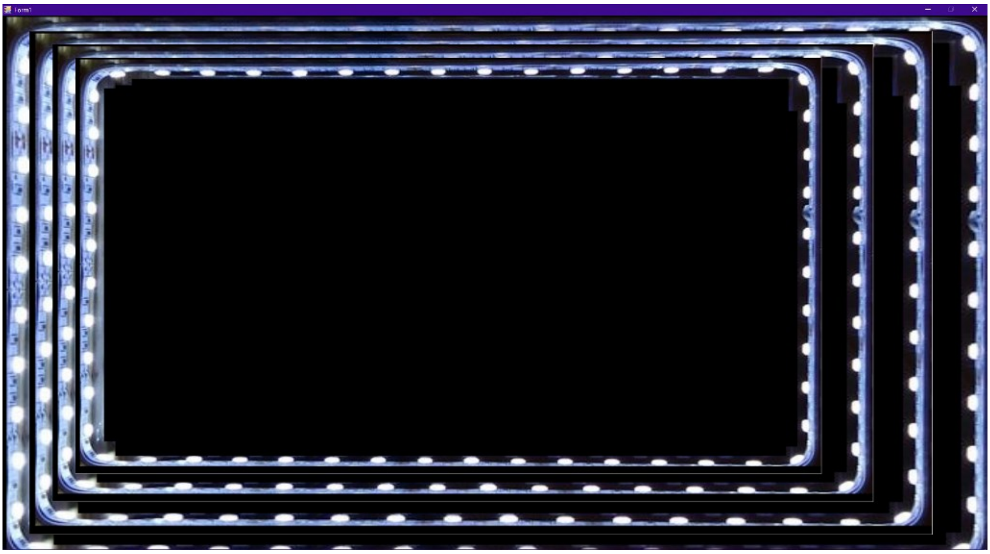

Fig. 6. The infinity mirror view, simulated in basic software.

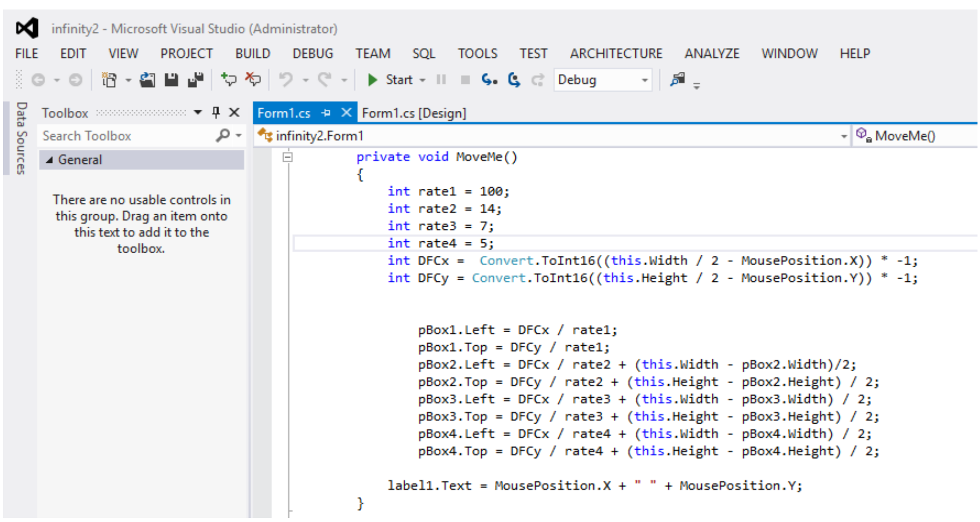

Fig. 7. The code section that commands the mirror movement – the movement proportions have been tested to become close to a real impression, but have also been calculated to amplify the impression, for a more visible difference, what the code does is to move the mouse pointer, actually.

5 Conclusion

After a viable saccade and fixation reduction system would have been developed, eye tracking would be present in most control systems for pocket apparatus (such as mobile phones), for laptop/desktop environments, and would be used for 2D and 3D applications of all information technology domains (entertainment, design, etc.)

Even if new challenges would come along the way of eye tracking systems development, solving the saccades and fixations is now the top priority towards progress.

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