Development of an Innovative Eye Movement Simulator Using Hand Gesture Recognition

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Background

The ability to check eye movements and recognize life-threatening diseases is an essential skill in medical practice.[1] Traditionally, this core skill was learnt and practiced through patient contact in clinical settings (e.g. hospitals and clinics). However, this approach has been met with increasing challenges in the modern medical curriculum including shrinking clerkship time and expanding student volume.[2] The limited availability of suitable patients has added unpredictability and inconsistent clinical exposure, resulting in inequalities of knowledge and skills among students.[3]

These issues highlight the need for pedagogical innovations. The use of simulation models provides new platforms for teaching and learning in medical education.[4] However, to date, only very few web-based simulators on eye movement have been reported.[5-8] A major common limitation is that users can only control virtual eye movement through an external device (e.g. a mouse or trackpad), which is an inaccurate representation of how eye movements are examined in real patients. Other challenges include the lack of evidence on the validity, reliability, and effectiveness, and aging platforms that reduce accessibility.

To address these limitations, we propose to develop the first eye movement simulator, that tracks the user's hand motion based on hand gesture recognition technology, to provide a realistic platform for learning eye movement examination that is fundamental and relevant to all healthcare professionals.

Objectives

1) To develop a first-of-its-kind eye movement simulator using hand gesture recognition that closely resemble the real world;
2) To introduce a new tool for teaching, self-practice and assessment of eye movement examination;
3) To evaluate the validity of the eye movement simulator as an effective teaching tool.

Methods

The extraocular movement simulator was developed de novo on Unity, a real-time 3D development platform. The user interface was built to display a virtual patient based on a 3-D face and eye model.

The user can use a finger to bring about eye movement of the virtual patient. Hand gestures of the user are recognized real-time through a simple web camera and analysed by a machine-learning framework from MediaPipe, an open-source framework by Google.

Eye movement of the virtual patient is programmed such that it follows anatomical and physiological properties of the extraocular muscles. Figure 1 demonstrates how a user practices extraocular movement examination skills on the simulator.

There are two modes in the simulator: practice mode and test mode. In both modes, users can personalize the settings and set up different clinical scenarios. There are six extraocular muscles and the degree of weakness/limitation of each can be adjusted to simulate various disease settings. In the test mode, different disease scenarios can be pre-set to allow for home self-evaluation of knowledge and study progress.

The content validity, face validity and construct validity will be evaluated.

Results

A prototype of the simulator was successfully developed. It can be accessed through a computer (PC) with a web camera). Figure 2 shows the user interface and the virtual patients' eyes move with the hand of the user.

Preliminary data of a pilot in showed a high user experience satisfaction score (weighted average 4.65 out of 5, when 0=poor and 5=excellent). Users also found the simulator to be realistic ("realism of virtual patient's faces and eyes"= 4.6/5, "realism of finger-based interaction"= 4.65/5) and facilitating learning ("facilitation in symptom memorization"= 4.7/5, "facilitation in underlying principles comprehension"= 4.6/5 and "strong complimentarity to book knowledge"=4.7/5).

Conclusions

This extraocular movement simulator is a cross-faculty (Medicine/Engineering) inter-pedagogical innovation. It makes good use of artificial intelligence, machine learning, gesture recognition and gamification technology to enhance the learning experience. It provides a new solution to clinical skills teaching in medical education both locally and abroad. It also has excellent potential for adoption in human biology education in general.

Figure 1. A demonstration of a user with the eye movement simulator. His hand gesture will bring about eye movement of the virtual patient in normal and disease settings.

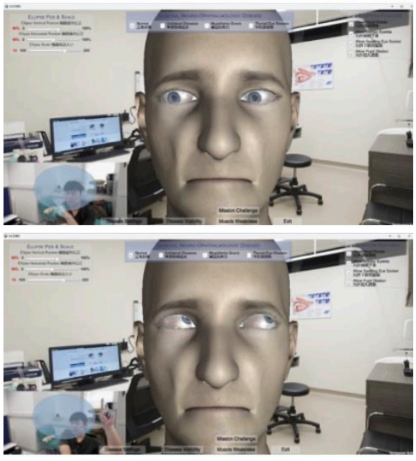

Figure 2. The user interface showing the 3-D virtual patient and the eyes, in a background of a real-life eye clinic. The eyes of the virtual patient moves in the same direction as the hand of the user. Upper: user's hand moving to the left; Lower: user's hand moving to right upper corner.

References

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