The Mind-Window: Brain Activity Visualization Using Tablet-Based AR and EEG for Multiple Users

Jonathan Mercier-Ganady∗
Inria/INSA Rennes, France

Maud Marchal∗
INSA Rennes/Inria, France

Anatole Lécuyer∗
Inria, France

ABSTRACT

In this poster we introduce a novel approach, called the "Mind-Window", for real-time visualization of brain activity. The Mind-Window enables one or multiple users to visualize the brain activity of another person as if her skull was transparent. Our approach relies on the use of multiple tablet PCs that the observers can move around the head of the observed person wearing an EEG cap. A 3D virtual brain model is superimposed onto the head of the observed person using augmented reality by tracking a 3D marker placed on top of the head. The EEG cap records the electrical fields emitted by the brain, and they are processed in real-time to update the display of the virtual brain model. Several visualization techniques are proposed such as an interactive cutting plane which can be manipulated with touch-based inputs on the tablet. The Mind-Window could be used for various application purposes such as for Education as teaching tool to learn brain anatomy/activity and EEG features, e.g., electrodes localization, electrical patterns, etc.

INTRODUCTION

The visualization of brain activity is mostly done off-line using desktop environments [4]. It is often based on electroencephalography recordings, i.e., a neuroimagery technique which measures and displays the electrical signals emitted by the brain at microvolt scale. In this case, the patient/observed person is wearing a cap fitted with electrodes. This setup enables the observer to watch the brain activity in real-time [3]. In most brain activity visualization software, interaction is performed using a mouse and a keyboard. This interaction usually includes rotating the cerebral data and selecting the proper visualization angle/perspective. Virtual reality and augmented reality have already been used for brain activity visualization purposes [2, 1]. Mercier-Ganady et al. have notably proposed the "Mind-Mirror" system which enables the visualization of brain activity "inside one's own head" using an EEG acquisition machine and a mirror-based augmented reality (AR) setup using Kinect tracking and a semi-transparent mirror. However this system is not a mobile setup.

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∗e-mail: {jonathan.mercier-ganady|anatole.lecuyer|maud.marchal} @inria.fr

Figure 1. Our novel "Mind-Window" approach enables one or multiple users to visualize in situ the brain activity of a person in real-time by using tablets and augmented reality. The display of the virtual brain is updated in real-time according to the real brain activity of the person which is measured thanks to an electroencephalography (EEG) cap.

It is meant for only one user at a time, equipped with an EEG cap and facing her own virtual brain "in action in situ".

THE "MIND-WINDOW"

General Presentation

In this poster, we propose a novel approach for real-time visualization of brain activity called the "Mind-Window". Our approach enables a single or multiple users to directly look at the brain activity of an "augmented" person thanks to a tablet-based augmented reality. Tablet computers can be targeted towards the head of a person wearing an EEG cap. These tablets are used as windows, displaying a video stream recorded by their frontal camera. A 3D virtual brain is displayed on top of the recorded video stream at the position of the head, tracked using an augmented reality marker (See Figure 1). The electrical activity of the brain is extracted and processed in real-time thanks to an EEG cap worn by the user. One objective of the Mind-Window is to display real-time brain activity while being simple to use. EEG was chosen because of its well-known high temporal resolution, and because of the relative low-cost and ease of use of EEG caps. Displaying a virtual brain at the same position as it would be if the observee's head was transparent requires retrieving the position and orientation of the head. The computed position and orientation of the observee's head are used to render the virtual brain superimposed to the camera feed recovered from the tablet PC. The tablets allow for a portable wireless display that can be positioned at will by the observers. The Mind-Window application retrieves EEG data from one or multiple EEG caps and outputs on one or multiple tablets the images showing the users wearing the caps superimposed with the

virtual 3D brain models. The orientation and position of each virtual brain are computed according to the specific viewpoint of the tablet on the AR marker. Compared to the Mind-Mirror [2], the Mind-Window is a multi-user portable setup based on tablets. It can display multiple points of view of the same brain activity.

The Mind-Window system is composed of multiple components which are displayed in Figure 2.

Figure 2. Mind-Window system overview. (1) EEG cap, (2) 3D AR marker, (3) tablet PC, (4) virtual brain representation, GUI: button bar (5), slider (6)

Visualization Techniques
Several visualization techniques have been designed (See Figure 3).
Brain topography: Viewing the most and least active brain areas is possible using a surface topography with colors ranging from blue/green (low activity) to red (high activity).
Cutting plane: Brain topographies often display only the surface activity of the brain [2]. It could be useful, in a medical context for instance, to view the brain activity below the surface. A virtual cutting plane allows the viewer to cut the virtual brain at any desired position.
Electrodes: The EEG cap used to capture the brain activity is composed of several electrodes placed on well-known positions on the head. Learning the localization and name of these electrodes and being able to link them with any brain activity could be useful for educational purposes.

Use Cases and Applications
The Mind-Window allows interaction with multiple users at the same time. We could identify different use cases depending on the number of users. One user could see her own brain activity by holding a tablet in front of her head and target a 3D marker. This could be used in Neurofeedback applications [2]. One person could be observing the brain activity of another person, moving around her while holding a tablet. This configuration could be useful within the medical field
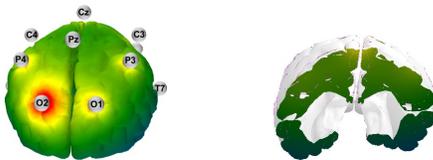

Figure 3. Left: Brain surface topography, showing the most active parts of the brain in red and the least active ones in blue and green. The EEG electrodes and their name can also be displayed, allowing users to check the electrode placement and learn how to place them. Right: A cutting plane allows users to see the inside of the virtual brain.

to view the brain activity. This setup could be suitable for educational purposes, where the observers are watching the individual's brain activity and have the ability to learn its localization (See Figure 1). Two users could both act as observer and observee, each one of them having an EEG cap, a 3D marker, and a tablet PC. This setup allows the users to see the brain activity of one another, e.g. during a brain-enabled video-conference. We believe that the Mind-Window could have applications in different fields such as medicine, education, or entertainment. The Mind-Window could represent an alternative way for physicians to visualize the brain activity. Typical medical brain visualizations are off-line [4]. Our approach allows for an online visualization of the brain activity. For teachers wanting to show the workings of certain parts of the brain, the Mind-Window could be a way to illustrate their lessons in real-time. The Mind-Window also has a potential entertaining use such as for enhancing the traditional videoconferencing by displaying the brain activity of each participant.

CONCLUSION
In this poster we proposed a novel approach called the "Mind-Window" which enables to visualize brain activity in real-time using Augmented Reality and one or multiple tablet PCs. A virtual brain model is displayed at the level of the skull of the real user and its representation is updated as a function of EEG recordings. We have designed several visualization techniques and tools such as a 3D cutting plane that can be directly controlled with the tablet thanks to gestural and touch inputs. Our novel approach is highly versatile and portable and could be used by one or multiple users in different applications such as for medical, educational or entertainment purposes.

ACKNOWLEDGMENTS

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