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Gaze-based Interaction

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8.1 From Eye Movement to Interaction

Nowadays, there are variety of computers available in our everyday life. Personal computers (PC) exist in the office and the home to support people’s activities. Cellular phones and Personal Digital Assistants (PDA) now carry huge amounts of information, and also work as a powerful data terminal connected to a wireless network for supporting their user’s ubiquitous life. TV sets in the living room are now ready to work with a set top box connected to a broadband network to access huge amounts of online content. In the car, audio systems and satellite navigation systems require complicated user operation. However, operation style with those variety of computers is still limited. Traditionally, users are required to use their hands to control an input device like a keyboard, mouse, pen, touch screen or remote controller for computer operation. Even though the computer style is diversified, we have few choices to control them.

Interacting with the computer by human eye gaze, or shortly, gaze-based interaction, provides a new interaction of style with the computer. The fundamental idea of gaze-based interaction is to measure the user’s gaze position on the computer screen with the eye tracking system, and applications react to the user’s gaze at some level. Eye tracking was initially a tool for psychologists to conduct experiments; during the last decade, a tremendous effort has been made on developing robust gaze tracking tools for various applications. Current gaze tracking systems are mainly used in two different fields: in medical diagnostics and for interaction [146].

Because the eye moves quickly to acquire information on the computer screen, the gaze position provides the key information to estimate user’s intent, and it reduces the operation time and operation workload. Moreover, a user is able to interact with the computer even if both hands are busy with different tasks. A variety of applications have been proposed for supporting our everyday activities.
Nielsen described traditional user interfaces as belonging to “Command-Based” interfaces where users have been required to pay close attention to the control of their computer [444]. That is, users are required to provide the appropriate commands in the appropriate syntax. Many gaze-based applications including eye keyboard, menu selection and other gaze-controllable Graphical User Interface (GUI) belong to the command-based interface, where users are required to point the target with their eyes, and then select it explicitly. On the other hand, there are different types of user interfaces, which can be called “non-command” interfaces [282, 444]. They allow users to focus on the task rather than on operating the computer [444].

In other words, the applications can be selective; the gaze is used as a control medium, or gaze-contingent; that is, the system is aware of the user’s gaze and may adapt its behavior based on the visual attention of the user [146].

In this section, we focus on interactive applications that utilize gaze tracking in real time.

8.1.1 Nature of Eye Movements

Before starting to describe the detail of gaze-based applications, we first introduce the features of eye gaze from the point of view of gaze-based interactions.

1. Fast. When we look at a target, the eye moves quickly to catch the target with the high-resolution area of the retina (called fovea). This is called a saccadic eye movement (or shortly, saccade), which is known as the very fast movement. The peak angular speed of the eye during a saccade achieves about 700 degrees per second. During a saccade, people are not able to control the eyes direction or target position, and if the final position is different from the target, an additional saccade occurs.

2. Unstable. Precise control of gaze position is difficult because the size of the fovea restricts the accuracy of eye targeting. In addition, the eye moves slightly even if it stays on the target. This is called a micro saccade. Once the eye stops on the target, it stays for a short period, generally from 100 msec to 300 msec (eye fixation). It sometime lasts more than 1000 msec. However, longer dwells on the same position are difficult and causes fatigue.

3. Uncontrollable. In general, the eye jumps by saccade to achieve the target; the eye does not move continuously except when following a slowly moving target. Intentional and exact eye movement is difficult if there is no target at the destination. For example, when users control the mouse cursor by gaze, they feel labored in comparison with hand operation.

When we build gaze applications, it is necessary to consider that the nature of eye movement is completely different from hand motor control.