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Reflections of Head Mounted systems for Domotic Control

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Introduction

Generally there are two kinds of video-based gaze trackers: Remote gaze trackers (RGT) and head mounted gaze trackers (HMGT) [Duchowski, 2007]. In RGT systems the system components are placed away from user e.g. on a table. RGT systems usually only allow for point of regard estimation on a planar surface (screen). Today, gaze interaction is done through RGT systems and mostly used for interaction with the computer screens. RGT gaze interaction has therefore been limited to help and assistance the disabled peoples sitting in front of a single screen. In the other hand HMGT systems are mounted on the user to allow for a higher degree of mobility. HMGT systems are commonly used for estimating the gaze point of the user in his field of view. So, unlike the RGT systems, these systems have at least one camera for capturing the eye image and another one for capturing the scene image. Mobility is the most important advantage of the HMGT systems compared to RGT systems. This advantage allows the user to have a much higher degree of flexibility and can be used for mobile usage like walking and driving.

In this report we would like to investigate the generalization of the concept of gaze interaction and investigate the possibility of using a gaze tracker for interaction not only with a single computer screen but also with multiple computer screens and possibly other environment objects in an intelligent house.

Domotics

The intelligent house is an automated house that allows some tasks be done intelligently. Controlling the house automatically also is called domotics [Bonino & Corno, 2009a, Bonino & Corno, 2009b].

Home automation may include centralized control of lighting, HVAC (heating, ventilation and air conditioning), security systems, audio-visual equipment or appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security. Home automation for the elderly and disabled can provide increased quality of life for persons who might otherwise require caregivers or institutional care.

With an intelligent home solution, we are always in command. Whether from any room of the house with simple to operate and discreet wall panels, or remotely via WAP telephone or web access, and also by using the new interactive ways such as voice interaction and gaze interaction we can contact the house and tell it what to do at your convenience.

Concept

At the present there has only been a very limited set of (if any) examples of gaze interaction systems intended for environment control that is accurate, flexible and robust. A gaze-based environment control system would be highly useful for e.g. virtual reality and domotic control/intelligent house as well as highly beneficial for both disabled people and elderly [Shi & Gale, 2007, Shi et al., 2007].

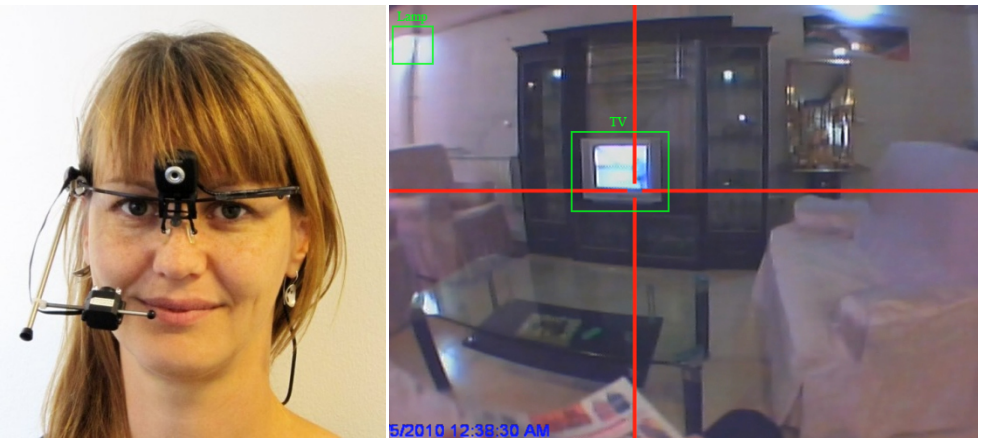

Figure 1: (left) A HMGT system and (right) a scene image

A HMGT system (left) and an image of the scene as viewed from the scene camera (Right) of the HMGT with a gaze position overlay is shown in Figure 1. The estimated gaze point is shown by a red cross as well as two recognized objects (TV and a lamp) in green. I would like to use HMGT since they allow for a much higher degree of flexibility and can be used for mobile usage like walking and driving.

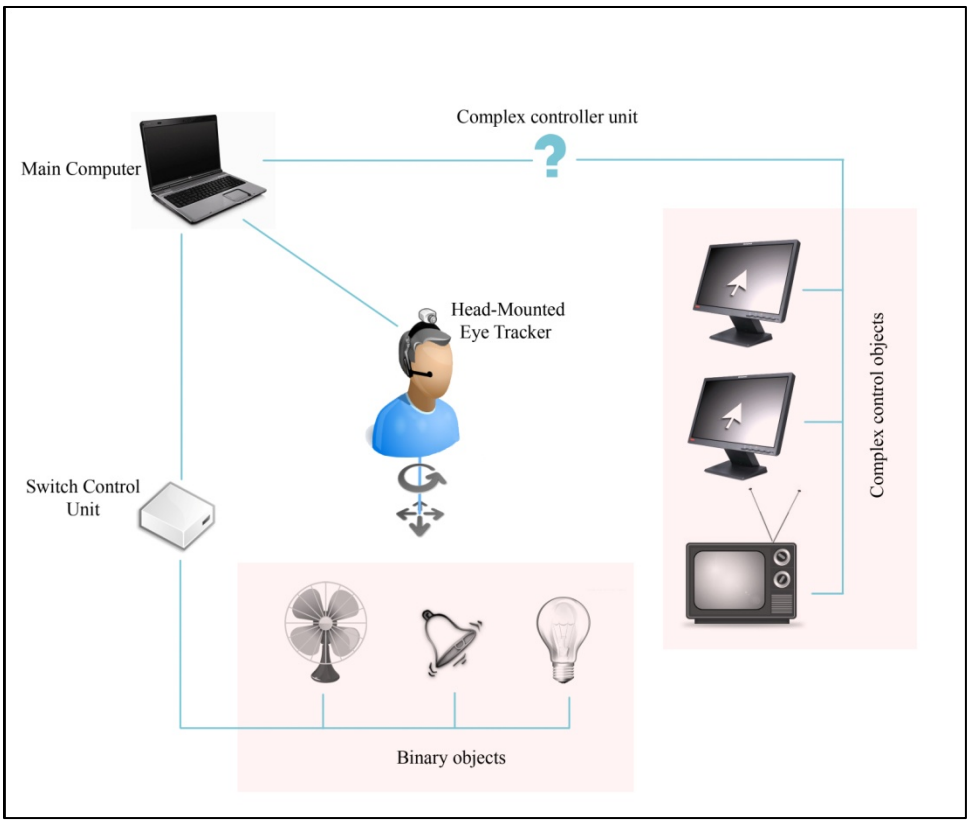

Figure 2: Schematic diagram of Gaze Environment control

As shown in the figure 1, controllable objects can be subdivided into two groups:

1. Binary objects (on/off switching objects)
2. Objects with complex control

Binary objects such as lights and fans can only be turned on or off. Complex control objects such as TV and monitors allows the user to do more complex tasks on the objects, such as turning the TV on, changing the channels and changing the volume up/down as well as moving the cursor on the monitor screen and click on the icons.

Binary objects have to connect to a switch control unit (this connection may be wirelessly in ideal case), and the switch control unit will be connected to the main computer. Connections between the complex control objects and the main computer need more than a single switch control unit because the user needs to do more complex tasks such as changing the channel of TV or moving the cursor. The question mark in the figure 1 and figure 2 shows this complex controller unit.

The head mounted eye tracker system with two small cameras will be carried by user and it can also be wirelessly in ideal case.

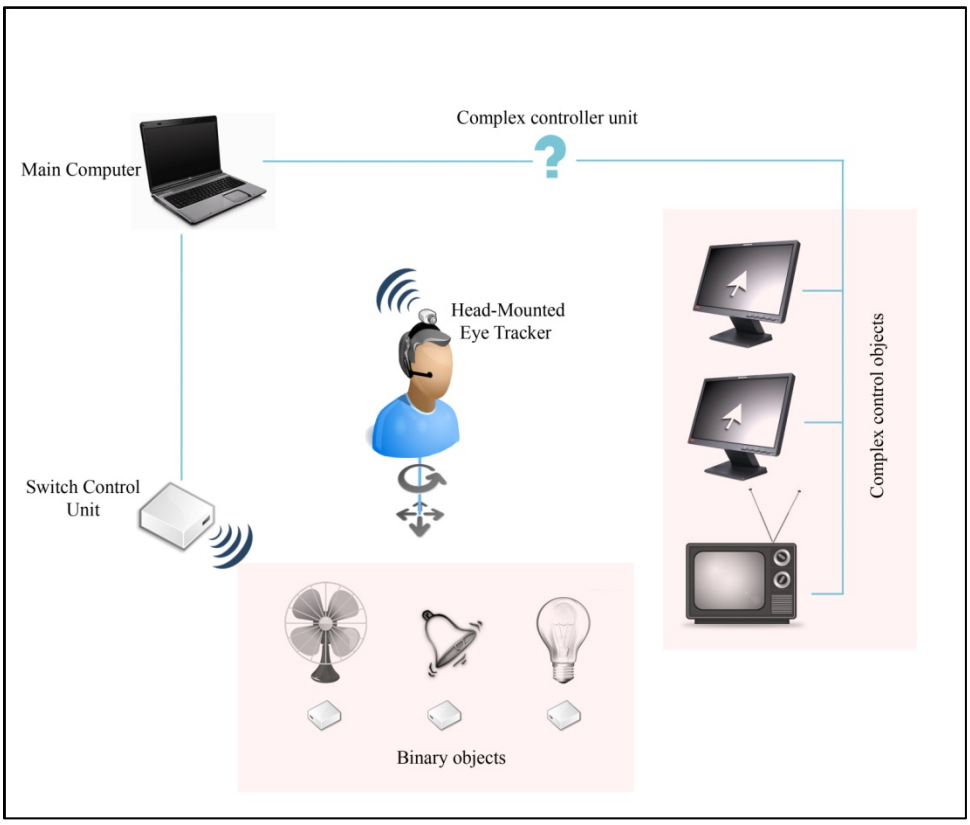

Figure 3: Schematic diagram of Gaze Environment control in ideal case

Gaze tracking and object recognition are the most important two parts of the gaze-based environment control.

However they also pose several challenges which can be addressed and categorized as follows:

Analysis of eye image: Which algorithms are fast, accurate and robust against the changes of environment light?

Gaze estimation: How to accurately map the eye position data to the scene image in front of the user is an unsolved research topic [Witzner & Ji, 2010].

Analysis of Scene image: Image from the scene camera needs to be processed in order to be able to detect objects in the scene. General object detection is a challenge but gaze may provide a means to speed up object detection.

Applications for domotic: How can interfaces for environmental control be designed.

The following sections detail these issues further.

Challenges and research questions

I will address the challenges and questions before discussing the main step of the thesis:

- An eye tracking process consists of two main parts: eye detection and gaze estimation [Witzner & Ji, 2010]. There are different methods for eye detection and the first question is which one is the best solution for HMGT. Fast and robust algorithms are needed while maintaining a good accuracy for pupil center detection. For example if we want to use a feature-based method, which algorithm can be used for pupil center detection. Additionally, a general weakness of many eye trackers is changes in the light conditions [Droege et al., 2008, Nguyen et al.,2002, Zhu et al., 2002]. These become even more challenging if eye tracker should be used in a standard household, where light conditions cannot be controlled.

- Imagine a user walking inside a house, looking at a lamp to turn it on, and then he will go a little further and turn his head to look at the monitor to interact with the computer. In this case, the eye, eye-camera, scene-camera and the scene can move relative to each others. The geometric relationship between them may be unknown have to be inferred through calibration [Lawrance & Eizenman, 2004].

- Regarding the hardware of the eye tracker, we have to design a light weight head-mounted system with a small eye camera and also a small scene camera. I will continue my research in HMGT to improve the techniques as well as keeping costs down. Additionally, I need changeable hardware for developing the algorithms and methods, and I need to adapt the HMGT for use in an intelligent house. I will investigate whether it is possible to transfer the video signals wirelessly to an external computer sufficiently fast. Having a wireless HMGT system gives the user more freedom to move inside the house.

- Controlling the objects in environment for example turning them on and off needs the controller unit. I will study how such a controller can be made. However, interaction with more than one monitor and also a TV is challenging.

- An important research topic will be to look into how the interaction between the user and software of the system can be done. For example when a user looks at an object, how can he be informed about it and possibility of controlling it. Different object types may require different types of interaction.

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