Gaze based interfaces and eye tracking system for Computer/Human interaction applied to AmI environments

Silvia Renteria , Artzai Picón, Ana Ayerbe
ROBOTIKER Infotech, Corporación Tecnológica TECNALIA, Parque Tecnológico, Edificio 202. E-48170 Zamudio (Bizkaia) (SPAIN).
{silvia, apicon, anayerbe}@robotiker.es
http://www.robotiker.com

Pedro Mª Iriondo
Systems Engineering and Automatics Department, Basque Country University
jtpirbep@bi.ehu.es

ABSTRACT

In the future, human-machine interaction will be based on the use of 'Virtual Senses'. Therefore, it is necessary to develop advanced interfaces able to interact with the user using new communication modes. This paper presents the development of an eye tracking system that will allow users full freedom of movements. The system will follow eye trajectory showing the coordinates of the point where the user is looking at and information about blinking and head position and rotation, enabling a gaze based interface for human-computer interaction.

Keywords

Eye tracking, AMI, advanced interfaces.

INTRODUCTION

Recent advances in the Information Technologies have had a great impact in the way we live, work and interact with our personal and professional environments through these technologies. Robotiker has been developing during almost one decade tech-nologies intimately related to Ambient Intelligence such as:

- Intelligent Interfaces.
- Digital Security.
- Biometrics
- Knowledge Technologies.
- Production of Software
- Wireless.

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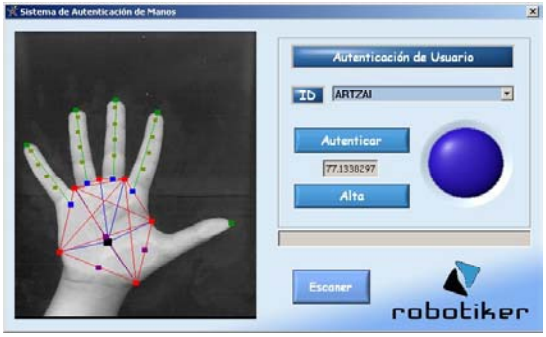

Fig. 1. Dual algorithm based hand recognition prototype integrated in an intelligent voice based interaction environment developed by Robotiker.

This Know-How allows Robotiker to integrate these technologies in the field of ambient intelligence.

Within the diverse forms of human communication, the sight, constitutes one of the most developed senses. Before acting, human beings observe their surroundings looking for elements to get information from the environment. The sight focuses in the interest object before deciding the action to take. The process to focus in an object in movement is, in the best situation, more than twice faster than the process using a classical electronic device such as a mouse.

Based on these premises, Robotiker and the Basque Country University are developing a system that approaches the analysis, study and development of a set of methods that will allow to locate and to follow the gaze of the user in order to receive information, to analyze their points of interest and to give back augmented information of the environment to the user.

OBJETIVES

This project proposes the development of an **eye tracking** system that can be used in a wide range of applications in the future.

The objectives of the project are as follows:

- To develop an **eye tracking** platform that allows user **full freedom of movements**.
- To follow **eye trajectory** showing the coordinates of the point where the user is looking at and information about blinking and head position and rotation.
- To develop a **multimodal human-machine interaction platform** based on eye tracking, that can be used in different domains.
- To develop a robust **biometric recognition based security system**, that works independently from the position of the subject using Face and Iris remote location.
- To study the **necessities** of enterprises and society in these issues.
- To introduce **new human-machine interaction** technologies that contribute to the improvement and increase of new applications and mobile services.

PROPOSED ARCHITECTURE

1- Eye Tracking devices

To develop this idea and to make possible the development of the previously described applications three types of possible systems have been identified:

- Environment integrated system
- Mobile system
- Combo systems

1.1- Environment Integrated System

The development of Ambient Intelligence environments needs to identify and locate the user so that context can be adapted to the necessities of the user.

This system allows the detection of **the head position(3D) and the detection and tracking of the eyes in intelligent surroundings** without restriction in the position of the user.

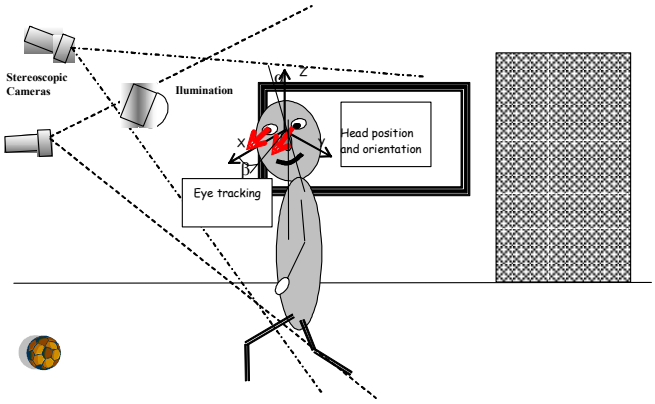

Fig. 1. Environment integrated system implementation

For the location of a face in a 3D space (position (x, y, z) and angle (α, β)) it's necessary to identify some face characteristic that allows to establish a head centred coordinate system. This is a complicate task and depends on the restrictions of the surroundings in which the face is located. For that reason in some cases marks or special illumination are used to minimize the fluctuations and variations in the external conditions.

1.2- Mobile System

There are some situations in which it is necessary higher resolution and speed for eyes location and tracking (for example in the case of disabled people who can use gaze driven language synthesizer). Therefore, some environments can not be supported by using global cameras or devices. In these and other cases it will be necessary to work with portable equipment.

The main developments of advanced portable/wearable equipment with visual interfaces have been carried out in the military and sport sector. The helmets of fighter and motor-race pilots include viewfinders that provide the information the pilot needs at every moment in a fast way. Some of them even determine the position of the head of the pilot

This project proposes the use of data acquisition and image processing systems within these advanced portable interfaces, that allow eye location and tracking **with high accuracy in real time** and identification of elements such as fast glances, blinking…

For this purpose, a wireless portable module will be developed to allow **total mobility of the user**. It will consist of sets of sensors for the detection of the pupil and external visualization, illumination and user interface systems.

In order to avoid sensors interfering with the user's field of vision, it will be necessary to develop specific elements to integrate within the portable equipment (for example within the frame of the glasses) or wireless mini-camera in

the lateral zones. The obtained images will not be natural images and will appear deformed as they will be obtained at a very small distance range or because matrix cameras are not used.

Therefore a specific software module must be developed to determine and follow the eye pupil, locate the exact focused point, and return the data to the user using a visualization integrated module.

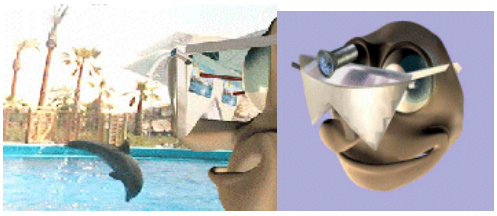

Fig. 2. Mobile System Implementation

The cameras must be placed in fixed points of the environment so that no interferences with other objects are made, to avoid problems when integrating them with other systems (face recognition, security systems in driving…)

1.3- Combo System

The previous systems cover most of the detected needs. However, they offer the possibility of a combined use that would allow a greater number of situations to be covered, as well as a higher advantage of the results.

High accuracy real time eye detecting and tracking will be achieved, as well as the position of the focused object in absolute coordinates. In order to achieve this the system will combine the information of the portable equipment indicating the position of the eye pupil relative to the user's face and the absolute position using 3D detection of the position of the user.

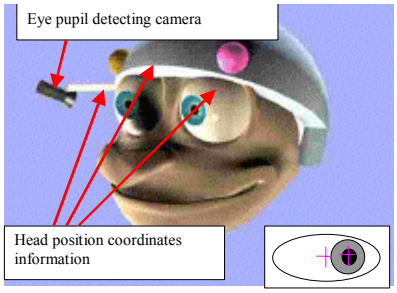

Fig. 3. .Combo System Implementation

The use of this kind of systems is specially interesting in:

- Zones where the position of the pupil or the location of the user cannot be determined from an outer point due to bad conditions of illumination.
- Situations in which the user is located in a very vast area or in a crowded environment where the positioning of many cameras is expensive or unsuitable.

The system architecture is as follows:

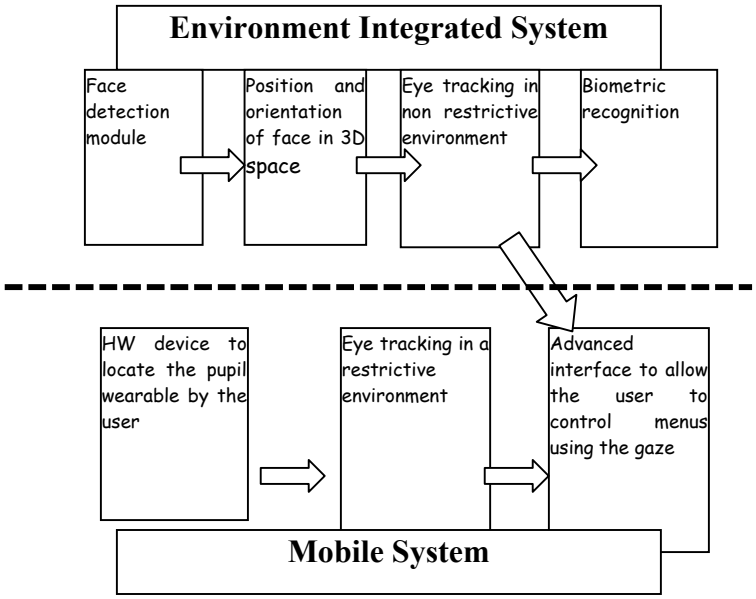

Table 1. System Layout

1- Control Interfaces

For the different use cases and systems several interaction methods are being developed to allow users to use their gaze as an instrument to communicate with the environment

For that reason, it is necessary to implement a multimodal **interface** of **Human/Machine interaction**, based in gaze tracking.

It's necessary to identify the accuracy, usability and restrictions of this type of interfaces for different applications.

It's also needed to establish standard models and architectures for man-machine interface based on the gaze (not WIMP - Windows, Icons, Mouse, Pull-down menus)

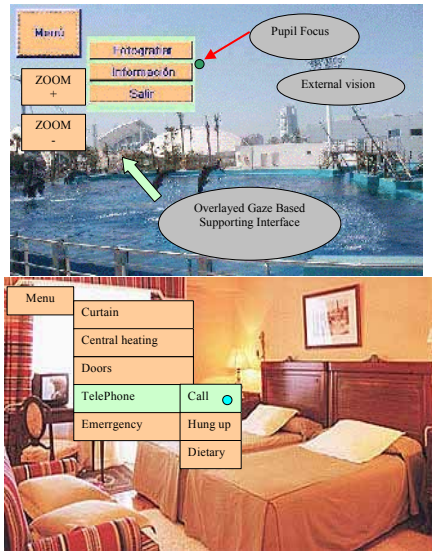

Fig. 4. Possible format of pupil controlled interface for different scopes of application. First as augmented reality support. Second as a home appliances control for disabled people.

APPLICATIONS

The system supports a wide range of applications such as:

Attention analysis: special education, drivers and workers behaviour, marketing, study of consumers (knowing where the user is looking at, it is possible to know their points of interest and attention).

Supporting for increased virtual reality: since the field of view is limited, the system allows to select the areas of interest of the user, and to show them with greater detail and show additional information of the area he is looking at.

Advanced Interaction: equipment for people with physical coordination problems or communication difficulties, like people with paralyses that can use eye movements to communicate. They could use a portable system that would analyse the movement of their eyes and convert these movements into spoken words.

Non-intrusive biometric system supporting: one of the present limitations of biometric identification systems, is the necessity of users explicit collaboration: in an iris biometric system, the user must place position near the acquisition device in order to be identified. If then position of the eyes could be located within the general environment, a zoom camera could focus the zone of the eyes with higher resolution for iris recognition.

Interaction with information systems: on logistic and transport, the system can provide information of delivery time, contents and other information about the elements the user is looking at.

Mobile advanced interaction: in special environments with accessibility problems: rescue teams, medicine….

CONCLUSIONS

- New interaction technologies are being developed to provide fast growing of new applications and services in Ambient Intelligence environments to support the enterprises and society needs in this field.

- An eye tracking and interaction platform is being created to allow users to move without restrictions while interacting with the system.

- A multimodal Human/Machine interaction platform is being designed to create a gaze based language

- Eye detection in the environment integrated system can support biometric platforms to perform identification without user collaboration.

REFERENCES

1. R. Cipolla, A. Pentland. Computer Visión for Human-Machine Interactions. Cambridge University Press. 1998
2. Cootes, TF Taylor, C "Locating Objets of Variying Shape Using Statistical Features Detectors" 4th European Conference on Computer Vision. Vol 1pag 465-474 1996
3. Graf, H.P., Cosatto, E ."Multi-Modal System for Locating Heads and Faces" IEEE/ 2. Int. Conf. on Automatic Face and Gesture Recognition. 1996
4.. A. Haro, M.Flickner, and I.Esaa. "Detecting and tracking eyes by using their physiological propertier, dynamics and appearance." In IEEE CVPR (2000).
5. Samah Ramadan, Wael Abd-Almageed, Christopher E. Smith, "Eye Tracking using Active Deformable Models" (2002).
6.. C. Ware and H.T. Mikaelian, ''An Evaluation of an Eye Tracker as a Device for ComputerInput,'' Proc. ACM CHI+GI'87 Human Factors in Computing Systems Conference pp. 183-188 (1987).
7. L.R. Young and D. Sheena, ''Survey of Eye Movement Recording Methods,'' Behavior Research Methods and Instrumentation 7(5) pp. 397-429 (1975).
8. Yow, K Cipolla, R. "A Probabilistic Framework for Perceptual Gouping of Features for Human Face Detection" IEEE/ 2. Int. Conf. on Automatic Face and Gesture Recognition 1996