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Mouse Navigation Control Using Head Motion

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Abstract: As there is great advancement in the technology in recent years, there has been much improvement in various fields of computing such as Human Computer Interface (HCI), Computer Vision and Perceptual User Interface (PUI). Input to the computers has sensed information about physical properties of user, places, or things. For example, computer mouse operates by motion imparted by user's hand. Many active researchers have been working on finding an alternative solution to control computer mouse like by using finger, eye, hand/palm, marked gloves etc. These all techniques may not be suitable to physically disabled people. This paper introduces how head motion of user can be used to control the mouse cursor. A way to create an application which replaces the input device mouse by using face of the user is proposed. Since face/head is primary part of human body. We introduce a face detecting system which precisely record the motion parameters from video at real-time. According to the head movement the cursor is navigated on computer screen. The mouse clicks are performed only if the user does not move cursor for specified time. This method thus ignores the use of other facial features which are difficult to track under certain conditions. For example, in eye tracking if the user is wearing spectacles it becomes difficult for camera to track the movement of eyes in low light condition. This method can be considered as an alternative way of controlling mouse for users with hand disability and can also be used for motion control games and simulation.

Keywords: Face Detection, Human Computer Interface, Computer Vision, Face Tracking, Mouse Control

I. INTRODUCTION

Recent development in the field of Computer Vision, Human Computer Interface (HCI), Gesture Recognition and Perceptual User Interface (PUI) has provided a way to make human life better. Nowadays we try various possibilities for interacting with computing device, instead of our traditional input devices, like keyboard and mouse. Today computers are becoming faster and more reliable, so it is possible to introduce an alternative solution to control computers.

This can be possible my making computers to capture the human's movements or perceptual behaviours [2]. It can be done by tracking down the movement made by human body by live video feed, which computer understands and interprets it into action or response. This technology is referred as perceptual user interface technology.

The HCI and PUI involves interaction with humans, so the computing devices needs to be efficient, reliable, secure and should provide fast performance to withstand various challenges. The most important part is the tracking of user's movement with a traditional normal webcam which records the user's movement and convert them to computer operations. The framework can be illustrated by Fig. 1.

Thus it provides a simple alternative way to control computing devices. It will also allow physically disabled people to access computer for various purposes. Thus it serves as assistive device to help disabled people. Also this system does not need to wear or use reflectors, or infrared devices, markers, etc [12]. This may be problem to some users [2]. Apart from helping disabled, it can also be used by general users for many things like interactive computer games; machine guided gymnastic, robot control, simulation.

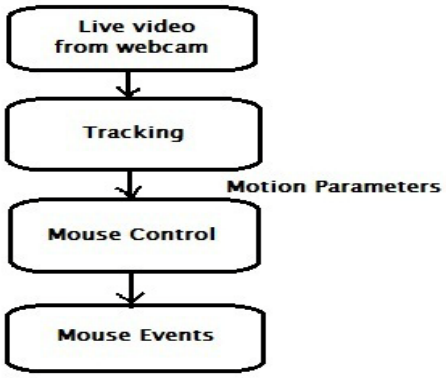

Figure 1. The Framework of the System

Head motion based mouse tracking system is a PUI which tracks the face movement in live video to move the cursor. Since head and face of human appears to be perfect part of body to track, and is perfect solution to hand-free computer interaction [10]. The progress in the field of face detection

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and tracking and improvement over the system hardware and software methodologies have made it possible to create a fast, reliable performing tracking system on computing devices[2]. Some commercial products have been also developed in recent years [4][5][6].

In past few years, many computer scientist and researchers have proposed a technique to move cursor and initiate clicks by movement of eyes, nose, face, nostrils[1][8][9]. Some use Infrared cameras are used for eye tracking, since human eye has infrared light reflectors. [1] proposed a technique in which 3D curvature of the nose makes the tracking more robust and highly accurate and for nostril tracking, the nostril can be identified by its dark colour and unique shape. All these systems require fast tracking, which allow users to control the mouse cursor comfortably. In head motion based mouse tracking the face is tracked, to track down the face movement we must first detect face, there are still some existing face detection algorithm, and methodologies which does not provide desired solution, or results with precision[11]. However, the [3] proposed a robust real-time face detection framework that is capable of processing images/videos rapidly with high detection rates. This method has three main key features 1. Introduction of new image representation called "Integral Image" which helps in allowing the features used by detector to be computed real quickly. 2. Simple and highly efficient classifier which is built using the AdaBoost Learning Algorithm. 3. Combining classifiers in a cascade which discards unnecessary features and concentrates on highly possible face like region of image.

II. METHODOLOGIES FOR DETECTING FACE

A. Robust Real-Time Face Detection:

In this method [3] images are classified based on their values of simple features. In simple word, these features are somehow similar to Haar basis functions. More specifically, lets use three kinds of features. First, the two-rectangle feature which is the difference between the sums of the pixels within rectangular region. The region is having same size and shape and is adjacent vertically and horizontally. Second, the three-rectangle feature which computes the sum within the two outside rectangles subtracted from the sum of center rectangle. Third, a four-feature which computes the sum between diagonal pairs of rectangles (see Fig. 2).

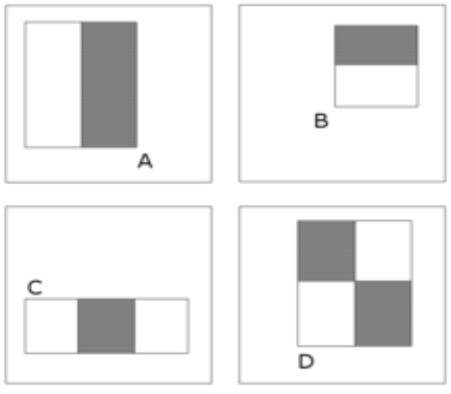

Figure 2. Rectangle Features

Rectangle features can be computed rapidly by using an integral image which is intermediate representation of image. Consider Fig. 3

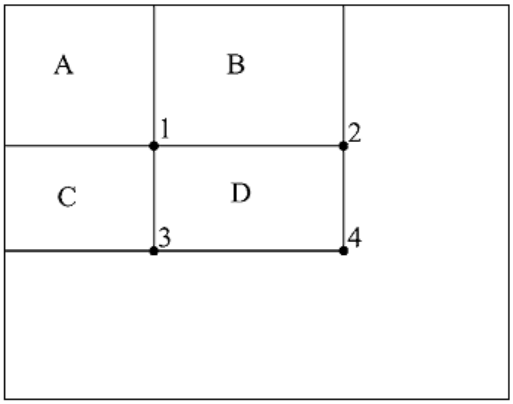

Figure 3. The sum of the pixels within the rectangle D can be computed with four array references. The value of the integral image at location 1 is the sum of pixels in rectangle A. The value at location 2 is A + B, at location 3 is A + C, and at location 4 is A + B + C + D. The sum within D can be computed at 4 + 1 – (2 + 3).

The evaluation of the strong classifiers which are generated in the learning process can be done quickly, but it isn't enough to run in real-time. For this same reason the strong classifier are arranged in cascade architecture, where each classifier is trained only on those which pass through predicting classifiers. If at any moment the classifier rejects the sub window under inspection, no further processing is done and it is continued for next sub window (see Fig. 4).

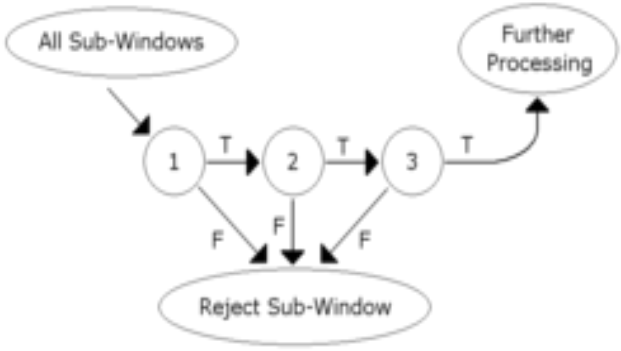

Figure 4. Cascade Architecture

The cascade therefore has the form of degenerate tree. In case of face, the first classifier in the cascade uses only two features to get false negative rate of 0% and false positive rate of 40 % [3]. This is done to reduce by half the number of times the entire cascade is evaluated.

The Cascade architecture has some interesting features regarding the performance of the individual classifiers. The activation of the classifiers entirely depends upon its predecessor. To match the false positive rates typically achieved by other detectors, each classifier can get away with having surprisingly poor performance. However, each classifier needs to be exceptionally capable if it is to achieve adequate detection rates.

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B. Model-Based Approach:

In model based approach [13] a model is used which describes the appearance, shape, and motion of faces to aid in estimation. This model has a number of parameter which specifies information about the shape of the resulting face and some describe its motion. Consider (Fig. 5)

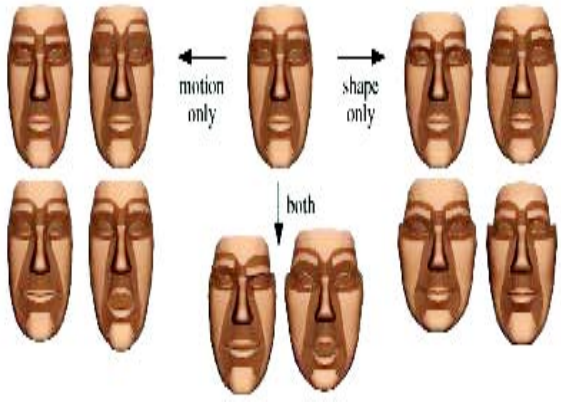

Figure 5. A model of Face

The Figure shows a default model (at top-center) can be made to look like someone by changing the shape parameters. It can also be used to display facial features like eyebrow frowns, raised, a smile, open mouth, etc. Just by changing features parameters. It is also possible to simultaneously change both shape and motion parameters. But the question arises how this approach can be accurate enough to detect face of a particular person? The answer is: it is not possible, but it will be represent any of the faces to an acceptable accuracy.

C. Face from Colour Images:

As [13] we know every colour image is composed of three primary colours Red (R), Green (G), Blue (B). These three colours are considered as the basis for the RGB-colour-space. So, colour which we perceive can be defined by a vector in the 3-Dimensional colour-space.

In this grayscale image is used, grayscale image is a image in which only shades of gray colour are present. The grayscale image requires less number of information for each pixel. As, the grayscale intensity is stored as an 8-bit integer with 256 different possible shades of gray from black to white, 0 is black colour and white is represented as 255.

This is done by:

$$\text{Grayscale} = 0.299 * R + 0.587 * G + 0.114 * B$$

After conversion of image to grayscale image, the image is segmented. Image segmentation is a process to divide an image into parts such that they have a strong correlation with the objects or areas present in the image. The image segmentation helps in detecting the face in a video. After this the important features from face is extracted which helps in tracking of mouse cursor.

From above three methods Robust real-time face detection is most suitable as it is most widely used method for real-time object detection. Training is slow, but detection is very fast. Our system uses OpenCV's face detector which is based on same method. This algorithm is implemented in OpenCV [7] as cvHaarDetectObjects().

III. MOUSE TRACKING

The Graphical User Interface (GUI) captures the live video from webcam and tracks the motion of head/face. The Mouse Tracking module is responsible for reading the motion parameters and translating them into mouse movement on computer screen. The conversion from human motions to move mouse cursor falls into three different categories direct mode, joystick mode and differential mode.

a. In direct mode, a one-to-one mapping from motion parameter domain to screen coordinates is established by calibration done.
b. In joystick mode, the cursor is moved by directions, such as left, right etc or by the sign. The speed of the cursor movement is determined by the magnitude of motion parameters.
c. In differential mode, the total cumulative of the distance covered by the cursor movement and some other motion parameters switches on/off the cumulating mechanism so that the motion can be reversed without affecting cursor position. This is similar to standard mouse mode. After the cursor is moved to a particular location, the mouse operations/events are executed, like mouse button clicks; according to user's motion parameters. Various mouse events (see Table 1)

Table 1: Mouse Event and Description

Mouse Event	Description
Click	Left and right mouse button click.
Move Cursor	Vertical, horizontal and diagonal movement.
Point	Up and down tuning, localization

User will use only the head/face motion to control computer cursor and initiate clicks. The application consists of GUI with start/stop buttons. When the user clicks on start button, the webcam will start capturing the live video and the algorithm will detect face in the video. After the face is detected, a classifier will be drawn around the face

And as the face moves the cursor will also move accordingly. For example if the face moves in upward direction, the mouse pointer will move up, and similarly if face moves in right direction the cursor will move towards right The GUI also consists of always on top window form with several buttons on it like Single click, Double Click, Right Click, Drag Click etc. User will select one of these operations by moving the cursor on one of the buttons. By default, single click is activated, now user is free to move cursor anywhere on desktop by using head motion and if user stops at particular point on screen for specific time then single click will be done. Now say a user want to execute a file with double click then the user will move the cursor on screen using head motion to taskbar button named ' Double Click' since single click is activated, so when user holds the cursor on double click button for specific time 'Double click' will be activated and now single click will be deactivated. Double-click will be activated until user stops the head movement at a point for particular time (see Fig. 6).

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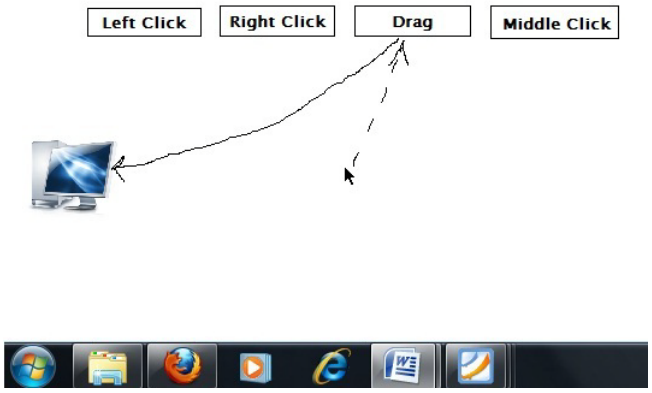

Figure 6. Representation of mouse clicks.

Dotted line represents the movement of cursor before click activation. The user moves the cursor to drag click button waits there for specific time then drag button gets activated and then the user moves the cursor (thick line) to desktop icon to execute/select files or folders. After drag click again single click will be activated. But what if user wants to move freely without any clicks on desktop? For that taskbar will have 'No-Click' button which will enable user to move freely without clicks on desktop. Clicks and their functionality:

a. Left Click: Allow selecting files or folders on computer screen.
b. Double Click: Execute or run the selected file.
c. Right Click: Display the drop down menu.
d. Drag: Left Click Down, which allows drag/move file.
e. No Click: Allows mouse pointer to move free, without any clicks.

IV. CONCLUSION AND FUTURE ENCHANCEMENT

In this paper, we researched various ways of camera mouse techniques. We indentified the problem domain and a alternative solution to it. We proposed to use face/head motion to control the movement of mouse cursor. We believe that our system can be alternative solution for future computing devices, such as PDA, Tablet, Laptops, and GPS. It may also inspire various PC based application like gaming, entertainment, robotics, etc. It may also help the disabled and elder people with less motion ability to access computer comfortably.

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