# Mouse Replacement Solutions for People with Disability in Movement: A Survey

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***Abstract :*** This paper examines various mouse replacement solutions designed and developed for the people with disability in movement, who have not yet received a fair chance like others to incorporate themselves in the world of Information Technology. Their mobility impairment makes them difficult to use the keyboard and mouse, the standard input devices of a personal computer. Many mouse replacement solutions had been proposed in the past three decades. Few solutions rely on specially designed hardware and software and can be used only for specific and very limited applications. Most of the mouse replacement solutions were driven by high-cost hardware system and most of the solutions require special hardware that enable the user to operate by usually wearing on and operating through the face or head. To reduce those overhead, user's head motions captured with a web camera are used to control the mouse pointer. Naturally people look at the object they wish to interact with; and to accurately estimate what a user is focusing on the computer screen, user's gaze direction should be tracked and not just the eye movements. Many systems use speech recognition to provide a simple and easy-to-use user interface to map the mouse click events. Few camera based mouse replacement solutions had implemented mouse click events such as single-click, left-click, right-click, double-click and dragging events. This survey on mouse replacement solutions for people with disability in movement paves the way for identifying the future directions for research and development**.**

***Index Terms* - Alternative mouse, assistive technology, hands free computing, gesture recognition, user interface, disabled users.**

## I. INTRODUCTION

As per Census 2011, in India, out of the 121 Cr population, about 2.68 Cr persons are 'disabled' which is 2.21% of the total population. 20% of the disabled persons in India are having disability in movement, which is about 5.4 million. Disability in movement includes the persons who do not have both arms or both legs; or are paralysed and are unable to move but crawl [1]. Today, Computer has influenced our life at greater extent and it's very hard to imagine the world without computers. People with disability in movement have not received a fair chance like others to incorporate themselves in the world of Information Technology. But they deserve for any assistance to achieve their inclusion in the Information society. Their mobility impairment makes them difficult to use the keyboard and mouse, the standard input devices of a personal computer. It's highly desirable to develop Assistive Technologies enabling them to use standard personal computers and many attempts have been made to meet the requirements. On-screen virtual keyboards can be used to emulate the physical keyboard and thus a pointing device mouse is adequate to use the computer with GUI software. Though variety of operations is introduced through mouse, the following and their combinations allow operating the GUI based computer: Cursor movement, Left Click and Right Click.

## II. SPECIAL HARDWARE AND SOFTWARE

Many mouse replacement solutions had been proposed in the past three decades. Few solutions rely on special hardware and software designed specifically for the people with disability in movement. Hutchinson et al. [2] designed a unique prosthetic device called the eye-gaze-response interface computer aid (Erica), a stand-alone workstation specially adapted with imaging hardware and software.

## III. VERY LIMITED APPLICATIONS

Few solutions were developed that can be used only for a specific and very limited applications. Takami et al. [3] proposed a computer interface device and image processor called environmental control system to control the switching of the electrical devices like TV, radio, lights and so on through the movements of the eyeballs and head.

## IV. HIGH-COST HARDWARE SYSTEM

Most of the mouse replacement solutions were driven by high-cost hardware system. For instance, Morimoto et al. [4] presented an eye gaze tracking system and quoted around US$20,000 (Oct/97) which was claimed as low-cost.

## V. HEAD-MOUNTED DEVICES

Most of the mouse replacement solutions require special hardware that enable the user to operate the computer by usually wearing on and operating through the face or head. Gips et al. [5] developed a system that allows the user to control the mouse cursor on the screen through five electrodes placed around his eyes. Lacourse et al. [6] developed a system for persons with only eye motor coordination called discrete electro-oculographic control system (DECS) where electrodes are placed around the user's eyes to record the polarization potential or corneal-retinal potential (CRP) of the eyebulb. In the system proposed by Soochan et al. [7], the user has to wear the goggle equipped with infrared sensors; the rotation of the user's head is estimated using the gyro sensor which is used to control mouse points; and the mouse events such as clicks/double clicks were detected using opto-sensors that can detect the blinking of the eyes. In the system proposed by Takahashi et al. [8], electrodes array is attached on the user's skin surface of anterior neck region to detect the left, right, up and down movements of the tongue that correspond the respective mouse cursor movement directions; and forward motion of the tongue that corresponds the mouse click action. Koichi [9] proposed a pointing device that is driven by tooth-touch sound and expiration signal where the bone conduction signal collected by a bone-conduction microphone, that the user wear, is utilised for clicking operation of the mouse; and the expiration signal gathered by piezo-film sensors is used to control the mouse cursor position. In the WiiMS system by Sylvester et al. [10], the user must wear IR glasses with two LEDs to track the user's head position for implementing the cursor movements and a pair of head phones with a microphone to implement the events of mouse buttons and keyboard. Chen et al. [11] developed the infrared-controlled human–computer interface for the disabled that utilizes infrared-transmitting module mounted on the user's eyeglasses. This system also comprises an infrared receiving/signal-processing module and a main controller. Evans et al. [12] presented a design of a head-operated joystick that uses infrared light emitting diodes (LED's) and photodetectors to determine head position, which is subsequently converted into signals that emulate a Microsoft mouse. Barreto et al. [13] designed and developed an alternate input device to control the mouse functions by producing EMG signals from muscles on the head through four bioelectrodes placed above pericranial muscles and above the occipital lobe of the cerebrum. In the improved version of Takami et al. [14], the user has to wear a special glass with three LED marks.

## VI. HEAD-MOUNTED EYE GAZE TRACKING

To witness more advancement in the head-mounted technology used for replacing physical mouse, few solutions tracked the movement of eye gaze to control the mouse cursor on the screen. Craig et al. [15] in their system, based on Eye Gaze Tracking (EGT) and electromyogram (EMG), placed EMG surface electrodes on the left and right temples, forehead and in between the eyebrows for hands-free control of the computer cursor. Lyons et al. [16] in their system, based on infrared-video Eye Gaze Tracking (EGT), placed three electrodes in the forehead, on the left side of the head, and on the right side of the head to develop a hands-off human-computer interface. Kocejko et al. [17] proposed an eye gaze tracking system that consists of two cameras, infrared markers and few electronic components that are attached to the head of the user by means of the glasses-frame. In the system by Arai et al. [18], the IR camera is mounted on user's glass to find the location of pupil; estimate the position where user is looking; and control the mouse cursor. Robert [19] proposed an Internet access technique that controls the cursor from eye gaze input through head mounted eye tracking system that is represented by a pair of video glasses and an infrared web camera directed towards the user's eye.

## VII. CAMERA AS A MOUSE

To reduce the overhead of using high-cost hardware system and head-mounted devices, user's head motions captured with a web camera are used to control the mouse pointer. Betke et al. [20], in their system "Camera Mouse", tracks various movements of the computer user such as the tip of the nose, eye tracking, lip tracking or any feature selected by the attending care and translates them into the movements of the mouse pointer on the screen. Akram et al. [21] presented an improved mapping strategy on the same that allows translation of minimal feature movement to pointer movement. Connor et al. [22] overcome the occurrence of insufficient matches in Camera Mouse, when the user move quickly or move out of the camera's field of view, by recognizing the missing feature and resume tracking the originally selected feature. Also, Epstein et al. [23], to address the problem of feature loss when the tracked image patch drifts away from the initially-selected feature or when a user makes a rapid head movement, developed and incorporated a system that tracks the facial features without feature drift, even during rapid head movements and extreme head orientations. John et al. [24], understanding the users with disabilities may not be able to comfortably hold their heads in a vertical position, proposed an adaptive system other than just horizontal and vertical movements for mapping the head movements with mouse pointer. Also Palleja et al. [25], Kim et al.[26] and Frank et al. [27] translate the user's head movements to on-screen mouse pointer movements. Nabati et al. [28], Zhu et al. [29], Kumar et al. [30], Woramon et al. [31] and Manresa [32] presented an approach for controlling the mouse pointer by detecting and tracking of face area. Jilin et al. [33] introduced a 3D model where the head orientation and translation are retrieved and employed to navigate the mouse cursor. Javier et al. [34], Chathuranga et al. [35], Bian et al. [36] and Gorodnichy et al. [37] used nose as a mouse cursor because of its prominence and convex-shape; and the nose feature can be seen at all times during the interaction with the computer screen. Mohamed et al. [38] proposed a system where the tip of the nose is selected as the mouse pointer. Vasanthan et al. [39] implemented the mouse cursor movement and click event through a set of five facial expressions namely left and right cheek movement; eye brow rise and down; and mouth open by placing a set of four luminous stickers at user's left cheek, right cheek, mouth, and centre of forehead. Chairat et al. [40] detected the centre of eye-pair for mapping with the mouse coordinates in computer screen. Gyawal et al. [41] controlled the mouse cursor using the movement of the user's face addressing the limitations such as lightening problem and unexpected movement of the face. Parmar et al. [42] defines a method for tracking the 'between the eyes' template and nose tip that can replace mouse movement. Morris et al. [43] uses the position of the nostrils relative to the face region to control the position of the cursor. Eric et al. [44] locates the tracking point near the upper lip and used to control the location of the mouse pointer.

## VIII. EYE TRACKING

Naturally people look at the object they wish to interact with. Hence moving the mouse cursor based on eye movement is more effective than tracking the head movement and other parts of the head or face. Yunhee et al. [45] and Fathi et al. [46] proposed the interface systems where the mouse cursor movement is implemented based on the user's eye movement. Kim et al. [47] proposed an eye tracking method to receive user's eye as an input signal to control a computer. The "Camera Mouse" by Betke et al. [20] and its customized versions Akram et al. [21] and Connor et al. [22] have achieved some success in tracking the facial features including eye, but not to the extent of determining gaze direction.

## IX. Eye Gaze Tracking

To accurately estimate what a user is focusing on the computer screen, user's gaze direction should be tracked and not just the eye movements. Eye gaze pointing is a very spontaneous means of pointing and almost no training is required for the user. Magee et al. [48] presented a system where the left and right eyes are compared to determine if the user is looking center, or to the left or right side. Sugano et al. [49] presented a method that learns the gaze direction by capturing the images when the user clicks a mouse button and used to predict gaze positions during the prediction stage. But this method is not suitable for the people with disability in movement. Uma et al. [50] segmented the iris part from the entire eye image, using a camera on which the infrared light source is mounted or an USB camera mounted close to the eye, to determine the gaze direction. Valenti et al. [51] estimated the visual gaze of a user by taking into account the joint head pose and eye location information. But the system finds the following drawbacks: moving the cursor from a point A to a far away point B was more difficult, as the system might have diverted to wrong paths; smooth cursor movements on the monitor was not possible, instead the users experienced direct jumps of the cursor to the gazed locations.

## X. Speech Recognition for Mouse Click Events

Many systems use speech recognition to provide a simple and easy-to-use user interface to map the mouse click events such as WiiMS system by Sylvester et al. [10] and Frank et al. [27]. In the system by Chathuranga et al. [35], the microphone captures the voice of the user and detects the voice commands which are used to issue mouse actions such as click, double click and right click.

## XI. Camera based Mouse Click Events

Few camera based mouse replacement solutions had implemented mouse click events such as single-click, left-click, right-click, double-click and dragging events. Betke et al. [20], in their system and in its customized versions Akram et al. [21] and Connor et al. [22], a mouse click is generated by the driver and received by the application program if the user keeps the mouse pointer within a specified radius for a fixed time. Yunhee et al. [45] and Bian et al. [36] implemented clicking events based on user's mouth shapes, such as opening/closing. Vasanthan et al. [39] implemented the mouse click event by user's smile i.e., moving both the left and right cheeks. Veena et al. [52] developed the blink detector that detects the user eye blinks when the person is static in front of the webcam. Kim et al.[26], Parmar et al. [42], Michael et al. [53], Gorodnichy et al. [37], Mohamed et al. [38], Fathi et al. [46], Zhu et al. [29], Kumar et al. [30], Woramon et al. [31] and Javier et al. [34] presented the systems that detect the user's eye blinks and analyzes the pattern and duration of the blinks; using them to provide input to the computer in the form of a mouse click. Chairat et al. [40] replaced the left and right click mouse events by blinking the left eye and right eye, respectively. Palleja et al. [25] uses unnatural blink of the eyes, opening the mouth and raising the eyebrow to generate the mouse click events. In the method proposed by Nabati et al. [28], when the users keep his/her face closer to the camera with a distance less than min_distance for more than 0.5 s, the left click event is generated. The same procedure is used to generate right click event if the distance is larger than max_distance. Jilin et al. [33] chose the detection of mouth opening to trigger the left-button-click event and the detection of mouth corner stretching to trigger the right-button-click event. Arai et al. [54] replaced left click mouse event by stopping the cursor position in the required location for specific duration and right click event by blinking. The drag / drop events are implemented by adding a drag / drop button in the screen keyboard where the first click is recognized as drag event and next click is recognized as drop event. Eric et al. [44] allowed complete use of a typical mouse, including moving the pointer, left and right clicking, double clicking, and click-and-dragging for users who can control head movements and can wink with one eye while keeping their other eye visibly open.

## XII. Conclusion and Future Direction

The survey on mouse replacement solutions for people with disability in movement paves the way for identifying the future directions for research and development. To reduce the overhead of using high-cost hardware system and head-mounted devices, web camera based solution is endorsed. Naturally people look at the object they wish to interact with. To accurately estimate what a user is focusing on the computer screen, tracking user's gaze direction is highly desirable. Tracking the user's eye gaze accurately is identified as a research challenge and opportunity. Implementing mouse click events through speech recognition system has several limitations such as it is inaccurate; requires special high-quality headsets with microphones; always has to make the voice clear and easy to understand; cannot use this system in noisy environments; and may not work well for people who have very heavy accents. Hence, the camera based mouse replacement solutions are highly recommended. Using eye wink/blinks for click events detection is highly natural especially if eye gaze tracking is used for controlling the mouse cursor. Recognizing the approximate single-eye wink of different users with different head pose paves the way for another research challenge and opportunity. Soft computing techniques such as fuzzy logic and neural network can be used to improve the efficiency of the mouse replacement solutions in necessary decision-making and predictions.

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