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Object Acquisition and Selection in Human Computer Interaction Systems: A Review

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Abstract: Object acquisition and selection are two important functions performed in most of the human computer interaction systems. Various techniques are devised by the researchers to perform these operations and the selection of a combination of object acquisition and selection techniques along with a feedback mechanism for a particular interaction system has become a research issue, especially, when the user of these systems are disabled persons. This paper presents a review on object acquisition and selection techniques used in human-computer interaction systems. The review process reveals that the existing object acquisition and selection techniques are not free from the problems of cursor instability, accuracy, response time, Midas-Touch problem, user fatigue, and the cost of commercially available eye-gaze trackers. It has also been observed that most of the interaction systems are available with mouse left-click feature. But, if we want to completely imitate the functions of a computer mouse then the interaction systems should provide all the mouse analogous operations including left click, right click, double click, drag & drop, cursor control, and page scrolling.

Keywords: *Human-computer interaction systems, object acquisition, object selection, mouse analogous operations, disabled users*

1. Introduction

Human-computer interaction (HCI) is a multidisciplinary field which deals with the design of new interaction techniques and enhancement of the usability and performance of existing HCI systems. A human-computer interface allows a user to connect with a computer naturally and more effectively. The research of designing user-friendly human-computer interaction systems has increased dramatically during past couple of decades and the focus of this research remains to design HCI systems not only for technical users but to devise HCI systems which can be efficiently used by non-technical and disabled users as well.

Like any system, a human computer interaction system has an input, an output and an algorithm that translates the input to output. The input can be in the form of pressing a button on a keyboard [1], mouse movement [2], audio signal [3], through images/video [4], physiological signal [5, 6] etc., and the output can be cursor movement [7], letter or icon selection [8], or another form of device control [9]. The system also provides a feedback in the form of audio and/or visual form so that the user or HCI system can adapt to optimize the communication.

Most of the HCI systems perform at least two important functions: object acquisition and object selection. Object acquisition means bringing the mouse cursor/focus on the object of interest. It refers to the process of reaching the target object through suitable target acquisition technique and it is a basic operation which is performed most frequently. Object selection means activating the selection trigger when the object of interest is having the cursor/focus. From object acquisition and selection point of view, HCI systems can be classified as [10]:

- Command Line Interfaces (CLI)
- Graphical User Interfaces (GUI)
- User interfaces specially designed for differently abled and aged persons according to their capabilities and needs

In either type of HCI, our goal remains to find the object of interest and perform selection by using suitable selection means. In a CLI, tab key is repeatedly pressed to move focus from object to object and selection is generally performed by pressing enter key. In a GUI, a mouse is operated to navigate and select an object. The mouse cursor is brought over object of interest and its selection is performed by pressing mouse left button.

Both CLI and GUI interfaces require some physical effort to acquire and select an object. But, sometimes a situation arises, in which, for a person performing physical efforts becomes difficult or impossible. In such conditions, a user can interact with computer by using other means such as speech, gestures, eye gaze & blinks, EMG signal, EEG signal etc. These types of interfaces may be called as specialised HCIs because these interfaces are designed by selecting input-output parameters according to the physical condition of a user. In these systems a user requires minimum or no physical effort to select an object. Further, these specialized interfaces may be classified as:

- **Physiological parameters based interfaces** measure certain physiological parameters of the user and object selection is performed after extracting features from the measurements.
- **Vision based interfaces** in which a camera tracks continuous movement of the user in the form of face motion, hand gestures, eye movements etc. and the computer takes decision accordingly regarding selection of an object.

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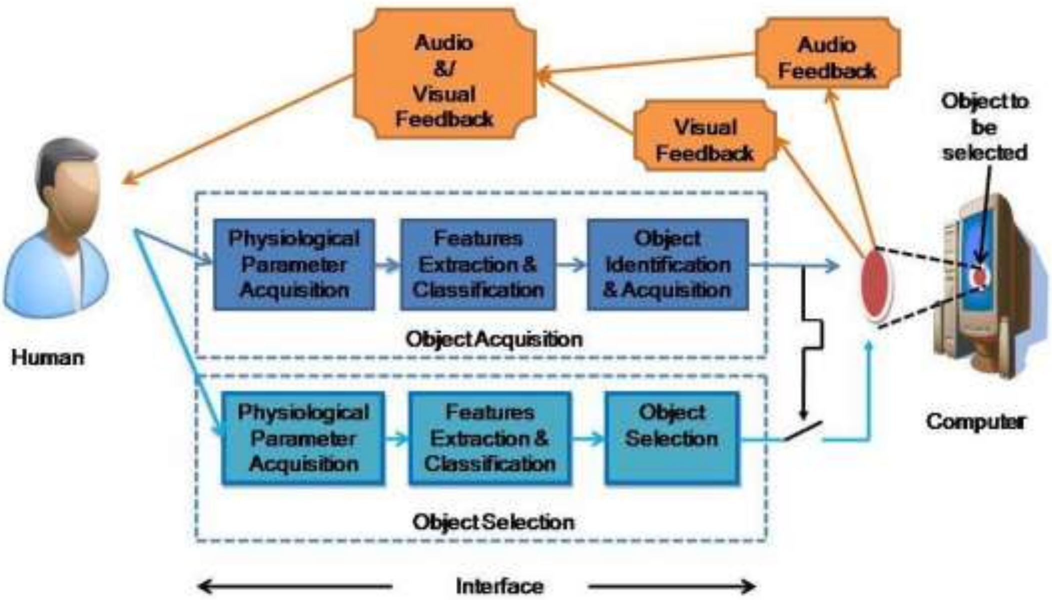

Figure 1 Generalized architecture of a physiological parameters based HCI system

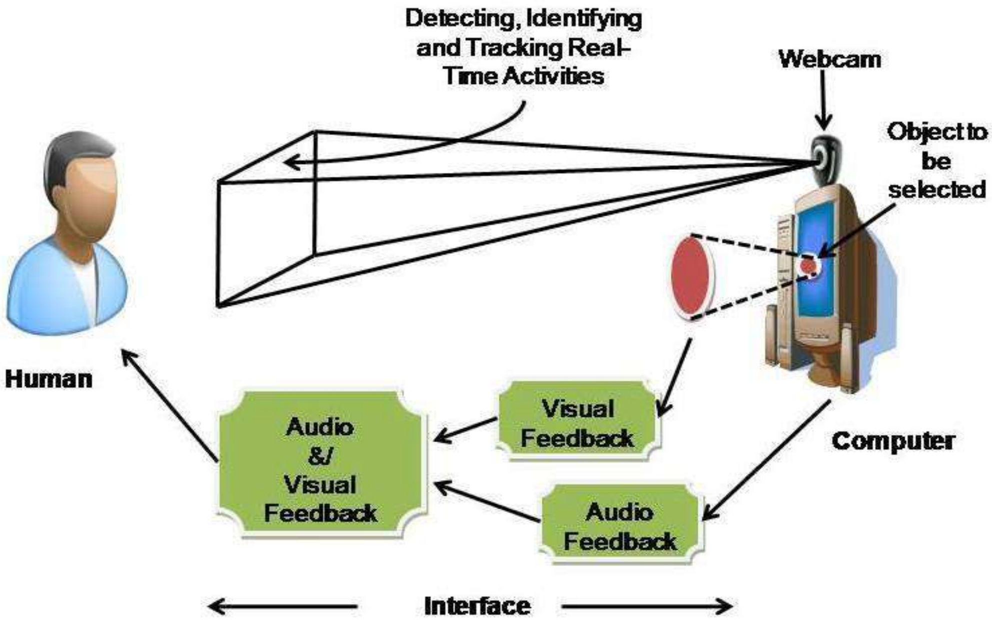

Figure 2 Generalized architecture of a vision based HCI System

Figure 1 shows an architecture of physiological parameters based HCI system. Three major parts of this system are object acquisition part, object selection, and feedback mechanism. In both object acquisition and selection parts the physical parameter of the user is acquired by using suitable sensors and signal conditioning circuits. This parameter is then analysed to find the required features and to use them for object acquisition and selection. Here, for object acquisition and selection the same physiological parameter can be used and the parameters may be different for acquisition and selection parts. For example, if object acquisition is performed by using eye gaze and selection by using eye blinks, then same sensors and electronic circuitry can be used for acquisition for both the parameters because both are generated by user eye movements. And, if object acquisition is done by tracking eye gaze and selection by using teeth click then different sensors and electronic circuits are required to acquire these parameters. In both the cases, eye movements may be detected by placing EOG electrodes around the user eyes. The architecture shown in figure 1 is prepared by considering two separate physiological signals for object acquisition and selection. Here, it can be observed that object selection task performed only if the system acquires the object to be selected. This process is shown in the architecture in the form of a switch at the output of object selection part and this switch is closed after getting command from the object acquisition part.

The second type of specialized HCI systems is vision based human computer interaction systems and its architecture is shown in figure 2. In vision based HCIs, computer cursor is controlled in proportion to the facial movements, eye movements, hand gestures etc. and the object selection operation is performed by using a suitable selection trigger. In these type of systems, a camera is used to acquire user images, and image processing & computer vision is used for detection and tracking of real-time user activities. The interface is very simple, cost effective and comfortable to use because it does not require sensors to be placed on the user body. The performance of this system depends upon the quality of camera and computation power of the algorithm. The type of feedback used in this system is similar which is used in physiological based HCI system.

Due to rise in applications around the computers and fall in their prices, the number of computer users in the world is increasing day by day. This number comprises experts, intermediate & novice users, physically abled & differently abled users, and users of different age groups. The way of interaction of these users with computers is different. The physically abled expert users can interact with computers effectively by any type of user interface. They can give input to a computer through a keyboard and/or by using a mouse. The physically-abled intermediate & novice users generally prefer to use mouse or other GUIs for interaction with computers. But the differently abled and elder users, those who have no/less control over their limbs, need specialised interaction means. As an example, eye controlled systems are designed for patients suffering from Amyotrophic Lateral Sclerosis (ALS) and other motor neuron diseases for which eye movements and eye blinks remain intact [11, 12]. This paper presents a review on object acquisition and selection techniques used in specialized HCI systems and the related issues.

2. Object Acquisition, Object Selection and Feedback Modes

Two important functions performed in most of the HCI systems are object acquisition and selection. The feedback used in an interaction system also decides its usability. This section explains the techniques used for target acquisition and selection in HCI systems and it also presents the types of feedbacks used to make interactions more efficient and user-friendly.

2.1 Object Acquisition

The term object acquisition refers to the process of moving cursor/focus on the object of interest in an HCI system by using suitable input means. The objects can be some of the following forms: icons [13], buttons [11], hyperlinks [14], pictures [15] or dialogue boxes [16]. The object acquisition or bringing cursor/focus over objects in a human computer interface is generally performed by using gaze tracking [17, 18], tongue movement [19], facial feature tracking [4], scanning method [20], menus [21] and hybrid approaches [22]. The selection of a typical object acquisition technique depends upon the physical condition of the user and is a deciding factor for performance and usability of an intelligent interaction system.

2.1.1. Eye gaze tracking

Eye gaze tracking is a process of calculating user's gaze point i.e. where a user is looking and is implemented by using a gaze tracker. In this method the motion of eye ball is measured in relative to the head. Gaze tracking is generally implemented by using electro-oculography (EOG) [23] and video-occulography (VOG) [24]. Electroocculography is a technique for detection of vertical and horizontal eye ball movements by placing EOG electrodes on the skin around the user eyes. The resultant signal is called as electroocculogram of magnitude and polarity depends upon the amount and direction of eye ball movement. The technique is cost effective [25, 26], covers wide range of eye view [26, 27], provides good accuracy & resolution, real-time, and simple [26]; but the long term placement of skin electrodes can cause skin problems and the user can feel uncomfortable with this method [26]. Also the electrodes can fall off when the user perspires [4].

On the other hand, videoocculography makes use of a video camera which continuously takes facial images of the user and sends to a software for processing as shown in figure 2. The processing of video frames is commonly performed by using MATLAB, C++ and some commercially or freely available software toolkits. The cost of this system depends upon the camera cost and the software used for image processing. Some commercially available eye gaze trackers (e.g. ERICA [28] and Tobii 1750 [8]) provide good accuracy and gaze resolution but their high cost is the major concern [29]. Although, gaze tracking can be performed by using simple webcams but these methods cannot beat high cost commercial gaze trackers in terms of accuracy and resolution. The method does not require any electrode to be placed over user skin, therefore, is very comfortable to use for long time.

In either of the gaze tracking methods (EOG or VOG) the mouse cursor is moved in proportion to the user gaze and is placed over the object of interest. The user then performs object selection using a suitable method discussed in next section. The method of gaze tracking is generally used for users those who can perform all types of eye movements accurately.

2.1.2. Facial features tracking

In this method the cursor position is controlled in proportion to the user face movement [4]. The tracking point can be user's eyes, nose, chin, forehead, eye brows or any other facial point. As in case of gaze tracking, the facial feature tracking is performed by using a video camera and image processing software. The method is used for users those who have control over their head movements and can precisely perform head/ facial movement for placement of cursor over the object to be selected.

2.1.3. Controlling mouse cursor using tongue movement

For critically ill patients, a tongue supported device was devised by [19] which allows the user to move mouse cursor in proportion to the tongue movement. The device functions on the principle of detection of IR waves reflected from the tongue reflector by a Nintendo Wii remote device and a computer, and conversion of tongue movement to cursor movement. The system can also be used for gaming, wheelchair control, small robotic systems, operation of domestic devices and emergency alarms.

2.1.4. Typing with menus

Eye typing using menus [21, 30] is an obvious choice for disabled persons who cannot use mouse or keyboard. Eye typing is a process of entering characters using eye gaze and an on-screen keyboard or menus. There are two approaches used in eye typing: direct eye typing and multi-tap typing approach [31]. In direct typing approach the user selects letters from an on-screen keyboard by using dwell time or eye blinks. The typing speed of direct character entry method as compared to manual typing is a major concern. In multi-tap typing approach the letters are ordered into groups. The user first selects the group in which the letter to be selected is lying and then letter selection is performed by using a selection trigger, which, reduces the area of virtual keyboard which further reduces the gaze area. This approach also provides the feature of word prediction/completion to increase typing speed. Therefore, to enhance the eye typing speed hierarchical menus [11] and word prediction [30] techniques are applied in interaction systems.

Table 1. An overview of combination of object acquisition and selection techniques

Reference	Object Acquisition Technique	Object Selection Technique	Apparatus used	Objective/s	Findings
[32]	Eye gaze tracking	Dwell time (150 ms)	3250R corneal reflection eye tracker	To compare gaze pointing and computer mouse for object selection.	Eye gaze selection technique is faster than a mouse for selection of both circle and text objects.
[23]	Eye Gaze Tracking	Eye blink	• Five Ag/AgCl electrodes, microcontroller, ADC, isolation, filters and amplifier for EOG measurement • P300 based BCI speller	To compare the P300 based BCI and EOG based system	The EOG based system is more efficient than P300 based BCI system in-terms of speed, applicability, accuracy and cost.
[33]	Eye Gaze Tracking	Antisaccade clicking	• MATLAB 6.5, EyeLink and Psychophysics toolbox • Optical tracking system (SR Research EyeLink II)	To explore the potential of object selection in gaze control environment using antisaccades and compare its performance with optimal dwell time.	Antisaccades did not show an improvement over dwell time, but, provide an alternative approach to dwell time selection.
[34]	Eye Gaze Tracking (EGT)	Tooth click (TC)	• Tooth click detector device • WiViK on-screen keyboard • Prototype remote EGT with single monochrome CCD video camera (1600 × 1200 pixels) and two near IR light source.	• To verify the feasibility of using EGT and TC to type on an on-screen keyboard. • To compare the performance of EGT-TC system with EGT-DT system	• The participants were able to attain typing speed using EGT-TC system comparable to the EGT-DT system. • TC provides greater degree of control than DT. • The proposed technique may be well suited for web surfing and reading on the computer.
[35]	Eye Gaze Tracking	Clicking with smiling	• Eye camera (352×288 pixels) and scene camera (597×537 pixels) • AWM630TX, AWM634RX modules • MS Visual C++, MS Foundation Classes, OpenCV & Boost libraries, OpenEyes software,	• To determine the effect of voluntary smiling on the performance of eye gaze tracking system.	• No degradation of the gaze tracking accuracy was observed when using voluntary smiling for object selection.
[36]	• Eye Gaze Tracking • Head Tracking	• Mouth Opening • Brows up • Manual key press	• Tobii T60 eye tracker • Logitech webcam Pro 9000, 320×240 pixels, 25 fps • Intel Core 2 quad, 2.66 GHz, 3 GB RAM	• To compare eye tracking and head tracking for pointing tasks • To compare mouth opening and brows up for object selection	• Gaze pointing resulted in fast text speed than the head pointing technique, but, gaze point caused a high variation of typing speed between the users and resulted in about doubled error rate as compared to head pointing. • The performance of gaze pointing highly depends upon the keyboard size. • Text selection using mouth opening is less erroneous as compared to brows up gestures. • The combination of gaze pointing & manual key press gave maximum typing speed (11.78wpm) for biggest keyboard.

[4]	Facial feature tracking (CameraMouse)	Dwell time (variable)	A computer, webcam, tracking algorithm (using template matching)	To test the performance of the CameraMouse on people without disability and people with disabilities	• The CameraMouse is a user friendly communication device and is easily adaptable to serve the people with disabilities. • The nose (as a facial feature) is the most suitable feature to be tracked.
[37]	Scanning keyboard	Double blink	• Ag/AgCl Electrodes • Filter (0.05-35Hz) • 16-bit ADC • Bluetooth 2.0 • Bremen BCI speller • Automatic scanning keyboard	To test the performance of novel wearable forehead EOG measurement for typing on two types of virtual keyboards.	• Using Bremen BCI speller the average accuracy and typing speed obtained was 91.25% and 10.81 letters per minute. • The average accuracy and typing speed for automatic scanning keyboard was 95.12% and 7.75 letters per minute
[19]	Tongue movement	Dwell Time (DT)	• Reflective surface on tongue • Infrared array & Nintendo Wii Remote • FreeTrack software for tracking tongue movement & cursor control and Dwell Clicker 2	To present a low-cost, portable, less-intrusive and easy to use design for tongue supported HCI system.	The proposed design was successfully tested for typing (6.2 wpm), gaming (Disc Dash), operating remote control car & line follower robot and activating emergency alarms.
[38]	Hand gestures for cursor control	Hand gestures to perform mouse clicks	• Computer • Genius FaceCam 320 • Hand pad • C language with OpenCV library	To propose a system for performing mouse analogous operations using hand gestures.	• Colour detection has been implemented for gesture interpretation as it can work under variable lighting conditions. • The gesture recognition rate was 100% when the experiment was performed at illuminance level of 54 – 400 lux.
[39]	Imaging movements of fist/s and feet (extracted from EEG)	Closing eyes for 2 seconds (extracted from EEG)	• PhysioNetEEG dataset • MATLAB software for feature extraction.	To enable the use of the available EEG headsets for computer control applications.	• Features of EEG (for imaging movements of fists & feet) were extracted using MATLAB algorithm and were converted to mouse actions. • A configuration for real-time implementation of EEG based HCI system has been suggested.
[3]	EMG	EMG	• Myo (myographic device) • Inertial measurement unit (IMU)	• To check the functioning of Myo armband when used in leg • To propose a myographic-based HCI for upper limb amputees	• Leg gestures can be profiled, as they produce consistent and distinguishable signals • Myo can be used to interact with computers and similar devices while used in a person's leg
[40]	Hybrid approach (eye gaze tracking & scanning technique)	Eye blink	Tobii X120 Eye Tracker and Microsoft Kinect	To present a new input interaction system for people with severe disabilities.	The proposed approach is faster than only scanning based systems and more comfortable to use as compared to existing eye tracking based systems.

2.1.5. Scanning method

In scanning method [20] one option/object is presented at a time and the user selects the required action by using a selection trigger. Scanning techniques are classified as switch based scanning [40] and automatic scanning [37]. The switch based scanning is operated by using a binary switch (e.g. eye blink) and in automatic scanning the control automatically scans all the objects placed in an interface. Generally in a scanning interface, to increase the text entry speed [41], the texts or objects are placed in the form of matrix containing rows and columns. The scanning process highlights each consecutive row of objects and the user operates a selection trigger for selection of a row. The control then starts scanning of each object of the selected row and finally the object of interest is selected by activating the selection trigger. The scanning interfaces can be used for typing [5] and gaming purpose [42].

2.1.6. Hybrid approach

To enhance the interaction system speed and usability a hybrid approach is proposed by [22] which is a combination of gaze tracking and single switch scanning techniques. In this paper, the target acquisition part was divided into two phases: initial ballistic phase and homing phase. In the initial phase the system moves the mouse cursor in proportion to the user gaze and the cursor is brought to the region of interest. The system is then switched to homing mode in which single-switch scanning is used to scan the objects placed in the region of interest. Finally, the object of interest is selected by triggering a selection switch when the focus comes over the object of interest. In this way, the hybrid approach reduces the eye strain due to using gaze tracking method only and increases the typing speed as compared to scanning method only.

2.2. Object selection

After the acquisition of object of interest, the next function of the interaction system becomes object selection. The means used to perform this type of function are known as selection triggers and the generally used selection triggers are the key trigger [1], where users press a key on the keyboard, and a dwell time trigger [31, 33, 43–46] whereby users fixate on an item for a period of time exceeding a predetermined threshold to trigger a selection. Other types of selection triggers such as eye blinking [20, 42, 44, 47–53], on-off screen buttons, gaze gestures, anti-saccades, pEYEs and Dashers [54], EMG signal [5, 55], mouth opening click [36], brows up clicking [36, 42], tooth clicker [34], and clicking with smiling [35] have also been used by the researchers.

2.3. Object acquisition & selection techniques as a combination in HCI systems

Depending upon the needs, capabilities and preferences of the users a combination of object acquisition and selection techniques is decided and this combination is an important parameter in deciding the performance and usability of the HCI system. Table 1 gives an overview of some of the combinations being used in the research and here it is revealed that the gaze tracking as a means of object tracking is applied in most of the cases. The gaze tracking proved to be a usable and efficient technique of object tracking if the user has control over his/her eye movements. Further, the object selection technique which is to be combined with the gaze tracking should not affect the performance of the gaze tracker. For persons suffering from ALS and other motor neuron diseases, scanning method of object acquisition (combined with eye blinks for object selection) is an obvious choice, because, these persons have limited control over their eye movements and cannot make use of gaze tracking method. For persons having control over face or facial muscle movements, the CameraMouse (freely available software online) is also a good choice. It makes use of face tracking for object acquisition and dwell time for selection of the object of interest. This category of users can also make use of tooth click and smiling for object selection in combination to gaze tracking. An electromyogram (EMG) based HCI system is proposed in [3] which can control the cursor movement and mouse clicks using EMG signals acquired through a Myo device placed in the user leg. This system can be used by upper limb amputees.

To better understand the diversity of object acquisition and selection techniques used in HCI research an information statistic is collected from the literature and presented in table 2. The papers are grouped according to the combination of object acquisition and selection techniques used. It can be observed from the table that in most of the researches the "gaze tracking method" of object acquisition along with "dwell time" & "eye blink" is applied for object selection. The researchers have also successfully tried other means of object acquisition and selection such as scanning method, face tracking, tooth clicks, EMG signal, EEG signals mouth opening etc. The selection of a combination of object acquisition and selection techniques depends upon the needs, capabilities and preferences of the user.

2.4. Object selection in virtual/augmented reality environments

From the user perspective the development of computer history can be seen in the development of human-computer interaction techniques The human-computer interaction has passed through three important stages: interacting with computers using keyboard, computer interaction using mouse and use of touch screens to perform computer interaction [56]. People always wanted to interact with computers in a more natural way and this lead to the development of virtual reality and augmented reality environments. In virtual reality, a software created environment is presented to the user such that the user feels it as a real environment. In augmented reality, existing environment is used with overlaid information on top of it [57].

Some of the object selection techniques discussed so far are also applied for object selection in virtual/augmented reality environments. For example, applying virtual hand (i.e. hand tracking) or virtual pointing in virtual environment for object acquisition and button press to confirm the selection [58]. Other popular techniques used to perform the selection trigger in virtual reality environment are voice command, event, gesture (e.g. AirTap and ThumbTrigger) hold & select (in which the selection is performed when the button is released), dwell on object and no explicit command [58]. Further, gesture, speech and gaze are best suited for interaction with augmented reality environments [59]. Interacting with augmented reality environment using touchable interface has also been cited in the literature [60].

2.5. Mouse analogous operations

In most of the HCI systems discussed so far, the object selection techniques perform mouse left click operation only. But if we want to completely replace computer mouse then these techniques should be able to efficiently perform other mouse analogous operations also viz. right click, double click, drag-drop, and cursor movement. To the best of our knowledge, there is no triggering technique which can perform all of the mouse analogous operations. The eye controlled HCI systems are becoming popular day by day. These systems control computers using eye movements (gaze tracking and blinks) and is an obvious choice for patients those who lost control over their body limbs. Through eye movements a user can perform mouse analogous operations e.g. left wink, right wink, and eye blink (blinking both eyes simultaneously) can be used to perform left click, right click, and double click operations, respectively. Table 3 gives a review on performing mouse analogous actions using eye blinks which depicts that except [61] none of the systems has performed all of the mouse operations. In these systems, the drag – drop along with cursor control functions using eye movements is still a miss. Further, the system performing all of the mouse actions [61] is suffering from low value of success rate and needs manual template update while detecting eye winks. The systems [20, 51] make use of specific time durations of eye blinks for performing different mouse operations, but, while using these type of systems the user has to adhere to the blink timings, which is a difficult task as far as 'easiness to use' factor of HCI usability is concerned. The performance of most of the systems mentioned in the table is affected by sudden illuminance changes [12, 62] and the movement of the user face [53]. Hence, to replace the traditional mouse with the modern triggering techniques, a novel technique needs to be devised which could perform mouse analogous operations under varying lighting conditions and the user should be able to freely move while using the system.

Table 2. Diversity of object acquisition and selection techniques in HCI systems

Object selection technique	**Object acquisition technique**						
	Gaze tracking	Face/head tracking	Scanning method	Tongue movement	Hand gestures	EEG	EMG
Dwell time	[32] [63] [43] [46] [64] [11] [65] [66] [54]	[4] [67]		[19]			
Eye blink	[23] [68] [12] [61] [24] [27] [11] [48] [69] [49] [47] [53] [70] [54] [22]	[71] [72] [52] [73] [44]	[37] [5] [42] [41] [20] [22]			[39]	
Saccades	[33] [74] [75] [54]						
Tooth click	[34] [76]	[77]	[78]				
Clicking with smiling	[35]						
Mouth opening	[36]	[73] [44]					
Brows up	[36]	[73]	[42]				
Manual key press	[36] [79] [1]						
Hand gestures					[38] [80] [81]		
EMG	[55] [82]						[3] [83] [84] [85] [86]
EEG		[39]				[83]	

2.6. Feedback mechanism

The third factor which decides the proper functioning and performance of an interaction system is the selection of a suitable feedback mechanism. Feedback is a process in which the system gives response immediately after the user performs an action. The user responds to the feedback provided by the interaction environment and therefore, it is an important factor in deciding the efficiency of an interaction system [58]. It can be any one of the following modes: audio mode [20, 41, 65], visual mode [30, 65], and the combination of audio and visual modes [26] as shown in Figure 1 and 2. Another type of feedback mostly used in virtual/augmented reality environment is haptic feedback method [58]. In audio feedback mode, a sound is activated on the selection of an object and in visual mode the appearance/background of the object changes on selection. The selection of a feedback mode depends on the object selection technique used and the physical condition of a user.

In virtual/augmented reality environments, visual feedback has to be used very carefully. It might be a distracting factor and cause excessive popping while dealing with cluttered objects and might even reduce the system performance Users often prefer the use of additional feedback modalities (haptic and audio feedback) with visual feedback. However, while interacting with dense environment, the audio and haptic feedback methods also make disturbing effects [58].

3. Applications of Object Acquisition and Selection Techniques in Vision Based HCI Systems

Vision controlled HCI systems proved to be a good aid for differently abled and aged persons. These systems are also being successfully used by normal persons to increase their level of comfort. Here is the list of some of the major applications of these systems published in the literature:

- Typing of block of letters using EyeGaze and GazeTalk system by persons suffering from ALS [87].
- Typing by using two-way scanning keyboard and eye blinks & eye-brow raises by the children with severe disabilities at Boston College's Campus [42].
- Web surfing by using WeyeB (Web eye Browser) [8], and EyePoint [1]
- Game controlling using gaze gestures [13]
- Mouse cursor controlling through face tracking [49], head movement [73], and eye gaze [1]
- Performing mouse click operations using eye blinks [61], tooth clicker [34], raising eyebrows [42], and clicking by smiling [35].

- Controlling the mobile phone activities by a person without upper limbs using eye blinks [88].

Table3. An overview on mouse analogous operations performed using eye movements

Reference	Mouse action performed	Technique used	Findings
[62]	Left click	Eye blink	• Accuracy Left & right click: 90% Double click: 80% • Performance of the blink detector affected by sudden illuminance changes
	Right click	Right wink	
	Double click	Left wink	
[52]	Left click	Left wink	• Sensitivity obtained is 60 – 90% for selection of objects all around the computer screen • Average sensitivity of controlling computer functions in real-time on the objects in the middle of the screen are better than those objects at the sides.
	Right click	Right wink	
[20]	Left click	Eye blink (200 – 350ms)	The double blink was successfully used as error correction command and left click was applied for text selection.
	Double click	Eye blink (500 – 600ms)	
[48]	Left click	Dwell time	A success rate of more than 96% has been obtained for key and mouse event control.
	Right click	Eye blink (1s)	
[51]	Left click	Eye blink (0.7-1.5s)	Overall accuracy obtained for the system is 87.4%.
	Right click	Eye blink (1.5 – 3s)	
	Double click	Eye blink (3 – 4.5s)	
[12]	Left click	Blinks of different durations	Accuracy of performing mouse actions > 80%
	Right click		
	Double click		
[61]	Left click	Left wink	Success rate Double click: 86.3% Left & right click: 81.8% Dragging: 95.2%
	Right click	Right wink	
	Double click	Eye blink	
	Drag and drop	Close left eye – move – open left eye	
[53]	Left click	Left blink	• Successfully used for eye typing • Unintentional blinks make false positives • Sensitive to fast face movements
	Right click	Right blink	
[71]	Left click	Left blink	----------
	Right click	Right blink	

4. Issues Associated to Object Acquisition and Selection Techniques

Despite of the successful development of various object acquisition and selection techniques in HCI systems there are still some issues which need to be addressed in making HCI systems more accurate, robust and user friendly. The foremost problems related to cursor control using eye gaze are the issues of accuracy [89], fatigue [22], cursor stability [90] and response time [89]. Although some commercially available gaze trackers are available which can provide very good accuracy but their high cost [29] still restricts them to be easily used in HCI systems. When eye gaze tracking is used for object acquisition and dwell time for object selection, then keeping a cursor stable on small objects becomes very difficult even when best quality eye trackers are used [22]. The use of shorter dwell time for object selection also leads to the Midas-Touch problem [74]. The use of dwell time along with menus restricts the typing speed and it is also challenging to find optimal dwell time value for each user. Although, a typing speed of 17.3 wpm [91] can be achieved by combing different selection techniques with bigram entry and word prediction but it is still less than the average manual typing speed which is about 40 wpm [31]. Hybrid approaches, like combining gaze tracking with scanning method [22], can be devised to improve the overall performance of HCI systems.

Most of the available HCI systems provide the left click mouse operation using eye blinks, eye brow raises, dwell time, EMG signal etc. But if we want to completely imitate the functions of a computer mouse then the interaction systems should provide all the mouse analogous operations including left click, right click, double click, drag & drop, cursor control, and page scrolling.

5. Conclusions & Future Scope

This paper discusses a review on object acquisition and selection techniques used in HCI systems, their applications and challenges to be addressed in future. It is learned that the object acquisition and selection techniques are used in different combinations to obtain optimal performance of an HCI system. The selection of these techniques depends upon the application, cost involved, and physically condition of the user. The issues of eye cursor stability, accuracy, and speed need to be addressed cost effectively. Further, most of the selection techniques proposed in the literature perform left mouse action only and if we completely want to replace the traditional computer mouse with the object selection techniques discussed in this paper, such as eye blinks, then these selection techniques should be able to efficiently perform all the mouse analogous actions viz. left click, right click, double click, drag & drop and cursor movement. However, some techniques are proposed in the literature to perform mouse analogous operations using eye blinks, but their limitations, such as, their sensitivity to variation in lighting conditions & user movements, restrict them to be used on commercial level. Further research needs to carry be out to enhance the usability of these systems.

Conflict of Interest

We have no conflict of interest to declare.

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