A Technical Review on Hands Free Computer Interface Devices

Purpose

Over the past decade, computer usage by people of all demographics has increased substantially. The computer is used to communicate with friends and family, to accomplish tasks in the workplace, and to shop at online stores for various items. Many people have looked for new ways to increase the potential usage of the computer by increasing the versatility and capability of user interaction as shown in [1]. Even as companies try to increase functionality for everyday use, other groups have attempted to create new ways for disabled individuals with limited physical capabilities to use computers. This paper reviews various hands free computer interface methods and devices for such people.

Current State of the Art

One common alternative to using a mouse is headtracking. Using a camera input device, software can track an object on a user's face and translate the physical movement into cursor movement. The object can be a card as in [2] and there are even research groups investigating using facial features, such as eyes for markers [3]. A commercial product of this system is called the HeadMouse Extreme [4]. It is sold by Origin Instruments for $995.00. It uses a mounted camera as the graphical device and adhesive dots as the tracking element. In 2009, a research group created a system using a WiiMote and glasses with LEDs mounted on them [5]. They valued the total cost of this setup at $50. While achieving similar functionality at varying prices, these systems all have the same design limitations.

One drawback of all these devices is that they require the user be in the line of sight of the camera at all times. This restricts both the distance the user can be away from the camera and the angle at which they view the computer. If the camera's line of sight with the marker is broken or the device is orientated in such a way that it isn't recognizable, the software won't function optimally or even properly. The software to process the camera images is usually CPU intensive. The bulk of the computation time goes into filtering each frame, identifying the marker, and following its progress in each frame. Another issue with such devices is that they require a secondary way to determine a user click. Mouse movement detection alone is not sufficient for computer interfacing. At a minimum it is necessary to identify a standard left click. There are many available options including voice commands, sip-and-puff apparatuses, or even recognized facial contractions, such as blinks or winces.

There have also been alternatives that don't require facial tracking through a camera. One such alternative uses a laser pointer projected onto a glass surface monitored by a camera [6]. The user holds the pointer in their mouth, and moves their head to change its focus. This allows some degree of freedom in user position as long as the laser can reach the glass surface. To differentiate left clicks and right clicks, the software recognizes the laser pointer turning on and off. Once for a single left click, twice for a double click, and three times for a right click. Another method created in 2012 uses a magnetized tongue piercing

[7]. The movement of the tongue is detected using a headset with magnetic sensor array. The researchers used it to interface with a wheelchair but the device's versatility was noted by the researchers. It could potentially be used to interface with computers as well. This device removes the restriction of requiring a camera's line of sight. If the device is within range of its receiver, it will still function properly. There is still the necessity to detect clicks, but cursor movement can be translated from tongue movements.

Device Comparisons

The performance of the devices is measured in frames per second (FPS) or bits per second (BPS). For systems with image processing being the brute work of the software, the limiting factor is the number of frames the program is capable of analyzing per second. The process involves taking a color or grey scale image, using subsequent filters to block out all pixels not related to the marker, and then inferring the marker's position in the image. The real time capability and detection accuracy are oftentimes proportionally and inversely related to FPS. Bits per second is the transmission rate of the signal processing software with the driver that converts the signal into cursor movements. While not completely dependent on FPS, it is influenced by it. A group found that providing a joystick-like mode to their software, BPS was increased. Instead of correlating head velocity with cursor velocities, it uses the deviation of the head from a neutral position to infer cursor movement. This allows frame analysis to be simplified if the marker's position is unchanged. Simply compare the current and previous frame and given a certain degree of similarity, cursor behavior, i.e. velocity and direction, remains unchanged. There has also been optimization through the use of Graphics Processing Units, or GPUs. They process the computational algorithms necessary to display graphically intensive programs on the computer display. When used with a parallel computing platform such as CUDA, or Compute Unified Device Architecture, the image filtering process time was almost halved, making the transmission rate of the camera the bottleneck in the system [8].

Building Blocks

As mentioned earlier, these devices all translate physical movements, specifically head motions, into cursor movements. This involves a device capable of producing a signal, whether that is an optical image from a camera or an analog output from a magnetic antenna. The software that translates the signal is usually run on the device that is being controlled. This reduces the onboard hardware requirements of the device, with the minimal requirement in some cases being a trackable feature. Unfortunately, the simpler the hardware being used, the more rigorous the software must be to compensate. The image processing algorithms for markers are often as flexible as allowed but still restricted by the line of sight requirement. The magnetic headset removes the need for line of sight and image processing but a more complex system for movement detection is required. Depending on the performance necessity, the hardware and software can be modified to compensate the other's shortcomings.

References

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