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DIY head-controlled mouse: an affordable assistive technology solution for people with severe motor disabilities

Amith G Nair

Hardware Engineer, NISH, Thiruvananthapuram.

Varun Sriram,

B.Tech (II year), RSET, Kochi.

Akila Surendran

SeniorEngineer,
CATI, NISH, Thiruvananthapuram.

Abstract

People with severe motor disabilities require a variety of options to access computer and alternative communication technologies. Tracking the head movement of the user to control the mouse cursor can be done in several ways - using a webcam or using sensors. Body-worn devices with gyroscope sensor that can track the head movement are available commercially as Assistive Technology (AT). Although these devices give greater independence to the users, they are expensive and not affordable in a developing country like India. We describe the development of an open-source, DIY webpage that will guide non-engineers to build their own low-cost head-controlled mouse using tools and materials that are available locally in India. We discuss the benefits of empowering individuals in society to make their own AT using rapid prototyping tools with the support of knowledge communities online.

Keywords

Head-controlled mouse, open-source assistive technology, assistive technology for severe motor disability, DIY assistive technology.

Introduction

According to the Census 2011, persons with disability (PwD) constitute 2.21% of the total population in India [1]. Although this is a significant section, in business terms, this is a scattered market. Persons with disability are scattered in terms of geography, and more importantly, each PwD is unique and would need a customized solution. On the other hand, AT devices must be of high quality, emphasizing reliability, robustness, and ease of use since these are used by individuals with disabilities for their daily activities. Worldwide, this situation leads to a prohibitive cost and a high abandonment rate of AT devices [2]. Open-source and free AT software solves the problem to an extent [3].

Several AT tools allow people with severe motor disabilities to interact with computers [4]. For example, there are adaptive switches that replace the mouse-click function, adaptive pointing devices for use with touchscreen devices, gaze-tracking, and head-based pointing.

Gaze-trackers like Tobii track the user's gaze to place the mouse pointer wherever the user is looking at the screen. Head-based pointing could be through a video-based interface or a sensor-based interface. Commercial head-trackers with a sensor-based interface either work with an optical sensor (Example: Tracker Pro, AccuPoint) or a gyroscopic sensor (Example: Glasshouse, Quha Zono). These are expensive, ranging from $500 to $2000 and out of reach of people with disability in developing countries like India.

Camera mouse is a famous, free software that maps the head movements captured by the computer camera to mouse pointer movements on the screen [5]. However, the software has drawbacks: (1) Camera mouse needs perfect lighting and a reasonable quality webcam to work well. (2) The software gets aware gets mis-calibrated often: the person needs to be constantly in the focus of camera or else the tracking point gets lost.

We propose a head-controlled mouse that can be made at a fraction of the cost of currently available commercial products and which is more user-friendly than Camera Mouse. We referred to open-source manuals in online DIY communities such as Instructables to adapt existing projects. We have used components that are locally available and we refined the code to make the head-tracking more precise. The instructions to make this tool are available on a GitHub page (http://bit.ly/hmouse), for anyone to replicate or improve upon. We intend to simplify the documentation such that anyone with a non-technical background can refer to it and make the tool for themselves or for a family member or friend.

Materials and method:

Arduino Micro is a microcontroller board equipped with an ATmega32U4 processor and a built-in USB. The ATmega32U4 processor supports the Mouse.h library in C++, which allows the board to appear as a native Mouse or Keyboard when connected to a PC. This library helps in the relative positioning of the mouse, that is, by moving the mouse pointer by a required number of points with respect to the cursor's current position. The output of the MPU6050 gyroscope module is converted to the position of the cursor in the Arduino Integrated Development Environment (IDE). The variables having the values of the gyroscope sensor can be converted to the corresponding mouse location by trial and error to get the perfectly calibrated pointer position values.

'Head mouse with MPU6050 and Arduino Micro' is the Instructables page we have referred to in developing this head-controlled mouse [6]. Further refinements to the available code had to be done to decrease the sensitivity of the gyroscope module and to increase the sensitivity of the pointer so that noise from the gyroscope is neglected to avoid the 'ghost movement' of the pointer. The casing for the head mouse was designed using Fusion 360 and 3D-printed in Ultimaker 2. We used the headphones' components to mount the head mouse over the head and hold those intact headphones. More details can be found on the GitHub page http://bit.ly/hmouse.

Results

In the first phase of our project, we tested the head-controlled mouse with around 10 able-bodied individuals who tried both the free camera mouse software and our DIY head-controlled mouse. Everyone preferred the DIY head-controlled mouse over the camera mouse software for user-friendliness and precision in tracking. They reported that the calibration of camera mouse sustained for less than 10 minutes while they could use the DIY head-controlled mouse for an extended period. The next phase is to test the

head-controlled mouse with PwDs. We intend to check its effectiveness especially with children with severe motor disabilities, who use Augmentative and Alternative Communication software.

Conclusion

Assistive Technologies empower persons with disabilities to greater independence and ease in carrying out their tasks in everyday life. The scattered user base, excessive cost and high abandonment rate of AT devices have contributed to the huge gap that exists between technology and the end user of AT in developing countries

like India. The 'Do-It-Yourself (DIY)' movement and the current generation of online, open-source communities have triggered a new wave of enabling passionate people with a bit of technical background to create DIY AT devices for persons with disability [7]. Today, rapid prototyping tools in digital fabrication and simple hardware platforms like Arduino make technology accessible to the masses, reducing the cost and giving them control over the design elements to customize the device as per their needs. as per their needs.

At the Centre for Assistive Technology & Innovation (CATI) at the National Institute of Speech & Hearing (NISH), we have embarked upon the journey of building an online repository of open-source Assistive Technologies. We have started with the digital fabrication of an adaptive chair for children with Cerebral Palsy, a portable wooden ramp, and a head-controlled mouse. The DIY head-controlled mouse with the sensor-based interface is cheaper than the commercial alternatives and more user-friendly than the existing free software with video-based interface for head-tracking.

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