Developing Entrepreneurial Skills through an Innovative Senior Capstone Design Project - MouseHead

Dr. Austin B. Asgill P.E., Kennesaw State University

Dr Austin B. Asgill received his B.Eng.(hons) (E.E.) degree from Fourah Bay College, University of Sierra Leone, his M.Sc. (E.E.) degree from the University of Aston in Birmingham, and his Ph.D. in Electrical Engineering from the University of South Florida. He is currently a Professor of Engineering Technology (Electrical) at Kennesaw State University (KSU). Prior to joining the faculty at KSU (formerly SPSU), he was an Associate Professor of Electronic Engineering Technology at Florida A&M University (FAMU), where he served as Program Area Coordinator and Interim Division Director. With over 30 years of teaching experience in Electrical/Electronic Engineering and Engineering Technology, he currently teaches in the areas of networking, communication systems, biomedical instrumentation, digital signal processing, and analog and digital electronics. He has worked in industry in the areas of telephony, networking, switching and transmission systems, and RF and MMIC circuits and system design. Dr. Asgill also has an MBA in Entrepreneurial Management from Florida State University. He has served on the board of the Tau Alpha Pi (TAP) National ET Honors Society since 2012 (Chair 2012-2014). He is a Life Senior Member of the IEEE, a Member of the ASEE, and is a licensed Professional Engineer (P.E.) in the state of Florida.

Dr. Cyril B Okhio P.E., Kennesaw State University

Cyril B. Okhio is a Faculty at the Southern Polytechnic College of Engineering & Engineering Technology, Kennesaw State University and an Adjunct Professor at Clark Atlanta University's Dual Degree Engineering Program. He earned his B.S. (Engineering) and Ph.D. (Mechanical Engineering) degrees from, and was an (Science and Engineering Research Council) SERC Post-Doctoral Research Fellow at the University of London. He is registered as a Chartered Professional Engineer (CPE) with the Council of Registered Engineers, United Kingdom; a Member of the Institution of Mechanical Engineers, UK and a Member of the Institute of Transportation Engineers, USA. Dr. Okhio has many years of administrative experience including Chairmanship of a Mechanical Engineering Department. Dr. Okhio understands that most engineering problems require multi-disciplinary solutions that embrace the new concepts of PLM approach so that the resulting solutions can be sustainable and all encompassing. Dr. Okhio has carried out experimental and numerical investigations of, and developed statistical analysis tools and computer codes, for the calculation of complex fluid flows. Some of this work has been published in international journals. He is currently involved in multi-disciplinary research and development concerning Condition Monitoring of Engineered Systems; applications of Additive Manufacturing Tools to the study of Design for Manufacturability of Engineering Components and Systems; Vehicular Systems and Safety Engineering, associated with SPSU Visualization & Simulation Research Center for which he is a co-PI. Dr. Okhio is very familiar with the level of technology and development, world-wide. He has visited many countries including Taiwan, Japan, Saudi Arabia, Zambia, Zimbabwe, Ghana, Senegal, Belgium, Germany, Austria, Italy, France, and he lived in the United Kingdom for more than 12 years. He is married with two children.

Developing Entrepreneurial Skills through an Innovative Senior Capstone Design Project - MouseHead

Abstract

Whilst the Senior Capstone Design Project course has traditionally been used to train students of engineering (E) and engineering technology (ET) with practical skills and to prepare them for real engineering life, there has been somewhat of a lack of training and encouragement of students to become entrepreneurs after graduating from their degree programs.

Through recent modifications and additions to the course content offered by the ECE and EET programs at Kennesaw State University, the Capstone Design course experience now includes a component that seeks to encourage the development of entrepreneurial skills.

In this paper we will present the design of an innovative Hands-Free Computer Controller (MouseHead), that was designed for use by individuals with physical impairments and disabilities. The paper also discusses some of the entrepreneurial aspects that were incorporated into the course through design process, and preliminary results from the project will be presented.

The limitations experienced by individuals with impairments and disabilities create many difficulties for those individuals, especially their inability to use certain technologies. With technology being such a driving force in society, more opportunities are created for those who are not able to leave their homes as easily. Individuals with impairments such as amputees, and paraplegics, need alternate ways of operating computers. Using mouse controls and typing may be difficult for those individuals, especially those with limited to no arm control which eliminates an avenue they could use for work and improving their lifestyle. MouseHead is designed to address this problem. It provides users the ability to control their computer using a combination of head movement, blinking, voice control, and simple gestures. Users will be able to move their head position to control the cursor, use their voice to operate simple functions, and even blink to control the mouse clicks. MouseHead gives those with impairments and disabilities the ability to completely operate a computer hands-free.

Index Terms *– Senior Capstone Design Project, Engineering (E), Engineering Technology (ET), MouseHead - A Hands-Free Computer Controller.*

I. Introduction

There is a growing importance of computers within the modern age. With more "work from home" opportunities being created, societies' reliance on computer interaction continues to advance. While this is not a problem in itself, there is an alienated sector of society that is unable to take advantage of these opportunities. A significant portion of the population struggles with impairments [1, 2]. With technology being such a driving force in society, more opportunities are created for those who are constrained and unable to leave home as easily. As opportunities grow, those with impairments, like amputees and paraplegics, need alternate ways of operating computers. Using mouse controls and typing may be difficult for those with limited to no arm control which eliminates an avenue they could use for work and improving their lifestyle. MouseHead aims to address this problem. It gives users the ability to control their computer using a combination of head movement, blinking, voice control, and simple gestures. Users will be able to move their head position to control the cursor, use their voice to operate simple functions, and even use a unique voice to text method that will allow for hands free typing. MouseHead gives those with impairments and disabilities the ability to completely operate a computer hands-free.

This innovative device was developed as part of the requirements for a Senior Capstone Design Project course for the Electrical Engineering Technology program at Kennesaw State University. The Senior Capstone Design Project course is designed to align with the ABET ETAC student outcomes (1-5) for baccalaureate electrical/electronic(s) programs. The course encourages the development of original innovative projects ideas that seek to address societal needs, and that may be suitable for further development into commercial products. The MouseHead project design team consisted of two senior students, one of whom served as the team leader.

The entrepreneurial value added to this Capstone course included teaching students how to apply economic methods in cost and revenue calculations; how to employ current Software Tools to create financial analysis spreadsheets in the processing of the selection of most appropriate Instrumentation, Systems and Tools; and developing the abilities of students in this class to demonstrate effective oral and written communication skills as well as a commitment to timeliness, quality work and continuous improvement. In addition, as a part of the Entrepreneurial component of the Capstone course, a team from the Robin and Doug Shore Entrepreneurial and Innovation Center, which is housed under the Coles College of Business, is invited every semester to talk to the students about entrepreneurship and innovation. They also provide information on how they can assist the students in obtaining internal, as well as external seed funding for exemplary Capstone Projects with a strong potential for commercialization.

The MouseHead project holds profound significance, particularly within the realm of assisting individuals with impairments or disabilities in engaging with technology. MouseHead transcends mere product innovation; it embodies a commitment to leveraging technology for the betterment of society. The journey of entrepreneurial development not only fosters innovation but also serves as a conduit for addressing crucial societal needs. By focusing on the intersection of technology and accessibility, MouseHead has the potential to significantly enhance the lives of individuals facing physical challenges. Structured training and development play a pivotal role in the process, allowing entrepreneurs to identify and implement technical attributes that cater specifically to the needs of individuals with physical impairments. Moreover, entrepreneurial development fosters a culture of inclusivity and empathy, driving innovation that prioritizes accessibility and usability for all. By collaborating with experts in the field of assistive technology and engaging with the community of users with disabilities, entrepreneurs can ensure that their products not only meet, but exceed the expectations and requirements of their intended audience. By embracing the challenges and opportunities inherent in creating accessible technology solutions, entrepreneurs have the power to catalyze positive change and empower individuals of all abilities to fully participate in the digital age.

II. Background

Assistive technology devices can help people with disabilities to function in multiple contexts and activities. Assistive technological devices such as MouseHead are beneficial for individuals such as paraplegics, disabled students, individuals with impaired motion control such as the aged, individuals who wish to have hands-free technology. Mousehead aims to construct a product that will be able to control operational tasks of a computer using the movement of the head and body.

Wearable technology will help simplify smaller tasks in a short period of time while giving the user all-day comfort and versatility. Microsoft Hololens, Google Glass, and Lenovo ThinkReality [3, 4, 5] are similar products based on smart glasses. Smart glasses are set to be the next big thing in technology, and in addition the rise of new communication systems and information technologies has encouraged people to interact with apparel-integrated technology accessories. It is understood that wearability is one of many primary concerns for users. “Assistive technology aims to augment function for individuals with disability to increase their ability to perform activities of daily living and interact with their environment" [1]. The Apple Vision Pro as an example, makes leaps in the wearable market, but it still fails on a key aspect of wearable devices: the ability to comfortably be worn. Their revolutionary headset still requires a large cord and storage for a secondary battery to be carried around by users. This was researched and investigated to improve upon the design of MouseHead. An internal battery is crucial to the seamless ease of use of a wearable device.

Preliminary research found that there are a number of similar products to MouseHead that have been designed to advocate hands-free interface movement technology for paraplegic individuals. The Nano Deluxe Bundle [6] is a product that enables the user to perform such tasks as drawing, photo editing, graphic illustration, and Computer Aided Design (CAD). The Nano Deluxe connects to the computer, tablet or speech generating device through a USB port and operates using standard mouse drivers. The MouseHead design is different from the Nano Deluxe due to its voice-control capabilities that allow the user to use speech-to-text dictation on a computer interface.

Another such product is the Tap Strap II which is a wearable device similar to the design of MouseHead that gives the user the ability to use the mouse features on a computer through a series of gestures. The Tap Strap II supports mouse compatibility that is controllable with your phone, laptop, and everything Bluetooth compatible, just by using finger gestures. The Tap Strap II is an elegant product but does not provide better user access than the MouseHead. While the Tap Strap seems like a great solution, it fails on its necessity of motor controls to simulate the gestures needed to operate the device. In order to use the device, the user needs to have accurate control of his or her limbs. This is where Mousehead comes into play; it uses head movement as opposed to limb movement for its sensory inputs. While controlling the neck and head is typically easier for those with motor impairments (depending on the specific injury), this seems like a more optional and viable route of control for computer input for those who lack the ability to use a typical computer and mouse setup.

III. Design Approach

The design of MouseHead can be primarily broken down into two parts: (1) the glasses and (2) the USB hub. As shown in Figure 1, the glasses will connect via Bluetooth with the USB hub, and the hub is then connected to the user's PC. The user will be able to interact with their PC completely hands-free through this Bluetooth connection. The entire system is designed around an Arduino microcontroller.

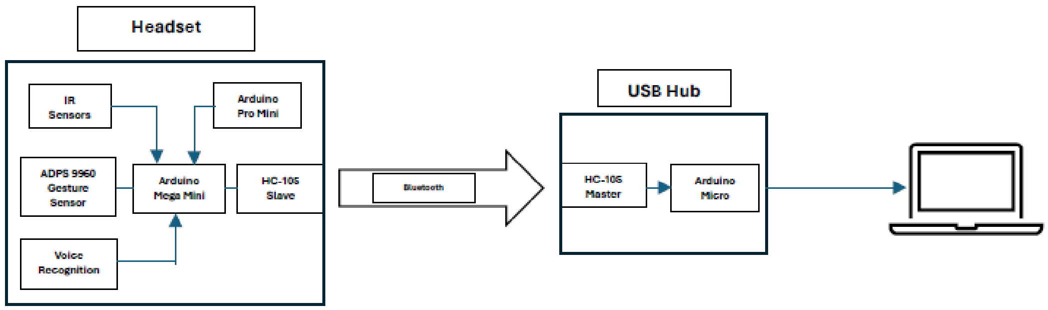

Figure 1. MouseHead Block Diagram

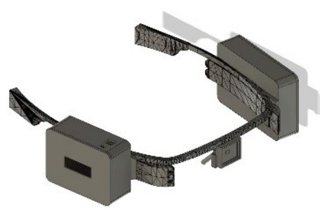

Figure 2. 3D Model for MouseHead Design

The glasses will consist of a 3D printed frame that sits on the user's head, right above their eyes but without obstructing their view. The electronics is hidden within a 3D printed enclosure attached to the glasses frame. Housed within this enclosure will be the brains of the operation, the Arduino mega mini.

The Arduino Mega is a well-known microcontroller board within the Arduino series that is based on the ATmega560 microcontroller and is known for its large amount of digital I/O, serial ports, and many other advantages. One downside to the mega is its large size. A lesser-known version of the mega, the Arduino mega mini, was chosen for the prototype. The Arduino mega mini utilizes the ATmega328 microcontroller and contains all the advantages of the Arduino mega without the drawback of its size, as its footprint is less than that of a standard Arduino uno. The prototype takes advantage of the multiple serial ports available on the mega mini. This mega will contain the main code and is tasked with controlling the blinking operations, Bluetooth communication, voice control, and many smaller operations.

The blinking control is accomplished by using IR sensors connected to the glasses frame. These sensors are located on the edge of the frame, right below the eyes, but again, without obstructing the user's view of their monitor. The Bluetooth connection between the glasses and the hub is done through the use of a module called the HC-05. This Bluetooth module allows a Bluetooth connection between a pair of modules through serial communication, one being set up as the master module and the other the slave module. The Arduino Mega mini on the glasses will contain the slave HC-05 and the master module will be used on the USB hub.

The voice control is done using a voice recognition module that can be programmed with voice commands. This module also communicates with the Arduino mega mini on the glasses through serial communication, which is why it is so important that the mega contains multiple serial ports. Some other functions that the mega mini may run are small things like controlling indicator LEDs and the OLED LCD.

Connected to the Arduino mega is the Arduino pro mini that controls the head position. The reason this is being done on a separate Arduino is because when the head cursor positioning function is running, it will be hard to simultaneously search for blinks and other features, so the positioning is handled on a smaller Arduino connected via serial communication. Attached to this Arduino is a gyroscope module that obtains the head position for cursor navigation. The Arduino pro mini will then relay this information to the Arduino mega.

The final piece of the MouseHead is the USB hub. This hub is plugged into the PC and allows users to connect to their PC via Bluetooth. Inside the hub is an Arduino micro. This Arduino has a unique feature that allows the Arduino to perform keystrokes on the computer, or in other words, it gives the Arduino the ability to take control over the user's PC. This Arduino receives information via Bluetooth through the HC-05 module and then takes this information to manipulate keyboard functions, such as controlling the cursor. Everything was programmed using the Arduino IDE, which uses a c/c++ dialect.

A lot of coding was involved in creating MouseHead, so it was necessary to break it down into stages. The first stage was tackling the head positioning code on the Arduino pro micro. Next was working with the Arduino mega mini and doing all the necessary functions such as the blinking function and working with Bluetooth. Next was the code for the USB hub. Once all the coding was completed the prototype was constructed. The 3D model was the first to be designed and then printed. After completing the 3D printing, all the electrical components were soldered together using perforated circuit boards and wires, and then all pieces were assembled, and a final prototype was completed. A significant amount of troubleshooting was needed during and after this stage due to the difficulty of trying to fit the vast number of components within a small frame. The final stage was testing and making sure all the functions operated as expected. MouseHead was designed with cost in mind, utilizing low-cost parts for the prototype. It was understood that the prototype would be more expensive than the mass-produced final product. Every effort was made to ensure that the prototype stayed below four hundred dollars. The total estimated cost of the prototype is $277 (parts only). It is believed that a mass production model (with current features only) would cost around $55-$56 per model after initial startup costs (like design and model fabrication), which fits the goal of producing a cost-effective prototype.

IV. Results

The final prototype satisfactorily accomplished all the tasks that MouseHead aimed to achieve. It provided users with a light weight, Bluetooth, and battery powered wearable headset (without requiring a power cord) that allowed users to control their computer. It encompassed voice control to allow users to shout quick commands and easily navigate without even moving. These features will all help to normalize the lives of those who are impaired and unable to perform these types of functions with a standard computer setup or on their own. While there are many potential upgrades to this system, this prototype serves as a great starting point from where this invention can be developed further. Unfortunately, due to time constraints in a one semester course, we were unable to test the prototype with impaired individuals. Preliminary test results of the prototype, however adequately demonstrated the main functionalities of the design.

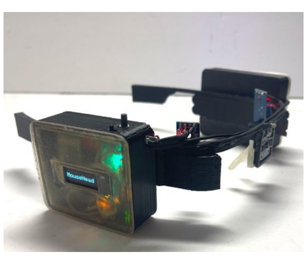

Figure 3. MouseHead - Right view
LCD screen for notifications
and operation mode

Figure 4. MouseHead - Left view
battery and voltage indicator

Figure 5. MouseHead -Top view

Figure 6. MouseHead – USB Hub

V. Problems encountered

While the overall design and production of MouseHead was impressive, there were still some problems experienced during its construction. The first major problem was the underestimation of the programming time required. The initial estimate of the amount of time it would take to create the code for MouseHead was around three to four weeks. The actual time spent on coding was double that time, around six to eight weeks. This was due to the large amount of code required to operate Mousehead. There are over 2000 lines of code across all elements (multiple microcontrollers) running the headset. This made the troubleshooting process difficult, especially when trying to locate a single bug within a single application or piece of hardware. Even with this underestimation, there were few problems encountered when constructing the hardware from the breadboard model, so this helped with completing the prototype before the planned deadline. There was also an issue with the APDS 9960 gesture sensor which functioned inconsistently. This sensor allows users to perform a series of hand swipes in front of the headset to control functions on the computer (for example swiping up or down in front of the headset would scroll up and down in a browser. While it performed well breadboard model, when the final model was constructed the sensor behavior became inconsistent with only around a 30% success rate. 3D printing also provided some challenges as many models were needed before the final design could be completed. After many attempts, an acceptable model was printed.

VI. Suggestions for Future Work

Even though the prototype construction of MouseHead was a complete success, there are some potential modifications that can improve the design for the future. These modifications would be to increase the response time, cursor movement, and frame of MouseHead. The Mousehead prototype is built within a 3-D printed enclosure attached with a microphone that allows the user to gesture actions needed to complete virtual tasks. In the construction of the MouseHead prototype, our gestor sensor did not respond well within large noisy environments. The sensor could record the essential functions of MouseHead such as new tab, start cursor, stop cursor, and multiple other actions. A better gesture sensor capable of capturing voice recognition within noisy situations could be incorporated into the design. This would also require more processing power. A more powerful processor will be needed to fully demonstrate all the capabilities. It would not only allow for better voice recognition and more accurate measurements, but it could add a whole new element to MouseHead, that is voice to text. This would give users the ability to directly type what they say, giving even more features to this device.

VII. Conclusion

In conclusion, the MouseHead senior design project was seen as a success. The final prototype is an acceptable solution to giving those with physical impairments a way to operate computers. MouseHead allows users to control a computer completely hands-free through head movements and eye blink detection. The addition of voice control gives users even more options when it comes to operating a computer. These options allow those with impairments that would otherwise have a difficult time using a keyboard and mouse the ability to operate a computer. While there were problems encountered when completing the prototype, a final working model was able to be completed. There is still a lot that can still be improved upon and added to MouseHead prototype to make it market ready. From more accurate voice recognition to a lighter frame, there is a vast number of directions MouseHead can still go. Overall, the project team was able to address the problem of creating a way to control a computer completely hands-free. This model is able to fully demonstrate the capabilities of MouseHead and is a great steppingstone to the future of assistive computer technologies.

References

[1] J. L. Collinger, "Functional priorities, assistive technology, and brain-computer interfaces after spinal cord injury", *Journal of Rehabilitation Research and Development*, vol. 50, no. 2, pp. 60–145, Nov. 2011.

[2] V. Rohit, "Visual Impairment and Blindness in Adults in the United States: Demographic and Geographic Variations from 2015 to 2050," *JAMA Ophthalmology*, vol. 134, no. 7, pp. 9–802, Nov. 2016.

[3] Alex Clipman, *"Microsoft Hololens 2 ushers in the next generation of augmented reality"*, Proceedings of the Mobile World Congress, Barcelona, Spain, February 24, 2019. Retrieved February 25, 2019.

[4] Albanesius, Chloe, "Google 'Project Glass' Replaces the Smartphone With Glasses", *PC Magazine*, April 12, 2012, Available at: https://www.pcmag.com/article2/0%2C2817%2C2402613%2C00.asp. [Accessed: Jan 25, 2023].

[5] *"Lenovo Introduces the ThinkReality A3 — The Most Versatile Smart Glasses Ever Designed for the Enterprise"*, January 10, 2021, Available at: https://news.lenovo.com/pressroom/press-releases/thinkreality-a3-most-versatile-smart-glasses-ever-designed-for-the-enterprise/. [Accessed February 4, 2024].

[6] HeadMouse Nano Deluxe Bundle for Windows, Origin Instruments, Available at: https://microassistivetech.com/HeadMouse-Nano-Deluxe-Bundle-for-Windows. [Accessed: Feb 4, 2024].