Project Proposal

Freely Adjustable and Accessible Keyboard and Joystick

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Executive Summary

The following proposes a device which will be built to aid a client with quadriplegic athetoid cerebral palsy. The device will be a modified version of a computer keyboard, integrated with a joystick, to replace a standard keyboard and mouse. The modified keyboard will enable the client to type faster and easier, while lessening the stress on his hands and fingers when typing. The joystick will make it easier for the client to navigate programs on the computer.

The proposal gives a background of the client and his disability, and states the purpose of the project. It summarizes the products available on the market now, and compares them to the proposed device. An overview of the device is presented, followed by a more detailed description. The methods for how the device will be constructed are given, and figures are also included to aid in reading the proposal. A rough estimate of the budget is calculated, and this is compared to other products on the market. In general, the proposal gives a description of the project’s necessity to the client, and the reasons why it should be funded.

Introduction

Background

The client this project is being designed for is a male student at Hampton Elementary School who is currently in fifth grade. He has athetoid cerebral palsy, which is a non-progressive neurological physical disability, and is also quadriplegic. Cerebral Palsy is the second most common neurological impairment in childhood, affecting eight to ten-thousand babies and infants each year. Cerebral palsy is a disability that begins at the fetal or infant stage, which affects the basic motor functions of victims, requiring assistive devices to perform basic everyday tasks. In most cases the need for a wheelchair is essential. Many people with this disorder have limited control over their appendages. Hand and arm movements can become distorted or unusable due to neuromuscular weakness. Walking becomes virtually impossible for most and daily tasks that the average person takes for granted, such as using their hands to grab an item, become extremely difficult. Children at school have it worse because writing or use of the computer becomes problematic.

The client’s cerebral palsy severely hinders all his motor abilities. He cannot walk and is dependent on a motorized wheelchair. He also has major difficulties trying to talk, and is forced to communicate using a keyboard to write what he wants to say. The disability also affects the position of his hands, distorting them in peculiar ways that make it very hard to perform basic everyday tasks.

Purpose of the Project

Communication is vital for students in the classroom setting. The client’s disability has made verbal communication virtually impossible, so he is forced to type anything he wants to say. Typing, of course, is also very hard for him, and slows down
his typing speed tremendously. Although the client is a smart and bright young boy, he cannot keep up with the rest of his classmates, because he cannot convey his thoughts nearly as fast as the average individual.

Using a keyboard is something that is taken for granted by most people, but is very difficult for people with cerebral palsy. Motor control is very limited, and the actual position of the hand can be altered, forcing it into an unnatural position. Trying to type using a hand that is twisted and distorted is a complex challenge for people with cerebral palsy. This can be very frustrating, as they cannot type nearly as fast as a normal person. The position the arm is stuck in can also put much strain on muscles supporting the arm. Because of this, typing for an extended period can become uncomfortable and eventually unbearable for a person with cerebral palsy.

The keyboard that the client uses right now is not suited to meet his needs. To be able to keep up with his class, he needs to be able to communicate at a somewhat normal speed. To be able to do this, he needs a keyboard that is designed specifically to meet his needs. The position his hand is stuck in makes it easier for him to type if the keyboard is almost orthogonal to the desk, although his present keyboard cannot be raised up to a vertical level. Also, his motor control is limited; leading to him to slam the keys on the keyboard, which eventually causes damage to the keys. By the end of the day, his arm becomes so tired from typing that his control is worsened and he is only able to type with his thumb. A keyboard is needed that can be positioned in a way that is desired by the client, eliminating stress on his hands. The keys need to be made bigger than average, and also extremely durable, so they are able to handle the force of his typing.

Navigating a computer using a mouse is something else that is practically impossible for our client. The precise hand movements that are required to use a mouse render it an ineffective tool. A suitable replacement for a mouse would be a joystick that has enough stiffness to handle sudden uncontrolled movements. By replacing a mouse with a joystick, he could have greater control with navigating a computer.

The purpose of this project is to design a keyboard and joystick that are geared to meet all of the client’s needs. By creating these devices, the speed of typing and using a computer will be greatly increased. With increased typing speed, the client will be able to improve his communication skills. When completed, this project will provide a means for the client to convey his thoughts in a timely manner, which will make it possible for him to keep up with his classmates.

**Products**

A current product available for patients with disabilities is called FrogPad (Figure 1), which is developed by FrogPad Inc. This is a keyboard that is designed for use with only one hand. The keys are big, but each key contains 4 symbols, which make it impractical for someone with cerebral palsy.
Patent Search Results

Searching the patent database turned up no patents on keyboards that resemble the keyboard being designed. The closest product is FrogPad, although this product varies distinctly from the keyboard that is being designed.

Project Description

Objective

The objective of this project is to design a keyboard, integrated with a joystick, to fit the requirements of the client. The keyboard will resemble a normal keyboard, although it will have minor variations that will make it unique and more applicable for the client. The joystick will work alongside the keyboard, providing an alternative method to an everyday mouse.

When finished, the keyboard should be about 23 in (l) x 3 in (w) x 12 in (h). Each of the keys will be about 2 in x 2 in. The reason for the enlarged keys is to make it easier for the client to press down on each key. With a normal keyboard, he has trouble only pressing one key, because each key is relatively small and close together. The uncontrolled movements of the client have to be taken into account. By creating keys that are 2 in x 2 in, he will have a much easier time pressing down on the desired key.

Another factor that has to be taken into account because of uncontrolled movements is that certain outbursts can cause the client to slam the keys with significant force. This can create a threat to the keyboard, and may even pose an electrical or physical hazard. Keys are needed that can withstand a good amount of pressure, but also need to be simple to type with. To solve this problem it has been decided that strong plastics need to be incorporated within the design, and springs with a good K value will be used. By using strong plastics and decent springs, the keyboard should be able to withstand certain spastic outbreaks.
What makes this keyboard mostly stand out from regular keyboards is the position it is in, and the layout of the keys. Unlike normal keyboards, there are less keys, and each individual key is bigger than normal. To implement this, the circuitry and key matrix of a regular keyboard will need to be redesigned to work with this keyboard. Instead of sitting on the desk like normal keyboards, this one will be positioned on a stand, putting it perpendicular to the desk. This is a request of the client, and it will make typing for him much less strenuous. A simple circular stand with a back-brace will be used to hold up the keyboard. A spring will be used to account for the pressure exerted on the stand by the client typing on the keyboard. The stand will also be heavy enough so that it will not move even if the client is typing with significant force.

The client has also asked that the keyboard look “cool”, so he doesn’t stick out working on a bulky, ugly keyboard. To meet this need, the keyboard will incorporate backlighting, possibly using LED’s. This should provide a “cool” effect, one which the client will most likely appreciate.

A joystick will also be incorporated in the final design, replacing a standard mouse. This joystick will probably be purchased from PQ Controls in Connecticut, and will be connected to the computer, just like the keyboard, using Bluetooth.

**Methods**

The computer keyboard being designed will consist of roughly 50 keys arranged in the ABCDE format (Figure 2). The keys will be twice as big as the standard sized key, approximately two by two inches. The guts of the keyboard will consist of precise circuitry that enables the information to carry from the board to the computer. The key matrix is defined by the circuits below each key. When a key is pressed, a switch is triggered in the circuit, resulting in a change of current. The current is then fed to the microprocessor where the vibration from the switch (bounce) is filtered, and the current is translated in the form of a letter, number, character or action. The microprocessor is able to decipher the difference between a lower case letter and an upper case letter with the use of a character map. Character maps are found in the ROM, which compare the location of a certain circuit on the key matrix. When the character is received by the microprocessor, it is maintained in its memory buffer before it sends the data to the computer. The signal from the keyboard is monitored by the keyboard controller. The keyboard controller is an integrated circuit that processes all of the data coming from the board, forwarding it to the operating system. The operating system then performs a series of checks before completing the task. When it reads the data, it verifies if the signal is a "system level command". Ctrl-Alt-Delete would be a system level command that brings up the task manager or reboots the computer. If not, the data being read is passed on to the opened application. From the application the data is then further analyzed to check if it is a command, such as Ctrl-s for save, or Alt-f which opens up the file menu in a document. Lastly, if the signal is not a command, it is considered "content", or simply the letters, numbers, and characters on the keyboard. The complete process from pressing a key to the information being translated on the computer screen is instantaneous.² (A flow diagram of the processes involved from pressing a key to having
that signal sent to the computer can be seen in Figure 3.)

When designing a keyboard, there are several different types of switches that make each keyboard different. For the purposes of this design, rubber dome switches will be used. In addition to being inexpensive, flexible rubber domes containing a hard carbon center provides exceptional durability; a necessity in this project. The switch works in the manner in which a plunger located on the key, when pressed, pushes against the rubber dome. The carbon center comes in contact with the flat surface beneath the key matrix, causing the circuit to be completed. As the key is released the dome returns to its original shape. To enhance ascetics an illuminated keyboard may be installed. This requires the use of light-emitting diodes (LEDs) or electroluminescent film incorporated into the key matrix.

The keyboard being designed, must be portable, therefore a wireless setting will be important. Wireless keyboards use batteries as a power source and either infrared, radio frequency or Bluetooth connections and a receiver will be plugged into the USB port of the computer. Although infrared is fairly cheap and easy to incorporate into a keyboard, it is difficult to generate a clean connection. Since infrared is a light source, it must make direct contact with the receiver, or in other words, the versatility of the keyboard is lost. This can be seen when one uses a remote control for the television; being forced to point the remote at the receiving box in order for the desired button to work. The keyboard being designed needs a greater range than what infrared can offer; therefore Bluetooth connection will be used. Its affordable price and advantage using radio-frequency makes it the optimal choice. Bluetooth 2.0 works at 3 mbps, communicating with low-power radio waves on a frequency between 2.402 GHz and 2.480 GHz. Bluetooth does not require a straight line connection between the transmitter and the receiver like IR, and it communicates with weak signals of about 1 milliwat, avoiding interference with other electronics.3

Before building the keyboard, the client will be consulted to determine the appropriate and most comfortable key arrangements. In addition, the client’s joystick grip must be established. His disability affects his hand control and strength; therefore an apt joystick handle must be implemented. From this point, a preliminary design will be constructed using a graphic design program such as Visio. Once all the dimensions are decided upon, the plastic parts can be custom ordered for the keyboard.

When an external design of the keyboard is complete, the internal circuitry can be formulated. The first step in creating the insides of a keyboard is the layout. This includes the key matrix and PCB design. In addition the microprocessor has to be incorporated into the circuitry. This will allow the keyboard to function properly. The microprocessor must be programmed specifically to the required keyboard settings. The microprocessor is essentially the brains of the keyboard. Without a proper functioning microprocessor, the keyboard cannot translate the buttons being pushed. Assistance from the computer science engineering (CSE) department in programming the microchip may be necessary. LED’s are going to be incorporated into the circuitry to give the effect of back-lit keyboard. The integrated circuit design is the last step in completing the internal sector of the keyboard. This part includes the keyboard controller that allows the keyboard information to transfer to the PC. Also as mentioned, rubber dome switches
will be used and a port for the Bluetooth connection must be established. When the internal design is finalized the project will be set for construction.

Before assembling the final product, there are prototypes and testing procedures that are crucial to its success. A mathematical representation of the circuit will be displayed using PSpice, MPLAB, and LabView. PSpice will be used to model the electric circuitry of the keyboard, MPLAB will be used to program the microprocessor, and LabVIEW will be used to simulate the final product. After this step has been completed, an informal design can be created to test the circuit for success. This may be used with a protoboard or a supplemental keyboard. If adjustments are needed, the mathematical models can be rearranged and practice keyboards can be altered to the best configuration. When the final design is completed and all tests have proven viable the final keyboard can be created.

Purchasing of the rubber dome switches, key matrix, PCB layout, electronic components (resistors, capacitors, wiring, LEDs, microchips etc.), and Bluetooth connections is the subsequent step. The internal structure will then be combined with the external keyboard interface. The keyboard will be mounted on it’s stand, and after connecting it with a computer, it will be ready for use. (A block diagram of the whole design operation can be seen in Figure 3.)

**Budget**

The average keyboard on the market is fairly cheap, but because the client’s keyboard is custom designed, the final cost will be higher. An average USB keyboard on the market costs roughly $30.00. An average backlit USB keyboard costs approximately $45.00. A FrogPad with Bluetooth connectivity costs $149.99. Here is the estimated budget for the project:

- Custom Built Plastic Parts: $100.00
- Rubber Dome Switches: $0.00 (taken from practice keyboard)
- PCB: $70.00
- Batteries: $10.00
- Key Matrix: $50.00
- Microprocessor: $0.00 (taken from practice keyboard)
- Practice Keyboard: $35.00
- LED’s: $35.00
- Misc. Electrical Parts (resistors, capacitors, etc.): $20.00
- Bluetooth Connectors: $75.00
- Joystick: donated
Total Estimated Budget: $395.00

Scaling the price of our project to be 35% of the prototype costs, the cost is $138.25, which compares with the $149.99 cost of FrogPad.

Conclusion

The finished product will provide our client with a keyboard and joystick designed to accommodate his disabilities caused by cerebral palsy. The keyboard will have large, durable keys, and the layout of the keys will be designed to maximize the usage of space on the keyboard. The device will be positioned perpendicular to the desk, so the client can press the keys without putting strain on his arm. To make the keyboard aesthetically pleasing, backlighting with LED’s will be implemented. By integrating the keyboard with a joystick, the client will have total control over his computer. This will increase his speed at using it dramatically, and with an increased typing speed, he will be able to communicate much easier and quicker with his teacher and classmates.

This device is being designed specifically with the client in mind, so it will never reach a large enough market to become profitable if it were ever to be mass produced. FrogPad seems to have control over this small market already, and trying to compete against them would be foolhardy. The rough estimate of $395.00 falls within our allowed $750, but as stated, this is a rough estimate. This price is based on the assumption that PQ Controls will be willing to donate a joystick for this project. If this assumption is false, a cheaper joystick will have to be implemented, raising the budget estimate. However, the total cost should still remain under the allotted $750.00 budget.

References