Computer Input Device for Muscular Dystrophy

Final Report

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Abstract

Muscular dystrophy causes severe difficulty in movement; unfortunately, this condition worsens with time. The client, who has this condition, has requested a device that allows him access to his personal computer. He is currently using a device fashioned by himself, but he would like an improved design so that he can control his computer more efficiently.

The goal of this project is to create a device that accomplishes this task; it should be more efficient than his current design. It should also be easier to set up, and simple to handle.

Taking these specifications into account, it was decided that splitting the design into three components would allow more adjustable usage. The three components consist of an arm support, a cursor device, and a clicking device. The arm support will be an adjustable ramp for the client's arms to rest on; the cursor device will incorporate an upside down optical mouse, and the clicking device will be a squeezable stick.

Future work includes finalizing the design for the clicking device, then ordering the parts and finally constructing the prototype.

Background

Muscular dystrophy causes the progressive loss of muscle tissue and the weakening of existing skeletal muscle. As a result of muscle loss and weakening, people with muscular dystrophy lose movement and motion as time passes. There currently is no cure, so treatment consists of attempting to limit the symptoms of muscular dystrophy.

Our client, Richard, has muscular dystrophy. Richard has very limited motion. He has movement in two fingers in each hand, and he can slightly turn his head. He does not, however, have full movement in those fingers. He can squeeze, and hold things in his right hand. In his left hand, Richard has less squeezing power and cannot hold things as well, but he can push hard enough to push a mouse button. Richard cannot get out of bed because of his limited motion. It is for this reason that he spends about eight hours a day using his computer. Richard enjoys using his computer for email, the internet and playing games. His computer truly is his connection to the world. Richard cannot use a traditional keyboard and mouse, and this why he needs a computer input device.

Current Design

Richard currently uses a traditional mouse with a large trackball as an input device for his computer. Richard holds a padded pencil in his right hand and uses the eraser end to move the trackball. This moves the cursor around the computer screen. To click, Richard pushes the mouse buttons with the pointer and middle fingers on his left hand. The mouse buttons have foam pieces attached to them so that Richard can reach them. The foam is also present so that pushing the buttons is easier on Richard’s skin. Muscular dystrophy has caused Richard to have extremely sensitive skin. This means that any contact point that Richard makes with the mouse, pencil, or any other surface must be padded. Since Richard has both hands centered around the mouse, his arms must be supported and propped up so that they are stable enough for him to be able to use his mouse. The current design uses multiple towels that are rolled or folded, and placed underneath both of Richard’s arms. The placement of these towels allows him to comfortably reach and use his mouse. Figure 1 shows the current computer input device and support system that Richard uses.

Figure 1: Current computer input design.

Problem Statement

Richard's current input device allows him to use his computer, but it is inefficient and time consuming to set-up. On average it takes about 30 min to get Richard settled. This is because the mouse and towels have to be in precise locations so that Richard can safely and successfully access his mouse. The stability of the current design is also an issue. Components of the current device often slip, and need to be readjusted. The tape holding the foam pieces on the mouse buttons does not hold very well, and when the foam slips, Richard is unable to click until somebody readjusts his set-up. These adjustments can take a few minutes, and they are needed a couple of times every hour. Another issue that Richard has with the current design is the inefficiency of his trackball. It takes Richard about six sweeps with his pencil across the trackball to move the cursor across the screen just once.

Richard needs a computer input device that is easy to use, efficient, and simple to set-up. It has to be reliable, durable, and long lasting. It also should be stable and safe, so that Richard can use it for long periods of time without discomfort or the need for readjustment.

Previous Semester's Design

A group of students from the Fall 2007 semester worked on designing a new computer input device for Richard. They decided to try and use a joystick to move the cursor around, a new mouse to click, and PVC pipe with Tempur-Pedic foam as arm supports. They focused mostly on the joystick in order to make moving the cursor easier for Richard. They extended the arm of the joystick by attaching a spring and a plastic cylinder taken from a pen. They attempted to calibrate the joystick using free software found on the internet. By the end of the semester their design was not quite complete. Software issues did not allow them to finish the cursor movement portion of the design. They were having difficulties zeroing the joystick, and Richard had problems with the cursor drifting while using the joystick. Set-up issues also occurred, as Richard was not quite able to get comfortable using the joystick [1]. Figure 2 shows last semester's design (new arm supports not shown).

Figure 2: Previous design. A joystick, which moves the cursor on the screen.

Arm Support

The first component of the overall design is the arm support system. This system should provide a quick and simple method to adjust the client's arms, allowing proper use of the computer input device. All three alternative designs for the arm support involve a modification of the previous team's design – the arm support pipe (See Figure 3).

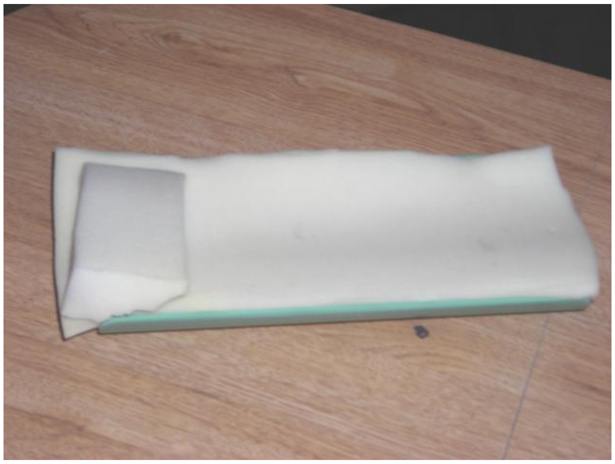


Figure 3: Arm support pipe, created by previous team.

Arm Support Design I: Scissors Lift

The first alternative design for the arm support is the scissors lift. This consists of a latticework of support beams connected at each end. With the rotation of a crank, this support is able to adjust vertically, up and down. Since little vertical adjustment is needed, this lift is able to rise only 6" (15 cm). The arm support pipe rests on the top platform, 10" (25 cm) in length and 4" (10 cm) wide (See Figure 4).

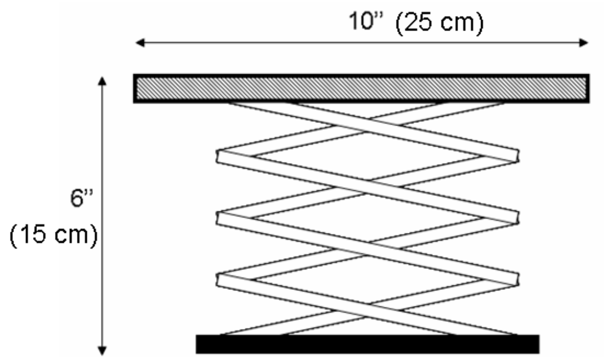


Figure 4: Scissors Lift Support. Adjustable, but not very safe.

While this may be adjustable, it has its disadvantages. It involves a mechanically complex design; many components are needed with an intricate system of beams and bolts. A design such as this is useful when supporting a heavy load. However, it becomes unnecessarily complex when dealing with light loads that can be supported by a more efficient system.

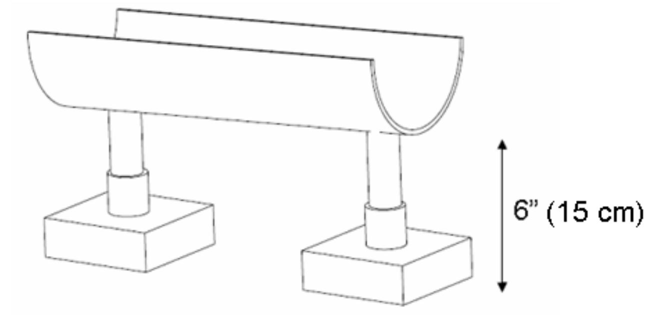
Another drawback to this design is the lack of pivotal motion. It can be adjusted vertically, which is important, but it cannot be tilted. In other words, the client's elbow must be at the same elevation as the wrist. This would be uncomfortable and impractical for the client.

Also, the collapsing of the crossbeams brings up an issue of safety. Appendages are very susceptible to becoming pinched in the beams.

Arm Support Design II: Dual Adjustment

The second alternative design for the arm support component is the dual adjustment system. This design eliminates all of the major disadvantages of the previous design. It consists of two support pipes at the front and back of the arm support pipe. These support pipes can be raised or lowered independently of each other, allowing both vertical and pivotal motion. It is also simpler and safer than the scissors lift since it lacks many complex components (See Figure 5).

Figure 5: Dual Adjustment Arm Support. Safer and simpler than scissor lift design.



The support legs each are 1" (2.8 cm) diameter PVC pipes. There are two per leg, with one fitting tight into the other. This allows for sliding up and down. The bottom of each pipe is welded onto a square support base, approximately 4" (10 cm) per side and 1" (2.8 cm) thick. The top of each leg is attached to the base of the arm support pipe using hinges, which allows one side to be higher than the other.

There is only one major drawback to this design. The client's elbow rests on a cushion atop his bed; it does not need to be raised or lowered. Hence, the support leg under his elbow is completely useless, since little adjustment to the elbow is needed. This disadvantage is taken care of in the next design, the adjustable ramp.

Arm Support Design III: The Adjustable Ramp

The final alternative design for the arm support component is the adjustable ramp. This design basically removes the unnecessary leg from the previous design, the dual adjustment system, which was its only major disadvantage (See Figure 6).

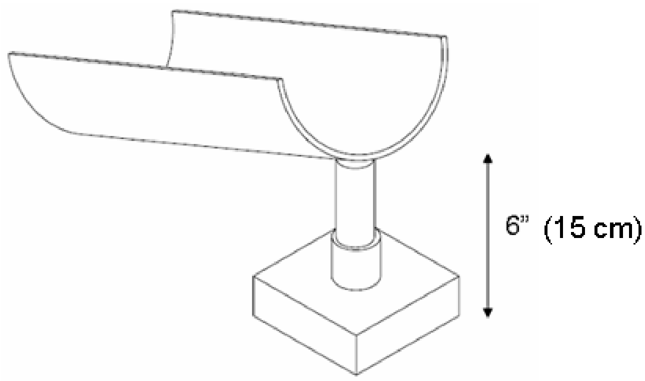


Figure 6: Adjustable Ramp. Even simpler than the dual adjustment system.

The components to this design are identical to the dual adjustment system, save for the fact that it is missing one leg. The support leg is still 6" (15 cm) long, composed of PVC pipe, welded to a base, and attached to the arm support pipe with a hinge. Now, with this design, the client's elbow rests at the legless end of the pipe, while his hand can be moved up and down.

Unfortunately, with the hinge, the arm support pipe, and the arm that it holds up, this design may be somewhat top-heavy. This may lead to tipping, so the base must be heavy to counteract this imbalance.

Arm Support Design Matrix

In order to evaluate each alternative design quantitatively, a design matrix is constructed. Ease of use is the most important factor in the matrix, since the main goal of this project is to make it easier for the client to use his computer. Durability is important; if the parts should wear down or break, the client has few alternatives to turn to. Safety is also key, taking into account the client's sensitive skin and inability to move should he need to in an emergency situation.

Complexity, or ease of assembly, is acknowledged; a simpler design is often a better one. Finally, cost is considered (See Table 1).

Design	Ease of Use (30)	Durability (20)	Safety (20)	Ease of Assembly (20)	Cost (10)	Total
Ramp	30	15	20	15	5	85
Scissors Lift	15	10	10	15	5	55
Dual Adjustment	25	15	20	10	5	75

Table 1: Arm Support Design Matrix. The adjustable ramp was chosen based on the different weighted criteria.

Because of the ramp's efficiency and safety, as well as its edge over the dual adjustment system, it is chosen as the final design.

Cursor Control

The second component of the overall design is the cursor control. The goal of this system is to provide the client with an easy method of maneuvering the cursor across the computer screen.

Cursor Control Design I: Graphics Tablet

A graphics tablet is a device that moves the on-screen cursor by tracking the strokes of a stylus across its surface (See Figure 7). The setup of such a device would consist of the actual tablet itself, and the stylus that must be moved across it. Graphics tablets are readily available through companies such as Dell or directly through their manufacturer, Wacom.

Figure 7: Graphics tablet [2]. Effective, easy to control cursor, but expensive

The advantage of this design lies in its simplicity and its similarity to the client's current setup. The only day-to-day setup involved with this device would be to place the tablet in front of him and plug it into a USB port on his computer. Like his current design, he would move the cursor with a series of small, stroking motions.

The major disadvantages to this design, however, are the cost of the device and the modifications that would be necessary for the client to effectively use this device. Prices of these devices start around $60 to $80, a significant portion of the project budget. Also, the device is normally configured for an individual who can make long, sweeping motions to move the cursor. Modifications would be necessary to "shrink down" the active area on the tablet to roughly the size of a nickel. The manufacturers of these devices stated that the smallest area that the tablet's active area can be shrunk down to is about the size of a credit card, which is far too large for the client. Therefore, extensive modifications may be necessary to make this device useable for our client.

Cursor Control Design II: Joystick

Readily available and inexpensive, a joystick could be modified to fit the client's needs. Last semester's team developed a prototype from a standard gaming joystick (seen in Figure 8), which required very little motion from the client's wrist and arm to move the cursor. All unnecessary components were removed from the device, and a long plastic rod was added to the joystick to give the client leverage (thereby making it easier for him to move the joystick).

Figure 8: Joystick controller. Works well, but difficult to position hand adequately

The difficulties in this design, however, are in the fact that it is very different from the client's current setup. The client would essentially need to re-learn the movements necessary to move the on-screen cursor. Instead of using small strokes to slowly move the mouse across the screen, the client would have to push the joystick in the direction he wanted the mouse to go.

Another difficulty is that this design would not be easy to setup. The client's arms would have to be positioned in a particular, precise position each day, and if his hand or the joystick slips, he would then have to be repositioned.

Cursor Control Design III: Reverse Optical Mouse

Many new models of computer mice use optical devices for tracking movement instead of rubber trackballs. If the mouse is turned upside down so that the optical device is facing upwards, anything to cross in front of this device will cause the on-screen cursor to move (Figure 9).

Figure 9: Reverse optical mouse design. Very sensitive, and easy to adjust.

Computer mice are sold at nearly every computer store and are inexpensive. Also, the optics in a computer mouse are highly sensitive, so the user would not need a large range of motion to move the cursor across the screen. If a small stylus of sorts could be made, the client could simply move this apparatus around near the optics of the upside down mouse, thus allowing him to efficiently move the cursor around on the screen.

This design could, however, require extensive day-to-day setup. It would also require extensive testing with the client to determine at what angle the mouse should be kept at, what kind of stylus (pointer) works best, etc.

Cursor Control Design Matrix

Table 2 is the design matrix for the cursor control component of the design.

Design	Ease of Use (30)	Durability (20)	Safety (20)	Ease of Setup (20)	Cost (10)	Total
Tablet	5	20	20	20	0	65
Joystick	10	15	20	15	10	70
Reverse Optical Mouse	30	15	20	15	5	85

Table 2. Design matrix for cursor control devices. The reverse optical mouse was chosen because of its overall high marks is nearly every category.

The “winner” was the Reverse Optical Mouse. The Tablet’s cost and concerns about how easy it would be for the client to use it, caused it to score the lowest. The Joystick from last semester scored lower than the Reverse Optical Mouse because it too had “Ease of Use” concerns. Therefore, the Reverse Optical Mouse design will be the design that is developed for the remainder of the semester.

Clicking Device

The third component of the overall design is the clicking device. This design should allow the client to right click, left click, and double click with ease. It should also be easy to set up.

Clicking Device Design I: Speech Recognition Software

The idea for this design is to install a program onto the client’s computer that will use verbal prompts from the client to click the mouse; that is, saying the word “click” will execute a click command and saying “double click” will execute a double click command. Programs that have this capability, while difficult to program, are readily available for purchase or download over the internet. The client has a microphone set up like the one in Figure 10 for vocally interfacing with the computer. The vocal option is desirable because it eliminates the use of the client's weaker left hand completely, thusly making the overall input device more reliable. It would also cut down on the amount of time required to set up the interface.

Figure 10: Headset for speech recognition software [3]. Serves many different functions, but unreliable.

The software that was chosen was a free internet download called e-Speaking Voice and Speech Recognition. This program has the ability to turn verbal prompts into on-screen responses; everything from saying "click" for a left click to "open excel" to open Microsoft excel is possible. However, the software is easily confused. When given to the client, it would read background noises such as the client's ventilator as commands. The client also had trouble using the software for quick tasks. For example, when trying to type on screen, the software had an undesirable refractor period between clicks. Overall, the ease of use of this particular software was too poor for it to be considered as a good alternative to the current design. It is still possible that a speech recognition software would work; however, it would be need to be a much more sophisticated program that will most likely be to expensive for the current budget.

Clicking Device Design II: Finger Guides

The idea behind this design is to modify the client's existing set up to prevent his fingers from slipping off the mouse buttons. Having guides for his fingers would also decrease set up time. The guides would consist of two small ledges, most likely made out of plastic, that would be attached via epoxy or other kind of adhesive to the mouse buttons. The plastic would be covered with foam so the client's skin wouldn't be irritated. The client's fingers would rest on these ledges, and he would click the same way he does with the current set up. A rough example of this design can be seen in Figure 10.

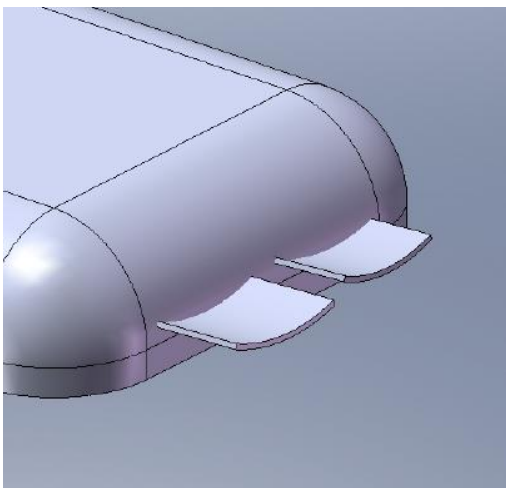


Figure 10: Finger guide design. Attaches to the buttons on a mouse.

This design has two main drawbacks. The first is the safety of the design. While every precaution would be made to be sure that no harm would be done to the client, there is no way to know for sure how the skin on his fingers would hold up with constant contact with something. The fingers on the client's left hand are especially sensitive, so it is possible that even with any safety measures taken with the design it would still cause pain. The second drawback is the difficulty in placing the guides. The fingers on the client's left hand are not straight; rather, they are curved slightly away from each other. In order to place guides that would most effectively hold his fingers in place, they would need to be placed closer to the sides of the mouse. This would decrease the contact area between the guides and the mouse, which would lead to a weaker bond between the guides and the mouse, and ultimately a device more prone to failure. A failure in the guides would be extremely dangerous for the client, which makes this design unfavorable.

Clicking Device Design III: Squeeze Stick

The idea for this design is to create a clicking device that would be easier for the client to use and would eliminate the problems with the current device. To make it easier for the client to use, the clicking would be done by the significantly stronger right hand. Since the right hand is also used for directing the cursor, the clicking device would need to be mounted onto the stylus being used to maneuver the cursor around the screen. An existing mouse would be rewired to a small switch located on the stylus. When the client wanted to click on something, he would simply squeeze the switch, completing the circuit in the mouse and sending the left click command to the computer. There are surgical probes that are similar to the proposed design, as seen in Figure 11. A right click would be performed by a click of a similar device for the left hand, which could be mounted into his arm support to avoid having to hold a switch all day.

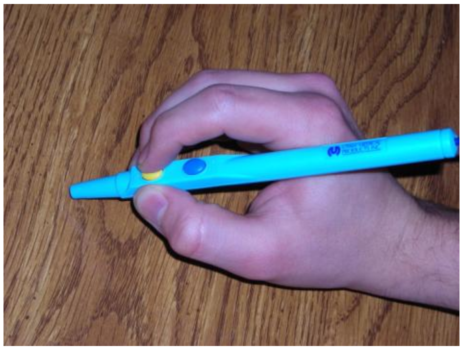


Figure 11: Squeeze stick. Clicks with the push of a button.

This design has a slightly higher degree of difficulty than the other two. In order to rewire the mouse, it would need to dismantled, and the existing clicking switches permanently turned on.

This can be accomplished by any means from soldering the wires together to applying constant pressure to the buttons. Also, the switch would need to be mounted on the stylus in such a way that it would put the majority of the weight towards the bottom (the side that is used to control the cursor). If the weighting is correct, it is possible the client will not be able to use the device for the full time he would like. Drawbacks aside, this design provides the safest, most reliable design alternative to the current set up.

Clicking Device Design Matrix

The design matrix (Table 3) shows that the squeeze stick is by far the best alternative for the clicking device design. The biggest advantage comes from the ease of use category. The squeeze stick was the only one that scored all thirty points, followed by the finger guide at twenty five and the voice software at fifteen. The squeeze pen distances itself further from the other two in the safety category (the finger guide was the only design that did not get all twenty points) and the ease of set up category (the squeeze stick was the only design that received all twenty points in this category). Overall, the squeeze stick only lost ten points, while the other two designs lost an average of eighteen, making it the superior design.

Design	Ease of Use (30)	Durability (20)	Safety (20)	Ease of Assembly (20)	Cost (10)	Total
Voice	15	15	20	10	10	70
Squeeze	30	15	20	20	5	90
Finger Guide	25	15	15	15	5	75

Table 3: Design matrix for clicking device design. The squeeze stick was chosen based on its ease of use and assembly.

Final Design

Two of the three components for this project were brought to completion. The arm support, started by the previous team, was finalized, and the clicking device was created.

Clicking Device

The squeeze stick was decided upon to be pursued at the mid-semester point. A standard surgical imaging probe was used for testing, having buttons on the side that can be clicked. This probe was brought to the client; however, there were several problems that did not allow him to operate the device properly. First, his fingers did not grant him enough strength to manually push the buttons himself. Second, if the tensile force in the buttons was reduced so that he did have enough strength to push them, he still cannot supply the dual motion of both clicking the device and holding it up in his hand simultaneously. With this drawback, we had to alter our approach.

When we reevaluated the problem with the clicking design he has now, we came to the conclusion that standard mouse buttons are not properly oriented in space to contour to his fingers. They were not designed to be clicked in such a way, and thus our next solution arose from this fact. If we could somehow remove the two separate buttons on a mouse, and orient them at any given height and angle, we could fit the two buttons directly under the client's fingers for clicking.

Unfortunately, using sophisticated plastic molding to custom-fit buttons for the client's specifications was not possible. It did not fit in the allotted budget, and there would also be concerns with trying to mold finger guides. The client has extremely sensitive skin, and even a prolonged exposure to plastic causes him skin irritation. So, instead of using a custom-fit molding technique for the buttons, the idea of extreme adjustability came into mind.

If the buttons were not molded to fit the client's fingers, then they should be very adjustable, so that they can be moved around until they are orientated in such a way that the client can click them. This approach was taken out to completion, and a prototype was constructed on this basis.

The buttons themselves were made of single pole double throw (SPDT) micro switches (the standard switch used for a regular mouse button) with small metal levers. The circuit diagram for these switches can be seen in Figure 12. Clicking the switch causes triggering of the button by connecting the common line to the normally open (NO) line.

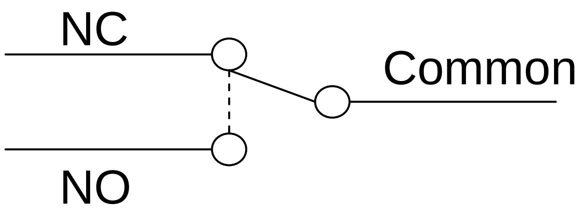


Figure 12: Diagram for common SPDT micro switch. NC stands for “normally closed.” NO stands for “normally open.”

A standard computer mouse was used to connect the SPDT micro switches to a USB cord. The micro switches pre-installed in the mouse were desoldered, removed, and replaced with electrical wire, which lead away from the mouse and ended at the new micro switches. Solder was used to attach the electrical wire to the new micro switches, and these junctions were secured with electrical tape.

For maximum adjustability, these micro switches needed to be attached to something that allowed them a wide range of motions, both directional and angular. They were attached to custom-cut pieces of stiff but bendable metal (made of paper clips) in a tetra-pod fashion (See Figure 13). To supply a base for these micro switches, corkboard was used. In the end, several layers of corkboard were needed for added stability of the buttons (preventing them from moving out of place). Finally, to prevent skin irritation from exposure to the metal lever, small soft foam pieces were glued onto the metal lever.

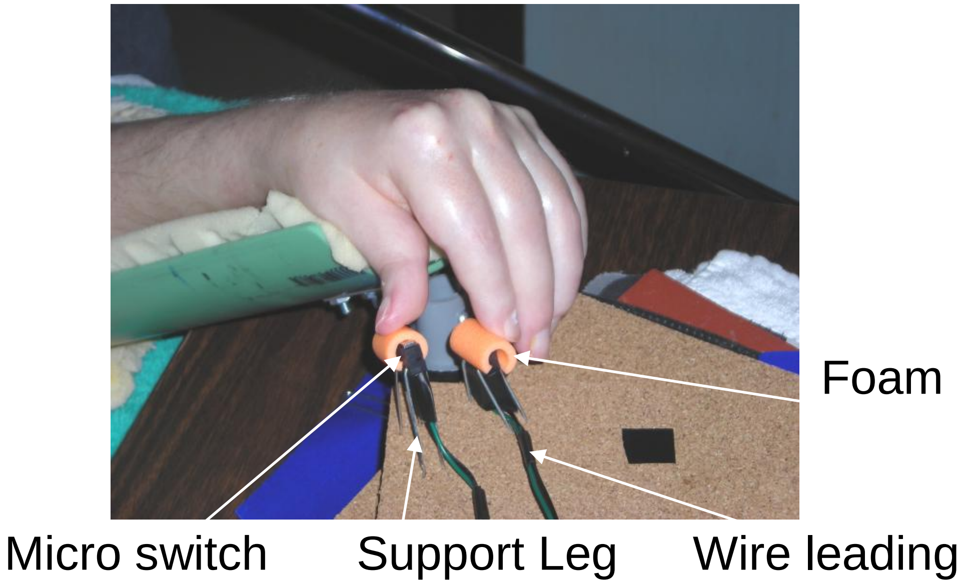


Figure 13: Diagram of clicking device while in use by the client.

The client uses this device by adjusting each micro switch individually. These switches can be raised, lowered, rotated, and tilted in any direction by simply pushing its legs into the corkboard at any desired angle and orientation. This allows for any configuration desired, and can be changed in case the client's specifications change from time to time.

The advantages of this design is obvious when considering its extreme adjustability, but it does have a few drawbacks. While it is very adjustable, this adjustment takes time. If the switches are completely out of place, it can take up to 20 min to adjust them properly for the client to use. Also, its adjustability sacrifices its durability. From being impaled repeatedly by stiff metal wire, the corkboard eventually forms lesions and holes, where it can no longer support the switches properly. Fortunately, this board is very cheap (found at most hardware or project stores), and can be easily replaced.

Arm Support

The arm supports are designed to be a simple ramp that supports the client's arm safely and comfortably. The main length of the arm support is made from a semi-circular length of PVC pipe 25.3 cm long. In order to insure the safety of the arm support, the PVC pipe is lined with 3 cm thick tempurpedic foam that has been cut to conform to the shape of the pipe. At the top of the support, an extra 5 cm of tempurpedic foam has been added to provide additional support for the client's palm.

The PVC pipe is supported by a length of adjustable electrical pipe. The total height of the electrical pipe is specific to each arm. The right arm support electrical pipe has a male pipe length of 9 cm and a female pipe length of 7 cm. The left arm support electrical pipe has a male pipe length of 7 cm and a female pipe length of 4 cm. The electrical pipe is connected to the PVC by a 5.1 cm strap hinge. The hinge is attached to both the PVC by #10-32 x ½" (0.4 cm x 1.3 cm) round head slotted zinc bolts, and to the electrical pipe by #10-32 x 1-½" (0.4 cm x 3.8 cm) round head slotted bolts. A hole ¼" (0.64 cm) in diameter was drilled in the PVC pipe 5.7 cm from the leading edge of the pipe in the center of the pipe. This hole corresponded to the farthest bolt hole on the hinge; other holes of equal diameter were then drilled to correspond to the other bolt holes in the hinge. These dimensions hold true for both the left and right arm supports. To attach the hinge to the electrical pipe on the right arm support, a hole ¼" (0.64 cm) in diameter was drilled 3 cm from the non o-ring side of the male pipe in the center. The hinge was then attached to the farthest bolt hole on the hinge. To attach the hinge to the electrical pipe on the left arm support, a hole ¼" (0.64 cm) in diameter was drilled 1 cm from the non o-ring edge of the male pipe. The hinge was cut just below the second bolt hole, and the second bolt hole was used to attach the hinge to the electrical pipe.

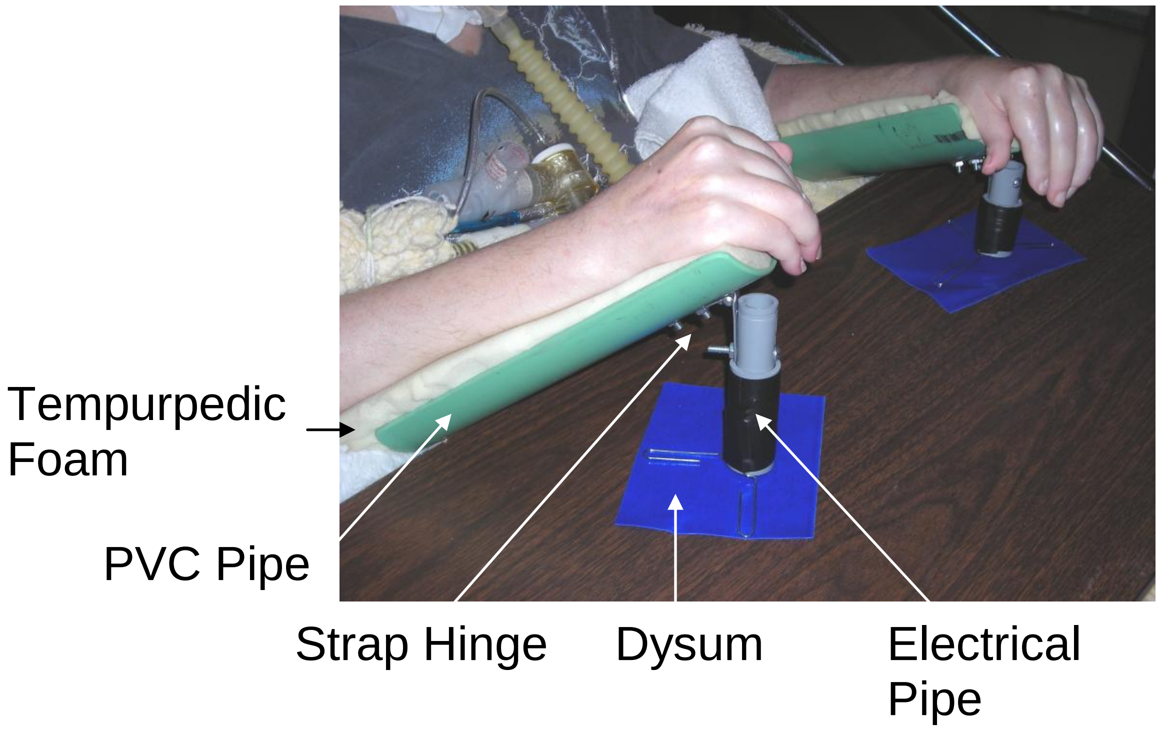


Figure 14: Diagram of Arm Support

To add stability to the arm support, three large paper clips were bent to 90 degrees and attached via electrical tape to the outside of the female pipe 90 degrees apart from each other. When using the support, a small square of dysum should be placed between the table and the contact points of the support to prevent slip.

Testing

Inherent in this project was the need to test every idea and prototype extensively with the client. If a prototype were built that the client could not use, the entire point of the project would have been missed. A testing session usually consisted of setting the client up with the device and having him use it for a period of several minutes. Then the client would be asked various questions pertaining to things such as his comfort, ease of use, etc. Adjustments would be made to his setup according the feedback received during these sessions. The arm support and clicking device prototypes were both tested extensively with the client before being fully developed into their current "end-of-semester" stages.

The first set of tests carried out was to determine if voice recognition software would work for the client. A voice recognition software package was installed on his computer and basic commands, such as "Left Click," were programmed into it. After showing the client how the program worked, it was left with him for two-week period to see how well it would perform over a longer period of time. Problems soon became apparent with this idea, however, since the program mistook the background noise of his respirator for the command to minimize the current window and the client had to use far too much effort to get it to recognize commands. In addition, other background noises caused the program to execute random commands that it "thought" it was being given.

The next test that was conducted was designed to see if the client could click a button that was mounted onto a stick (squeeze-stick). A squeeze-stick was placed in the client's hand between the index finger and the thumb. He was then asked to try to hold the device and depress one of the buttons. Not only did the button require more force to depress than he could exert, but he also did not have the strength or coordination to hold the device by himself. This design did not work because it simply required too much strength and coordination from the patient's hands.

Since it seemed that a switch that required very small force to depress was needed, the next test that was conducted was aimed at determining whether or not the client could depress a lever-micro-switch. The first stage of testing simply involved a team member holding the switch and the client attempting to “click” the switch. This was quite successful, as the client reported having no trouble using the switch.

The next phase of testing was done with a lever-micro-switch that was wired into a computer mouse. Knowing that the client was able to depress this type of switch, this test was mostly conducted to determine how the switches should be positioned so that the client could easily use them. This test consisted of putting the switches in a particular position, asking the client whether he was comfortable and whether he could “click” both of them, and then adjusting them based on his feedback.

This test showed that a lever-micro-switch is the only feasible type of switch to use for this project. It was also found that the stability of the switches is very important, as they would wiggle a little when he clicked them. Also, they must be easily adjustable, as he seemed to need them positioned differently every day. Finally, the sharp metal corners of the switches must be covered to protect his sensitive skin

.

Figure 15: Diagram of Arm Support from previous team [1].

The testing of the arm supports was less extensive, as the only requirement of them was to safely support his arms in such a way so that he could use his computer easily. Working off of the prototype for these from last semester, the first test simply involved placing the client's arms into them (see Figure 15). He was then asked about how comfortable his arms were in them, and the support was inspected to ensure that the foam adequately protected him from the harsh, plastic edges. It was found that these supports needed some modification, as they were not at all stable and did not raise the client's arms above the level of the table (as was needed to allow him to use his computer).

Once modifications had been made to the arm supports to make them for suitable for the client's needs, they were tested once again. It turned out that they were now decently stable and the foam protected his arms from the plastic, but the design was still not perfect. The modifications had caused the arm supports to raise his arms far off of the table, so far, in fact, that he could not use his computer easily. He also asked for more palm support as his hand was sinking deep into the foam.

These modifications were made, and this same test was repeated. The client was quite satisfied and could operate his computer very easily. He did, however, request even more support for his palms as his hands were still sinking into the foam quite a bit. It was also noted that some work still needs to be done to improve stability, as the supports still had some “play” in the lateral direction.

This testing showed that care must be taken in the design of the arm supports so that no sharp edges are exposed, and they must be very stable as the client could be hurt if they were to tip over. The dimensions of these supports must fall within a very narrow window; otherwise the client’s arms will either be too high or too low for efficient use of his computer. Finally, the palm of the client’s hand must be adequately supported, or otherwise his hand is in a very uncomfortable position.

Conclusion and Future Work

As a team, it was felt that significant progress was made this semester. A working clicking device and arm supports were built, and these two designs worked quite well when used simultaneously. The price of this design is also well within the budget of $200 outlined for this project at the beginning of the semester. Not only will this design be far easier to set up than the client’s current design, but also it will also not require frequent adjustments throughout the day.

Some minor concerns that should be addressed in the future involve the arm supports and the clicking device. The clicking device could be made a little sturdier and it could be mounted onto a stable, solid surface. Further measures could also be taken to ensure that the metal edges do not irritate the client's skin. As far as the arm supports go, modifications should be made to improve the palm support and the lateral "play" of the hinge should be fixed. Measures could also be taken to incorporate the clicking device and the arm supports into one unit, rather than two separate ones that have to be set up independently. Overall, however, these two parts of the project are nearly completed and are safe for the client to use.

There are a few safety measures that should be considered in the future with the new clicking device and arm support. The foam on both the arm support and the clicking device should be checked regularly for degradation and wear because it is unknown exactly how long the foam will last. This is important because the client's safety is our primary concern, and if the foam breaks down it could potentially become harmful. Also, the bolts on the underside of the arm support should be checked periodically to make sure they are still tight. If these bolts become loose, they could cause the arm support to lose some of its stability.

The main part of the work that needs to be done in the future is the designing of a cursor control device. During the course of this semester, a cursor control design that was easy for the client to use and would cost under $200 simply could not be found. However, given more time for testing and research, it is possible that a cost efficient cursor control device could be designed. An idea for cursor control did emerge this semester that would have involved using a stylus, whose motion was tracked by an optical mouse, but this idea would have required an extensive amount of testing and there simply was not time. If a cost effective solution could be devised, however, then the client would have all three parts needed to be able to easily access his computer.

References:

[1] Mi, Takami, Kim, and Werbeckes. Computer Input Device for Individual with Muscular Dystrophy. 2007.

[2] Graphics Tablet photograph. Retrieved from www.dell.com on March 5, 2008

[3] Headset photograph. Retrieved from www.provu.co.uk on March 6, 2008

Appendix

Product Design Specifications: Computer Input Device

Revised:
March 10, 2008
March 11, 2008
May 5, 2008

Team Roles:
Team Leader: Steve Welch
Communications: Andrew Bertram
BWIG: Matt Parlato
BSAC: Joe Decker

Function: The device must assist the client in accessing his personal computer. He is currently using a modified trackball mouse, but this device is difficult for him to use and requires a large amount of time to set up each day. Our goal will be to design a device that not only replaces the current "trackball-setup" but one that can also be setup quickly and efficiently. An arm support system will also be designed to hold the client's arms in a position that will allow him to easily access his computer input device.

Client Requirements:

- Input device must allow him to have full access to his computer with minimal physical movement
- Arm supports must be very stable
- Input device must require less continuous adjustments than current trackball-setup
- Input device and arm supports must be able to handle continuous use of at least eight hours per day

Design Requirements:

- Input device and arm supports cannot irritate the client's skin
- Both the arm supports and the input device must be easy to setup and take down on a daily basis

- Input device must require little technical expertise to setup each day (preferably, it would plug into his computer's USB port)
- Device must not require an extensive amount of effort from the client

1. **Physical and Operational Characteristics**
    a. **Performance Requirements:** The input device must allow the client full access to his computer for at least 8 h each day. It must allow require minimal physical

movement on his part. The arm supports must be able to comfortably support his arms for at least eight hours each day. Neither of these devices can allow the client's arms and hands to slip into a position from which he cannot access his computer. Finally, both the arm supports and the input device must function well on a regular basis without requiring frequent adjustments throughout the day.

b. **Safety:** The primary safety concern with the input device and arm supports is that they cannot irritate the client's skin. For instance, a surface as smooth as that of finished wood or smooth plastic would be far too rough for the client's skin. Also, the client lacks significant feeling in his skin, so he would be unable to tell if his skin is being damaged. Therefore, extra care must taken to ensure that all surfaces he touches are extremely soft/forgiving and will not damage his skin in any way.

c. **Accuracy and Reliability:** The device should be precise enough to move the cursor exactly where the client desires with extreme sensitivity. The range of motion is only up to three centimeters, so extreme reliability is needed.

d. **Shelf Life:** The device will be used and stored in a standard apartment home. It must have a shelf life of about the average computer mouse.

e. **Operating Environment:** As stated in part d, this device will be used in a standard apartment home. These are ideal conditions with room temperature ranges. Dust may be a concern, as it might enter the device and cause malfunction.

f. **Ergonomics**: The arm support device must have adjustable height. The wrist should be adjustable from 0 to 15 cm above the table; the arm should be able to adjust laterally. The client's fingers can move in circular motion, approximately 3 cm in diameter.

h. **Size:** The mouse interface must fit into the client's hand, and the arm support must fit on his computer desk

i. **Weight:** Interface should not has excessive weight where the client can't hold it up for 8 h.

j. **Materials:** All materials that come in contact with the client's skin must be soft enough to not cause damage. All other materials must be durable enough to sustain general wear from use

k. **Aesthetics, Appearance, and Finish:** Appearance and aesthetics are not of main concern, and finish should be fit for comfortable use

2. Product Characteristics

a. **Quantity:** One unit will be needed.

b. **Production Cost:** The budget is $200. Since one unit is needed, no production cost limit other than the budget is required.

3. Miscellaneous

a. **Standards and Specifications:** Our device must meet or exceed the efficiency of the current computer input device. Our device must also meet or exceed the speed of set-up time of the current device.

b. **Customer:** The user of our computer input device is an individual with muscular dystrophy. Other individuals with limited arm, hand, and finger movement could also use our device.

c. **Competition:** Our competition is the current device, which consists of a mouse with a large trackball, foam attached to the mouse buttons, and towels as arm supports. Other competition for computer input devices for people with disabilities includes speech recognition computing and optical devices (head movement moves cursor, eye blinks click the mouse).