Redesigning a Gaming Controller
Second Semester Report
Spring Semester 2008

By
Junis Hamadeh
Luke Lawrence
Rob Hasslinger
Lorie Fike

Prepared to partially fulfill the requirements for
ECE402

Department of Electrical and Computer Engineering
Colorado State University
Fort Collins, Colorado 80523

Report Approved: ____________________________________________
                                   Project Advisor

_________________________________________________________
                                   Senior Design Coordinator
Abstract

The idea of redesigning a video game controller for the physically handicapped came about when a man with Muscular Dystrophy approached CSU with such a request. He, and people with similar conditions, are not able to engage in any but passive entertainment. Watching TV and reading can get very boring; there is a need for those with limited movement to be able to engage in more active forms of entertainment, such as playing video games.

We began this project by exploring existing technologies. There is a great deal of assistive technology already in use. However, this technology is used for assisting those with handicaps in communication, learning, and other such practical means. We did find some controllers which could be used for gaming. The problem with these is that they are very expensive, and often specialized for those with no movement below the neck. A controller designed for those with limited movement does not seem to exist, much less one which is fairly affordable.

We have constructed several designs to accomplish our project's goal. We built a circular array of 8 buttons, pressed with one hand on top of a wooden disk. This design was used with a Game Cube, but could be adapted for use with other consoles. We also constructed a redesigned Nintendo DS, using two sets of four buttons that were much lower profile and easier to press than those used in the first design. This redesign could also be adapted to work with other gaming devices.

Several technologies have been explored for future development. Adapting optical mouse technology looks especially promising. We also looked into Webcam and foot-based button technologies. These will be explored further and put into designs and testing in following years.
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Chapter I – Introduction

Redesigning a gaming controller began with a man with Muscular Dystrophy, who has effectively become our client, approaching CSU with the idea of creating a controller that he, and people with similar conditions, could use to play video games. With this beginning, we set off to explore current technologies and possible implementations of this idea.

As we explored the possibilities, we found that we had to define our scope to something smaller than just a video game controller for the handicapped. Since the initiator of the project has Muscular Dystrophy, we decided to define our initial user base as those with physical disabilities that still allow for some movement. We decided against designing games for those with cognitive disabilities or with no movement capabilities at all, at least initially, simply because we cannot cover every possible angle in only one year.

Exploring current technologies lead us to many interesting discoveries, and a greater knowledge of what is available for assisting disabled individuals in day to day life. We were even able to find a few, highly expensive gaming devices. However, none of these devices seemed to target the user base that we had decided to work on.

We have created two fully functional prototypes of two different designs. The first is designed for the Game Cube, and could be used for any system that uses 8 or fewer buttons. The second is designed for use with the Nintendo DS, but could be easily adapted for use in other systems that have only 4 buttons. It is possible to add buttons to the DS redesign, but this has not been implemented or tested. Both designs show great promise, but only the Nintendo DS has potential for being usable by our client.

In chapter 2, we will further examine the reasons for starting and pursuing this project. In chapter 3, we take a close look at the existing technologies for assisting disabled individuals. Then, in chapter 4, we explore the prototypes that we have constructed and their testing. Finally, in the chapter 5 we look at possible routes for future teams, and the conclusions that have been drawn from our project so far.

Chapter II – Project Catalysts

Our group was approached by a man with Muscular Dystrophy to redesign a gaming controller to fit his mobility needs. His journey through life has been long and difficult and marked with pain, suffering and debilitation:

- Born with Werdnig-Hoffman’s Disease, a form of Muscular Dystrophy (MD), and life expectancy of less than two years.
- At age of 12, once again, given less than two years to live because of scoliosis, a side effect of MD. Endured months of painful operations which he had only a 10% chance of surviving.
- Has always been confined to a wheelchair with no use of his legs, arms or hands. [1]

Despite the odds, our client has persevered and is now seeking more active forms of entertainment besides reading and watching TV. As capable and compassionate engineers, we accepted the task of “redesigning a gaming controller” for someone with limited mobility.

Before we could go to the drawing board we needed to understand the limits of mobility that he has as well as others with muscular dystrophy. We did some research on MD and first answered what the disease actually is so we could develop some design constraints. The muscular dystrophies (MD) are a group of more than 30 genetic diseases characterized by progressive weakness and degeneration of the skeletal muscles that control movement. Some forms of MD are seen in infancy or childhood, while others may not appear until middle age or later. The disorders differ in terms of the distribution
and extent of muscle weakness (some forms of MD also affect cardiac muscle), age of onset, rate of progression, and pattern of inheritance. The important factor is that the muscles are constantly in degeneration, which in turn puts limits on our design. [2]

In the primary stages of the project we are just focusing on limitations in mobility. Our client and others with muscular dystrophy have the same cognitive skills of able-bodied individuals. It is for this reason that we are only focusing on the hardware of the gaming controller and not altering the clock or speed of the software. Also, many concerned with affordability and does not want to fork out hundreds of dollars for a gaming controller. It is for this reason that we have chosen to retrofit an existing controller to fit our client's mobility needs.

We have begun further research by visiting local facilities in Fort Collins and meeting with patients and workers to develop a range of motion to develop our design constraints. Foothills Gateway and Respite Care are working with us in conjunction with the university’s Occupational Therapy Program to develop testing methods with our future designs. Testing and methods are further explained in the appendices.

Chapter III – Current Technologies

In order to get an idea of what we might do with our project, we began to research current technologies available for disabled people both in gaming and in everyday life. We needed to figure out in what direction to go with our gaming controller, so the first thing we did was to go to the Occupational Therapy department at CSU. Within this department, there are many assistive technologies being used to help disabled students operate computers by using a mouse head tracker. “A head tracker is an alternative for the computer mouse that allows people with head control to control a computer. A dot is placed at the forehead or an eyeglass and the head tracker uses the reflections of infrared light to calculate the position of the head.”[3]

Figure 3.1: Sip and puff device
http://www.enablingdevices.com

Other devices we discovered that might be useful are the sip & puff controls, shown in figure 3.1. This switching device activates two functions with only one tube. Sipping is one function and puffing another function. These devices usually come with something to be attached to the wheelchair since it is a device designed for a quadriplegic person. There were plenty of other switching devices but most of them were either too expensive or not applicable to our design constraints.

Other technologies exist for assisting those with physical handicaps to interact with technology. Unfortunately, all of it is either aimed at very light physical limitations, or is far too expensive to meet our project's goals. With this in mind, we began to form our redesigns.

Chapter IV – Current Designs

1. Game Cube Redesign and Testing

Our first redesign was for a Game Cube controller. We attempted to put all 8 primary control buttons into an array of buttons that could be easily pressed with one hand. So, we created a circle of
buttons, with a disc suspended over them. The disc could then be tilted in one direction or another to press the buttons. This first design had a large half-sphere attached to the top of the disk, intended to allow for a hand to rest on top of it and easily tilt the disk. This circle of buttons would then be wired to a connector. This connector was made to plug into one of our two testing devices. This first design is shown in figure 4.1.

![Figure 4.1 The first Game Cube controller design](image)

We devised two methods of testing our controller. The first was a circle of LEDs, set in a PC board, which would light up when a button was pressed. Our idea was that this would tell us which buttons were easy to press and which ones were harder or impossible to press. The second method of testing was to just attach our controller to a disassembled Game Cube controller and attempt to play a game. The LED board could plug directly into the connector that the buttons were wired to. The Game Cube controller was wired into the spots on the PC board that the LEDs would have been attached to, thus allowing the circle of buttons to connect to either device. We found that all 8 buttons could be pressed, and that our design could be used to control a Game Cube.

When our first design was tested on our client, the man who originated the project, we found that the box was far too tall for him, and that the half sphere was very difficult for him to get his hand on or around. So, we decided to tweak the design.

Our second design for the game cube was fundamentally the same as the first, but with the added goal to have the lowest profile physically possible. The box that contained the buttons was made to be thin enough that the buttons nearly touched the bottom of it, the disk on top was lowered to be just above the buttons, and the large half-sphere was removed. This design was again tested by our client, and it was still a little too tall, and the buttons were far too difficult to press. The only possible way to fix these problems was a complete redesign with different buttons, a different set up, and an abandonment of the enclosed box idea. This lead to our pursuit of the Nintendo DS.

![Figure 4.2 The second design for the Game Cube. While it is much lower profile than the previous design, it still did not work for our cleint.](image)

The Game Cube design was not successful in allowing our client to play video games, but we feel that it may still be viable for individuals with less severe handicaps. Thus it was not a total failure, although it did not reach all of our project's goals.
2. Nintendo DS redesigned and tested

After the Nintendo GameCube idea did not work for our client, we decided to follow up on one of the client’s original ideas of using the Nintendo DS with a bouncy ball resting on the buttons and him rocking the ball to push the individual buttons, since the client had already been using the Nintendo DS and had beaten an entire game with this method. His only real complaint about the Nintendo DS was that the buttons were much too close together for him to use, so he wanted the position of the buttons to be more flexible. So relocation of the buttons was the first task to accomplish but of course not the last. When we added a new member to the team, an occupational therapist (Lorie Fike), to better understand his Range of Motion, we learned that we needed a low profile control button pad. That was actually one of the reasons the GameCube did not work, its profile was much too high for the client to position his hands comfortably on the controller. We had several ideas of creating a low profile controller, which included printed circuit boards (PCB) from other controllers. The most efficient one we discovered, however, was out of a Sony Playstation 2 (PS2) controller. The controller consists of a thin plastic sheet and has exposed carbon contacts on it which form the buttons/switches. The drive circuit is on a separate PC board that attaches to the plastic sheet controller. This was the lowest profile controller available to us. We purchased our first DS, which was a refurbished item, from GameStop and began disassembly of the system.

The first problem we ran into was unscrewing the Tri-Wing security screws Nintendo employs in all of its controllers and systems. We had to modify an existing screw driver in order to open the DS. Once we finally opened the DS we located the switches for game play and began disassembling them. The switches consisted of a simple round concave piece of metal that was attached via an unknown kind of glue film and rested on two outside contacts, one on the right and one on the left. There is another contact in the middle that is activated when the metal piece is bent down onto it, i.e. a button is being pushed. The outside contact in some cases was the low potential (Ground) but in other cases the inside was the low potential. We had to measure and record all the individual setups in order to find a common ground, so we didn’t have to wire each individual ground. Now that we had established the setup we began soldering the thick solid wires to the contacts and then soldering the other side of the wires to the LED printed circuit boards mentioned earlier, which we kept the wires from the board to the DS fairly short. These boards have the D-Sub female connector attached to them so that we can interchange the controllers we make by attaching them to the male D-Sub connector. The controller plastic pad was attached to the PC board where there was good contacts to solder wires as well. We soldered the wires to the contacts that led to the buttons we wanted to use and soldered the other side to the male D-Sub connector in the appropriate places. We then attached the original rubber pads that had a carbon button in them, back to the plastic controller, a different rubber pad on each side to see which one works best. The client could rest a bouncy ball in the middle of the rubber pad and rock the ball with his hand to press the buttons. Now we had something that we could test on our client.

When we went to test it, however, we ran into only more problems. It seemed that the buttons were being shorted somewhere and the touch screen was not responding either. One of the rubber pads attached was too far apart for the client as well. The thick solid wires we used, as well as the length between the board and the DS, seemed to also pose a problem. Motivated by our curiosity in our mistakes we went to find out what was causing the short to occur. The short was actually because of the plastic controller pad we were using. The Sony PS2 controller employs low resistance switches which we were unaware of but recognized fairly quickly. We separated the connection to make them a fairly high resistance to coincide with the resistance in the DS which is effectively infinity. Once the buttons worked we attacked the next problem, which was the touch screen. This was also a fairly obvious problem, the ribbon that connects the touch screen to the DS motherboard had come lose somewhere in
the process. We tried to reattach the delicate ribbon but only further damaged it to the point of no return. We had to replace the DS with another refurbished DS we ordered and received shortly after. We repeated the soldering based on the previous positions of high and low but this time we used thin stranded wire that was more flexible and easier to solder to small contacts. We also made the wires longer from board to DS to increase the flexibility of position. Wiring the high and low potentials of the new DS the same way as the prototype turned out to be another problem since the position of high and low had changed for some of the switches in this DS. We fixed this problem right away and continued on to fix the last problem, the bigger rubber pad. We replaced the bigger rubber pad with the smallest one available to us and comparable to the other side. Now we had a working product to test on the client again.

![Final Nintendo DS design](image)

Figure 4.3 Final Nintendo DS design

This time all the buttons worked and weren’t shorted, the rubber pads were small enough, and the touch screen worked. Nonetheless, it did not work because there was not enough force or leverage for the client to push the buttons and activate them. However, the additional pressure needed to activate the buttons was very minute. The client was able to activate individual switches by just pressing on his hand with a stick he held in his mouth (this stick was in his mouth originally to work with the touch screen). So we knew there were very minimal adjustments we had to make to get it to work. Based on the client’s previous experience with these controllers he mentioned weakening the rubber that acted as a spring in the buttons, which seemed like a good idea and something we would want to follow up on. We did weaken the physical structure of the rubber and the buttons, which are now able to be pushed by just the weight of a large bouncy ball. The testing however will not be achieved before the due date of this report. Future reports will include the conclusion to this design. We have high hopes that this design will be functional for our client.

Chapter V – Conclusions and future work

1. Design plans for next year

Rob Hasslinger, a Junior in Electrical Engineering, has been researching and exploring technologies and designs that could be used for next next year. The results of his research follow.

1.a Introduction of Future Designs

The purpose of this project is to investigate future ideas for the “Redesigning a Gaming Controller”, senior design project. We worked under the supervision of Brian Misek of Avago Industries. We concentrated on several areas to accomplish this task. The first item we will go over is
the design kit given to the team by Mr. Misek. Next we will discuss in detail several solutions tailored to the needs of team’s current subject, Lance Carr. We will investigate options to add to the current design focused on utilizing Lances head movement. Next we will look into other options for people with different types of handicaps. We will concentrate on people with arm amputations. Finally we will conclude by making a recommendation for the direction this project should follow for next year.

1.b Design Kit

We were given an ADNK-3061 Solid State Mouse Sensor Reference Design Kit by Brian Misek of Avago industries. First we will explain the overall workings of the mouse design, and then elaborate on specific parts.

Figure 5.1 Cross Sectional Assembly of Mouse

A 720 nm light wave from a LED is projected onto a surface through a prism. The sensor measures changes in position by optically acquiring sequential surface images and mathematically determining the direction and magnitude of movement. This information is then processed by the microprocessor then relayed to a PC in the way of machine code.

We will first discuss the operating theory of the ADNS-3060 high performance optical mouse sensor. The 3060 is capable of sensing motion up to 40 inches per second and an acceleration of 15g’s. It measures changes in position by optically acquiring sequential surface images and mathematically determining direction and motion. It contains an Image Acquisition System, a Digital Signal Processor, and a four-wire serial port. The sensor uses the lens and prisms to illuminate the surface with a low angle illumination, creating shadows on an objects surface. The Image Acquisition System then takes an image and compares it to a reference image using a correlation function to see if there has been movement. These images are then processed by the Digital Signal Processor which calculates the change in x and y positions. This is then processed by an external microcontroller via the serial port.
The next piece of equipment we will discuss is the Cypress CY7C63743-PC Microcontroller. This is an 8-bit controller with a 12 MHz internal CPU clock. It is a one-time-programmable microcontroller designed specifically for USB and PS/2 operations.

**Figure 5.3** Block Diagram of Cypress CY7C63743-PC Microcontroller

1.c Lance Carr

In conjunction with OT Lorie Fike, of the Occupational Therapy department, the team has designed several controllers utilizing hand motion only. Since Lance has limited movement with his
hands, a design constraint has been controllers with eight controls or less. This will of course limit the games or even gaming systems available for him to use. For example the original Nintendo has eight active controls, but newer systems may use up to 16 active controls for a particular game. However Lance does have great mobility with his head. The head could provide an additional ten active controls used during game play. The team has researched several different options. These options include a fixed head design, as well two far field designs. Two design ideas were centered on the Avago Technologies ADNK-3061 Solid State Mouse Sensor Reference Design Kit. The third would utilize a webcam from a PC.

First we will discuss the fixed head gyroscope design. The basis behind this design would be to use the current mouse technology along with a head mounted gyroscope to provide an additional eight active controls. This option is fairly straightforward. The sensor has an approximate range of 2 mm with the current optics system. This means that it would only need to be mounted to a gyroscope. The Cypress Microcontroller has the ability to process information from the ADNS-3060 sensor and relay it as an electrical impulse. This means that the gyroscope could be hard wired directly to a controller’s joystick with a minimum amount of programming. There are several advantages to this solution. The first advantage is a very low cost. The next advantage would be that this is the most closely related option for the technology given to us. This design would not too far from the original design of the mouse kit. Because of this there would be less programming, therefore less things to go wrong. Also there would be greater accuracy in control of head movement. Since you can control the sensitivity of the motion detector you could still have great control, while still not have to worry about small head movements? There are also several disadvantages to this design. The first would be obtaining an adjustable gyroscope that would mount on the head. The next problem with this design is the obvious bulk involved with all this equipment. The cord coming of the head would also be a possible nuisance. Finally this would not be a “sexy choice.” For research a team member attached a mouse to his head and played an online video game for one hour. He complained about a terrible crook in his neck afterwards.

The next solution would be a far field infrared motion detection system. The basic concept of this project would be to detect the motion of the persons head from a motion detector mounted on the television. Below is a diagram of a possible design.
First you would need to use a different LED since the 720 nm is still in the visible spectrum. A LED from a common television remote control operates at 920 nm which is out of the visible light spectrum. This would then be reflected off of a piece of metal attached to a person’s head. For cost purposes polished piece silver would also work. The light from the LED is then reflected back to the optics system. This would be the most difficult portion of the whole task and where the project could encounter hold ups. This would then read by the sensor and translated the exact same way that the mouse registers a change in direction. The reason this would be a viable option is because you would not need great accuracy. Once the information was collected from the motion sensor it could then be ran through a program in a PC. This would break all movements into nine different quadrants as shown.

![Diagram of optical mouse](image)

**Figure 5.4 Optical Mouse Diagram**

This would create eight different commands with the center quadrant being a dead zone, protecting against unwanted commands due to small head movements. This same design principle could also be accomplished with the gyroscope idea, but is the only realistic option for this layout. Advantages of this design would be less bulk on the head and a possible low production cost. The major
disadvantages are accuracy and range. A for this design concern would be the ability to build an optics system.

When researching optics systems, the most common material that was available was on building a PC webcam. Since the point of the previous solution was a low cost motion detector, the camera would accomplish the same objectives with greater accuracy. Since cameras and tracking software already exist, the only obstacle would be translating this information to the gaming system. The advantage of this design would be the same as those of the LED sensor with greater accuracy. The disadvantage of this would be relative ease in design. A possible option would be using the camera in conjunction with the Cypress microcontroller as an independent unit.

With all of these solutions two extra controls could be easily configured by using the left and right hand buttons. These could be used to create two mouth controllers. One would be activated by biting down and the other activated with the tongue. These could be used in a number of capacities. The select and start buttons seem to make the most sense to me. This would be ideal because you mount them on something that would be mounted over the shoulder, like a water hose. Since the select and start buttons are seldom used the subject would not have to keep this additional controller in their mouth.

1.d Other Disabilities

The previous options were all researched with a specific subjects needs in mind. However there are other people with handicaps that prevent them from playing video games. In this section we will discuss ideas for other possible solutions not specific to Lance.

With the United States in a war at the present time, there are soldiers coming home with different amputations. So we discussed several possibilities that may be good to look into for those limited to only one hand. One possibility would be to make use of a glove that detects motion in the fingers. The theory behind this concept would be that with five digits you could have ten different controls all with one hand. A concern with this option is that it may be difficult to accurately control all ten digits.

Another option would be to use foot pedals in conjunction with other options all ready discussed or implemented. These could be used in several different ways. The obvious is each pedal representing one or two commands. Another interesting possibility would be to build two foot pedals each representing a change in direction. This could be used as a joystick where the change in y would be the left and change in x controlled by the left foot. This could be easily accomplished using the motion sensor provided with the mouse kit. This could also be done where both directions were controlled with the dominate foot, leaving the other foot available for more options. A team member attempted to “surf” for an hour, using his foot to control the mouse. He quit after only twenty minutes due to his knee being in terrible pain probably due to the lateral movement. We do not recommend this as a possibility.

Other options that may be looked into would be biometrics. Voice recognition for various commands could be a powerful tool. Another possibility would be to track eye blinks as buttons.
1.e Recommendation of Future Plans

In conclusion we have explained the technology given to us. We then laid out various plans to use this technology for future design projects. We also have suggested various other options that may be interesting to investigate in the future using other technology. After researching these ideas we would have to conclude that it would be worth it to go forward with the far field infrared motion sensor. We also think that the other options would be good to try first to work out any programming issues. I also would recommend going forward the foot pedal implementation. Used in conjunction with the current project, both of these designs would be viable options to replace a video game joystick.

2. Conclusions

We have undertaken the task of retrofitting existing controllers to allow handicapped individuals to enjoy video game entertainment. The current technology is far too expensive, and a design that can be easily made and purchased is needed.

Our initial design and prototype for the Game Cube is promising, although it does not work for those with especially severe handicaps, such as our client. Our second design, that for the Nintendo DS, has had a rough time getting completed, but has huge potential for our client and others with that sort of severe disability.

Throughout our research we have learned that physically disabled individuals, especially those with muscular dystrophy, live very boring lives. While able-bodied individuals have the freedom to play sports and be active, consumers have targeted them as their main audience for video-games. One would think that in our current state of technological affairs there would be more of a market for individuals who cannot perform such active tasks. After working with our client and others with similar limited mobility we feel compassion as capable engineers and are compelled to bring them an affordable, reliable, working product.
References


Bibliography


"Lance Carr "Art from Inspiration, Inspiration from Art."." Lance Carr "Art from Inspiration, Inspiration from Art."."


People:


“Kluas Harting” C.S.U. 6 April 2008
Appendix A – Budget

We began this semester with the standard budget for Senior design, $50 for each student per semester. With some additional donations, we ended up with a little over $300 for our the year. We have spent $304 thus far, with donations of several controllers, a Game Cube Console and a few games as well as 20 PC boards. Our budget for the year, with the amounts spent is summarized by the following table:

Table A.1: A summary of our first semester budget

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<td>Nintendo DS</td>
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Figure A.1: A chart summarizing our first semester budget

In detail, we have purchased 32 switches, 8 LEDs, 2 Nintendo DS handhelds, wire, solder and Plexiglas. We have had many controllers, 2 Game Cube consoles, 2 Game Cube games, 100 LEDs, plywood, paint, tools, and a some other misc equipment donated or lent to our project.
Appendix B – Testing Methods

In order to test our various designs, we had one subject with muscular dystrophy. In the future, other subjects with this and other degenerative diseases that limit motion as well as subjects with other disabilities that would inhibit the dexterity needed to use a standard gaming controller will be tested. Ideally, we would want at least 10 subjects to test each design, and for each to spend a significant amount of time on each one.

Our initial tests were simply functionality – if it was even possible for our test subject to use. Future tests will collect data on if the subjects were able to light up each of the LEDs connected to the buttons consistently, how easy it was to light up each LED, and if using the device for an extended period of time made it easier to use. A second test will consist of each subject playing games with each controller. Data should be collected on a scale of 1 to 10 for each of these tests and each button, with 10 being perfect and 1 being completely unusable. Any comments on how the design could be improved will be appreciated and taken into consideration in future designs.

Once the data and feedback have been collected, we will collect the data into a table, analyze it and create a better design based on these results. Once improved designs have been constructed, further similar testing will be required.
Appendix C – Design Constraints

- Affordable
- User has some motion in hands or feet
- User has little or no cognitive disabilities
- Design is usable enough to play video games
Appendix D – Nintendo DS Specifications

Materials needed:
1 Sony brand PS2 controller
1 Nintendo DS
Lots of Wire
Solder

Specifications:
Attach Wire to DS buttons – Scrape Epoxy off of buttons first
Scrape the black short between the contacts on the PS2 board or the buttons will short themselves
Attack wires to PC board connector on the PS2 controllers – follow wire tracings in the plastic board
Attach rubber button pad to PS2 controller board
### Appendix E – Lance's Range of Motion

<table>
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<th>Joint</th>
<th>Degrees of AROM Right</th>
<th>Degrees of AROM Left</th>
<th>Normal Degrees of ROM</th>
<th>Lance's % of normal Right</th>
<th>Lance’s % of normal Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbow extension-flexion</td>
<td>88-98 gravity eliminated</td>
<td>88-98 gravity eliminated</td>
<td>0-150</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Forearm supination/pronation</td>
<td>No active/90</td>
<td>No active/90</td>
<td>80/80</td>
<td>56%</td>
<td>56%</td>
</tr>
<tr>
<td>Wrist extension-flexion</td>
<td>No active/0</td>
<td>No active/95</td>
<td>70/80</td>
<td>0%</td>
<td>63%</td>
</tr>
<tr>
<td>Wrist ulnar/radial deviation</td>
<td>90/no active</td>
<td>95/no active</td>
<td>30/20</td>
<td>180%</td>
<td>190%</td>
</tr>
<tr>
<td>Thumb Abduction</td>
<td>No active</td>
<td>No active</td>
<td>0/70</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Thumb MP extension-flexion</td>
<td>5-10</td>
<td>0-10</td>
<td>0-50</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>Thumb IP extension-flexion</td>
<td>40-45</td>
<td>+20-10</td>
<td>0-80</td>
<td>6%</td>
<td>38%</td>
</tr>
<tr>
<td>Index Finger MP extension-flexion</td>
<td>0-5</td>
<td>10-15</td>
<td>0-90</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Index Finger PIP extension-flexion</td>
<td>90-95</td>
<td>32-60</td>
<td>0-100</td>
<td>5%</td>
<td>28%</td>
</tr>
<tr>
<td>Index Finger DIP extension-flexion</td>
<td>10-15</td>
<td>30-45</td>
<td>0-90</td>
<td>6%</td>
<td>17%</td>
</tr>
</tbody>
</table>

*AROM= Active Range of Motion

*Lance has significantly decreased range of motion in his elbow, forearm, wrist, thumb and all digits. He has no active use of his middle, ring or little fingers. His disease is a progressive disease that has resulted in both decreased strength and joint contractures which significantly limit his ability to engage in work, self-care and leisure pursuits.*
Acknowledgments

We would like to thank Lance Carr for originating this project, and for working with our group on several occasions to get us started. Also, Walt Grady from HP gave us many pointers and a lot of excellent advice on our project. Brian Misek from Avago also came in and discussed several more technologically advanced ways for us to design a gaming controller, including the optical mouse technology and the radial array method of retrofitting. Lorie Fike, an occupational therapist, joined our team to assist us in interfacing with clients, and checking the workability of our designs. Finally, we would like to thank our advisor, Dr. Olivera Notaros for all of the direction that she has given us over the semester, for keeping us on track and for pushing us to the point we have arrived at.

We would also like to thank Buy Back Games of Fort Collins for donating a Game Cube controller, Game Cube consoles, numerous controllers from other systems, and two Game Cube Games.