CHAPTER 21
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MULTISENSORY ENVIRONMENT

Designers: Prachi Asher, Brandy Hill and Beth Wirick
Client Coordinator: Asha Asher, Sycamore School District
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INTRODUCTION

The goal was to create a portable multisensory environment for students with severe disabilities. Schools use multisensory environments (MSE) to establish and improve perceptual and cognitive skills that students with various disabilities often have difficulty developing. Because of their disabilities, these children may not respond to traditional treatment and educational methods. This behavior may be partially due to a sensory imbalance. This MSE is designed to improve sensory imbalance. It is an interactive tool for both therapeutic and leisure activities. The children are sensitive to their surroundings and any changes to it. MSEs offer controlled experiences.

This MSE has one button that controls the stimulation whereas in a MSE room, all devices are controlled separately. The MSE allows choice, independence and the teaching of specific skills, and the same sensory experience as a multisensory room.

SUMMARY OF IMPACT

The MSE met the basic specifications of the client. The auditory and visual senses are stimulated through the use of lights, sounds, and actions generated from twelve different devices. The student uses a single push button to control these various generic devices. The teacher or therapist has several options to control how the MSE will function. The teacher first selects how the student buttons will function: hit and hold or timed. Other options include a selection of three scenes and the option of removing a device from the environment. Users found the environment absorbing and fun to use.

TECHNICAL DESCRIPTION

The approach to the solution was to use a tri-fold science fair board design with dimensions that fit a standard table. The tri-fold surrounds the student to give the effect of an environment. The casing of the MSE is made of plywood mounting panels and backboards. The frame is made of pine. Each panel is 2.5 feet high and three inches thick. The two side panels are two feet wide while the center panel is 2.5 feet wide.

Figure 21.1. User Interacting with the Multisensory Environment.

Figure 21.2. User Interacting with the Multisensory Environment.

There are a total of twelve devices included in the MSE. The first panel (purple) consists of an Ultra Violet Light, Beaded curtain, Bubble column, and a series of Christmas lights. The center panel (blue) consists of Christmas lights, a tap light, a mini fan, a fiber-optic spray, and a lightening storm. The last panel (green) consists of a bubble column, Christmas lights, and rope lights. All of the devices operate on 12 V AC/DC or less. Two of the devices have mirrors mounted behind them to give the illusion of depth to the device. Most of the small devices are mounted on a ¼ inch thick panel of wood that is permanently fixed within the casing.

All of the button functions are set and controlled by the teacher. The internal circuitry for the teacher options is read and executed by the microprocessor. The student-controlled button is plugged into the project box, which contains the main circuit, located behind the MSE. These switches control each device, one at a time, when pressed. The circuitry for the MSE is fitted into two project boxes that are externally connected to the backboard of the center panel. There are two devices that use motors: the fan and the beaded curtain. These motors are small three-volt project motors that can be purchased at any hobby shop

The MSE operates using a microprocessor and various analog and digital circuitry. The MSE is powered by 120 VAC that is readily available. The main portion of the circuitry utilizes logic gates, monostable mulitvibrators, and a flip-flop to transmit signals from the teacher options to the six input pins (P0-P5) of the microprocessor. Approximately thirty different integrated circuit chips (ICs) are used, half of which are complementary metal oxide semiconductor field-effect transistors (CMOS). The remaining ICs are transistor-transistor logic (TTL) components. The chips were placed onto sockets and wire wrapped together on a standard project board. An effort was made to minimize the power dissipation and thereby minimize the operating temperatures. Since the operating conditions do not require many rapid switches from one logic state to the other, CMOS components are preferred.

Ten pins of the microprocessor are designated as the output pins. Four go to the light portion of the devices and six go to the sound chip. There are a total of twelve light devices but only four output

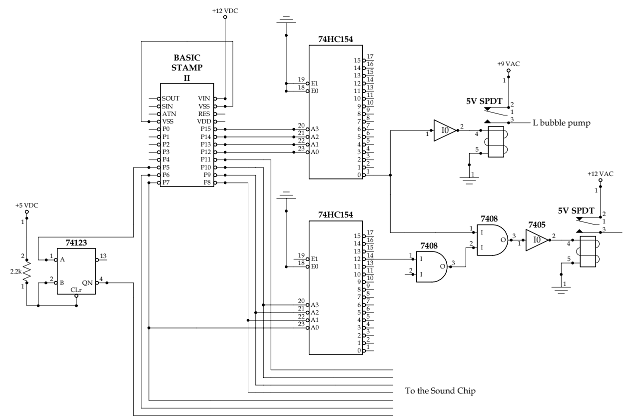

Figure 21.3. Output Electrical Circuit.

pins. To remedy this problem, a four to sixteen decoder was used. A decoder uses a four-bit binary input and gives sixteen different outputs. Each device is connected to one output of the decoder. Following the decoder, a buffer was used to get a clean five-volt output and also increases the current. Following the buffer, a relay was used to connect the device. A relay is an electromechanical switch that uses a small voltage, which in this case is five volts, and is capable of switching to high voltages. This is necessary because some of the devices use voltages greater than five volts to operate.

The wiring of the devices are shielded by ¼ of an inch thick piece of wood, approximately the same height and width of a panel, that screws into the back of each panel thus making it hard for children to access. Also, this design allows the owner to be able to replace damaged parts (i.e. bulbs or motors) for some of the devices. All the external wires have been encased in plastic tubing so that they are not pulled or snagged.

The total cost of parts and labor was $1000.

MOVABLE VIBRATING CHAIR

Designers: Jacob Abraham, Teena Manimalethu and David Walker
Client Coordinator: Marlys Loyer, United Rehabilitation Services, Dayton, OH
Supervising Professor: Dr. Chandler Phillips
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INTRODUCTION

The movable vibrating chair is a system that provides multiple sources of stimulation to individuals with various mental and physical disabilities. This chair is designed to enhance the reactions of clients for different motions and sensory perceptions. Most of the patients at the facility have cerebral palsy (CP), but there are also individuals who have had head trauma or strokes as well. This system aids in the rehabilitation process of the patients. The multiple modes of stimulation include vibrational, vestibular, and auditory stimulation.

The vibrational stimulation involves a change in the patient's daily routine and even a change in blood circulation. Some of the clients are extremely uncomfortable at changing positions. This is known as gravitational insecurity. The vestibular mode of stimulation (a tilting mechanism) allows the clients to become accustomed to changes in positions. The auditory stimulation feature helps in keeping the clients calm while experiencing the vibrational and vestibular stimuli.

SUMMARY OF IMPACT

The system provides vestibular, vibrational, and auditory stimulation. Upon delivery to the client coordinator, two clients were able to test the product. The therapist was able to use every feature in the chair and both therapist and client reactions were positive.

TECHNICAL DESCRIPTION

The chair used for the base design is a minivan captain's chair. This chair features two arm rests, firm cushioning, a standard reclining feature, a chair mounted seat belt, a detachable headrest, and a pocket located in the back. It has a steel framework that provides a reliable and sturdy base. Most of the components and structures on the chair are detachable which allowed for easy alterations. Since the chair is manufactured by the automotive industry, data were obtained and analyzed for forces on the chair, center of gravity and moments of inertia to aid in the design process. The chair is reupholstered with vinyl upholstery for ease of cleaning and protection of internal components. Footrests from a wheelchair are attached for the comfort and convenience of the user.

Figure 21.4. Movable Vibrating Chair.

Vibrational stimulation is achieved with an existing product. It is a chair pad with various motors that produce different vibration intensities at different speeds. The chair pad has 10 motors, various intensities, various speeds, and can be controlled by using a handheld control panel attached to the pad.

Vestibular stimulation is achieved with a three-level tilt table attached to the base of the frame of the chair. This system is comprised of three independent four-sided steel frames. Each frame is 20 inches on each side and is made of angle iron. This gives a good strength to weight ratio and lends itself to easy construction.

There are walls along each frame, which are connected by axels of 3/8-inch diameter. The bottom frame is static while the middle frame tilts side-to-side, and the top frame tilts forward and backward. Actuators from a power-seat cause the tilting action. The actuators consist of a 1.5 Amp DC motor turning a cable, which runs a worm gear that drives a screw. The pivot point is 10 inches away from our actuator. Through trigonometry, it is known that a 1.76-inch displacement will create a 10-degree tilt. The actuator provides two-inch displacement in each direction; this is more than adequate for the required ten degrees of tilt.

To control this tilting motion, control of the direction of rotation of the motor is required. This is accomplished by controlling the polarity with a double-pole double-throw switch. A 12-Volt battery powers the twin 1.5 Amp motors. The charge on the energy cell is maintained by an automatic charger, which charges at 1.5 Amps. If the tilt system is run continuously for one third of the day, it can charge for the remaining two thirds of the day. This will allow it to be fully charged at the beginning of each day.

Figure 21.5. Three-level Tilt Table.

An auditory stimulation system is implemented by mounting a CD player and computer speakers onto the chair. The CD player is shock resistant and waterproof, making it rugged enough to withstand the abuse it may take in the rehabilitation center. The speakers are mounted near the headrest, so they will not interfere with patient transfer. This is a cost effective solution that allows the client to choose from a wide selection of music and sounds.

The total cost of parts and labor was $1250.

COIN RECOGNIZER

Designers: Matthew Beach, Brian Kandell and Matthew Roberts
Client Coordinator: Ms. Marcia Thomas, Green County Educational Services (Xenia, OH)
Supervising Professors: Dr. Blair Rowley
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INTRODUCTION

The Coin Recognizer was designed to teach users how to associate coins with their corresponding monetary value. With many of the interactive children's toys on the market involving money, the user does not handle real money and instead touches buttons that look like coins. It may not be easy to associate a button with a real coin. Another problem is that some children know the value of the coin they have, but they don't know how many it takes to arrive at a specific total. The solution was to make a device that identifies a real coin that is put through a slot (similar to a pop machine), and then audibly returns the coin's name and value along with a total of the value of all the coins entered up to that point.

SUMMARY OF IMPACT

A device was produced that allows the user to input a coin and recognize the monetary value of the coin in two distinct ways. The user is able to see the value of the coin on a digital display. The design allows for multiple coins to be accumulated and the total amount of money to be displayed simultaneously with the previous single coin value. The user is also notified audibly of the value of the coin. The product includes a voice chip that tells the user the value of the current coin inserted and the total value of all coins inserted. This design feature, coupled with the digital display, will be able to assist a vast number of users with either visual or auditory impairment.

All design requirements were achieved in the final product. All desired goals except that of battery power were also achieved. Feedback obtained upon final delivery of the product to the client indicated that the children find the device simple and motivating to use.

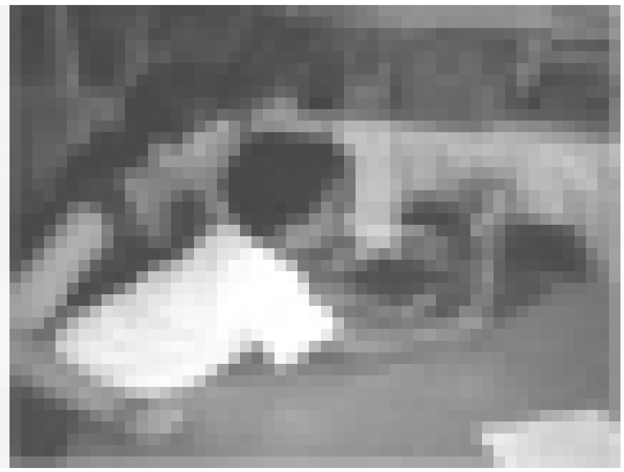

Figure 21.6. Coin Recognizer.

TECHNICAL DESCRIPTION

The final product used a coin sorter for a base unit that sorted coins by their respective diameters. Optical sensors were used to detect coins as they were inserted into the unit. The advantages of the sensors were that they did not miss any coins and did not have a "bouncing" problem associating with mechanical switches. Fig. 21.6 shows a circuit diagram of the infrared LED and phototransistor matched pair that was used for coin detection. The beam intensity of the sensors was proportional to the inverse square of the beam length. The resting voltage was proportional to the inverse of intensity. Therefore, the voltage was proportional to the distance squared. This information was used to determine the required voltage to operate the sensor accurately at the specified distance.

The BASIC Stamp II microprocessor was selected as a microcontroller because of its ease of programming and its ability to meet all of the computational and control requirements. The BASIC Stamp II interfaced with all of the components of the system (i.e. LCD and voice module) and its cost was also minimal (donated).

After much evaluation of different LCD displays that work with the BASIC Stamp II it was decided that the 120x32 graphic LCD was the best choice for the project. The most influential factor for this decision was that the children have limited reading ability and any display must be as easy to read as possible. The graphic LCD provided for smooth fonts with two different sizes (large or small). The graphic LCD also provided the option of displaying bitmap graphics. A use for this feature could be the display of a graphic representative of the coin entered or removed. Although this LCD was the most expensive, its unique and impressive features offset the high cost.

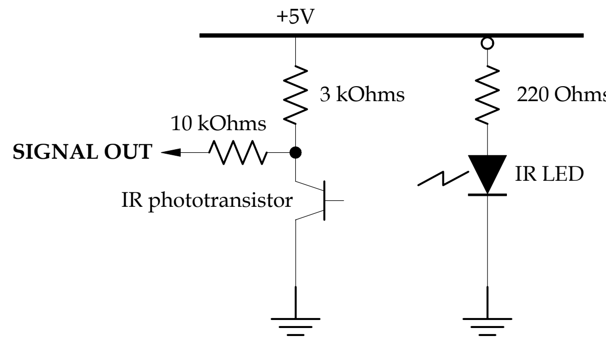

Figure 21.7. Circuit Diagram of Infrared LED and Phototransistor.

Audio feedback to the user was achieved with a Quadravox QV306m4-P preprogrammed playback module, a Board of Education (from the makers of the BASIC Stamp II), an inverter, and 22-gauge wire. The Quadravox module was selected because it comes preprogrammed with 240 commonly used words and phrases (i.e. numbers, math, money etc.) with excellent speech quality. It also has a variable volume option that was useful for the client coordinator when the device was used in a classroom setting.

Figure 21.8. Coin Subtraction Plate.

The device also allows for subtraction of coins from the final total. This is achieved by mechanical removal of the coins from the tubes where the sorted coins are placed. The user presses a button that causes a plate to push a coin from the tube.

The plate has a round notch with the same diameter as the specific coins in the tube. When a coin has been removed by pressing the button, the microprocessor calculates the new total and informs the user visually and audibly.

The total cost of parts and labor was $675.

VOICE ACTIVATED VOICE REPEATING TELEPHONE SYSTEM

Designers: Richard McKinley and Jenna Warman
Client Coordinator: Ms. Elaine Fouts, Gorman Elementary School (Dayton, OH)
Supervising Professor: Dr. Chandler Phillips
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INTRODUCTION

The project has been designed for pr-school children in the age range of three to five years with cognitive and developmental delays. Children with these disabilities often play in parallel mode rather than an interactive mode. This means that they play with similar toys in analogous ways, but they do not directly interact. These children often have problems with verbalization, pronunciation, phone etiquette, and communication with others. A voice activated voice repeating telephone was designed in an attempt to address these problems.

The voice activated voice repeating telephone system consists of three phones. One phone automatically records the child's voice until he or she stops talking. Once talking is terminated, the system automatically plays back the message. The repeating telephone gives feedback to the children and encourages communication and vocalization. The other two phones provide a direct communication link between two different children. Essentially, they operate as an open phone line between two individual phones. The telephone system allows children to communicate in an indirect route, which alleviates much of the apprehension associated with direct communication. The response characteristic promotes the pattern of talk-listen and reinforces correct pronunciation and grammar.

SUMMARY OF IMPACT

The design of the voice activated voice repeating telephone system satisfies a majority of the required and desired specifications detailed by the client. The mechanical design of the stand allows it to be easily folded and transported. The ergonomic design permits two subjects simultaneously to sit or stand on the same side of the stand. The product can be easily cleaned and is water resistant with the exception of the handset. It is expected that the children will benefit from its use in that they will increase vocalization and socialization skills.

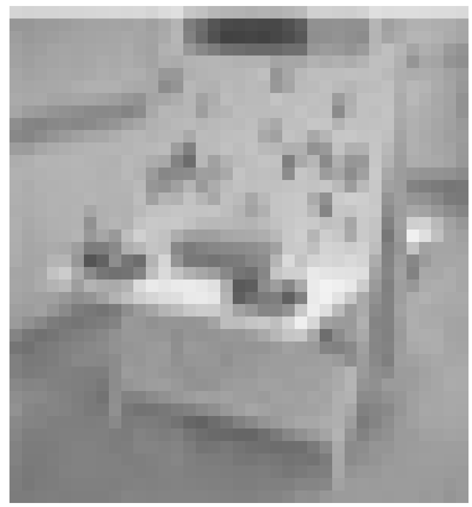

Figure 21.9. Voice Activated Voice Repeating Telephone System.

TECHNICAL DESCRIPTION

In order to meet the specifications given by the client, it was decided to use three separate subsystems; a single person set-up, a two person direct talk set-up, and a structure to house the phones and circuitry. The first subsystem is a voice activated, voice repeating telephone that automatically records and plays back the subject's voice. This single person set-up utilizes one toy phone so that there is no direct interaction with another person. A voice-activated switch (VOX) from Ramsey Electronics and a record/playback chip from Radio Shack were selected to complete this objective. When the subject talks into the microphone in the handset, the VOX enables the chip and begins recording a message up to 20 seconds in length. After the child stops talking for two seconds, or when the end-of-memory is reached, playback is initiated. The child then hears the recorded message through the speaker in the handset. The chip cannot record a new message while a previous message is being played back to teach the talk-listen pattern of communication. The speaker and the microphone wires travel through tubing from the handset to the phone. These wires then continue to the record/playback circuitry. Due to the size of the overall circuit, it was placed in a foam-insulated chassis box. This subsystem makes the children more comfortable with their own voices and provides feedback to teach proper phone etiquette and increase vocalization.

The second subsystem consists of two toy phones that work together to provide direct open line communication between two subjects. This is accomplished through the use of hands-free two-way communication walkie-talkie circuitry. This circuitry is transferred from the walkie-talkies to a set of toy phones. The same power supply from the single person set-up is used to power this configuration. A voltage divider provides the three volts required for operation. Tubing that connects the handset and phone base insulates the wiring for the speaker and microphone. The system provides endless open communication. The two phones are placed on opposite sides of the stand. The two-person set-up allows subject-to-subject interaction, but prevents face-to-face confrontation.

The final subsystem is the stand that houses the toy phones and the voice record/playback circuitry. Due to the client specification of easy mobility and storage, it was decided to construct an assembly similar to a folding easel. The folding easel design has a triangular frame that can be collapsed using a hinge. The construction of this structure consists of white painted wood and ¼ inch plastic PVC board. Handles were placed on both ends of the frame so the stand can be lifted and carried. In addition, an eyehook latch is attached on both ends to secure the frame in the closed position during relocation and storage. The phones are mounted on a horizontal platform that is supported by a stainless steel hinged diagonal beam. The single person set-up circuitry is placed in a chassis box mounted in the middle of one of the horizontal platforms. For added visual stimulation, scenes are painted with acrylic paint on both sides of the stand.

The total cost of purchased parts and labor was $775.

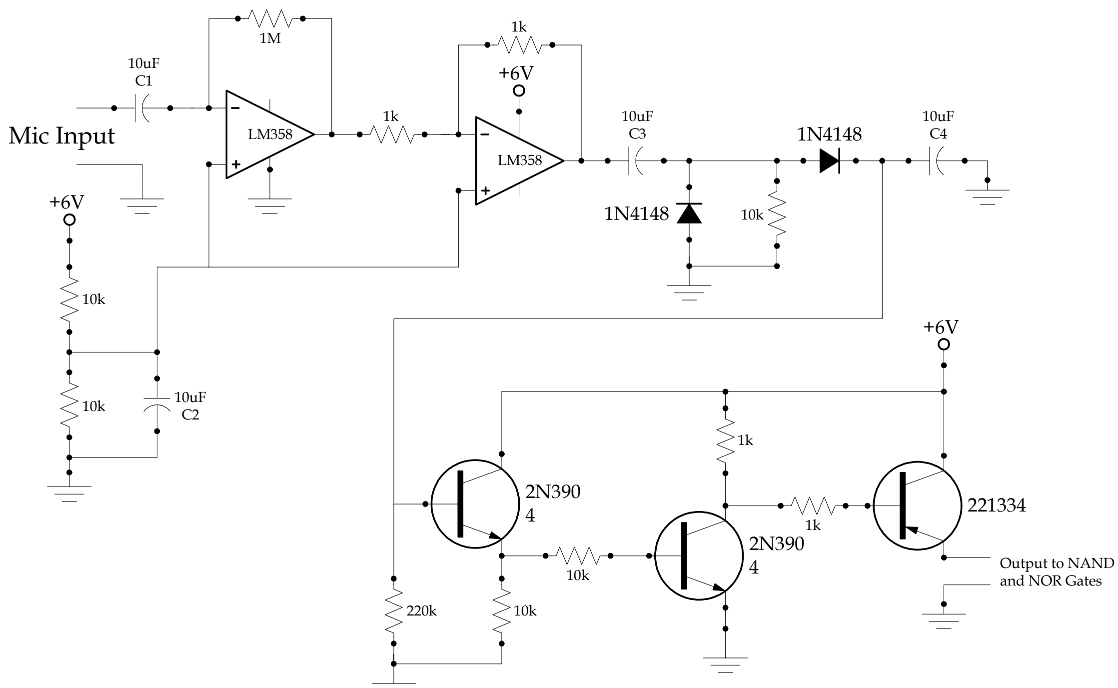

Figure 21.10: VOX Circuit Schematic.

TRANSDUCER FOR MEASURING NORMAL AND SHEAR STRESS

Designers: Adam Fournier and Andrew Lewis
Client Coordinator: Ms Alena Hagendorn, Ohio Transportation Research Center (East Liberty, OH)
Supervising Professors: Dr. Ping He and Dr. David Reynolds
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INTRODUCTION

This project involved designing a device that measures both the normal and shear forces exerted on a sensor via the capacitive method. The capacitive method involves the relationship connecting the change in capacitance between two plates to an applied shear and/or normal force on those plates. As the space and area of overlap between the plates change, so does the value of the capacitance measured. No such model existed that could measure contact normal and shear forces between two surfaces.

The specifications of the design are modeled from the existing capacitance method that measures force in the normal axis. Since the design had to have the ability to measure force in three dimensions, five capacitors were used. One capacitor measures normal forces while the other four peripheral capacitors measure shear forces. The capacitors on opposite sides of the main capacitor are wired together such that the direction of force application can be seen by the change in phase of the voltage output. The circuit balances and remains balanced until a shear force is applied. Once the forces are removed, the original capacitance is achieved by way of springs placed at opposing corners of the floating top plate that re-center the device after forces are withdrawn.

SUMMARY OF IMPACT

The designed product met all of the requirements. Some areas for further expansion and improvement include further centering the device such that the output is initially a flat baseline, placing known loads on the device and measuring the magnitude of output signal produced, and finally a the micro-machining of the design into a much smaller model. Possible implementations exist in prosthetics design relating forces between the soft tissue of an

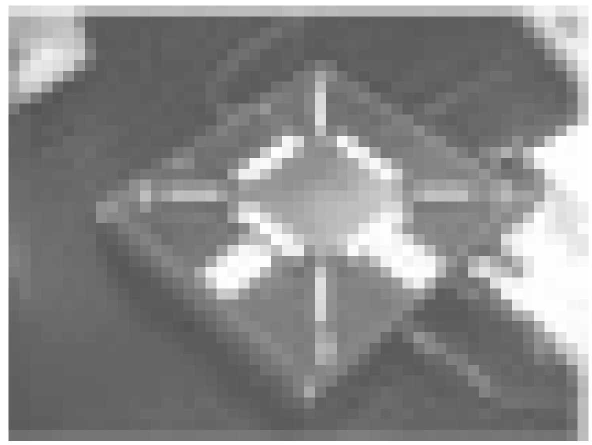

Figure 21.11. Transducer for Measuring Normal and Sheer Stress.

amputated limb's skin and contact surface of the socket, bed sore applications, robotics and other commercial applications.

TECHNICAL DESCRIPTION

The final product has the implementation of a five-capacitor system. The capacitor transducer system is primarily made of plastic and a copper alloy. The transducer system is mounted atop a product box that holds the circuitry and the plugs for all the necessary connections. The central capacitor measures applied forces normal to the top plate while four peripheral capacitors measure the applied shear forces. The two-peripheral capacitors opposite each other are coupled together and wired in to the following circuit, shown in Fig. 21.11. In this way, the changes in the output voltage would be measured in three groups. First, the voltage between the top plate and the central base plate and then two output voltage pairs between opposing peripheral capacitors and the top plate. To make sure measurable signals were obtained the voltage signals were amplified by a series of instrumental amplifiers.

The size of the capacitor transducer was determined by scaling up Ko's idea (US patent # 5,528,452) by a scale of 100. This gave the dimensions and range of capacitance for our design. Ko's capacitive pressure sensor operated at 5.5 *p*F. The desired 5.5 *p*F required that the base electrode and the top electrode be separated by four mm (three mm of air and one mm of dielectric). To achieve 5.5 *p*F the side capacitors needed an overlap of 7.5mm with the top electrode along with a separation of one mm. A series of springs was used to resolve the issues of re-balancing the system after the forces are removed. The idea for using springs came from the patent of Xu et al. (US patent #6,341,532), which used "zig-zag" springs to keep the top capacitor electrode balanced and centered. To reduce friction between moving surfaces four pieces of Teflon were cut and placed over the peripheral capacitors. Teflon was chosen not only because of its low coefficients for static and kinetic friction, both 0.04, but also because it was inexpensive, malleable, and readily available.

To prevent the various components of the design from coming into contact with each other and causing a short, a series of buffers and spacers were used. A thin plastic sheet was placed on the central base capacitor to prevent a short between the top plate and the lower base plate when a sufficient normal force is applied. The Teflon covers on each of the peripheral capacitors prevented the top plate from causing a short, and the Plexiglas spacers prevented the base plate from causing a short with the peripheral capacitors as well. During construction the peripheral plates were carefully placed such that there was no contact between them, thus ensuring there were no shorts in the circuitry at any time.

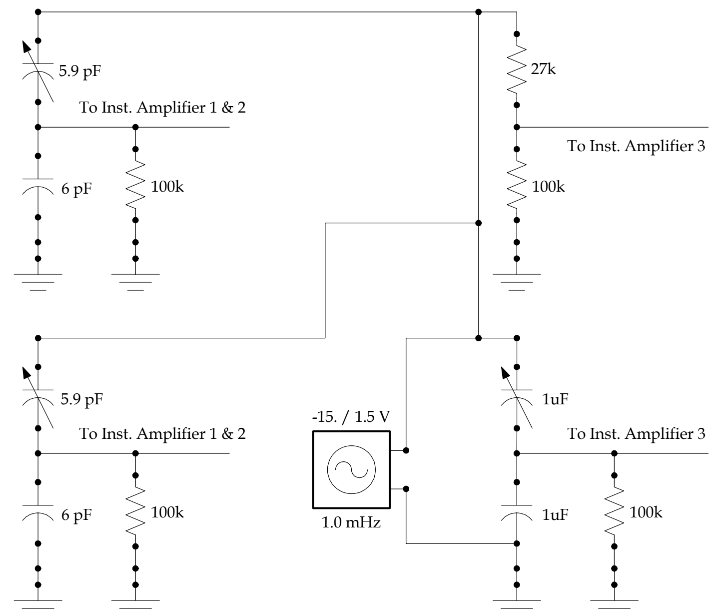

Figure 21.12. Circuit Design Implemented in Testing with the Capacitor Sensor.

The operation range is designed to be easily changed. By varying the spring constants, different magnitudes of shear forces can be measured. By varying the thickness of the top plate, different magnitudes of normal forces can be measured. The transducer was designed to displace three mm in both the + & - X and Y dimensions. Using the range of forces desired for prosthetic applications, shear forces of 15 kPa and normal forces of 100 kPa, the ideal spring constants were 30.26 lbs/in.

The total cost of parts and labor was $550.

THE SWITCH OPERATED SENSORY TABLE

Designers: Todd Burman, Nicole Jackson and Jeff Martin
Client Coordinator: Ms. Tracy Gomez, United Rehabilitation Services (Dayton, OH)
Supervising Professors: Dr. Ping He
Biomedical, Industrial and Human Factors Engineering Department
Wright State University
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INTRODUCTION

The switch operated sensory table is designed to encourage users to make use of upper extremity movements through various types of stimulation. The users include individuals that have had strokes, cerebral palsy, mental retardation, developmental delays, brain injuries, or autistic tendencies. Some of the patients have limited movements due to degrees of paralysis. The age range of users that was given by the client coordinator is between three and fifty years. The switch operated sensory table is a device for presenting various stimuli to the user through four physical senses: touch, smell, sight, and sound.

Most current designs for stimuli presentation involve just one component for interaction. The problem with such designs is that users like variety and wish to interact with many kinds of stimuli. If the user does not like the single component given, he or she will tend not to interact with that component. Most designs also do not incorporate multiple senses, but instead focus on one or two senses in their stimuli. The switch operated sensory table combines multiple forms of stimuli that are recognized through four of the senses.

SUMMARY OF IMPACT

The final product was a table that will improve the upper extremity movement and provide stimulation of users with physical and cognitive disabilities. The feedback received from the client coordinator indicates that users were drawn to all of the stimuli in the table and readily attempted to use their upper extremities to manipulate the various stimuli.

TECHNICAL DESCRIPTION

The tabletop is 36 inches in diameter with an overall thickness of three inches. It has a 1.5 inch hollow compartment, with a volume of 0.72 cubic feet. This compartment houses the internal electrical components. Four sheets of square plywood arranged in a crossing pattern separate the tabletop into four sections, each one focusing on a specific sense. The tabletop is made of ¾ inch oak plywood, with the top half of the tabletop capable of rotating independently of the bottom half. Two 36 inch circular pieces of plywood, along with two 36 inch OD/ 33 inch ID plywood rings, were utilized to construct the tabletop. The middle of the table also has two six-inch diameter circles placed inside the hollow. The circles are centered and fastened to the top and bottom inner surfaces of the hollow compartment. These circles help to carry the weight of the table and control the centering of the table during rotation. A pin is seated in the middle of these circles. The pin is a 1 ¾ inch solid copper cylinder with a ½ inch diameter. This pin acts as a central axis during rotation to keep the tabletop from shifting.

The top half of the tabletop has press fit ball plungers inserted into drilled holes, which aid with the rotation of the tabletop. Calculating the weight of the upper half of the table and comparing this to ball plungers that have a starting force of five pounds and ending force of fourteen pounds determined the number of these plungers needed. In order to lift the weight of the table, five ball plungers were needed. The plungers are spaced evenly along the outer edge of the upper half of the tabletop where it touches the lower half. A sheet of plastic is placed on the bottom ring to reduce friction between the ball plungers and the surface of the wood. The tabletop has four clasping locks that allow the therapist to lock the tabletop into place, preventing unsupervised rotation. The stand portion of the unit places the bottom edge of the tabletop at a height of 28 inches above the ground. This height was selected for wheelchair accessibility. The base of the stand is from an office chair, attached to one inch iron piping. The piping was covered with two inch PVC piping for cosmetic purposes. The base has locking castor wheels that allow the table to roll efficiently, but prevent movement when the wheels have been locked.

The table is divided into four sections, one for each sense. The boundaries between each section are clearly defined by two dividers pieced together. The dividers have been held in place through the use of shelf pins, which were glued into the table to keep the dividers stable. Olfactory stimuli occupy the blue colored section of the table. When a switch is pushed, a fan propels scented air through a vent on the top of the table. The user can select two different scents, which can be changed by the therapist.

The visual stimuli section features a plastic wind dome and buttons illuminate different colors when pressed. When the wind dome switch is pushed, a motor at the bottom of the dome starts to run and causes colorful puffballs to fly about in the dome.

The touch stimuli section has textiles of varying textures such as smooth, soft, rough, hard, etc. Another stimulus in this section is a mechanism that vibrates when the patient pushes a button. The last form of stimuli in the touch section of the table involves a Koosh ball. This allows the user to compare the rubbery spindles to the textures of the fabrics.

The auditory stimuli section has a musical keyboard that can play a single note or more than one note, depending on the number of keys pressed. A demo button in this device allows for the patient to hear assorted tunes. There are also buttons that feature pictures of different animals. When pushed, these buttons will make the noise the corresponding animals make. Also included in the auditory stimulus portion of the table are various noise-making objects. The objects are connected to a turntable so they are all easily accessible.

The battery is placed under one of the components on the tabletop so that it is easy to access. This permits the client to plug it in to recharge overnight. The battery puts out 13.1 volts and is rated at 9.5 amps per hour. The components require 3.3 amps if every one of them is activated at the same time. This allows the table to run for almost three hours with every component being utilized continuously in this time period.

The total cost of parts and labor was $850.

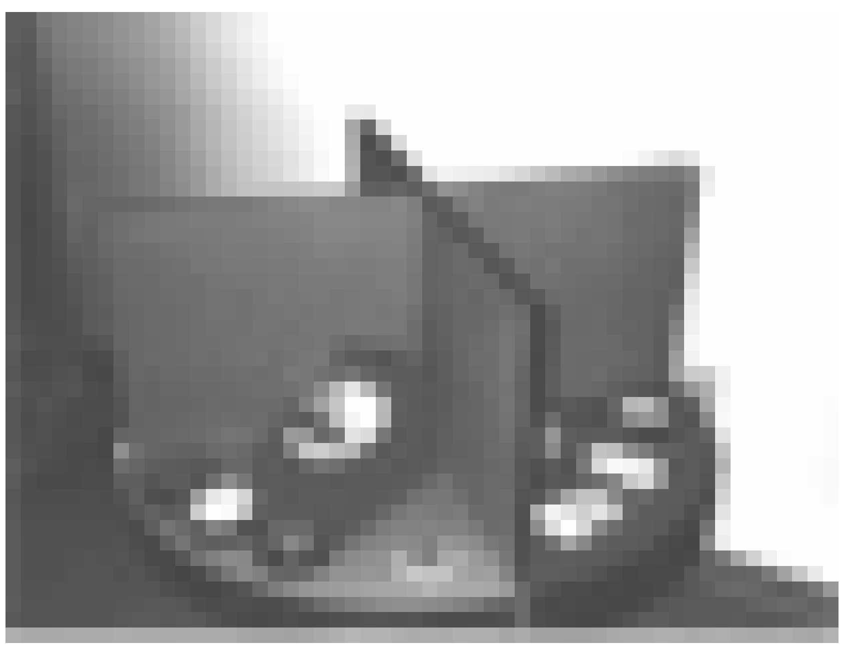

Figure 21.13. Switch Operated Sensory Table.

MANIKIN CERVICAL INTERFACE PLATE FOR TWISTING SIMULATION

Designers: Christy Harm, Erica Johnson and Ryan Justice
Client Coordinator: Chris Perry, Wright Patterson Air Force Base, Dayton, OH
Supervising Professor: Dr. Ping He
Biomedical, Industrial and Human Factors Engineering Department
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INTRODUCTION

Manikins are used in industry today to assess the possible injuries imposed on humans. They are commonly employed in the automotive industry and in the design of ejection seats for the Air Force. In research and design facilities, it is essential to model the human neck's response to impact. An important aspect of the manikins used to model the response of humans is biofidelity, or the ability to accurately behave in the same manner as a human. The effects of side impacts have been of recent interest; however, a manikin capable of modeling the human neck response to a lateral impact did not exist. When a human is impacted laterally, the inertial properties of the head cause it to rotate about its vertical axis.

The purpose of this project was to design a cervical interface plate for the Hybrid III manikin's 3-Segment Neck to allow for rotation about the vertical axis. This will allow the head and neck of a manikin to accurately model the human response to a lateral impact. The manikin being used in the Air Force Research Laboratory (AFRL) was called the Hybrid III and did not have this capability. The neck being used was the Hybrid III 4-Segment neck. The Hybrid III has only lateral, forward, and backward movement. The client recently expressed the need for the development of a manikin/cervical interface plate to simulate rotation about the vertical axis.

SUMMARY OF IMPACT

Torque testing of the springs using two separate methods led the design team to the same conclusion—the springs were not created with the proper spring coefficients. This manufacturing error prevented verification of the cervical interface plate's properties. However, the testing procedure generated data that show that the cervical interface plate does provide the quadratic response that the team designed it to simulate. With new springs that have the correct spring coefficients, the design will work as intended.

Figure 21.14. Exploded Solid Works Drawing of Cervical Interface Plate Mounted Between the Hybrid III 3-segment Neck and the Mounting Plate for the Hybrid III Head.

TECHNICAL DESCRIPTION

The final product consists of several parts working together with the Hybrid III head and neck to produce the rotation response. The product consists of torsional springs, a bearing, a top plate, a bottom plate, and a damper.

The torsional springs provide the resistive force to the rotation of the top plate that simulates the human response. Two torsional springs were used to model the quadratic response data produced by the Articulated Total Body (ATB) simulation software package. A smaller spring was used to model the ATB simulator data from 37.5° to 55° of neck rotation from the eyes-forward position. From the data, a linear best-fit line with a slope of ~221 [in*lbs/˚] was analyzed by the group for this angular range. The diameter of 1.3125 inches is smaller than the inner diameter of the larger spring; therefore the smaller spring could be placed inside the inner diameter (1.375 inches) of the larger spring, thus maximizing the inner cavity space of the bottom plate. The larger spring was used to model the ATB simulator data from 55˚ to 70˚. From the data, a linear best-fit line with a slope of ~390 [in*lbs/˚] was analyzed by the group for this angular range. Because the springs both have a straight offset design, the same activation mechanism was used for both springs. As the top plate rotates, it is free to rotate until 37.5˚. At 37.5˚, an aluminum catch compresses the smaller spring through 55˚. At 55˚, the same aluminum catch compresses the larger spring, and both springs are compressed through 70˚.

A bearing was placed in the apparatus to make the rotation as smooth and effortless as possible. In the interest of simplicity a single row, deep-groove ball bearing was selected for the product. Selection of the bearing was dependent on the dimensions of the cervical plate and the outer diameter of the large spring. The load capacity requirement for the bearing was minimal, and not a factor in the selection process.

The features of the top plate were designed to activate the other parts of the design to simulate the desired response. The top plate serves the purpose of connecting the entire design to the Hybrid III 50% head. The entire top plate itself was machined from one piece of ALUM-6061 (minus the ball bearings and titanium screw). The components of the top plate include the catch for the springs, the bearing wall, the titanium screw and the ball bearing, and the four screw holes.

Over the duration of the design process, the bottom plate design was the most changed part of the entire product. The reason for this fact is the bottom plate interacts either directly or indirectly with every other portion of the final product, and it interacts directly with the Hybrid III neck. The entire bottom plate was machined from one block of ALUM-2024.

The damper consists of the damper backing and the damper foam. The backing is made of ALUM-2024.

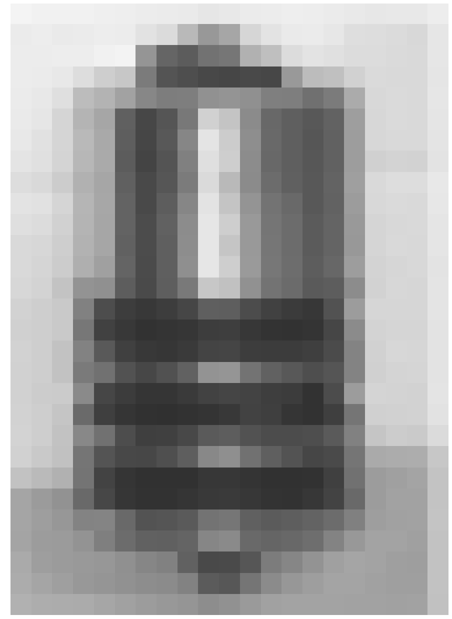

Figure 21.15: The Interface Plate Mounted Between the Hybrid III 3-segement Neck and the Mounting Plate for the Hybrid III Head.

It was designed under considerations for both strength and size. The ringed portion of the backing slips over the beveled portion of the rod, and a 2-56 screw is used to secure the backing to the rod in the proper position. This construction provides the damper system with enough strength to endure the rotational energy exerted on it during dynamic testing of the interface plate. The arm of the damper is designed such that a piece of Confor foam can be fastened to it. The Confor foam damper designed for the interface plate has one main objective: energy dissipation. Under the rigors of dynamic testing, the system has an inert tendency to return to the 0˚ position with a large amount of velocity. The damper foam, therefore, is designed to meet the aluminum catch on the top plate and allow for the transfer of energy from the top plate into the foam. As the foam, which will deform, absorbs the blow from the catch, the velocity of the top plate will be reduced, and the top plate will return to the position determined by the specifications. Industrial strength Velcro will be placed on the damper foam to help slow down the top plate's rotation and ensure the top plate will come to rest within the specifications.

The total cost of parts and labor was $950.