CHAPTER 12
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A Workout Station for Wheelchair Users

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INTRODUCTION

A 23-year-old male who recently lost the use of his legs wanted to stay in shape. The workout stations that he looked at were either too restrictive or difficult to use. As a result of his need not being fulfilled by commercial systems, a workout station has been designed for use by people in wheelchairs. The needs of people with paraplegia that will be using this station dictate certain criteria that must be met in the design. One such criterion that must be addressed is the accessibility of the station itself. Due to the relative expense of wheelchairs and the wear and tear that exercising in them can cause, the station is designed for the user to transfer out of the chair and into the station. The station has plenty of room for the user to transfer into it from their wheel chair. Another problem that must be resolved is the difficulty of changing the weight that is used for exercise. Free weights can be difficult and inconvenient to handle. With free weights the user must move to a different location in order to change the weights. On this station, the resistance can be changed by the controller that is affixed across the lap of the user. Another problem that is addressed is the difficulty of changing exercises. Again, in other stations the user either has to move to a different location or the amount of exercises that the machine is capable of is greatly decreased. In this station, the different exercises are easily accessible from the same seat, with the option for six different exercises. Although this workout station was designed to be wheelchair accessible, it can be used by just about anyone. The machine only has positive resistance. Without the negative resistance, there is no danger of the bar *or* machine snapping back and injuring the user. The range of weight that the machine has ranges from 5 to 200 pounds on each arm. This range of weight can accommodate persons who have rehabilitation or fitness as their goal.

SUMMARY OF IMPACT

All people should exercise to maintain optimum health but designers of exercise equipment do not always think of the population who have physical disabilities. This design allows a wheelchair user to recover strength during the time of rehabilitation and stay healthy as a maintenance regimen.

TECHNICAL DESCRIPTION

The main component responsible for the resistance that occurs during exercise is a magnetic particle brake. The brake applies a resistance in the form of torque on a bar through the center of the brake. A rack and pinion system connects the bar that goes through the center of the brake and the bar that is to be moved by the user. The movement of the bar across the gear is met with resistance from the brake. The bar must be forced in each direction that it is moved. This means there is no negative resistance. An illustration of this brake system and **the station** are shown in Figures 12.1 and 12.2.

The brake is located 45" off the ground, which is about the distance to the shoulder when sitting. This height is adjustable if it is not even with the shoulder. The brake is supported by a 2" x 2" steel L support. The "L" shape prevents the brake from displacing forward during the exercising as well as helping to support the chair. The bottom of the support extends horizontally out to, but not exceeding the front of the chair. This was necessary in order to allow easy wheelchair access to the chair. These supports are connected together by a cross bar. The chair sits on this cross bar. Also connected to this cross bar is a pair of supports, extending back to the ground and up the back of the chair. These supports restrict the displacement of the brake and main support bar, as well as help support the chair.

Changing the resistance of the brake is done via a control panel. This control panel is attached to a Vel-

cro strap that is hooked up across the user's lap. While holding the control panel in a position of easy access, the strap also acts to support and hold the user is the chair. The desired weight is programmed into the panel. The panel then sends that information to the power source that feeds the brake. The power source then sends out the voltage to the brake that corresponds to the desired resistance.

When the particle brake has electric current running through it, the resistance that is being used to work out is also being used to hinder the movement of the bars from moving in the vertical and horizontal directions. When this current is cut off, the bars are free to move in any direction. To change exercises the user presses a switch located on the handles of the workout bar that de-energizes the particle brake. This is the kill switch that can also be used in case of emer-

gency during exercising. With no resistance offered by the brake, the bars can be moved to the position desired for the next exercise. For the kill switch to be depressed, the user hands must be on the handlebars. This prevents the bars from falling down when the current is turned off, avoiding possible injury.

There are three suggested positions for the bars during exercising. One is directly overhead. In this position shoulder presses and lateral pull downs can be done. Another position is directly in front of the user, or horizontal. In this position, the bench press and the back press are the two exercises. Finally, the last position is straight down. In this position, dips and biceps can be worked out.
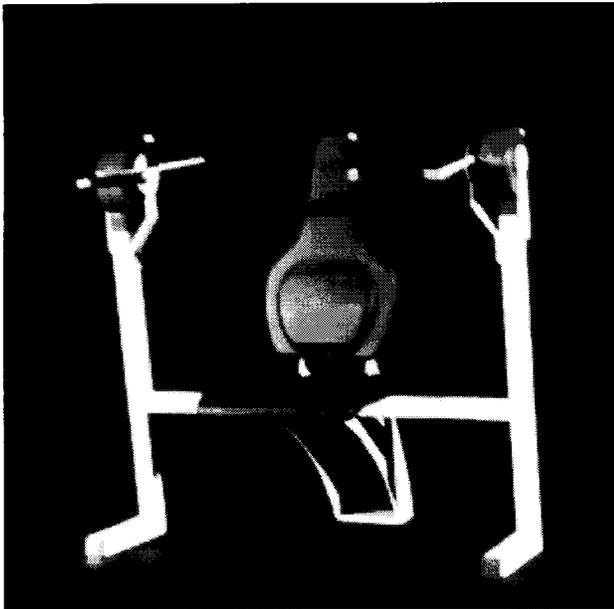

Figure 12.1. Front view.

Figure 12.2. Side View

Talking Bingo Game for the Physically Challenged

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Client Coordinator: Norman Stenzel
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INTRODUCTION

The purpose of this computer program is to allow a person with a physical and speech impairment to lead a bingo game party. The software interfaces with the current speech synthesizer and control input so that the bingo numbers are randomly selected and then called to the group. This program includes a master bingo board to display previously called numbers. The present number will be displayed as well. There are five selection icons on the computer screen. These icons are highlighted in a sequential order so that any are selected by pulling on a string attached to a switch. This is necessary since it is the only reliable motion the client possessed. The program is written in assembly language.

SUMMARY OF IMPACT

The ability for this person to interact and lead a group of people in a game playing activity has brought great joy. The nice part of this project is that the woman who uses it can be independent and control the activity that is one of the few things she has control over in her life.

TECHNICAL DESCRIPTION

The program starts by asking the user to set the desired speed of the game. The three speeds are: fast, medium and slow. Each selection places a different value into the game clock counter. The clock counter memory variable holds the time the user has to make a selection. The program defaults to the fast speed. After the correct speed has been entered, the program then prompts the user to indicate whether the pull switch is being used. It the user responds yes, then the computer will accept inputs from both the pull switch and the keyboard. If the answer is no, then the program will disable the code that checks for the pull switch input. The keyboard input is still available. Following the input selection prompt, the main menu is displayed. The program calls subroutine MENU that displays the five bingo functions available to the user. These are:

1) Call a new number

2) Repeat old call

3) View master board

4) Start new game

5) End Game

"Call a new number" calls a subroutine that generates random numbers. The seed for the random number generator is based upon the time of day. The random number is enclosed in some text and routed on the serial communications line as "THE NUMBER IS B 14" which is announced on the voice synthesizer. The number is then stored in a memory buffer.

"Repeat old call" calls a subroutine that accesses the last number stored in the memory buffer. The routine displays the contents of the memory variable and output those contents over the serial communications line to the voice synthesizer.

"View Master Board" calls a subroutine that will display the memory buffers holding the called bingo numbers. It also reinitializes the screen.

"End Game" brings up another prompt asking whether of not the user wants to end the game. If the user presses the keyboard then the game ends; otherwise, the game continues after a short delay.

TV Controller for the Physically Challenged

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INTRODUCTION

For persons with severe physical disabilities, even the simplest tasks are sometimes impossible. Additionally, commercial products are mainly geared towards people without disabilities, making most of them of little use to the disabled. The purpose of this project is to enhance the functionality of a television remote controller to be used by a person with severe cerebral palsy. The design consists of a controller acting as an interface between the TV remote control and the user. The controller takes as input a pull on a string resulting from an abduction movement of the left arm, which is one of the only voluntary motions that the user can produce. From the switch that is activated by the string, most of the TV functions can be accessed independently.

SUMMARY OF IMPACT

This project has provided increased independence for a woman with severe physical limitations due to cerebral palsy. By having a device custom designed to make use of the limited motion that this woman possesses has allowed her to control at least a small part of her environment. She can change channels and adjust the volume independently.

TECHNICAL DESCRIPTION

The TV interface controller that was built operates in eight states. Initially it starts in state zero that corresponds to the rest state. All states afterward are indicated by corresponding LEDs on the interface controller. At the pull of the string that activates the switch, the controller moves to the TV ON/OFF state. Pulling the switch in this state causes the television to mm on or off. After a selected amount of time, the interface automatically moves to the next state, which is channel up. Pulling the switch during this state advances the channel on the television. Again, after the same length of time as before, the remote controller moves to the next state that gives the user the option of decrementing the channel. A secondary function allows the user to cycle between these states. Following this state are the volume up and volume down states. The remaining states are not used. The logic used to implement the state machine consists of an EPROM and a quad D flip-flop. The EPROM is used to generate the and/or combinations which are then fed to the corresponding inputs of the D flip-flop to generate the next state. The present state is re-routed as an input to the EPROM. The inputs to the state machine are as follows. "S" is the signal from the pull switch. This signal is high when the switch is pulled and low when the switch is released. The pull switch is fed through a debouncer to ensure a stable input to the machine. "S," is a "one shot" version of the pull switch. This signal gives more control1 in interpreting the client's input than "S" because our client cannot control the time she holds the switch. "C" is the signal from a timer circuit notifying the state machine that the time to wait for input has elapsed and it should. The move to the next state. The EPROM combines this signal with "S" to ensure that the switch is not being pulled when "C" goes high. This further ensures that the machine does not jump ahead of the user. "LP" is the input telling the state machine to cycle between the channel up and channel down state. It becomes a one when "S," is initially pulled in either one of these states indicating to the state machine that there is an interest in changing channels. "LP" goes to zero depending on a counter. The state machine outputs five signals corresponding to the five TV functions that are implemented by the controller. These signals are pulsed and fed into five analog switches (HI-300-5). The purpose of the analog switch is to short circuit two wires of a specific remote control function when the control input to the analog switch is high. When the wires are shorted, the commercial remote sends the corresponding signal to the TV set. The approximate cost of the project is $80.

Hardware-Based Keyboard Emulator

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INTRODUCTION

The Hardware Based Keyboard Emulator was constructed to allow people with very limited movement to interact with a computer system. This project is designed specifically for a person with Muscular Dystrophy. The device uses two air tubes with pressure switches on them, a circuit board with a microcontroller and logic circuitry, and a specially modified standard IBM keyboard.

This client uses Morse code, entered by sipping and puffing on the air tubes, to enter the equivalent of keystrokes that were sent to the computer. The microcontroller accepts the switch inputs from the air tubes, and controls the logic circuitry that sends signals to the original circuitry of the keyboard. The circuitry of the keyboard interprets these signals as normal keypresses and then sends them to the computer. The keyboard is fully functional as a normal keyboard, so the computer can be shared between a disabled and non-disabled person with no additional difficulty.

SUMMARY OF IMPACT

The Hardware Based Keyboard Emulator allows this person with severely impaired movements to interact with today's technology. Use of the emulator allows access to all of the wonders of computing, educational programs, entertainment, the ability to write via a word processor, and access to the world via Telecommunications. It has opened a world of enjoyment and opportunity for this person.

TECHNICAL DESCRIPTION

The Hardware Based Keyboard Emulator is designed with the requirements that it be able to emulate any key on the keyboard, as well as commonly used key combinations, by use of Morse code input. It is also required that the emulator not use any of the resources of the computer to avoid incompatibility problems with some software. Three pressure switches are used to supply the Morse code input.

Two of the switches are connected to one hose where the positive pressure side of one switch is connected to the negative pressure side of another switch and the two are connected to a single tube. With this configuration, a sip or a puff on the tube results in the closure of one or the other switch. This acted as the tube is used to enter dots and dashes of the Morse Code signals. A second tube connected to a single switch provides the end of character signals. The Intel 8751 microcontroller reads Morse code dot, dash, and end of character signals (three different switch signals.)

Figure 12.3 shows a block diagram of how this system works. Upon receipt of a switch signal, the microcontroller adds the signal to a shift register, if it is a dot or dash, or looks the shift register up in a table if the signal is an end of character signal. After receipt of an end of character signal and subsequent table lookup, a control signal is sent to the logic circuitry that actually sends the signal to the keyboard processor. Within the keyboard itself, there is an XY grid of wires, with keys at the intersections of these wires. When a key is pressed the two wires are connected and the keyboard processor senses this. The keyboard processor clocks 16 of the wires (X lines), one after another, every 10 ms. When a key is pressed, the clock signal is passed to one of the Y lines that goes back to the processor. The processor senses the clock signal on the Y line and knows the key at position X,Y. The logic circuit implements this same function, passing the clock signal from a given X line to a given Y line to simulate a keypress. There are 16 X lines and 8 Y lines. A sixteen to one multiplexer and a one to eight demultiplexer are used to pass the clock signals from the X lines to the Y lines. The Mux and Demux are controlled by the microcontroller. In addition to the Mux and Demux, a set of four-tristate buffer are connected to implement four special keys: shift, control, alt, and insert. Some other circuitry, pull-up resistors and simple gates, is also necessary to get the concept to work. The control, alt, shift, and insert keys are combined with any other key on the

keyboard. They are sent as a one-shot, i.e., applied to the next key entered, or as locking keys. Insert is added at the clients' request for a particular program he wants to use. Power is supplied from a wall plug +5 volt power supply. The project cost is approximately $270. The most costly single part is the modified keyboard for $95.
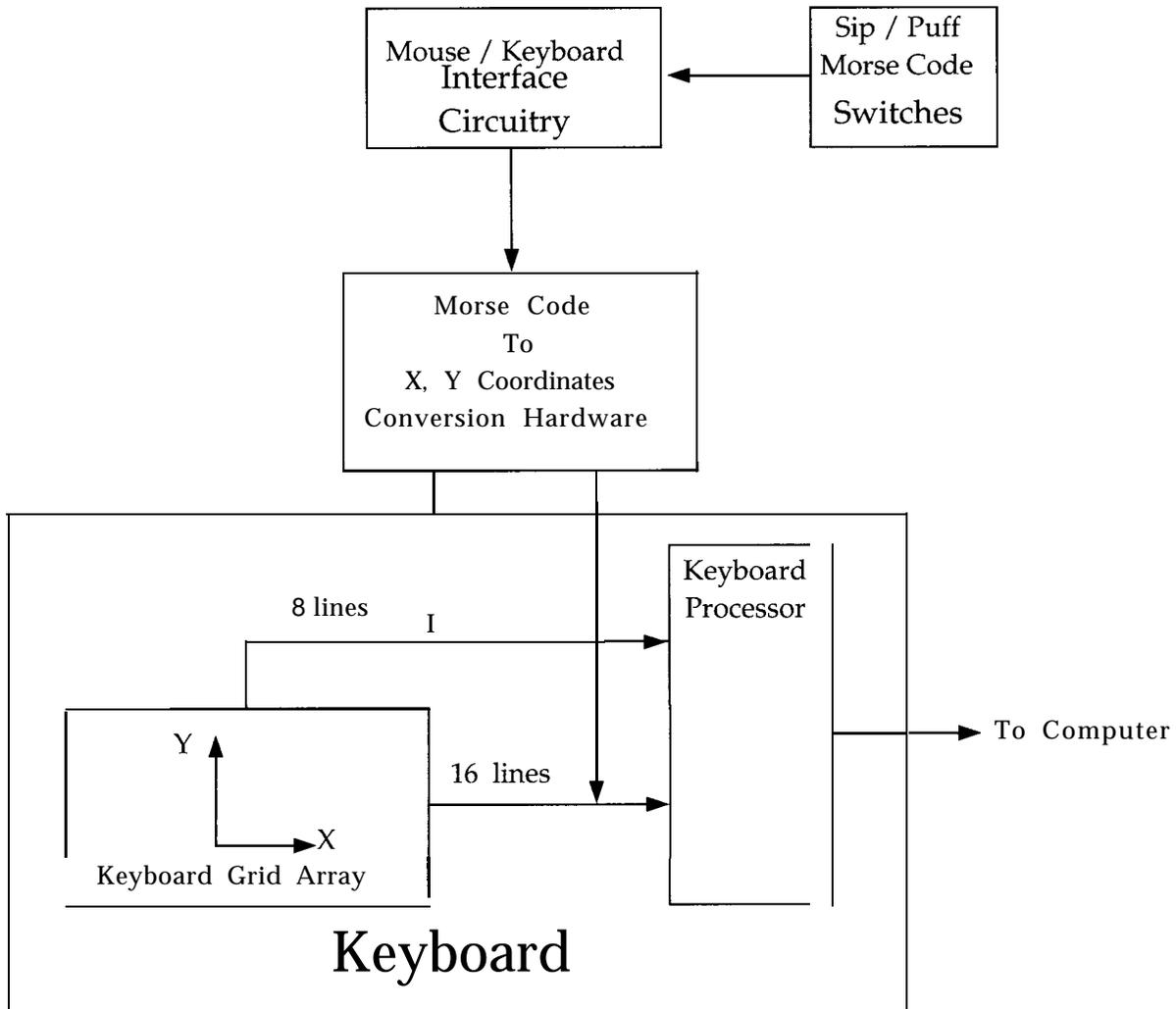
Figure 12.3.   Block diagram of Morse code keyboard emulator