CHAPTER 9
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PORTABLE DIGITAL COMMUNICATIONS ASSISTANT

Designers: Andrew Dahl, and Greg Gergen
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INTRODUCTION

A digital communications assistant device (shown in Figure 9.1) helps people with speech disabilities communicate with others. The device that was designed is a second-generation of the project, and aims to overcome deficiencies of the first version. The device is required to be portable, programmable, easy to use, reasonably priced, reliable, versatile in its recording ability, and easy to understand. The interface consists of eight interchangeable cards that will each contain eight pictures. Each picture represents a phrase that the device will play when that picture is touched. In most cases, the phrases are arranged by context. For example, cards are organized for home, work and mealtimes. This system allows for versatility while also keeping the interface simple.

While there are commercially-available products that offer similar functions, they are typically expensive, difficult to operate, and not easily portable. This device overcomes these issues and offers significant advantages over existing products.

SUMMARY OF IMPACT

The digital communications assistant can help a user compensate for communication difficulties. The new design keeps the small size and portability of the original device. The dimensions are approximately 7″ x 4″ x 1¾,″ about the size of an engineering calculator. The device is powered by a regular 9V battery for portable use, or it can be plugged in during those times when portability is not required. The simple interface requires very little from the user, so clients with a broad range of abilities are able to operate the device. The device is also easy to program and needs no additional equipment to do so. This allows for the device to be easily customized for any client or situation. The completed device, shown in Fig. 9.1, is currently in use.

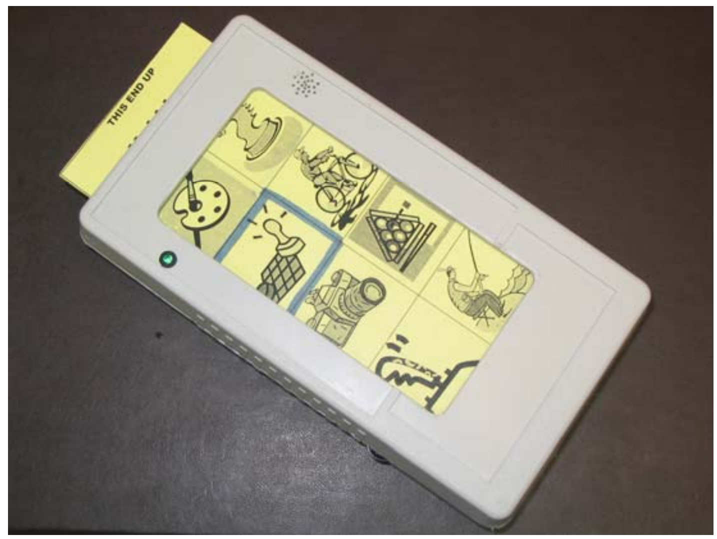

Figure 9.1. Portable Digital Communications Assistant

TECHNICAL DESCRIPTION

The digital communications assistant is composed of four primary blocks: 1) a card detector; 2) a user interface; 3) a controller; and 4) a record and playback unit.

At any given time, the Portable Digital Communications Assistant stores up to eight phrases for up to eight cards, for a total of 64 phrases. To distinguish which card is present in the device, the user must press a button designated on the card. The device uses an optical switch to determine when a card is inserted into the device. Once this happens, the device waits for the user to press a button on the card indicating which card is present. This is similar to popular commercial reading toys for children.

Once the card is inserted, the user selects a phrase by touching one of the eight pictures displayed. The touch is registered by a sensor matrix created on a printed circuit board. When contact is made, one of two four-button touch-sensing chips produced by QProx (QT60040) interprets the signal. The QT60040 digital outputs are then inverted and encoded by an eight-to-three line priority encoder before being sent to the microcontroller.

The microcontroller interprets the input from the encoder, and determines which button is being pressed. It then initiates either a play or record operation. The specific operation is set by a toggle switch on the left side of the device. For the "play" and "record" operations, the microcontroller controls the memory locations that are used. This is necessary because the audio is divided into two-second chunks, which allow for dynamic memory allocation during both recording and playback. The device can have at most 64 messages and record up to eight and a half minutes total. The memory needed for these operations are stored in the microcontroller's EEPROM.

Recording and playback are achieved using the Winbond Electronics ISD5116, a specialized audio storage chip. The audio is stored at a sampling rate of eight kilohertz, the maximum available on the chip. The input to the audio chip is a biased electret microphone circuit that uses a noise-canceling microphone, which helps eliminate some of the background noise. The audio output is fed through an LM 386 differential audio amplifier prior to being routed to an eight-ohm speaker. Volume control is achieved by adding a 50 kilo-ohm variable resistor thumbwheel between the two inputs of the amplifier. The operation of the ISD5116 is controlled via the I2C interface on the microcontroller.

A 9-volt source powers the device. This can be either a 9-volt battery or 9-volt wall transformer that plugs into a port on the side of the device. When the device is not in use, it can be powered off using the switch on the right side of the device. A reset switch is located inside the battery compartment, which allows the user to erase all messages from the memory and reset the device in the case of a malfunction.

The device can be produced for around $130 per unit for a small run, a price significantly lower than similar commercially-available devices.

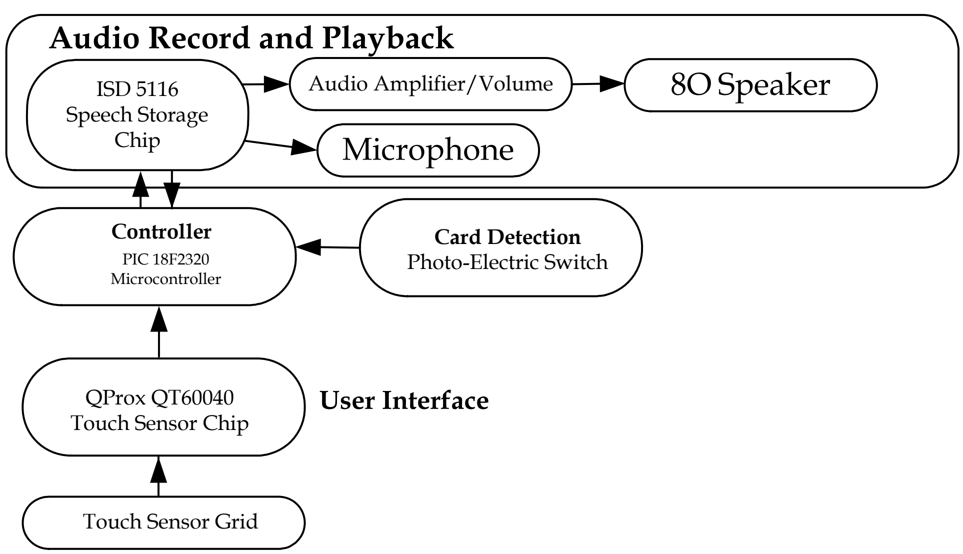

Figure 9.2. System Block Diagram

CONVERSATIONAL SPEECH ASSISTANT

Designers: Matthew Stockert, and Shawn Heilman
Client Coordinator: Mona Sticha, Friendship Inc.
Supervising Professor: Dr. Roger Green
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INTRODUCTION

The Conversational Speech Assistant is designed to facilitate improved communication between a man with a cognitive disability and the staff of a center for people with disabilities. The staff suggested that the client's intelligibility might improve if a device could be created which would record his speech and play it back at a slower speed without altering pitch.

There are many programs available for personal computers that allow recording of speech and playback at variable rates. Often, these programs alter pitch or possess extraneous features that are undesirable in this application. The Conversational Speech Assistant offers a solution to this problem by allowing playback of recorded speech at a reduced rate while maintaining the pitch of the original message. Additionally, this device is a stand-alone product that does not require the use of a computer.

SUMMARY OF IMPACT

The Conversational Speech Assistant allows easier communication and comprehension between the client and the staff. The client is routinely asked to repeat his sentences or to speak louder for the staff to understand what he is saying. With the use of the device, the staff is now able to play back the client's speech and, if needed, play it back at a reduced rate with no reliance on a computer. When the device was delivered to the client it was determined that it did increase intelligibility.

TECHNICAL DESCRIPTION

The conversational speech assistant is designed to be: 1) small; 2) light; and 3) easy to use. The hardware consists of a Texas Instruments TMS320C6711-DSK evaluation board, a PCM3003 audio daughter card, and an AC to DC power supply. Figure 9.3 depicts the system block diagram.

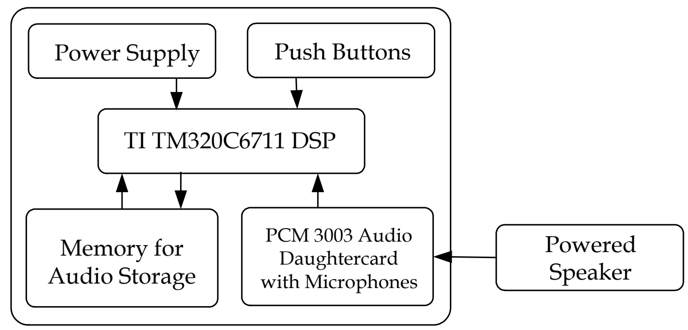

Figure 9.3. Block Diagram of Conversational Speech Assistant

The DSP evaluation board receives input from two sources, the daughterboard and microphones. The control of the unit is achieved via three push buttons mounted on the enclosure. Output is achieved via speaker jacks on the evaluation board to external powered speakers. Volume of the output can be controlled by adjustment knobs on the external speakers. The enclosure, dimensioned approximately 10″ x 7″ x 2,″ is constructed from 0.25″ and 0.125″ black acrylic, machined with supporting orifices for input power, speaker output, button mounting, and microphone input.

When the "record" button is pressed and held, the device captures an input speech passage. Speech is saved to memory on the DSP evaluation board as integer data points at a rate of approximately 36 kHz. Input samples are manipulated using an algorithm called SOLA, which effectively and accurately increases the length of the original speech passage and incrementally saves it to memory. This algorithm is executed while speech is being recorded and is interrupted to save each successive data point when needed. Playback of either the original passage or the slowed passage is possible by pressing the appropriate button on the face of the enclosure.

The heart of the conversational speech assistant is the SOLA algorithm. Figure 9.4 depicts the algorithm graphically. The SOLA algorithm segments the input signal into overlapping frames of 30ms length, the start of the n^{th} frame being positioned at 10n milliseconds from the start. The time-scaled output is created by overlapping these successive input frames with the start of the n^{th} frame now positioned at (20n + K) milliseconds, where K is a deviation allowance ensuring that successive frames overlap in a synchronous manner. The value K is determined for each frame using a correlation function that compares the overlapping segments and finds the overlapping position where the waveforms are most similar. The overlapping waveforms are weighted linearly before recombination so that the n^{th} waveform's amplitude goes from 100% to 0% while the $(n+1)^{th}$ waveform's amplitude goes from 0% to 100%. Dissimilarities in overlapping frames are characterized by soft clicking or popping sounds in the output. The completed product is shown in Figure 9.5.

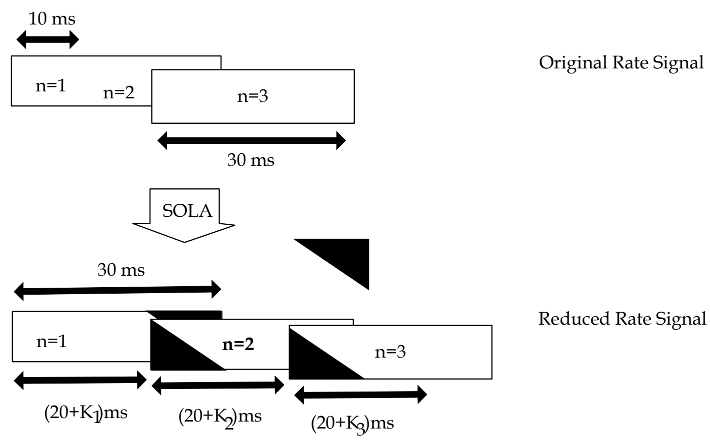

Figure 9.4. Graphical Depiction of the SOLA Algorithm

The cost of design and construction of the Conversational Speech Assistant is approximately $500. This cost can be drastically reduced if large-scale production is employed.

Figure 9.5. Conversational Speech Assistant

THERAPEUTIC HEATING ZONE SYSTEM

Designers: Jaden Ghylin, and Matthew Kruckeberg
Client Coordinator: Dianne Wanner, Developmental Work Activity Center
Supervising Professors: Dr. V.V.B. Rao, and Dr. Roger Green
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INTRODUCTION

The therapeutic heating zone system is intended to provide targeted heat therapy for individuals with rheumatoid arthritis or other chronic aches and pains. The system is designed to fit into a wheelchair and is comprised of six heat zones, each independently controlled by the user. The system is designed to be: easy to use, small, operable on standard AC wall voltages, and machine-washable. It also includes independent zone controls.

The completed system, shown in Figure 9.6, contains four heat zones in the wheelchair pad and is capable of powering two auxiliary zones for external use. The system includes a simple remote control, which displays the current state of the zones and allows the user to change the heat applied to each zone. Bar graph displays are used to show the amount of heat applied to each zone. Pushbuttons are used to increase or decrease the heat applied to each zone. This approach maximizes simplicity and limits the range of motion needed to operate the device. The system also utilizes a number of Velcro straps to ensure a secure attachment to the wheelchair. This guarantees that the system remains in place and can continue to offer targeted heat therapy even if the individual is moving in the chair.

SUMMARY OF IMPACT

This system aids in the relief of chronic pains associated with rheumatoid arthritis or other similar conditions. This relief provides the user with a more comfortable environment when participating in normal daily activities. The system targets the afflicted areas to ease the pain experienced by the client.

TECHNICAL DESCRIPTION

The system block diagram is shown in Figure 9.7. As the figure shows, the system is comprised of four primary units, including: 1) power source, 2) user interface, 3) control, and 4) heating zones.

Figure 9.6. Assembled Therapeutic Zone System

The power source for the system is a standard AC wall outlet.

The user interface utilizes a bar of eight LEDs and two pushbuttons for each zone. The bar of LEDs displays the current level of heat applied to the zone. One pushbutton is used to increase the temperature, while the other pushbutton is used to decrease the temperature. There are a total of six LED bars and 12 pushbuttons on the user interface.

The control unit contains a microcontroller and supporting circuitry. This unit accepts input from the pushbuttons on the user interface and provides the output to the LEDs on the user interface. The control unit also has six outputs to the power unit to control the power to the heating zones. The microcontroller controls the amount of power applied to the heating zones through a method known as burst mode. Also known as proportional control, "burst mode" allows single cycles of AC to pass either completely or not at all. Thus, for 50% burst mode, half of the cycles are let through and half are not. Using this method, the microcontroller can efficiently scale the output power of each zone independently from 100% down to 0%. By using burst mode to scale power, the system retains nearly 99% efficiency in the power control process. Also, the microcontroller is synchronized with the 60 Hertz AC line voltage in order to switch the line voltage at the zero crossing points and thus avoid unwanted switching characteristics.

The power unit is responsible for regulating and rectifying the AC input voltage to provide DC power to the control unit and user interface. The power unit executes the actual switching of the AC voltage as determined by the control unit. This switching effectively controls the output from each of the heating zones. Six modified AC waveforms are produced in the power unit and are sent out to the six heating zones.

Figure 9.6 shows the user interface and the heating zone system. The small plastic enclosure houses the user interface and the control unit. The large fabric enclosure houses four of the six heating units. The other two heating zones are provided as auxiliary zones to be used with external heating pads. The power unit is located behind the fabric enclosure. All connections from the power unit to the heating zones are made through standard wall outlet connectors. This allows for any commercially available heating pad to be used for auxiliary zones.

The development cost of the therapeutic heating zone system was approximately $750. The cost would be less if it were produced in mass quantities.

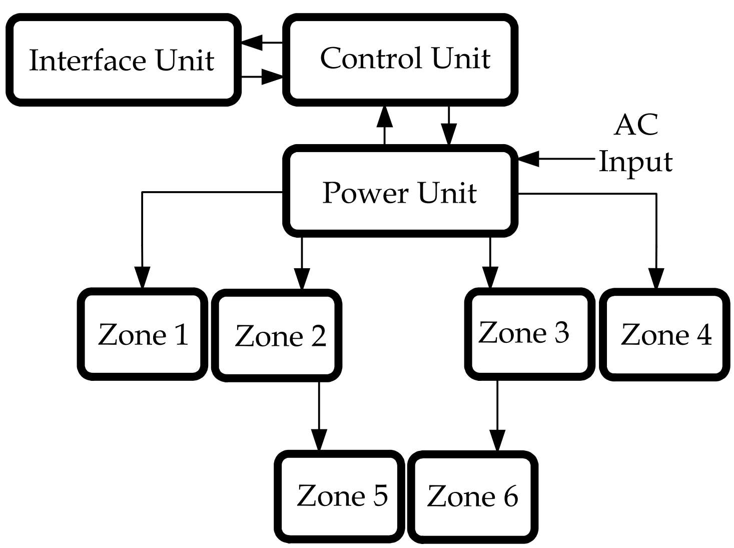

Figure 9.7. Block diagram

REMOTE DOOR ALARM

Designers: Jon Hanson, and Adrian Freidel
Client Coordinator: David Hoverson, SVEE Home
Supervising Professor: Dr. Roger Green
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INTRODUCTION

Some individuals in a home for adults with developmental disabilities are on restricted diets, such that it is necessary for the staff to monitor what they eat. The staff members requested an alarm system to alert them when someone opens the pantry door. They wanted this alarm system to be discrete so that only the staff would be aware of the alarm. To fulfill this need, an alarm system was designed and built consisting of two units: a door-mounted sensor and a pager that alerts staff when the door is opened. Both completed units are shown in Figure 9.8.

SUMMARY OF IMPACT

Since staff members are immediately aware of pantry access, they can address any problems of inappropriate access. This obviates the need for a more intrusive access control method, such as keeping the pantry under lock and key at all times.

TECHNICAL DESCRIPTION

For the pager to respond to the sensor, a signal must be transmitted between the units. This transmission is achieved with a Chipcon CC1010 RF transceiver/microprocessor on each unit, as shown in Figure 9.9. The small footprint of this chip (64 pin quad flat pack) necessitated that the printed circuit board (PCB) be professionally manufactured.

The pager and sensor have similar hardware requirements. Therefore, a single PCB design was used for both units. A header on the PCB allows access to the serial programming interface (SPI) as well as power, ground, reset, and one 8-bit microprocessor port. The PCB also has a flexible printed circuit (FPC) connector in order to attach a liquid crystal display (LCD) to the pager. The sensor unit has a magnetic switch that is triggered by a magnet on the door. Other features, such as the LCD circuitry, remain unpopulated on the sensor unit PCB.

Figure 9.8. Completed Pager and Door Sensor

The pager features a vibrating motor in addition to the LCD display. An Optrex C-51496 LCD was chosen because it has a controller chip embedded in the LCD's packaging, enabling the LCD to be very compact. This LCD also contains internal voltage boosting circuitry, which allows the pager to operate exclusively on +3VDC.

The system's software is designed with system expansion in mind. If the SVEE Home should wish to monitor additional doors in the future, those doors could be monitored with the original pager. Rather than using an addressing scheme that maps a door's unique address to a text string, each sensor directly transmits the message that is displayed on the LCD. With this design strategy, adding another door to be monitored is accomplished simply by programming each new sensor with a unique message.

Since both of the units are designed with portability in mind, battery life is another concern. To maximize battery life, the design includes some important power-saving strategies. First, the sensor remains in shutdown mode while the door in question is closed. This allows it to consume virtually no power for the majority of the time. When the door is opened, it transmits its alarm message a series of times and shuts down once again.

The pager also has a power-saving strategy, slightly different from the sensor. The pager's microprocessor periodically wakes up from sleep mode, checks for an incoming RF signal, and returns to sleep mode if there is no signal present. Since the pager is turned on for long periods of time, this method decreases power consumption without affecting the reliability of the system. If there is an incoming signal when the pager checks, it writes the received message to the LCD and pulses a vibrator motor three times to notify the staff. The LCD displays the message for approximately 20 seconds and then powers off. Additionally, once the pager receives the sensor's message, it responds by sending the same message back to the sensor. When the sensor receives this confirmation signal, it immediately stops transmitting and shuts down.

The majority of costs involved in the project are due to the professionally manufactured revisions of the PCB. The costs of individual capacitors, resistors, etc., are comparatively insignificant.

The project cost was approximately $600. Units could be produced for a much lower cost (approximately $25 per unit) in volume.

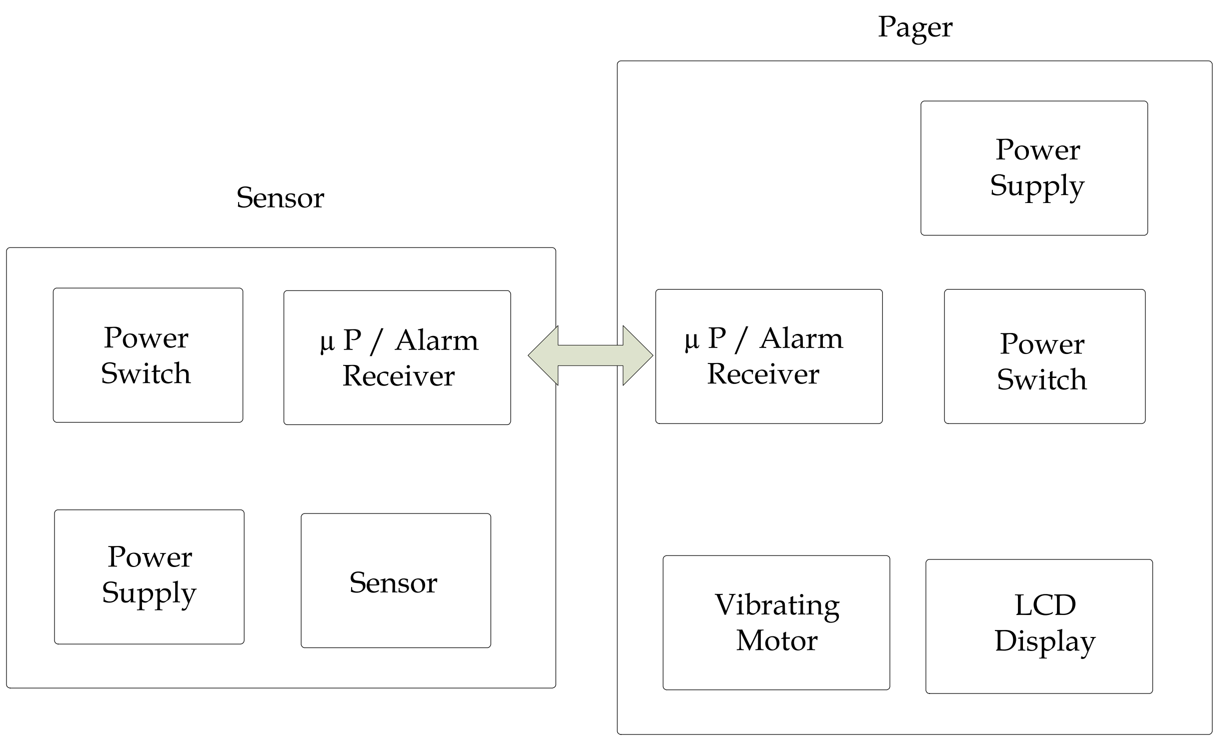

Figure 9.9. Block Diagram of System

NURSE ALERT SYSTEM

Designers: Shawn Carlson, and Tanner Seibel
Supervising Professor: Dr. Jacob Glower
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Fargo, ND 58105

INTRODUCTION

The nurse alert system is a nighttime incontinence monitor. The objective of this project was to develop a moisture detection system to indicate to caregivers if it is necessary to wake the user and change his or her bedding. Prior to the nurse alert system, the user was awoken by the caregiver several times during the night to determine if care was needed. This device is designed to allow the user a restful night while still being monitored.

There are several similar commercially-developed products on the market. The main difference is that these devices are designed to aid children in potty training. When moisture is detected, an audible alarm is activated to wake the user. The nurse alert system is designed to be unobtrusive to the user while alerting the caregiver.

SUMMARY OF IMPACT

By being able to detect when care is needed, the user may sleep more during the night and receive care as needed. This system also gives the caregiver more flexibility to carry out his or her nightly tasks and

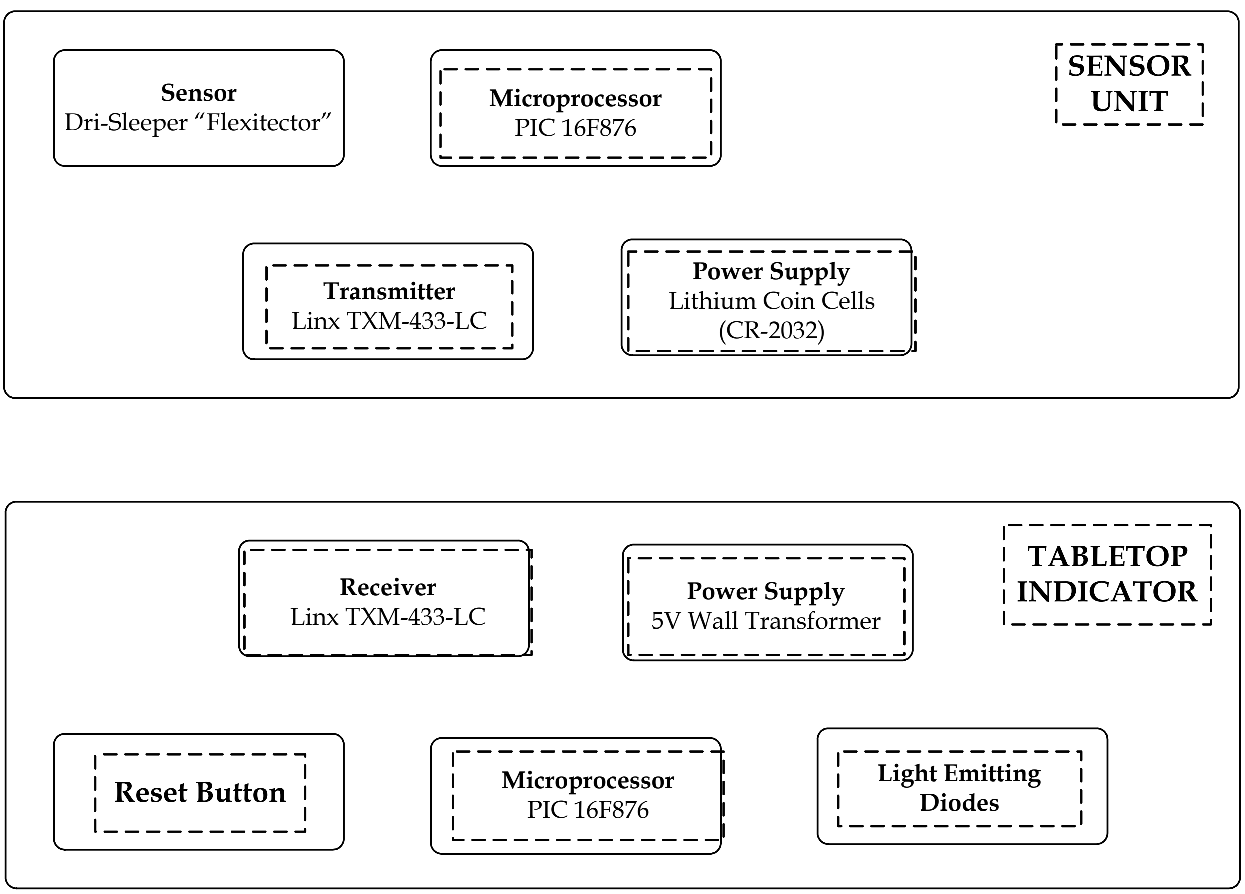

Figure 9.10. Block Diagram

only periodically check the status of the sensing unit.

TECHNICAL DESCRIPTION

The nurse alert system is comprised of two units: a sensing unit and a tabletop indicator. Figure 9.10 shows a block diagram for each device. The final product is shown in Figure 9.11.

The sensing unit is composed of a resistive-type sensor, a microprocessor, and a wireless transmitter. The resistance of the sensor decreases as it becomes exposed to moisture. This change in resistance is detected using an analog-to-digital converter on the microprocessor. The microprocessor compares the raw data against a set of predetermined values. It then determines the degree of wetness present at the sensor. Wetness is categorized as dry, moist, or wet. If the sensor becomes disconnected from the sensing unit, the microprocessor will detect this. A voltage regulator is used to maintain a constant operating voltage. If the operating voltage falls out of tolerance, the voltage regulator relays this error to the microprocessor. The microprocessor sends the appropriate serial communication to the transmitter. The transmitter then sends this information wirelessly to the tabletop indicator.

The tabletop indicator is composed of a microprocessor, LEDs, a reset button, and a wireless receiver. The wireless receiver relays the signal sent from the sensing unit to the microprocessor. The microprocessor decodes the signal and lights the corresponding sensor status. The tabletop indicator is updated by the sensing unit every 15 seconds. If a dry signal is received from the sensing unit, a green LED is illuminated. If a moist or wet signal is received, the LED will flash amber or red, respectively. If the sensor determines a wet condition, the red LED will remain flashing until the caregiver acknowledges this state. The reset button is used when the indicating unit gets locked into this wet state or if an error has occurred. If a valid signal has not been received within two minutes, a communication error LED is illuminated. The transmitted signals are coded with a unit identification number so multiple units can be used in the same environment.

The overall cost for this project is $93.50. This includes all of the components that are required for manufacturing. This cost does not include expenses associated with manufacturing a printed circuit board. In quantity, each professionally manufactured circuit board would cost approximately $35.

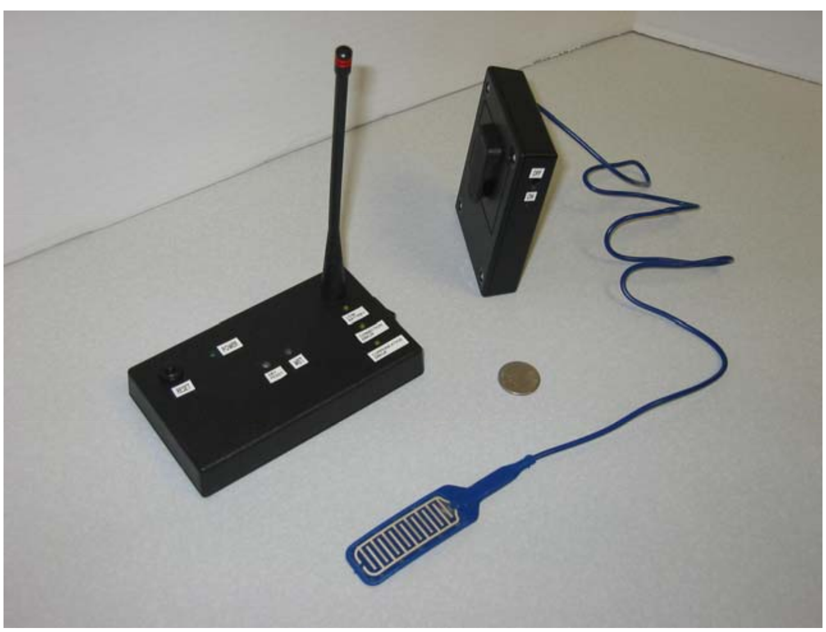

Figure 9.11. Completed Nurse Alert System

PAGE-TURNING SYSTEM

Designers: Scott Muggli, and David Schaefer
Supervising Professor: Dr. David Rogers
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INTRODUCTION

With limited upper body mobility, a task such as turning the pages in a book can be difficult. A device has been developed to aid in turning the pages of a book or magazine. There are very few models on the market today which perform such a task. These models have various drawbacks, including high prices and limited warranties. The intention for this project is to design a reliable low-cost solution that will compete with current models. The completed product is shown in Figure 9.12.

Figure 9.12. Completed Page-Turning System

SUMMARY OF IMPACT

The system allows the user to turn pages both forward and backward by using a joystick. Precise control allows for the turning of one to several pages at a time. With minimal practice, the user can manipulate these functions easily.

TECHNICAL DESCRIPTION

As shown in Figure 9.13, the page-turner is composed of nine blocks: 1) AC/DC power supply, 2) PIC micro-controller, 3) sway arm motor controller circuit, 4) roller motor controller circuit, 5) sway arm motor, 6) roller motor, 7) input joystick, 8) roller, and 9) sway arm.

The page-turning device has a wooden, wedge shaped enclosure similar to that of a desktop podium. The enclosure is covered in black felt with a hinged top for easy repair and maintenance. An on/off switch is located on the front panel next to a joystick. Power is provided by 120V AC which, in turn, is converted to +3.3V and +5V DC. The +5V DC is supplied to a PIC16F876A microcontroller, which controls motor speed and direction. The +3.3V DC powers four CMOS ICs, which convert signals from the microcontroller into pulses for the specified motor.

A four pole joystick gives the user four different operations. Pushing the joystick right or left will move the sway arm position in the corresponding direction. Up and down joystick motions will control the rubber covered roller. Up rotates the roller clockwise for advancing pages in a book; down rotates the roller counterclockwise for turning pages in the reverse direction.

The joystick's four poles (normally open switches) are fed into four pins on the PIC. Depending on the input, the PIC determines motor selection and direction. The PIC will then output a set frequency square wave to the corresponding motor control circuit. The controller circuit steps the motor once (1.8 degrees) for each pulse of the square wave. The PIC also sets the direction of the motor by toggling an appropriate output pin.

Page-turning is accomplished with two stepper motors. The first motor controls a sway arm which rotates across the face of the book, in a motion similar to turning a page. The sway arm is composed of hollow metal tubing which allows the flexible shaft a pathway to the rubber covered roller. This roller is controlled by the second stepper motor. The roller's main use is to spin slowly, causing the desired page to flip over the sway arm.

The caregiver first must slide the book's cover under the elastic straps provided. The power switch is located next to the joystick along with a power indicator light. To advance one page in the book, the user needs to manipulate the joystick. The user starts by pressing the joystick to the right until the roller rests on the page. The joystick is then pressed up to start the rubber covered roller in motion. The roller will rotate clockwise, gradually causing the page to buckle up near the center of the book. The page will then flip over the sway arm. By pressing the joystick to the left, the user will complete turning the page. The sway arm may be adjusted as required to aid in turning or reading the pages of the printed media. Turning in the opposite direction requires a similar procedure.

The total production cost of the page-turning system was approximately $297.

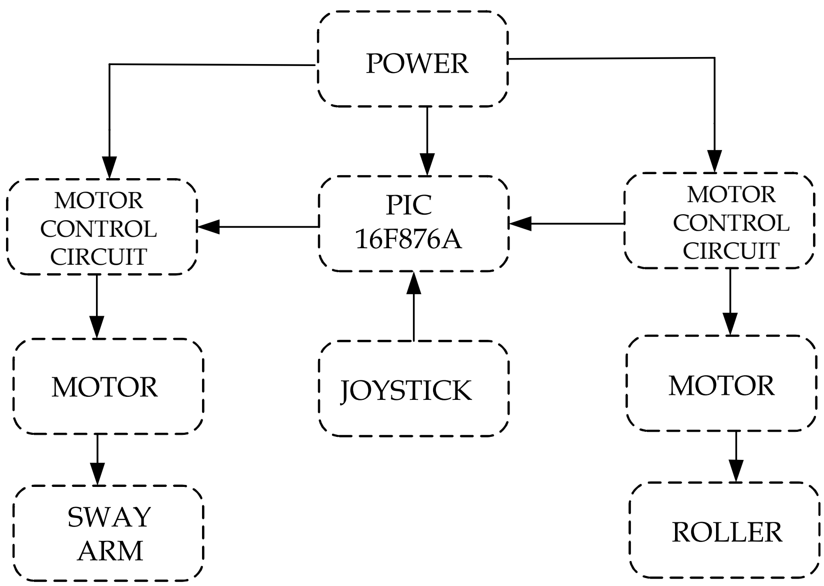

Figure 9.13. Block Diagram of Page-Turning Device

VIBROTACTILE STIMULATION PAD

Designers: Betty Wey, Jennifer Wilken, and Rebecca Barrows
Client Coordinator: Connie Lillejord, Anne Carlson Center for Children
Supervising Professor: Dr. Ivan T. Lima
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INTRODUCTION

The vibrotactile stimulation device is designed for a center for children with disabilities The vibrotactile stimulation pad is designed to be: 1) portable, 2) durable, and 3) able to provide different stimulation patterns. For portability, the device pad and its controls easily mount on the back of a chair with no exterior connections. To avoid external connections, the device is powered by batteries, which can be recharged whenever the vibration pad is inactive. Mounting the pad and its controls on a chair also helps maintain durability by keeping the device behind the chair back and out of reach. Finally, by designing separate control and driver circuits, the vibrating motors can output different patterns at different intensities, based on user-controlled settings.

The vibrotactile stimulation pad also serves as the first step in a series of projects to develop an aid for the visually impaired. The goal of the future aid is to guide individuals through their environment using vibrotactile stimulations to the head.

SUMMARY OF IMPACT

The vibrotactile stimulation pad, shown in Figure 9.14, allows clients to use vibrotactile sensations in different situations. The device serves its intended purpose: it is portable, robust, and outputs different patterns and intensities. Some of the center's clients find input to the touch receptors on the skin to be soothing. Before the device can be used in future vision applications, improvements are needed, including motor control improvements and size reductions.

TECHNICAL DESCRIPTION

As seen in Figure 9.15, the vibrotactile stimulation pad includes five main components: 1) a power circuit, 2) driver circuits, 3) control circuits, 4) switches, and 5) a vibrating motor array. Each of the

Figure 9.14. Completed Vibrotactile Stimulation Pad

components, excluding the power circuit, is divided evenly among two printed circuit boards.

The power circuit consists of a battery source, an on-off switch, and a power jack. When the vibrating device is turned on, the batteries provide power to the device. However, when the switch is placed in the charge position, an AC adapter can be attached to the device to recharge the batteries. In the off position, the device is neither operating nor charging.

Eight driver circuits are created using 555 timers, resistors, and capacitors. All the drivers receive input from a variable resistor, which is accessible by the user. Based on the resistance selected by the user, the drivers output a variable duty-cycle square wave. The change in duty cycle increases or decreases the intensity at which the motors vibrate. Each of the driver circuits is responsible for providing input to one of the eight motors.

Each control circuit is implemented using a PIC microcontroller and a 16-bit I/O Expander, which communicate via an I2C bus. Four different vibration patterns are supported by the PIC software: 1) all motors on; 2) a puddle wave; 3) a vertical wave; and 4) a horizontal wave. Using the pushbutton, the user can cycle through the different patterns of the device.

Sixteen chips, containing four switches each, are used to control which motors receive input from the driver circuits. Each of the switches consists of an input, an output, and an enable. The input to the switches is supplied by the driver circuits.

The vibrating motors are arranged in an 8 x 8 array, yielding a total of 64 motors. A grid of this size is used to allow motors to be spaced evenly at approximately an inch apart and cover most of the chair back. Also, the array needs to provide adequate resolution to output different shapes, which will be used for the physiological studies for future aids. In the final device, the motors are attached to a pad with Velcro and covered with a thin fabric case. Velcro attachments are used for mounting the device onto the back of a chair. The vibrotactile stimulation pad rests on the front of the chair back, while the box containing the electronics is attached to the back.

The cost of this project, including all parts for the vibrotactile device, is approximately $490.00.

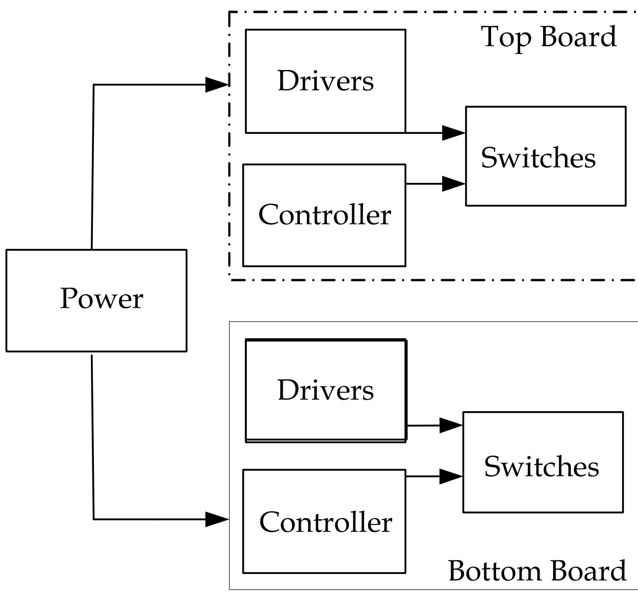

Figure 9.15. Block Diagram of Vibrotactile Device

SHOULDER TILT INDICATOR

Designer: Ryan Hanson, Justin Hofer, and Dan Olson
Supervising Professor: Dr. Roger Green
Department of Electrical and Computer Engineering
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INTRODUCTION

The shoulder tilt indicator is designed for a client who recently had a stroke and is sometimes unable to determine if his shoulders are level. The shoulder tilt indicator system monitors the angle of the user's shoulders and notifies him or her when they exceed a threshold from level. The device is designed to be lightweight, portable, comfortable, and easy to use. Comfort is important so that the client is able to wear the shoulder tilt indicator for extended periods of time.

The user wears the shoulder tilt indicator system as a vest. When the device detects that the user's shoulders are not level, the device sends an output to the user. The LCD shows the angle of the user's shoulder and is continuously updated by the controller. The client can choose the alert output mode: a buzzer or a vibrating motor.

Figure 9.16. Completed Shoulder Tilt Indicator

SUMMARY OF IMPACT

The client is able to wear the shoulder tilt indicator during his daily routines with minimal limitations from the device. He does not have to constantly monitor whether his shoulders are level because the device alerts him when they are not. The completed device is shown in Figure 9.16.

TECHNICAL DESCRIPTION

The shoulder tilt indicator consists of a sensor, an LCD, a microcontroller box, and a button box, as shown in the system's block diagram in Figure 9.17. The shoulder tilt indicator is attached to a vest, which allows the client a comfortable way to wear the device. The main component of the shoulder tilt indicator is the sensor, which is an AccuStar electronic clinometer. The sensor is a capacitance-based tilt sensor. When tilted, the capacitance of the sensor is changed. The capacitance is then converted to a voltage that is proportional to the angle. When the sensor is at zero degrees, the output of the sensor is one-half the supply voltage to the sensor. The sensor output is linear for plus or minus 60 degrees of angle. Additionally, the sensor has low power consumption.

The microprocessor receives the output from the sensor and determines when the user should be alerted. Since the device is to be worn by the user, the power supply is a six volt rechargeable battery. A rechargeable battery supplies the power for the entire device.

The shoulder tilt indicator consists of two printed circuit boards (PCBs) enclosed in two separate enclosures. One of the PCBs is the battery and the microcontroller, and the other consists of the user's buttons to control the device. The user's buttons consist of: 1) the power button, 2) sensitivity up, 3) sensitivity down, 4) output mode, and 5) calibrate. The sensitivity buttons let the client adjust the threshold used to activate the alarm. For example, the sensitivity level while the user is taking a vigorous walk is less than when the user is sitting in a chair.

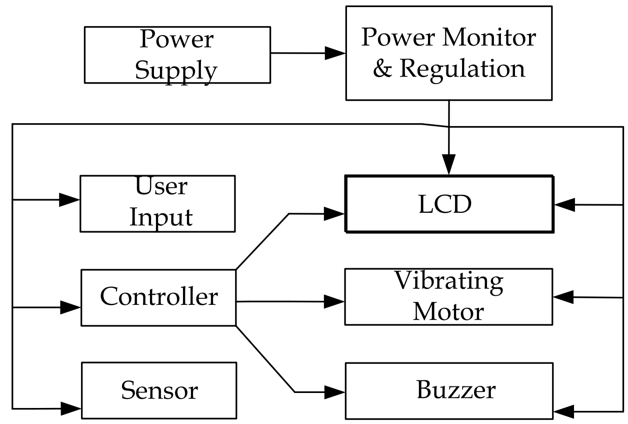

Figure 9.17. System Block Diagram

The output mode button changes the mode of output for the client. The buzzer and vibrating motor are positioned on the shoulder straps of the vest to maximize the user's ability to hear and feel the output. The vibrating motor mode can be used while the client is wearing the device in public. The calibrate button allows the sensor of the shoulder tilt indicator to be calibrated to zero degrees. Such calibration would enable the device to work accurately even if the sensor were not mounted onto the vest properly.

The device costs approximately $300.

AMBULATORY BRAIN COMPUTER INTERFACE

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INTRODUCTION

A brain computer interface (BCI) system allows a person with paraplegia or other immobilizing disabilities to control a device with his or her thoughts. Normally, BCI systems have two phases: pre-training and training. The pre-training phase determines parameters necessary for thought classification. This project deals specifically with the training phase. Typical BCI systems require a long training process in a lab environment. The lab environment is neither conducive for actual use, nor desirable for most users. The ambulatory brain computer interface (ABCI) system (shown in Fig. 9.18) is designed to allow an individual to train outside of the lab environment while engaged in a variety of activities. This gives the user more freedom and flexibility in training, thus making the training process more efficient. The system works by first collecting electroencephalogram (EEG) signals, via electrodes placed on the head, and then conditioning and processing the signal. The signal is then classified by the PDA program as left or right. The PDA provides the user with audio and visual feedback while recording the training results.

SUMMARY OF IMPACT

This lightweight, portable, and easy-to-use system gives researchers a new tool for studying the potential of portable training. Long-term training is the key to controlling a device using thoughts. With this portable system users are able to train throughout the day. This gives individuals with immobilizing disabilities a tool to interact with their everyday environment.

TECHNICAL DISCRIPTION

The ABCI system is comprised of three distinct parts: 1) electrodes and instrumentation, 2) microcontroller, and 3) PDA. The instrumentation and microcontroller printed circuit boards along with the power supply are all enclosed in a small box. Controls on the box allow the user to turn the device on or off, adjust channel gains, plug in electrodes, and connect serially to the PDA. Figure 9.19 shows a system block diagram.

Figure 9.18. Completed ABCI system

The main function of the instrumentation stage is to collect the EEG from the user and output that signal to the microcontroller. There are two channels, each comprised of two electrodes placed on the head, and a reference earpiece. A series of filters and user-adjustable amplifiers limit the EEG signal to a range of 1 to 25 Hz, and a peak-to-peak amplitude of 5

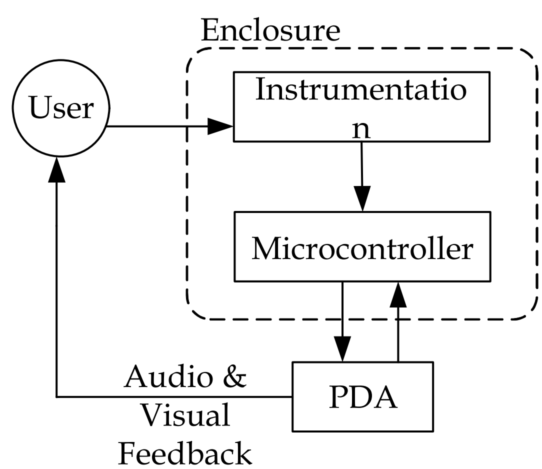

Figure 9.19. ABCI System's Block Diagram

volts, suitable for the microcontroller.

The microcontroller operates in two modes: 1) raw signal , and 2) train. The raw signal mode samples one channel of the EEG signal and sends that signal directly to the PDA to be viewed for signal verification. In train mode, the microcontroller samples both channels of the EEG signal, performs user-defined digital filtering, calculates RMS power for each channel, and then sends the power calculations to the PDA using serial communication. The sampling rate is 128 samples per second. The digital filter is an eighth-order bandpass elliptical filter implemented using second-order sections. It is adjustable to capture specific brain wave frequency ranges. RMS power is calculated every one-half second and sent to the PDA for classification.

The PDA uses two programs written using LabVIEW PDA module. The first program is used to view one channel of the EEG signal in real time. The program allows the user to choose which channel to view, which also lets the user to verify the signal and proper electrode connections. The second program is the ABCI training program. This program has four modes: 1) start, 2) input test, 3) train, and 4) settings (as shown in Fig. 9.20). In "start," the user enters his or her name and training session number. This information is used to generate a file to save the training results. "Test" puts the microcontroller into train mode and allows the user to view and verify the input power signal.

"Train" is the major component of the program. The user enters in the number of trials and classification parameters. At this point, the user presses the start button to begin the training process. The user controls the audio and visual feedback using only his or her thoughts. The phrases, "think right," "think left," "correct," and "wrong" are given audibly and visually. For the command "think right" the user tries to move the LabVIEW bar (Fig. 9.20, bottom) to the right. The user also hears a tick in his or her right ear, which gets louder as the bar progresses to the right. The "think left" command operates in a similar manner. The final mode is for advanced settings. This gives engineers access to main program settings and provides troubleshooting information. These settings are generally not to be adjusted by the user.

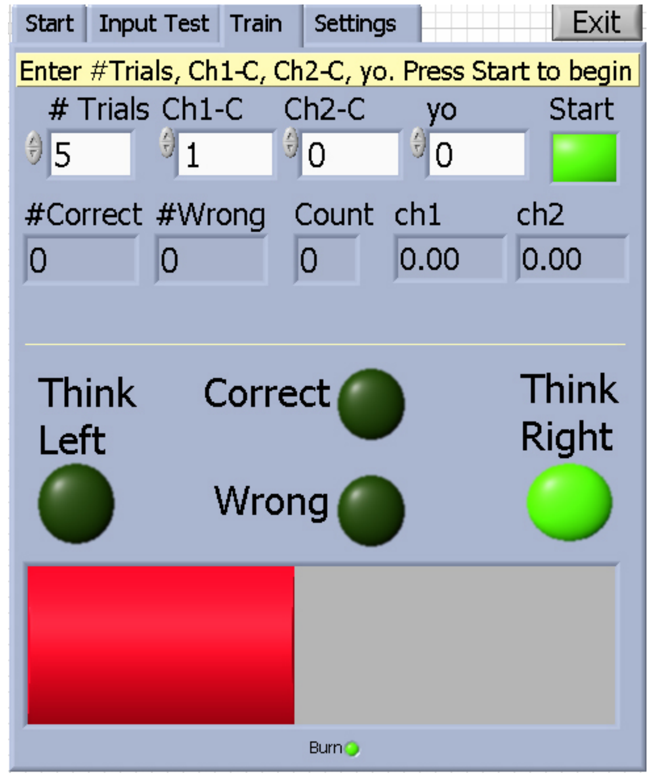

Figure 9.20. Lab VIEW Training Program

The project cost was approximately $750, the majority of which was associated with the purchase of the PDA and LabVIEW software.

PRODUCTION REPORT ASSISTANT

Designers: Kristin Schroeder, and Josh Shones
Client Coordinator: Dianne Wanner, Supervisor, Developmental Work Activity Center (DWAC)
Supervising Professor: Prof. Val Tareski
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INTRODUCTION

A center provides services for approximately 50 adults with developmental disabilities. It allows these individuals to perform meaningful work and earn money. Throughout a full day of work, individuals receive training in socialization and adaptive living skills. Additional programs to help them attain supportive or competitive employment are also offered. The individuals are paid on a piece rate basis for the work they do correctly, requiring staff members to keep accurate and detailed records. The current record system consists of a half sheet of paper for each individual. At the end of each day, information is recorded on the paper to indicate production results, supervision levels, doctor's visits, and appearance. The paper system is cumbersome, especially when information is needed from a previous day and staff members have to sort through piles of papers. Furthermore, mistakes are likely when sorting and tallying information by hand. The new electronic system provides a paperless solution that is accurate and fast, thereby allowing staff to dedicate more time to work with clients.

SUMMARY OF IMPACT

The electronic system allows staff members to monitor each individual's production more efficiently, eliminate bulky paper stacks, and streamline the storage of data for audits and year-end reports. With the paper system, an hour or more of the day is set aside to organize and tally the data for an administrative assistant. Over the course of one year, the system can save staff up to 250 hours. A supervisor said, "I am so excited about the possibilities this could bring to our program…I can't tell you how much staff time will be saved for our program."

TECHNICAL DESCRIPTION

Two Dell Axim X30 PDAs were purchased with Pocket Excel preinstalled, for proof of concept, as seen in Figure 9.21. Microsoft Excel and Pocket Excel spreadsheets are custom formulated. The spreadsheets include: 1) names of individual workers; 2) four tasks for each individual; 3) level of supervision needed; 4) appearance/hygiene for the day (the staff refer to this as "presentability"); and 5) the number correct out of the total number attempted at each task. These spreadsheets are made to work on Pocket Excel, which requires only simple formulas. Figure 9.21 shows an example of everyday recordings in the spreadsheet.

Each PDA supports every client, which allows staff members the flexibility to check on any individual. Due to limitations in Excel, a separate spreadsheet is used for 25 individuals; thus, two sheets are needed for the 50 DWAC clients. When the administrative assistant receives all of the PDAs at the end of the day, data from all spreadsheets are automatically combined into the master spreadsheet. The master spreadsheet includes Excel functions and formulas that search for each individual's name in every spreadsheet and then locate and tally the corresponding data. The administrative assistant copies the organized results from the master spreadsheet into customized software. The spreadsheets can be transferred to the computer via three methods: USB, IR, and Bluetooth.

The staff participated in the design effort, creating a true collaboration between the design team and client. During mid-design, the staff field tested the system for three weeks and provided valuable feedback, which was incorporated into the final design to ensure product quality and usefulness.

The approximate cost of the project is $570.

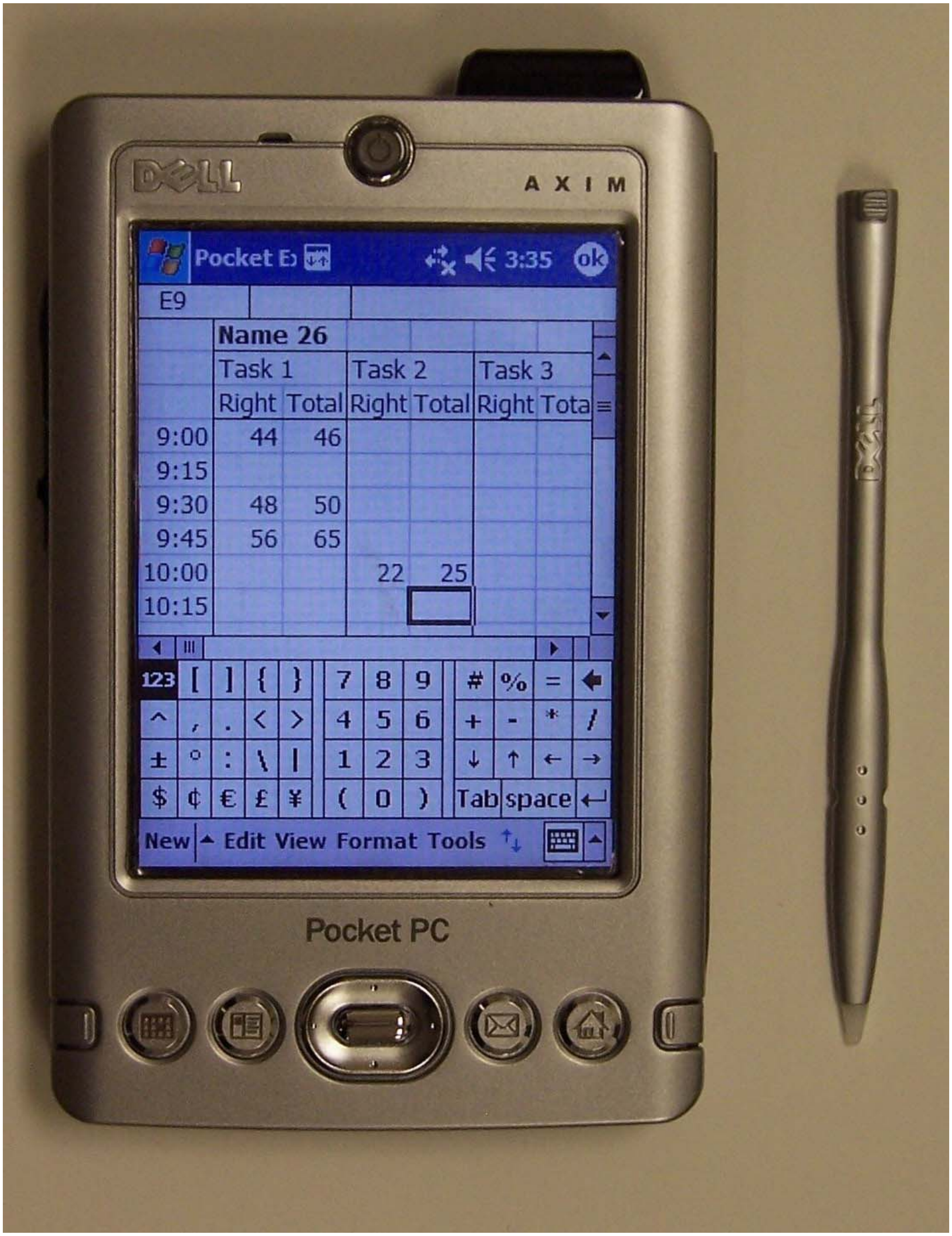

Figure 9.21. Dell Axim PDA Displaying Production Spreadsheet

BOCCE BALL SCORING SYSTEM II

Designers: Russell Cook, Shaun Schmeig, and Phil Stich
Client Coordinator: Shelly Woodcock
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INTRODUCTION

A device was designed to provide Special Olympics officials a bocce ball coring system that is fast, accurate, and easy to use. Bocce ball is played by two teams consisting of two players each. The object of the game is for each team to alternate turns throwing the bocce balls, with the intent of having the team's balls rest closest to the target ball, known as the pallino. This system helps judges determine the closest (winning) ball. The completed prototype system is shown in Figure 9.22.

SUMMARY OF IMPACT

The Bocce Ball Scoring System II makes the judging process much more efficient. The design accomplishes this by accelerating the scoring process, increasing precision, and reducing the number of judges needed. Only one judge is needed for this system, and the scoring process can be completed in just 10 seconds over the amount of time it takes to set the units on each of the bocce balls.

The newest design is superior to the previous bocce ball scoring system, which was located inside of the bocce balls. Upon encasement, the audio signals are almost completely absorbed by the material of the bocce balls, preventing proper operation of the system. This problem is avoided in the new design by using external circuitry, which is placed on the bocce balls after they have been thrown. The current design is an improvement over the previous design in several other ways as well. First, the current system is more practical to implement physically. Any bocce ball set can be used. It is also much easier to replace one of the ball locators than to have to replace a whole bocce ball with the electronics inside. Second, the current system is able to operate correctly in a noisy environment. The previous design required a quiet environment for the system to work properly. Third, the current design uses an audio signal that does not need to be filtered. The audio signal on the previous design, created by a buzzer and received with a microphone, needed to be filtered and modified into a usable signal. Any variable delay added by the filters could greatly affect the precision of the measurements. The signal created by the ultrasonic sensors in the current design only requires a gain stage before it is used. Therefore, the current design has higher precision than the previous design.

Figure 9.22. Bocce Ball Scoring System II

TECHNICAL DESCRIPTION

As shown in Figure 9.23, this system is comprised of a hub unit, which sets over the pallino, and three bocce ball locator units, which are placed on the bocce balls. The system determines the winning balls using a combination of radio frequency (RF) and audio signals to calculate the distance to each ball. The hub first sends out an RF signal to start and synchronize timers in the ball locators. Then the hub sends out an audio signal using ultrasonic sensors to stop the timers in each of the ball locators. Because of the relatively slow propagation of the audio signal, the timers in the closer locators will be stopped before the timers of the locators that are farther away.

Once the timers in the ball locator units are stopped, each unit sends its timer value back to the hub using the RF transceivers. The microprocessor in the hub uses these values to calculate the winning ball or balls. The hub then transmits the winning ball information back to the ball locators, commanding the winning ball or balls to flash their LEDs.

Power is supplied to each unit using alkaline nine-volt batteries. Using standard batteries, the system operates continuously for six to seven hours. By turning units off between rounds, the system is able to operate for approximately 200 scorings.

This system is controlled by a PIC16F876 microprocessor. The RF transceivers in the design are RFM DR3000 modules. The audio transmission and detection is performed by 40 kHz ultrasonic sensor pairs made by Panasonic. For a complete eight-ball system, there is one sensor in each of the ball locator units and 10 sensors on the hub unit. Each sensor on the hub covers a 36 degree interval around the hub in order to achieve line of sight to each ball on the playing field. The user interface of the system consists of a reset switch on each unit and an extra switch on the hub that starts the scoring process. The display on each ball locator unit consists of LEDs that display the system status and information on the winning ball or balls.

The Bocce Ball Scoring System II detects the closest ball with a theoretical precision of approximately .06 mm per count of the timer. During testing, however, the system consistently determined the winning ball between two locators that were placed approximately one millimeter apart.

The cost for a complete eight ball system is approximately $950.00. The hub unit alone costs $150.00 to manufacture, and each ball locator unit costs $100.00.

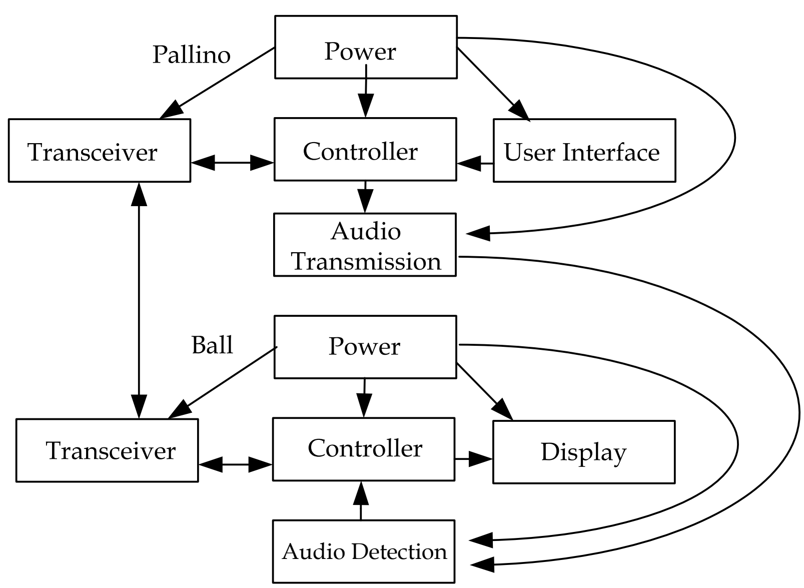

Figure 9.23. Block Diagram of Bocce Ball Scoring System II