CHAPTER 9
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WIRELESS MONITORING SYSTEM

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INTRODUCTION

The wireless monitoring system alerts caregivers when clients enter a bathroom. The system is designed to be discrete, portable, and durable. Two proximity sensors detect general entries and a magnetic coil detects individual-specific entries. The detectors are hardwired to a transmitter that wirelessly transmits alert messages to a receiver. The receiver is carried by the caregiver so that they are notified when someone enters the bathroom. The caregiver may choose from a combination of three alerts: a flashing LED, an audible buzzer, and a vibrator.

Several monitoring systems are commercially available such as cameras and RFID-based systems like those found in clothing stores. However these systems are generally expensive and are not well suited as bathroom monitors. RFID systems can cost thousands of dollars, and cameras violate privacy laws when placed in a bathroom. Unlike commercially available systems, the wireless monitoring system balances the detection, privacy, and cost needs of the Developmental Work Activity Center (DWAC).

SUMMARY OF IMPACT

The wireless monitoring system is developed for a client who has a history of flushing inappropriate items down the toilet. The monitoring system therefore helps the caregiver prevent damage to the plumbing system. The two detectors are easily hidden from sight. As seen in Figure 9.1, the coil detector may be placed under a door mat, and the small proximity sensors may be inconspicuously placed on the wall. At 3" x 2.5" x 2.5", the receiver is portable and easy to carry. The system uses durable parts and packaging to ensure reliable operation for years to come.

The completed system, shown in Figure 9.2, is currently in use at the center. The caregivers are pleased with the device, and it is currently helping them to prevent damage to the plumbing system.

TECHNICAL DESCRIPTION

The system block diagram, shown in Figure 9.1, is comprised of three main parts: 1) detectors, 2) transmitter, and 3) receiver.

The wireless monitoring system uses two detection methods: general and individual-specific. The general detection method uses two proximity sensors placed in series to determine whether someone enters or leaves the bathroom. The sensors are linked to a PIC18F4620 microcontroller. If the outer sensor is activated first, then a person has entered the bathroom and the microcontroller increments a counter. If the inner sensor is activated first, then a person has left the bathroom and the microcontroller decrements a counter. Any count greater than zero indicates that the bathroom is occupied, in which case the microcontroller sends an alert message to the transmitter.

Individual-specific detection requires the caregiver to implant magnets into each shoe of the client. When the client walks over the doorway coil, a voltage is induced and amplified by a high-gain DC op-amp. A signal is then sent to the PIC microcontroller, which again communicates an alert message to the transmitter.

The second part of the monitoring system is the transmitter. Once the PIC microcontroller receives a signal from one of the detectors, the PIC then outputs a constant signal to an MS series Linx Technologies encoder. For this design, only four of the eight available outputs are used: one for each of the four ways to alert the caregiver. The encoder sends a digitally-coded message to the transmitter which then mixes the message with a 418 MHz carrier.

The third part of the system is the receiver. The receiver demodulates the received signal. The recovered coded message is then sent to the decoder, which drives the appropriate alert outputs. A yellow LED illuminates when the proximity sensors detect that someone enters the bathroom. When the coil sensor detects that a specific client enters the bathroom, the red LED, vibrator, and buzzer are all activated. A silent mode is available to disable the buzzer.

The detectors and transmission system are powered using a wall outlet while the receiver is powered by two AAA batteries. The receiver is equipped with a switch to turn off the system and save battery life. To power down the transmission system, the caretaker unplugs the unit from the wall.

The cost of the complete system is approximately $105.

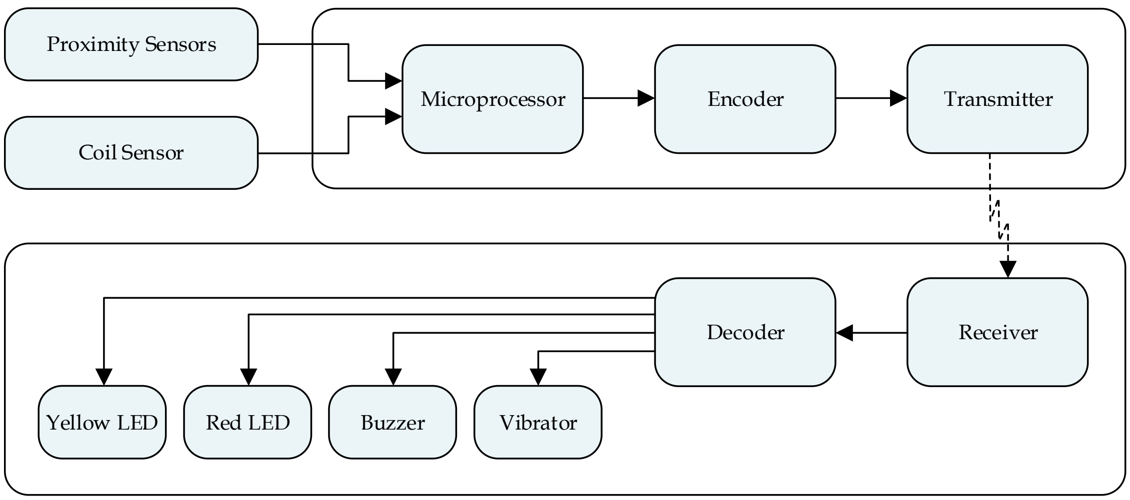

Fig. 9.1. System Block Diagram.

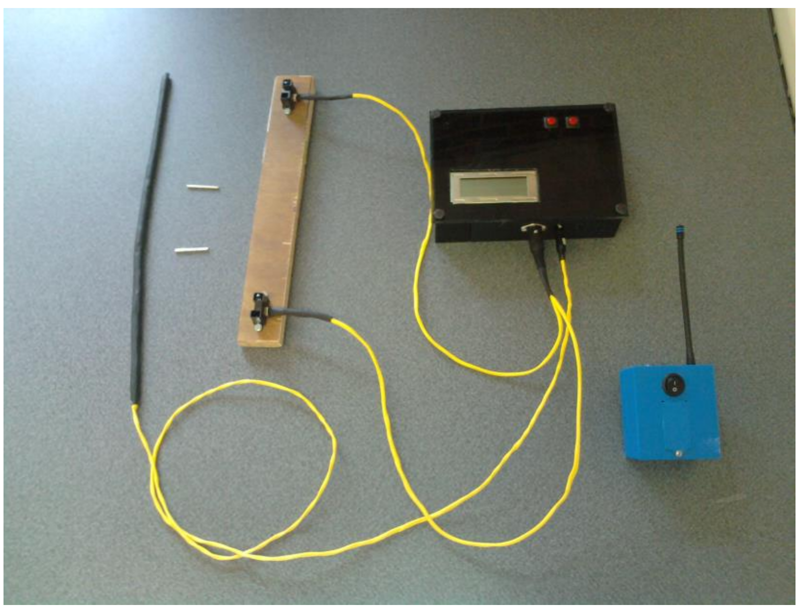

Fig. 9.2. Wireless Monitoring System.

SOUND-ACTIVATED LIGHT BOX

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INTRODUCTION

The sound-activated light box is an interactive sensory device for the Anne Carlsen Center for Children. The box is designed to be engaging, simple to use, and durable. The sound-activated light box is comprised of inputs, control circuitry, and a large display of high-quality RGB LED Neon-Flex Rope Lights arranged in a pattern of eight concentric circles. Vibrant and colorful light patterns are produced automatically or in response to sound or touch. Figure 9.4 shows the completed device.

Although there are sound-activated lights available on the market, most are geared toward disc jockey equipment and many produce strobe effects. These lights do not appeal to the client due to the potential of strobe-induced seizures. The sound-activated light box avoids these dangers and instead creates soothing rippling patterns, much like those produced by a stone being tossed into a pool of water.

SUMMARY OF IMPACT

The Anne Carlsen Center provides educational, residential, and therapeutic services to young individuals with disabilities. The center has a sensory room which is filled with various sensory devices such as a motion activated piano and passive bubble tubes. The sound-activated light box provides the center an additional tool to engage and entertain the children. Upon delivery, the Anne Carlsen Center staff said that the box went "above and beyond" their expectations. The center is eager to install and utilize the box in their sensory room.

TECHNICAL DESCRIPTION

The sound-activated light box consists of five main components: 1) inputs, 2) embedded microcontrollers, 3) rope lights, 4) power supply, and 5) enclosure. Figure 9.3 provides a block diagram of the system. A three way toggle switch selects one of three modes of operation: automatic, audio, and button. In all operation modes, color changes progress from the inner ring outward, thereby producing soothing ripples of color.

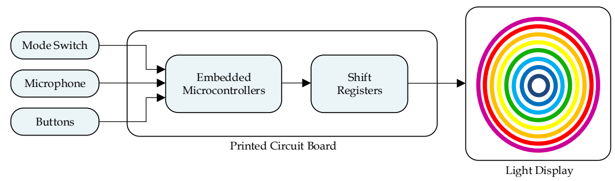

Fig. 9.3. Block Diagram.

In automatic mode, the embedded controllers continuously change the color of the rope lights without any input from the user. In this mode, the lights cycle through 180 colors in 23 seconds before starting over. Automatic mode allows a passive way to enjoy the light display of the box; this is particularly useful to accommodate individuals with severe physical limitations.

In audio mode, a microphone converts sound into a low-level electrical signal. An operational amplifier circuit conditions the signal to the zero-to-five volt range required by the microcontrollers. The microcontrollers then sample the signal using on-board 10-bit analog-to-digital converters. The sampled signal serves as the basis for output color: soft sounds produce "cool" colors (blues), loud sounds produce "hot" colors (reds), and intermediate sounds produce the gradation of colors in between. To reinforce a cause-and-effect relation between sound level and color, the system responds rapidly to changes in sound level. Still, color changes take approximately one second to propagate from the innermost to outermost rings. Thus, the system output is responsive yet soothing. The cause-and-effect relation between sound and color is intuitive for individuals of all skill levels.

Button mode allows users to change the color of the lights by pressing and holding one of the two five-inch buttons. One button causes colors to cyclically transition from "cool" to "warm"; the second button causes colors to cyclically transition in the opposite direction. In this mode, it takes approximately 11 seconds to cycle through the entire color range. The somewhat long cycle time ensures users of broad ability range can successfully obtain the colors they desire.

Two PIC 18F4620 microcontrollers manage system operations. To determine mode of operation, the controllers continuously monitor a three-way toggle switch. If needed, the controllers then read the appropriate input (button or microphone) to determine the current output color. In the case of the microphone input, samples are processed at a 20 kHz sampling rate using a maximum-based filter that reduces flicker and ensures proper output color range. To set a particular output color, the intensity of the red, green, and blue components must be set. Since there are eight rings, the total number of required outputs is 24. Pulse-width modulation (PWM) is used for each output; the intensity for each RGB output is directly proportional to the duty cycle of the PWM wave. Shift registers are used to extend the limited number of PIC outputs to the needed 24 outputs. The outputs of these shift registers are clocked by the PIC controllers every 7 microseconds. This rapid switching is far faster than the human eye can detect and gives the output the illusion of a fixed intensity that is proportional to the duty-cycle of the PWM wave. The controllers also sequence colors from the innermost ring to the outermost ring to establish an output pattern that resembles rippling waves.

The RGB LED Neon-Flex Rope Light is made with high power LEDs that are spaced evenly every three quarters of an inch. The RGB LEDs are also known as multi-colored LEDs because they can create nearly unlimited color variations by blending various intensities of the primary colors of red, blue, and green. The LEDs, which are housed in a flexible plastic casing with a semi-transparent rounded plastic top, give the illusion of neon lighting. As seen in Figure 9.4, the rope light is sufficiently flexible to form the innermost circle, which measures 4.7″ in diameter. The rope lights are powered by a 24 volt AC to DC power supply.

The power supply derives its 24 volt DC output from a 120 volt AC input. The sound-activated light box draws approximately three amps of current, the majority of which is used to operate the rope lighting.

Fig. 9.4. Sound-Activated Light Box.

This current draw is well below the 9.2 amp rating of the power supply and ensures the power supply remains cool. Voltage regulators are also used to provide the various voltage levels required by components of the box. A simple switch allows power to be turned on and off.

The device enclosure, which measures 4′×2.5′×6.5″, is made of painted wood and particle board. The rope lights are protected by a 32″ × 26″ piece of Plexiglas that has an applied frosted film. Excess system heat, which primarily originates with the power supply and voltage regulators, escapes the box through two venting ports. Two 3.5mm mono jacks are used to connect buttons to the box.

The total cost of the sound-activated light box is approximately $1200, including $800 for the rope lights, $100 for the power supply, $90 for the buttons, and approximately $200 for electronic components, printed circuit boards, paint, Plexiglas, and other components.

ANDROID OS REMOTE CONTROL

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INTRODUCTION

Built around the Android operating system (OS), the Android OS Remote Control, referred to as the AOS Remote, is designed to be inexpensive and easily operated. It can control multiple electronic devices such as televisions, DVD players, radios, or cable boxes. Any Android-compatible device can use the remote control application. The application communicates commands through Bluetooth to a custom hardware module. A microprocessor then converts the command to an appropriate infrared signal for the target entertainment device. The AOS Remote is designed to be compatible with multiple user inputs, thus accommodating various forms of disabilities. The application is controlled by any USB-based input device including trackballs, joysticks, and buttons.

There are similar remotes on the market, but these products are typically expensive, large, or do not properly accommodate persons with disabilities. The Relax and the Relax II are infrared transceivers that can control up to ten electronic devices. The Relax II costs approximately $600 and is rather large. Remote control applications are available for Android devices, but the user can only control compatible devices. For example, DIRECTV provides an application allowing users to control their satellite using an Android device. However, if the user does not own compatible DIRECTV hardware, he or she cannot use the application. Unlike these other applications, the AOS Remote includes this necessary hardware. The AOS Remote allows each client to customize the application to operate any infrared-controlled electronic device.

SUMMARY OF IMPACT

The client for this project is a twelve-year-old boy who has limited mobility. He is not able to independently control any entertainment devices. The AOS Remote allows the client to independently control multiple electronic targets without help from a caretaker. To accommodate the client's proficiency

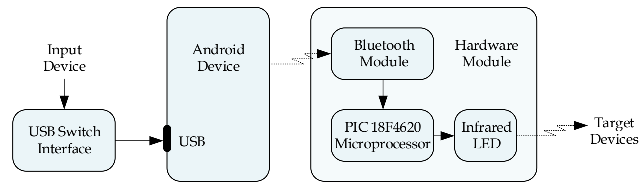

Fig. 9.5. System Block Diagram.

Fig. 9.6. Screenshot of the AOS Remote Application.

with a two button head-mount interface, the client's Android OS Remote is controlled by two buttons, as shown in Figure 9.7. The client uses these two buttons to toggle through the options of the Android application and then select his desired option. The application implements text-to-speech, which verbally confirms each selection. This increases the functionality of the AOS Remote, because the client relies heavily on auditory confirmation. The application also has the ability to have commonly used TV channels or radio stations pre-programmed to increase ease of use. Most assistive remote controls do not have this feature.

TECHNICAL DESCRIPTION

As shown in Figure 9.5, the AOS Remote is composed of four main components: 1) an Android device, 2) a Bluetooth module, 3) a microprocessor, and 4) an infrared LED.

The Android device controls the operation of the remote. As shown in Figure 9.6, the main menu contains simple functions such as volume up or down and channel selection. There are also selections that take the user to submenus, such as favorite channels or numerical keypad. Input devices are connected to the Android device through a USB switch interface. The switch interface provides a mechanism to associate various input devices with different control actions such as toggle, select, and directional movement.

When the user selects a command, the Android confirms the selection with text-to-speech. All Android devices made after Android Version 2.1 have native text-to-speech. Once a selection is made, the application sends a signal through Bluetooth, which is also native on all Android devices.

The AOS Remote uses a BTM-182 Bluetooth module that receives a signal from the Android device once a selection is made. The BTM-182 has a built-in antenna that receives the command data. A PIC18F4620 decodes the BTM-182 output and creates a target-appropriate infrared control signal. This control signal is then output to an infrared LED. The electronic target accepts the input and performs the desired function.

The Bluetooth module, microprocessor, and the LED are housed together in the hardware module. A six-volt AC/DC converter provides power to these components through a five-volt regulator. The enclosure must be positioned so that the infrared LED is within transmission range of the target electronic devices.

The client's AOS Remote cost is $600, which includes $400 for a View Sonic G-Tablet and $200 for the Hardware Module. The Android application can be distributed free of charge.

Fig. 9.7. Android Device with two button inputs.