CHAPTER 17
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VOICE-ACTIVATED ENVIRONMENTAL CONTROL SYSTEM

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INTRODUCTION

An environmental control system (ECS) for a residential house was developed. It enables a person to control any house appliance by voice and therefore is especially important for people with limited physical ability.

In order to simplify the design work, an existing remote controlled (X-10) ECS was modified to become voice activated. This ECS is controlled via a desktop personal computer, thus making it easier to interface the speech recognition engine (Realize Voice Lite) with the menu interface developed in Visual Basic and the external hardware interface built using simple electronic components such as transistors, resistors and relays.

The hardware and software were designed and documented carefully in order to make sure that if simple modifications are needed to be made in the future, the modifier will only have to modify the Visual Basic code. The user does not need to have any technical background.

SUMMARY OF IMPACT

This voice activated ECS was costume designed and delivered to an elderly person who lives alone in a house. She has severe arthritis, is overweight, and has had several open-heart surgeries.

The external hardware was mounted inside an 8′′5′ by 8′′5′ by 4′′ box as shown in Figure 17.1 and therefore fits easily on the coffee table inside the living room.

The system has been installed and functioning for about two weeks. Initial testing proved this design to be worthwhile. Figure 17.1 shows top view of the entire system.

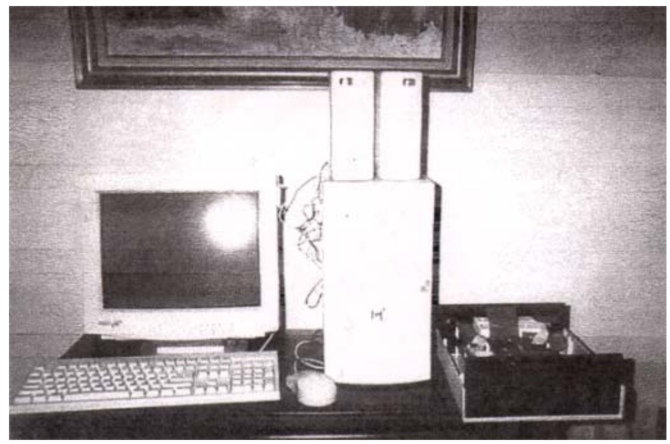

Figure 17.1. Top View of the ECS.

TECHNICAL DESCRIPTION

The voice-activated ECS consists of two software (voice recognition and Visual Basic implementation) and three hardware (opto-isolating, decoding and relay) circuits.

The software portion of this project consisted of two Microsoft dependant programs: Visual Basic 6 and Realize Voice Lite. Visual Basic was used to write a user-friendly visual drop-down menu with an embedded implementation program. Similarly, Realize Voice Lite was used for speech recognition purpose. Realize Voice Lite accepts discrete commands, such as “TV-ON,” and therefore was found to be the best voice recognition software for this project.

When the user gives a discrete voice command such as “TV-ON” to the system, the voice recognition engine tries to match the inputted command with one of the menu options. If a match is found, the menu will display “TV-ON” on the screen and at the same time will try to output a certain 4-bit binary bit pattern through the parallel port. Since Visual Basic doesn't have input/output capabilities, a 32-bit input/output dynamic link library that gives Visual Basic the ability to write and read from the parallel port was copied in the working directory. An embedded program that includes subroutines for each different command was then written. Each of these subroutines, as in the "TV-ON" case, outputs or writes a distinct 4-bit binary bit pattern to the parallel port and at the same time displays the command implemented on the screen. The 4-bit output is then sent through an opto-isolating circuit, which protects the parallel port from being damaged by a sudden voltage spike in the relay circuit.

When a signal high or "1" is received at the anode of the light emitting diode (LED) its corresponding transistor turns on and lets the signal through. Similarly, for an input of low or "0", the corresponding output transistor outputs a low, thus letting the signal through. Therefore a four-input opto-isolating circuit was used to isolate the external circuit from the PC without changing the signal output from the parallel port.

The output of the opto-isolating circuit was fed to a 4-16 decoding circuit built out of 74LS154 IC chip. The decoding circuit decodes the four-bit signal and outputs all high except for one output. This output that remains low is thus the decoded output that represents that specific voice command given by the user. All 16 outputs are then inverted using a 74LS04 inverter to turn that decodes output to a high "1" state and switches the rest to a low state. This coded or high output is then interfaced with its designated relay circuit.

The relay circuit is then interfaced with either the X-10 ECS remote control or the universal remote control, depending on what it is controlling, thus serving as a switch. The two outputs of each relay are hardwired into the remote so that, when a decoded signal turns on a specific relay, the switch inside the relay gets thrown, completing the circuit in the remote control. If the transmitting remote control is the X-10 remote control, the transmitted signal is received by a transceiver. The transceiver then sends a pulsating AC signal over the house AC power line to the appropriate appliance module.

VOICE ACTIVATED ENVIRONMENTAL CONTROL SYSTEM

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INTRODUCTION

The Voice Activated Environmental Control System (ECS) was designed to provide a control of common household appliances by a person with paraplegia. This system (Figure 17.3) gives a person the ability to control multiple televisions, numerous lights, a telephone, an automatic door, and various other appliances.

SUMMARY OF IMPACT

Upon completion, the system was installed and tested in the client's apartment. The client, who has limited upper extremity movement, is uses an electric wheelchair. The system enables him to keep himself entertained and safe when he is left alone and unattended, often for as long as eight hours a day. Prior to the installation of the system, the client would often be left stranded in the dark while watching a single television channel. When this became tiresome, he would toggle the power of his radio with a mouth stick to listen to talk radio. Now that the system is installed, he can scan through the channels of either of his televisions at the appropriate sound level. He can also adjust the lighting to meet his needs. Use of the telephone and the automatic door not only ensure safety and independence, but also a sense of freedom to communicate with others from outside his apartment.

TECHNICAL DESCRIPTION

Voice commands presented through a wireless microphone (Sony WCS-999), which is connected to the sound card of a personal computer. Microsoft's Speech Application Programming Interface (SAPI) 4.0 analyzes the data received by the sound card. Microsoft's SAPI parses incoming voice data and creates tokens that control events in a Visual Basic application. This application has a Windows-style interface (Figure 17.3) that allows the user to navigate through menus using voice commands.

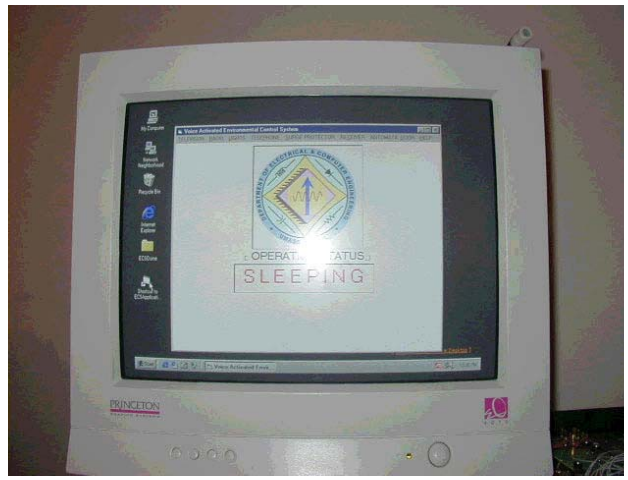

Figure 17.3. Voice Activated ECS User Interface.

The Visual Basic program was written to handle the voice commands and send the appropriate bit pattern out the parallel port. For telephone control, the Visual Basic program was written to interface with Thought Communication's FaxTalk Communicator to allow both the initiation of outgoing phone calls as well as receiving of incoming phone calls through the use of Diamond's SupraExpress 56K Speakerphone Modem.

The controller circuit, shown in Figure 17.4, is connected through the personal computer's parallel port. To protect the parallel port from unwanted signals, an octal three-state buffer (74HC244) was used. The outputs of the buffer were then connected to a decoder. The 5-32 decoder was constructed by combining two 4-16 (74HC154) decoders. By using a decoder, a binary number input can be used to assert just one of the 32 outputs. The outputs of the decoder were then connected to an array of single-throw, single-pole electrical relays (HE3600). These relays contain two control pins and two contact pins. A 5-volt signal was connected to one of the two control pins while the other control signal was connected to the appropriate output of the decoder.

By driving the output of the decoder low, the relay will close the contacts of the two contact pins, thus acting as a switch. These relays were connected to the buttons of two television remote controls, an X-10 transmitter, and a door remote control. A power supply was then constructed to supply the appropriate voltage throughout the controller circuit.

The door remote control requires 9 volts, the integrated circuits use 5 volts, and the two television remote controls use 3 volts. After a current draw analysis, it was decided that a 9-volt 800mA DC transformer would be used. This was connected to a cascade set of voltage regulators. The LM317 adjustable voltage regulator was used to obtain 9 volts and 3 volts while a 7805 voltage regulator was used for the 5-volt power supply. One red and one green light-emitting diode were added to the plastic casing to indicate the power and status of the circuit.

The total cost of the hardware was approximately $250.

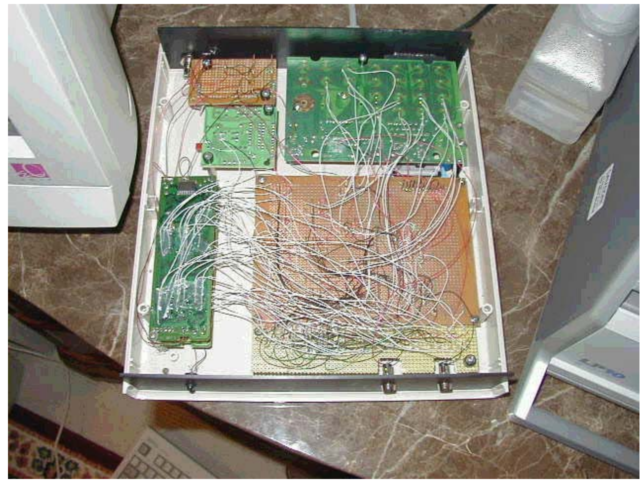

Figure 17.4. Voice Activated ECS Controller Circuit.

AUDIBLE BAR CODE SCANNER TO HELP PERSONS WITH VISUAL IMPAIRMENT IDENTIFY PRESCRIPTION BOTTLES

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INTRODUCTION

An audible bar code scanner was designed to identify prescription medications for individuals with visual impairments. A customized message is played back each time a bar code on a prescription bottle is scanned. The design allows for seven 12.8-second messages to be stored. It can be configured for other message lengths or quantities depending on a client's needs. When the device is given to the user it is set up to only playback messages. The client can put any information he or she wants in the message, for example, the name of the medication, dosage, time of day to be taken, and any precautions.

SUMMARY OF IMPACT

The device will be used by an elderly man with visual impairment, who cannot see well enough to read his prescription labels. He wants to be able to play a message corresponding to his prescriptions to tell the name and proper dosage. Having the audible bar code scanner will reassure the client that he is taking the proper dosage

The only comparable commercial device found costs approximately $2,000. The current device can be made for less than a quarter of that price, which may enable a much larger population to have access to this type of device.

TECHNICAL DESCRIPTION

The dimensions of the plastic enclosure of the device are approximately 6″ x 9″ x 3″. The power is supplied by an AC adapter. The scanner used is a low current digital bar code wand scanner. The only controls for the user are a power switch and a volume control. There are two LEDs: one for showing that the power is on and the other for

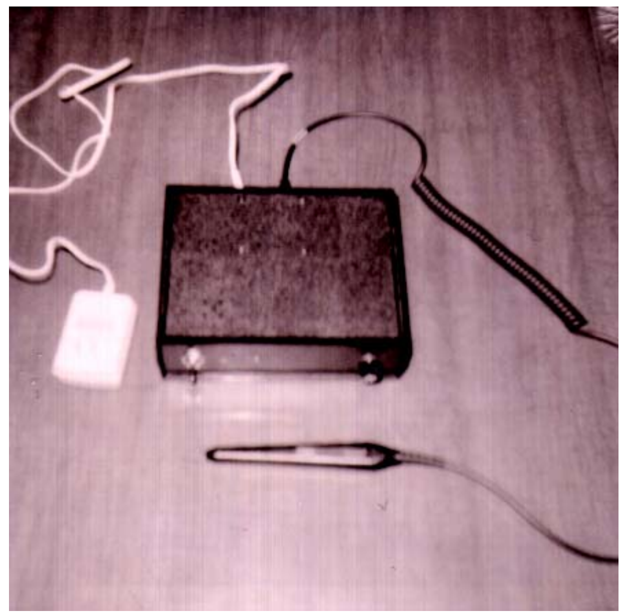

Figure 17.5. Audible Bar Code Scanner.

indicating when the decoder IC has successfully read the bar code.

The functioning of the different stages of this design can best be explained by following the flow of data from the input to the output of the system. Once the user scans the bar code using the wand scanner, the circuitry inside the scanner outputs TTL-compatible voltage levels corresponding to the bars and spaces. This digital signal is input to the bar code decode IC where it is converted to the ASCII equivalent binary numbers. The parallel outputs of the decode IC are used to access the data. The design uses the three lowest order bits of the ASCII number since there are seven different messages to play back. To output the bits to shift registers, the write strobe, which the decode IC asserts when it outputs the data to the external RAM chip, is used as the clock signal for the six shift registers, two in series for each parallel output, to which the bits will be sent.

The different messages on the voice chip are selected by applying different logic levels to the address input lines of the corresponding chip. By knowing where the bits for each number are in the shift registers, the proper parallel output from each pair of shift registers can be connected to the corresponding address input on the voice chip. To start playback of the message, a low pulse must be applied to the chip enable input of the voice chip. Conveniently, when the bar code decode IC completes a successful bar code read it outputs a series of low pulses to sound a beeper. This beeper output is connected to the chip enable input of the voice chip, so that when a bar code is scanned, the address inputs are set to the right levels by the process described earlier, then playback is initiated by the beeper signal.

The cost of materials was approximately $300, most of which was for purchasing the scanner.

VOICE-ACTIVATED BED CONTROL SYSTEM

Designer: Anlong Pham
Client Coordinator: Sam Afroh
Supervising Professor: Donn Clark
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INTRODUCTION

The Voice-Activated Bed Control System was designed to help people who cannot use their hands to operate an electric bed. This device is attached to the bed near a patient's head. To operate the bed, the patient simply speaks a simple command, such as "head up" to raise the head and the shoulders. The device is trained by the users for voice recognition. It can not recognize words that sound alike, such as "head up", "set up", and "get up". To train the device, users must use distinct commands. The device can be improved for general environmental control.

Figure 17.6. Voice Recognition Device.

SUMMARY OF IMPACT

Users can command the device to raise or lower their heads, shoulders, backs, and legs. The degree of elevation is flexible. The user can stop it at postion he or she desires. This enables patients to feel more comfortable, and provides greater independence and mobility.

Figure 17.7. Voice-Activated Bed Control System.

TECHNICAL DESCRIPTION

The voice recognition circuit (HM2007) receives a voice command via the microphone. It compares the incoming command with commands stored in memory. If they are match, it outputs 8-bit signals. However, only 4 bits are used for this device. The decimal converter (4028 BPC) receives 4-bit signals and converts them to 10-decimal signals. Only five of them are used for five commands. The flip-flops (74HC74N) receive five input signals and keep them always high, even when extraneous noise occurs. The relay serves as a switch. It closes the bed switch when it receives a signal. When the switch is closed, the motor runs to operate the bed.

To use the device, the user must train it. The speech recognition system can recognize the voice as speaker-dependent or speaker-independent. Speaker dependence has the highest recognition accuracy. Speaker independence enables the system to recognize the voice of more than one user. The system is set up to respond to five commands: to raise the head and shoulder, lower the head and shoulder down, raise the knee, lower the knee, and stop at the current position. The cost of the parts is about $250.

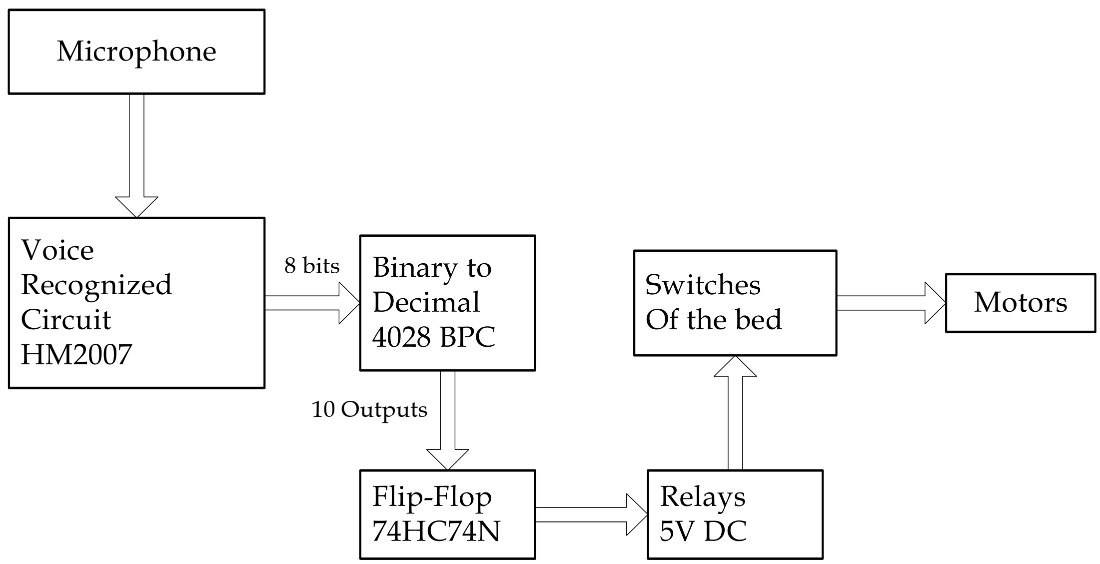

Figure 17.8. General Block Diagram.

CYBER-LINK MIND-MOUSE ENVIRONMENTAL CONTROLLER

Designer: Vivek Santhana
Technical Resource: Dr. Andrew Junker
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INTRODUCTION

The environment controller is an application program designed to enable control of electronic appliances through a computer interfaced with an external device that uses forehead muscle movement. This project was primarily a research-oriented endeavor to demonstrate that such a system could be achieved. The Windows-executable program should be able to turn on lights, TV, radio or any other electronic device plugged into an AC outlet. The appliances would be triggered on or off with X10 transmitter and receiver modules. Upon completion of the project, a potential client will be trained to use the system, and ultimately control his or her home appliances via a headband attached to the computer.

SUMMARY OF IMPACT

The design criteria for the project to enable simple operation through an automated application interface. This was successfully achieved. The application interface directly scans the buttons that will be programmed to send X10 signals commands on form load. Thus the user will never have to navigate the interface, but simply lift his or hers eyebrow to send an ON/OFF command to a specific appliance.

TECHNICAL DESCRIPTION

The cyber-link mind-mouse is the first of its kind that uses forehead muscle movement along with brain states to send mouse commands to the computer. The cyber-link consists of a hardware device along with a headband with three sensory electrodes strapped to the forehead. The hardware device and software trainer program were designed, developed and produced by Dr. Andrew Junker of Brain Actuated technologies. The cyber-link server is a DOS program developed to train users and adjust personal settings.

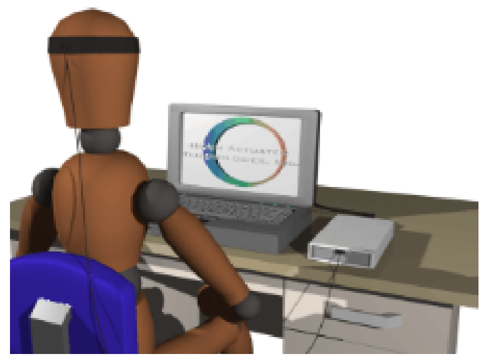

Figure 17.9. Environmental Controller.

The cyber-link has a C.A.T interface that is a windows .exe program programmed to control third-party applications. The cyber-link environmental controller (CEC) was therefore integrated with the cyber-server to control CEC through the headband sensors. The C.A.T was also implemented to start using a short-cut key (CLT-alt-z) to start it. The C.A.T was further automated to perform automatic scanning. A command button in the application section of the interface was programmed to issue a command to initiate the CEC. Automated scanning allows for hands-free control of appliances.

The total cost of the project was approximately $1000.

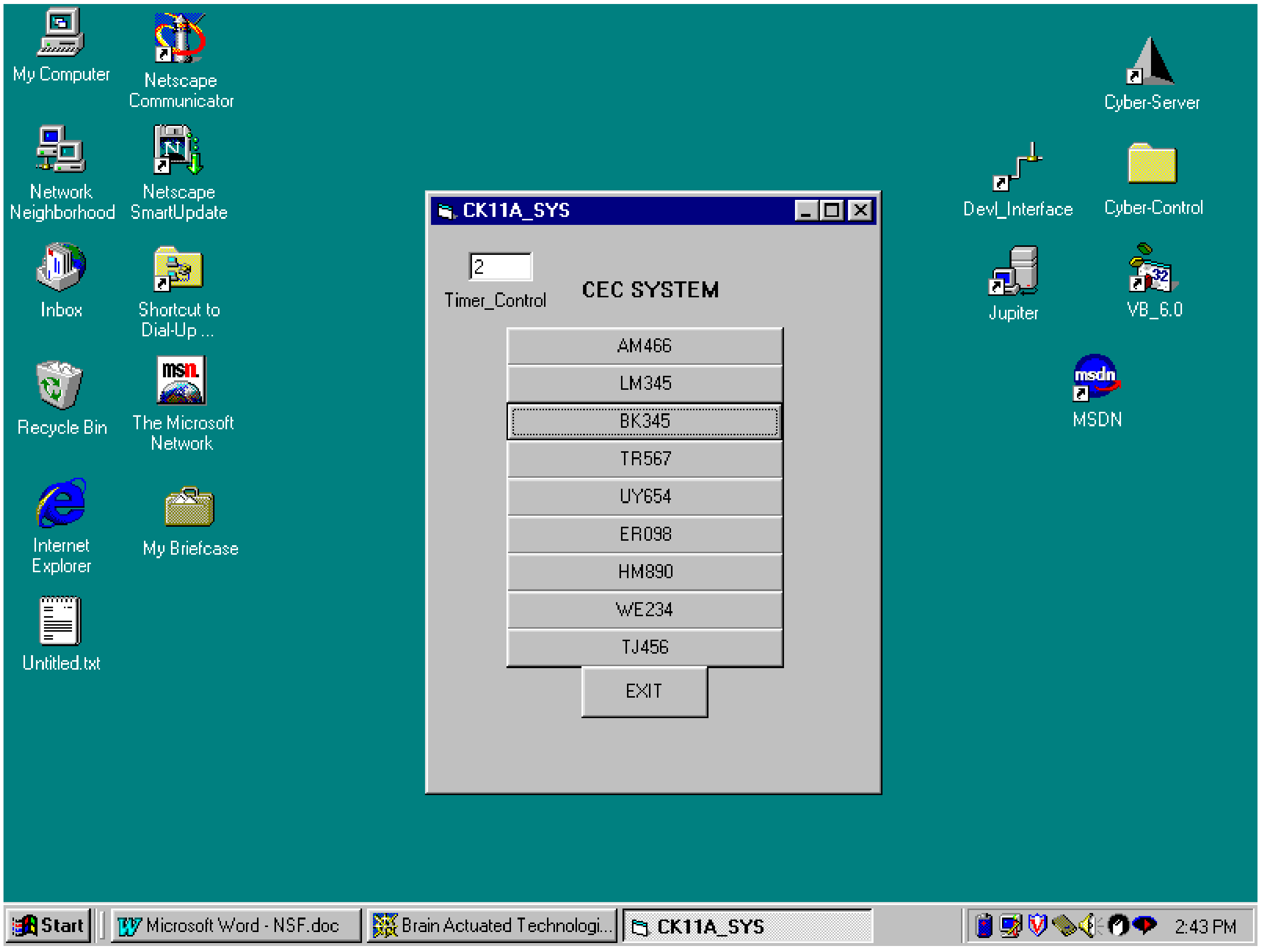

Figure 17.10. CEC Application Interface.

VOICE ACTIVATED ENVIRONMENTAL CONTROL SYSTEM

Designers: Chuong Tong and Thai Ly
Client Coordinator: Rod Dadcy
Supervising Professors: Prof. Clark
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University of Massachusetts Lowell
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INTRODUCTION

A Voice Activated Environmental Control System (ECS) was designed to be a small, sensitive, affordable, and easily operated by voice control. It is also designed to be universal, controlling most of the electronic systems in a house.

SUMMARY OF IMPACT

The device is used by a man with sever motor problems due to ALS. It enables him to control almost all of his household appliances. He can control lights and fans, dial and answer telephones, adjust the channel and volume of his TV, and control his cable box. The overall ECS system is shown in Figure 17.11.

TECHNICAL DESCRIPTION

The ECS involves both hardware and software. The software consists of a pull-down menu interface, with source code in Visual Basic programming language. The pull-down menu interface is required for monitoring the status of the house, such as what appliances are on or off. The menu interface can be accessed by voice or by mouse. For the purpose of this project, Realize Voice sound recognition software is used to control the menu interface. When the pull-down menu is active, the computer sends out an 8-bits signal through the parallel port to communicate with the hardware, the controller interface. The pull-down menu is shown in Figure 17.12.

The controller interface receives the 8-bits signal

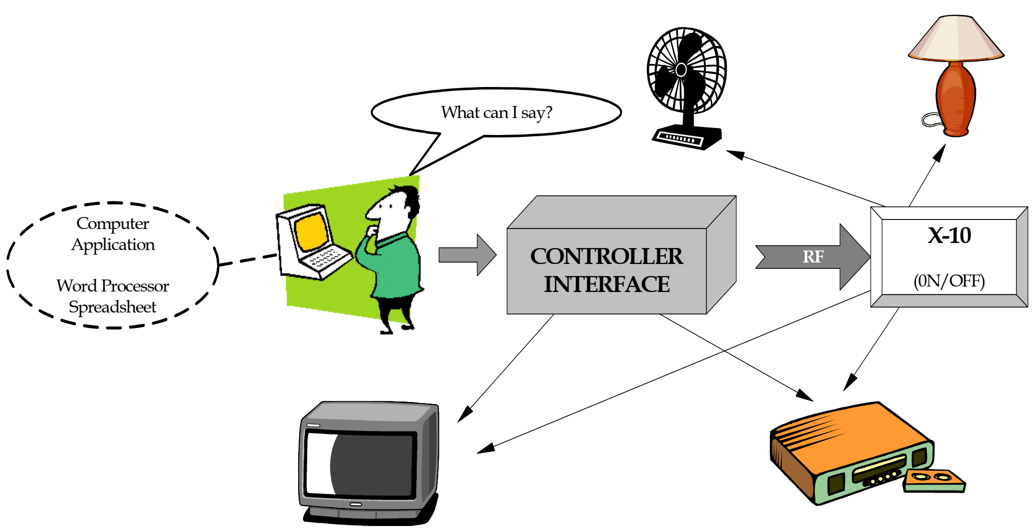

Figure 17.11. The basic overview ECS's system can control.

from the parallel port and the decoder (74154) decodes the signal to a 1-bit low signal. The output from the decoder is active low; therefore, the inverter (7404) is required. The 1-bit low signal is inverted to a 1-bits high signal, which triggers the corresponding relays. Each particular relay is connected to each control button of the X-10 transmitter or the universal remote control. The transmitter communicates with the receiver. The receiver then communicates with a particular X-10 module using radio frequency (RF). The module controls a particular appliance. By using the X-10, no hard-wire installation inside the house is necessary.

For example, when the relay triggers the button of the universal remote control, the remote control becomes active, and it will control either the TV the channel and volume or the cable box channel.

To ensure appropriate volume control two volume control knobs are used, one for up and the other for down. These two knobs are hardware-controlled, making it more convenient and easier to use for the user. Before the 8-bit signal is decoded, it must be sent through the power protection circuit, the opto-isolator (CNY 74-4), which protects the parallel port and the device from damage. For additional protection of the computer motherboard, the secondary parallel port I/O, assigned at a secondary address (&H278), is used. The complete controller interface and the X-10 receiver are shown in Figure 17.13.

Figure 17.12. ECS Pull-Down Menu.

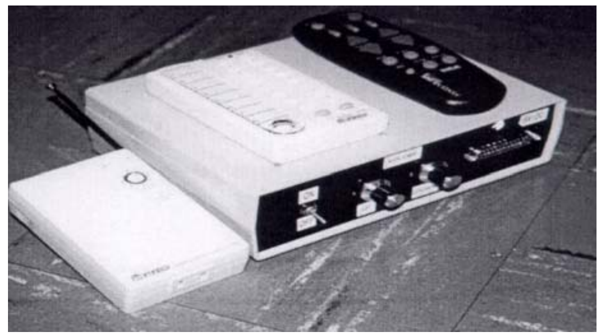

Figure 17.13. Complete Controller Interface and X-10 Receiver.

VOICE-ACTIVATED PHONE

Designer: Matthew Ciampaglia
Client: Chris Shanahan
Supervising Professors: Donn Clark and Alan Rux
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Lowell, MA

INTRODUCTION

A voice-activated phone was designed for an adult who has limited use of his arms and hands. Via voice commands, this phone can place and receive calls as well as navigate through voice mail systems. The device makes it possible for a person lacking manual dexterity to use a phone because button pushing is replaced by speaking.

SUMMARY OF IMPACT

The client has a clerical job in a university maintenance department. He uses a wheelchair and has limited use of his arms and hands. The Voice Activated Phone enables him to place and receive phone calls in a way that is easier for him. He now uses the voice-activated phone to dispatch work crews so they can attend to the university's maintenance needs.

TECHNICAL DESCRIPTION

The voice-activated phone consists of three separate entities: a voice recognition system, a telephone, and logic circuitry to connect them.

The heart of the voice-activated telephone is a HM2007 voice recognition kit, a hardware-based kit that can be trained to recognize and respond to spoken words. The kit uses an Application Specific Integrated Circuit (ASIC) that utilizes digital signal processing techniques to characterize and identify spoken words. These processed words are stored in a memory chip. The ASIC and the memory chip work in concert to compare spoken words with stored words. The ASIC uses the memory to implement a matching algorithm that determines whether or not the spoken word is the same as any of the stored words. Upon finding a match lack of a match the ASIC produces a response. It is this response that is monitored and used to dial a phone number.

Figure 17.14. Voice-Activated Phone.

The phone's user does not need to understand the ASIS or the kit's processing algorithms. All the user has to do is turn the device on and place the kit into training mode. Next, the user speaks a word into a microphone and assigns it a number. Then, when the kit is put into recognition mode, it will recognize a trained word when one is spoken into the microphone. It will then respond by displaying the number that the word was assigned in the training mode. It is this numerical output that passes through the logic circuitry and acts as a key press on the phone's keypad.

The second major component in design is the logic circuitry, which consists of a few commonly available integrated circuits and a Programmable Array Logic (PAL). The commonly available integrated circuits include decoders, buffers and opto-isolators. These parts are used to route the voice recognition kit's numerical output to the appropriate opto-isolator, which electrically performs a key press. The kit will not recognize a word if there is excessive background noise or if a word did not get properly trained. So that the phone will not respond to one of these errors, the PAL detects these errors and shuts off the logic system's output buffers before n erroneous signal can be sent to the phone.

Opto-isolators are used in the voice-activated phone's logic circuitry. Opto-isolators are a type of optical switch. When they are turned on, they connect two leads. Since opto-isolators can be used connect two leads the same way that pressing a button connects two leads, opto-isolators can be used to simulate the pressing of buttons on a phone keypads. To successfully simulate a button being pressed, the leads on the phone that are connected when a button is pressed were extended from the phone's internal circuitry and fed into the opto-isolators. When the opto-isolators are turned on, the leads are connected, simulating the press of a button.

The third major component of the voice-activated phone is the phone itself. The phone used is one of the standard-issue university phones, compatible with the university's existing telecommunication network. The phone has a keypad and a set of four memory buttons. All of these buttons were interfaced to the logic circuitry and could be activated using voice commands.

The cost of the material used to make this device was approximately $230. Much of the cost is due to the voice activation kit, which costs $140.

VOICE-CONTROLLED HOSPITAL BED

Designers: Thomas Kelly and Paul Moskal
Client: Samuel Afroh
Supervising Professors: Prof. Don Clark and Alan Rux
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Lowell, MA 01854

INTRODUCTION

Once a person with quadriplegia is positioned in his or her bed for the night, he or she must summon a caregiver if there is a need to adjust positioning. A semi-mobile universal voice recognition control for a common hospital bed was designed for use by people with physical disabilities. Most individuals with restricted motor skills can utilize this type of control.

Design requirements were that the device:

- Recognize commands from multiple people (due to the high turnover of patients in hospital) second,
- Not respond to random noise and conversations, and
- Have a transportable microphone and display (because certain patients have diseases that require them to sleep on a different side each night).

The designers are not aware of any other existing device that meets these requirements.

SUMMARY OF IMPACT

The voice control unit has been installed on the bed of a 45-year-old man with quadriplegia. Prior to the installation of this unit, he would repeatedly have to summon the caregiver during the night to reposition the bed for a more comfortable position. Since the installation of this system there have been no additional trips into the bedroom by the caregiver for the purpose of position adjustment. In addition to the decreased caregiver workload, the client has enjoyed the freedom of moving himself and becoming more independent. He has mentioned that sometimes, when bored, he will give commands to the bed to practice and entertainment.

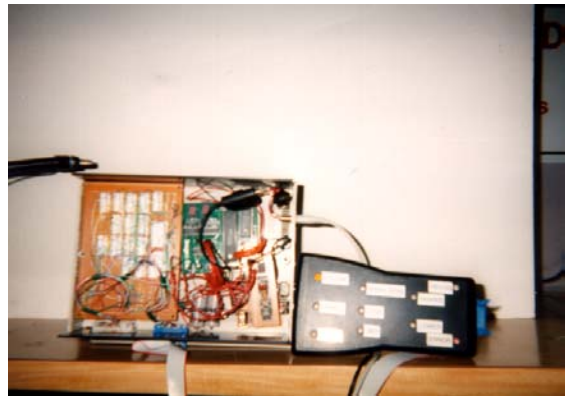

Figure 17.15. Voice-Controlled Hospital Bed

TECHNICAL DESCRIPTION

The device is made up of three components: the microphone, the electronic unit, and the status display.

The microphone is a noise-canceling unit, which was chosen due to the requirement that the unit not activate from random commands or background noise. The status display is provided to allow the user visual confirmation of the spoken command. It also aids in the learning phase required for the unit; all of the commands that are recognized by the circuit are labeled here, and the start to finish command sequence for a certain action is a natural progression from left to right. The display, as shown in Figure 17.5, provides 10 colored LEDs, which illuminate when a specific state has been activated.

The electronic unit, which is placed under the bed, is made up of five separate modules. The first of these modules is the power supply. The power supply is comprised of a 5v voltage regulator (7805) and a large capacitance (2mF), which is fed from a store-bought 6v DC power supply. The capacitance was required due to the inadequate ripple of the DC power supply. This ripple was approximately 1.5v and with a significant load, this circuit varies from

≈400 to 500 mA, the input voltage would drop below the threshold for the 5v regulator and the circuit would fail.

The second element of this device is an audio amplifier. This amplifier was required to allow the microphone to be placed a comfortable distance from the user's head so there would be no obstruction of view. This circuit, shown in Figure 17.6, was implemented using an Lm 358 op-amp. This circuit was chosen so that a 5v source could be used and the output would have a positive offset of 1.5v so the lower portion of the voice wave would not be truncated, which would effect the accuracy of voice recognition.

The next element, module three of the circuit, is the most important, and the component most of the design was framed around, the HM2007 voice recognition chip. The chip, along with its circuitry, can be programmed easily to a specific user. The unit stores a voice signal in memory with a BCD number location associated with it. When the circuit recognizes a command the BCD number of that command location is sent to a decoder. However, if there was an error in the recognition, one of three preprogrammed error codes is output to the decoder. This is the signal that is input into the next stage, the fourth of the design, the logic circuit.

The logic circuit decodes the HM2007 signal, which is taken care of by two 74154 decoder chips (one each for the most and least significant bits). It also controls the display via the corresponding gates, which enable various commands that are actually displayed on the status display. The logic circuit has been designed to act as a state machine made up of the most commonly used ICs and D-type flip-flops and is able to store the previous state or command if there is an error in the recognition circuitry in the middle of a command sequence. The logic circuit has a double activation command, which requires that there are two commands to be spoken in succession to activate the system. A typical activation scheme would be, "System", followed by, "Enable". This activation is implemented using two 74174D flip-flops in series with the clear of the first being activated by any command other than "Enable". This activation command sequence helps aid in the requirement of no random activation of the device. Finally, the logic circuit controls the six relays that enable the six movements possible with a hospital bed (i.e., shoulders up/down, legs up/down, and bed up/down). The control of the bed follows two-word activation followed by "Shoulders", "Higher", or "Stop". There is an option of saying, "Lower", so that the shoulders will lower; or the user may simply start another command sequence for a different section of the bed. When maneuvering the bed, the command "Deactivate" puts the unit in a rest mode until the activation sequence is recognized.

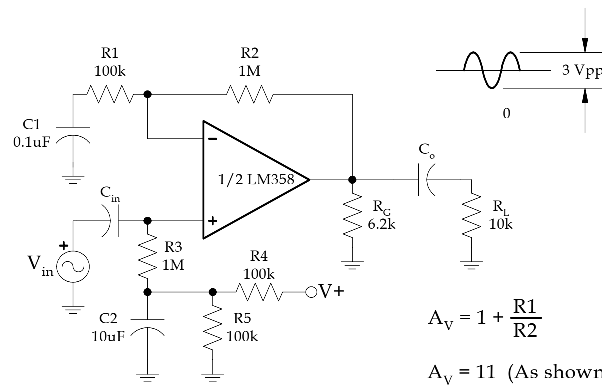

Figure 17.16. Microphone Amplifier Circuit

The voice recognition chip has proven to be only approximately 85% accurate. Therefore, it is important that the logic circuit be able to save states so as to not make the command sequence repetitive and troublesome.

The cost of this project was approximately $300. This price could be reduced considerably if multiple units were fabricated.

DIGITAL ODOMETER

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INTRODUCTION

This project involved producing a digital odometer for a man who is paralyzed from the neck down. He is vice president of residential operations for a paving company. In addition to estimating job cost, billing clients, and interacting with potential customers, he is in charge of measuring areas to be paved. The odometer enables the client to measure areas with minimal help. Using his tongue to close two switches, he starts, stops and saves measurements to be viewed later. The odometer keeps track of job numbers, measurement numbers within a job, as well as actual measurements.

Some design specifications have changed throughout the process of designing and testing the odometer. At the request of the client, some modifications had to be made, such as keeping track of measurement numbers within a job and adding warnings to alert the user of possible application errors.

SUMMARY OF IMPACT

Before this digital odometer was developed, the client was using a mechanical device to measure distance. Using this mechanical device required his nurse's constant help. The nurse had to reset the device after every measurement, record the measurement and later dictate all measurements to him so that he could record them on a spreadsheet program. The digital odometer eliminates the constant need for help. The nurse is only involved when the odometer is to be turned on or off, switched from measuring to viewing modes, and put in the clear mode. The cleint, using only the two switches that he controls with his tongue, does the rest of the work.

In addition to displaying measurements, the odometer's display shows error messages if there are any user errors. For easy viewing, the display is mounted about two feet from the client's eyes. The odometer also has a data saving feature that prevents data loss in case of electrical power loss.

TECHNICAL DESCRIPTION

The odometer design was divided into five subsystems, each with different functions:

- Data gathering,
- Data control,
- Data processing,
- Data display, and
- Power supply.

Data Gathering

This subsystem consists of a rotary encoder and a metal wheel. The basic operation of this sub-system is as follows. The small metal wheel is spun by one of the wheelchair wheels in gear-like fashion. The rotary encoder is fastened to the small wheel by its shaft and therefore is spun by the small metal wheel. As the encoder's shaft spins, it outputs an electrical signal proportional to its shaft rotational speed. This signal is made of electrical pulses emitted by the encoder as it turns. The number of pulses per revolution is 128. The surface of the metal wheel that makes contact with the wheelchair wheel is gnarled to avoid slipping between the two wheels.

Data Control

The data control system consists of three toggle switches and two touch (tongue) switches. The tongue switches are for the client's use, while the toggle switches and the power switch are for his nurse's use. A typical workday consists of eight jobs (eight areas to be measured). To measure distances, the nurse turns the 'gather' switch on and the client uses the two tongue switches to start and stop measurements, store measurements, and keep track of job numbers. To view measurements stored, the nurse puts the 'process' switch on and the client uses the tongue switches (as scroll up or down keys) to view measurements in memory. To clear memory, the nurse turns on the 'clear' switch and the client uses the tongue switches to clear all measurements.

Data Processing

The Micro-controller used for the odometer is a Motorola HC6811. The software program that controls odometer operations is written in assembly language. The program's S.19 file was burnt in an 8k EEPROM chip and installed on a Motorola Blue development board NMIX-0021. The program relies heavily on two hardware interrupts (tongue switches 1 and 2) and one software interrupt (pulse accumulator overflow). The program waits for the user to activate a tongue switch, determines which tongue switch was activated, investigates the status of the three solid toggle switches, and then decides what portions of the program to execute.

If tongue switch 1 closes and the 'gather' switch is on (and the other 2 toggle switches are off), the odometer starts measuring distance (if the Start/Stop Flag is clear) and the LCD displays the message 'measuring.' The odometer stops measuring distance if the Start/Stop Flag is set, and the LCD displays the measurement just taken. If tongue switch 1 closes and the 'Process' switch is on (and the other 2 toggle switches are off), the LCD shows the next measurement stored in memory. If Tongue switch 1 closes and the 'Clear' switch is on (and the other 2 toggle switches are off), the LCD sets a clear flag and waits for the user to close the clear switch.

For clarity, anytime the user closes switch #2, the LCD shows the message, 'Switch 2'. If tongue switch 2 closes and the 'Gather' switch is on (and the other 2 toggle switches are off), the odometer increments the job number (unless the current job is 12, in that case the next job number becomes 1). If tongue switch 2 closes and the 'Process' switch is on (and the other 2 toggle switches are off), the LCD shows the previous measurement stored in memory. If tongue switch 2 closes and the 'Clear' switch is on (and the other 2 switches are off), the odometer checks the status of the clear flag. If the flag is set, the odometer clears all memory and displays the following message on the LCD : 'Cleared'. The Odometer then clears the flag. If the flag is clear, the odometer does not clear memory; the LCD displays the following message: 'Not Clear'.

If either of the tongue switches is activated and more that one toggle switch are on, the LCD shows error messages. The error messages also show what switches are currently on.

Data Displaying

The data displaying system consists of an LCD that is located close to the client's eyes. The LCD and the micro-controller are interconnected using serial lines.

The LCD is backlit and the characters are clearly visible indoors and outdoors. The program sends appropriate data (ASCII characters and alpha numerics) to the LCD to display measurements and messages. This LCD needs only 3 wires to operate: 5V dc, Gnd and serial input. The LCD is enclosed in a solid plastic box and is light enough to be mounted using only Velcro.

Power Supply

Since a 12-volt dc source is available (two car batteries in parallel to operate the wheelchair's motor) and all the electronics used need 5 Volts DC, a (5 V - 1amp) DC voltage regulator was used. When the odometer is at full power, all the components draw about 180 mA. Therefore a 1A regulator is more than sufficient. There are, however, about 1.2 watts dissipated in the regulator, so a heat sink was attached to keep it cool.

Software Summary

The software program saves the stack pointer and associates the three interrupts with the appropriate interrupt vector locations.

The program checks to see if the odometer is being used for the first time. This is necessary because the 68HC1 EEPROM locations ($B600 to $B800) have $FF from the manufacturer. If it is the first time that the odometer is being used, all EEPROM is cleared ($00 is written to all EEPROM location). All Interrupts are enabled and all Variables are initialized. The program then investigates the last measurement stored in memory, reads the job number from that measurement, and increments it by one to set the next job number. If there are no measurements stored in memory, the next measurement will be measurement 1.

Subsequently, the program waits for interrupts. This is beneficial because the 'Wait' instruction puts the 68HC11 in power saving mode. Nothing else happens until a touch switch is closed. In other words, all other subroutines are called from the three interrupt service routines. As soon as a hardware interrupt occurs, the program does a software debounce by jumping to a 'delay' subroutine. The program then determines which switch was activated and what appropriate subroutines to execute.

Figure 17.17. Digital Odometer.