EZ Cookin'

A redesign of a microwave accessible to all

Abstract

The goal of this project is to design a microwave interface that will allow people of all abilities, even those with disabilities, to operate it with ease. There are currently very few microwaves of this nature on the market. To solve this problem, our group developed two design solutions: a cheaper base model and a mid-range model. Both of these designs incorporate the EZ Access feature. After developing the designs, a computer simulation of the base model was built in order to test the usability of the interface. A cost analysis study was run to make sure the cost of our designs compared favorably to the cost of similar designs already on the market. In the future, usability testing needs to be conducted on the simulation and prototypes need to be built.

Problem Statement

The goal of this project is to make modifications to the design of an existing microwave to make it so easy to use that individuals of all abilities can use the machine. Major brand name designs have few or no accessibility features for less-able individuals, making it difficult or impossible for these people to use a microwave without buying an expensive, custom microwave. The purpose is not to design a microwave specifically for disabled individuals, but rather a microwave that is so easy to use and competitively priced, everyone will want to own one.

Background

It is estimated by the United States (US) Census Bureau that 19.4% of the 252.1 million non-institutionalized US citizens are disabled in some way. Thus, there is a large market for specialized consumer products for these individuals. Smaller products manufacturers that build their own devices or modify existing products are attending to this market. Although these products exist, they are considerably more expensive than off-the-shelf consumer products and are usually only geared toward a specific disability,

i.e. blindness, deafness, etc. It is the team's goal to design a product, specifically a countertop microwave oven that will be comparable in price to off-the-shelf consumer goods, cater to all levels of ability in a single model without post-production modifications. Thus it would not appear to be made for all persons and not for persons with "disabilities." To accomplish this, one must first understand what the abilities of the projected consumers are, in order to make a design. Furthermore, a short background on the microwave oven should be explored.

The disabilities being considered will be broken up into four major categories. These categories include visual impairment, auditory impairment, cognitive impairments, and physical impairments and summarized in Figure 1. Of the total population, 5.16% has some sort of visual impairment, which includes total blindness, limited visual capability, and color blindness, the inability to distinguish between certain colors (2). 8.58 % of the US population suffers from an auditory or oratory disabilities such as total deafness, difficulty hearing in a normal conversation, and difficulty of others understanding what they are saying (1). People with cognitive disorders make up 28.1 % of the total population (3). The list of these disorders is extensive, ranging from mild retardation to total mental incompetence. Some of these disorders include Down's syndrome and Alzheimer's disease. 15 % of the population has a physical disability (3). Physical disabilities can be broken up into three subcategories. These categories are people limited in major physical activities (4.56 %), those limited in the kind or amount of physical activity (5.67 %), and those with physical limitations other than major limitations (4.72 %). A major physical activity is considered to be playing for ages 0-5 years of age, attending school for those ages 5-14, and work, housekeeping, bathing, eating, dressing, household chores, and daily errands for all other ages (3).

The first countertop microwave was introduced in 1967 at a retail price of $495. By 1986, 25 percent of U.S. households owned a microwave oven, up from less than one percent in 1971. Today it is estimated that microwave ovens are in more than 90 percent of U.S. households (4). Because microwave ovens are such a widely used appliance, designing one that is accessible to everyone would be valuable.

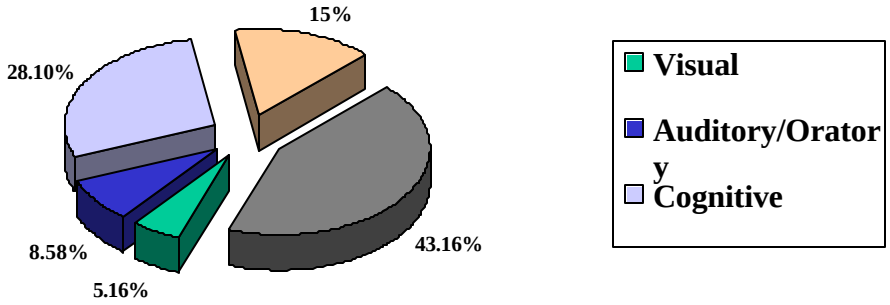

Figure 1. Disability By Type (3)

EZ Access

EZ Access is an interface enhancement developed by the Trace Research & Development Center that can be applied to almost any electronic device. The application of the EZ Access button to a device allows individuals who are unable to see, unable to read, or unable to hear well to use the device with minimal inconvenience.

EZ Access is designed with three layers of help features (10). The first layer helps the user identify a button. With the EZ button held down, this feature allows the user to press any other button and have the name of that button spoken aloud and displayed on the screen. An example in our microwave design would be the button for "Go". The first layer of help would say, "This is the 'Go' button." This occurs without the function of the button being activated. A second press of the button activates the second layer of help. This layer gives the user a brief description about the function of the button. For example, "Use this button when you want the microwave to cook for the time displayed. You can stop the microwave at any time by pressing 'Stop'." The third layer of help would give any special features of the button.

Another feature of EZ Access is the 3-Button-List feature (10). This allows the user to cycle through all the functions on the appliance using simple up and down arrows. When the user gets to the desired function, a single press of the EZ button will activate the function.

The final feature of EZ Access is called ShowSounds (10). When this feature is activated all sounds made by the device that are necessary for understanding what the device is doing will be shown on the display. This feature is useful for people who are hard of hearing and also for anyone using the device in a quiet environment such as a library.

Important Design Criteria

Designing a microwave that is accessible to everyone is not a simple task. There are many requirements and standards that must be met. Along with this, the production cost of the microwave must be competitive with current lower priced models. Some of the standards that must be met are governmental standards, such as the Americans with Disabilities Act (ADA), which protects the rights of individuals with disabilities to have access to public institutions. The ADA provides guidelines for appliance design in making them more usable for all (4). Other groups such as the Trace Center at the University of Wisconsin have taken these guidelines further and outlined design criteria for more accessible designs. One of their trademark ideas is the EZ Access concept, as discussed earlier in the report.

The design criteria were described in the PDS and then prioritized by features that would be desirable in the final design, which are attached in the Appendix. High priority features are features that must be included in the design. Many of the high priority features are simply a matter of appearance and are easy to implement. They include items such as large buttons, large font, logical layout, and no abbreviations. Other high priority features include EZ Access, LED cues that appear when functions are selected, and keeping the frequency of visual display flashing less than 2 Hz.

Medium priority features shall be included only if they do not exceed the cost limitations of the final product. Items that are medium priority include volume control, smoke detectors, buttons that light up when pressed, and Braille stickers to place over the control panel.

Low priority features will be included only if their cost adds little or nothing to the final cost of the microwave. These features could be added for convenience but their omission does not limit the range of users. Programmable cook keys, a quick reference card, and a headphone jack are all low priority features.

Solutions

Upon analysis of the design requirements, it was determined that only one major design would meet all of the high level design requirements and remain a low cost model. From this base model, features can be added to make it more attractive to buyers looking for a higher end microwave, called the mid-range model. The features of the base model are shown in Table 1.

Base model features
• Simplified control pad • Cooking function buttons that light up • Pre-programmed cooking buttons • EZ Access button • Rotating turntable that ensures food is cooked evenly

Table 1. Base Model Features

Figure 2. Base Model Control Panel

This design has a control panel that is as simplified as possible. Shown in Figure 2, the design concept is a top to bottom to control model. As the user enters commands, they will move from the top of the control panel to the bottom. Along the top of the control panel are the power level buttons. The user can select from three power levels:

Defrost, Medium Cook, and High Cook. When pressed, these buttons light up and stay lighted throughout the control cycle. On the right side of the top row of buttons is the Set Clock button. This button allows the user to set the time of the built-in clock in the microwave. Next, the user will enter a cook time on the numeric pad. Time can be entered in multiple ways. For example, to enter a time of ten minutes, the user could enter "1-0-0-0" or could also press "1-0-Minute." To cook, the user will press the green Go button. To cancel cooking, Cancel can be pressed to simply stop the cooking.

Other features that are included on the base model are the pre-programmed cooking buttons. If the user wants to simply cook a bag of popcorn, they can press the Popcorn button to automatically set the proper time and power level of the microwave. Pre-programmed cooking buttons will also be provided to cook beverages such as hot water or coffee with the Hot Beverage button and to cook frozen dinners with the Frozen Dinner button. Another added feature is the EZ Access button. When the user presses and holds the blue EZ button, the controls on the microwave will be audibly identified by a voice prompt to assist a user who is visually impaired instead of requiring the user to locate controls on the microwave by trial and error. The EZ Access feature can be extended to provide more help by pressing the button again to provide verbal information about the function of the control on the microwave. Like most comparable microwaves, the microwave will have an automatic turntable that will spin at approximately 5 rotations per minute to ensure that the food is cooked evenly.

Some purchasers may desire more than just basic features in their microwave. For those individuals, those more desirable features have been added to the basic design to create the mid-range model. The possible features include: programmable preset buttons that can be programmed by the user, a smoke detector built into the microwave to detect burning food and alert the user, a door opening mechanism powered by a solenoid to aid users who might have difficulty opening the push button door, and a LCD display that displays more information about the currently selected control and its function. These features are summarized in Table 2.

Figure 3. Mid range model control panel.

Mid-range model features
• Programmable preset cooking buttons • Built-in smoke detector • Solenoid-powered door • Larger LCD display

Table 2. Base Model Features

Simulation

The microwave interface computer simulation was created using Macromedia Director 8, which uses a high-level programming language called Lingo. This format was chosen because it allows users to run and interact with the simulation remotely over the Internet using Macromedia's Shockwave Player. This makes it easy to obtain feedback on the current design, so the testers can identify areas of improvement. The interface is intended to function exactly like an actual microwave user interface, allowing the user to enter cook levels, cooking times, and simulate all other features of the conceptualized microwave, including the EZ Access button.

The major difficulty of creating the simulation was learning to use Macromedia Director 8 and the Lingo programming language. Although the programmers were acquainted with other high-level, object-oriented programming languages, such as C++ and Java, Lingo functions in a significantly different way, requiring sufficient time and effort to fully understand how to implement it. Also, this simulation was not simple, and required much time creating graphics, functions, and the code to link them together. In spite of these difficulties, the simulation has been created and allows an accurate portrayal of the proposed design.

Cost Analysis

A cost analysis of various microwave oven features was performed. Industrial Engineering Professor Stephen M. Robinson, who teaches a course on engineering economic analysis, recommended the protocol for analysis. The additional costs of the number of pre-programmed cooking function buttons, a help screen and volume control were determined through a survey of 38 countertop microwave ovens currently on the market. The sample was comprised of 16 subcompact (with cooking power of 600-700 Watts) and 20 mid or full size (cooking power 700-1100 Watts) capacity microwaves. For each feature studied all other variables were held constant. Therefore, for analysis, microwaves were separated into two groups based on capacity and cook power; these groups were sub compact and mid-full size. The number of pre-programmed cook function buttons was analyzed for the change in cost between three groups: 1-4, 5-6 and 7-10 buttons. The average price increase for increasing the number of buttons from 1-4 to 5-6 was $6.65 and from 5-6 to 7-10 was $14.85. The additional cost for a help screen function was determined to be $5.50. For the volume control function the price increase was $7.15. None of the microwaves in this sample were equipped with a built-in smoke detector. Thus, the extra cost of this feature would not need to be added in order to make our EZ design competitive with the market, however this is a feature that should be looked into further.

The additional costs of features such as LEDs to light buttons for visual cues were found from various part suppliers. The average cost of the diodes is between $2.20 and $4.95.(7) The cost associated with the EZ access feature includes a simple push button

that should click or give some type of auditory feedback, a voice synthesizer or voice chip, and a licensing fee. The push button should not have significant cost associated with it.(8) A 20 second voice chip typically costs $6.99. Finally there is a 0.25% of the retail cost of the microwave per product license fee paid to WARF.(8) All of the costs outlined above should be taken into account in determining the final prototype features and retail price of the final product.

Potential Problems

A number of potential problems may arise in the implementation of our design. First, programmable buttons would require that the user be able to program the desired functions. If the user was cognitively disabled this would be difficult, even if instructions were provided. The program function would need to be very simple to use or a helper would have to do this for the user. Most likely a person with a cognitive disability would have someone to help him or her with this, but in designing this feature we should assume they do not. The LCD display is the biggest aid in helping the user use this feature. This type of display would guide the user through the process by displaying messages for what the user should do next.

There is also a potential problem with the application of the Braille stickers that could be placed over the buttons. When a blind person is attempting to apply these stickers, they are going to need a guide as to which button is which. In this case we are again assuming that they will have to do this task themselves. One way to address this problem is to provide a layout of the microwave interface with Braille labels on the proper buttons. With the aid of the textured buttons, the user should be able to find which sticker goes on which button through feel.

When it comes time to build a prototype, we will encounter problems because of our limited knowledge of microwave hardware and in programming microprocessors. Because of our lack of experience with microwave components we will need outside help to draw circuit diagrams that will represent a working microwave. Similarly, we have no experience programming microprocessors. Thus, we will need to learn another programming language. This takes much time and effort.

Cost Estimate:
As long as fabrication does not occur, the only costs incurred will be the cost of the IE 662 textbook (approximately $25). Development of the circuit diagram and computer simulation will not cost anything.

Conclusion

A possible ethical issues arises in deciding who to exclude in design tradeoffs. Inevitably these tradeoffs need to be made because our project is financially driven. Thus decisions need to be made about features that add too much to the cost and certain individuals will not be able to use our microwave. Another ethics problem that needs to be considered is confidentiality in testing. We will have to be very careful that our subjects' privacy is protected.

The next step in this project is to use the computer simulation to conduct usability testing. Because the simulation is designed to work exactly like the real microwave interface, a very accurate study can be conducted to determine our design's ease of use. Adaptations and modifications to the design may follow testing. Once the design has been testing, an accurate circuit diagram will need to be created detailing the electronics of the interface. With this diagram a working prototype can be made.

References

1) www.cdc.gov/nchs November 14, 2000
2) www.census.gov April 1995
3) www.dinf.org March 1997
4) http://www.gallawa.com/microtech/history.html 2000
5) Law, Chris and Vanderheiden, Gregg "The Development of a Simple, Low Cost Set of Universal Access Features for Electronic Devices"
6) Macromedia Director 8 Shockwave Studio Lingo Directory, Macromedia, Inc, Feb 2000.
7) http://trace.wisc.edu/docs/compliance_with_the_ada_for_itm/comply_comp1.html November 1996
8) http://www.radioshack.com/
9) Rosenzweig, Gary Using Macromedia Director 8, Macmillan Publishing, 2000

10) http://vs01.tvsecure.com/~vs0111a/drhvw.html

11) E-mail 4/30/01, Chris Law

for further information please consult the project binder

Appendix

Attached to this document is:

Prioritization of design features
PDS
Simulation Code

Prioritization of design features

High Priority Features

- Distinct auditory tones for different input control types: functions, numbers, and preprogrammed keys. May include auditory feedback of either tones or speech output for function keys, numbers, and alerts
- Incorporation of EZ Access features
- Wording on the control panel is simple and self-explanatory. No abbreviations are used.
- In case of conflicting commands, microwave defaults to most recent command.
- Auditory signals within the range or 500 and 2500 Hz so that they are easily heard
- LED cues appear when functions are selected and set, when the microwave is performing certain functions, and when cooking is finished
- Frequency of visual display flashing is about 1 Hz. This feature increases accessibility for individuals at risk for seizure disorders.
- Push button door requires minimal physical force to open.
- Door push button is large and located at oven lower right to provide a visual cue and to be easily reached and pushed.
- Oven door swings wide open. Oven opening is large
- Number pad is in standard “telephone style” layout
- Tactile location bump on number 5 of number pad

- Keys are grouped according to type and shape
- Keys are large
- Horizontal and vertical arrangement of keys corresponds to sequencing of keys when setting the microwave
- Lettering on control panel, displays, and in documentation is sans serif and highly contracted with background. Size, width, and spacing of lettering is chosen for maximum legibility

Medium Priority Features

- The microwave will accept cooking time, defrost time, and power level in various orders and default to first defrosting, then cooking at a given level
- "Minute" function button allows entry of a time in minutes with fewer selections. Conventional entry of time in minutes is also accepted.
- Oven will accept entry of cook time and "Start" with or without use of "Cook Time" function key.
- Volume control to change volume of tones
- Output speaker placed on the bottom of the microwave, near the front
- Turntable eliminates need to turn or stir food during cooking.
- Documentation contains a quick reference card with step-by-step directions for most common cooking tasks.
- Smoke detector monitors food in oven.
- Snap on cover facilitates access to oven light for changing the bulb.
- Keys have raised outlines
- Keys have central indents
- "Start" and "Stop" buttons are color coded
- Braille stickers that can be placed over the buttons on the control panel
- Buttons that light up when pressed

Low Priority Features

- Programmable cook keys for commonly prepared items. These keys provide a preset cook time and power level with only two input selections
- Programmable functions require several sequenced commands to reduce the possibility of accidental reprogramming.
- Re-positional plastic pocket keeps guides for microwave use readily available.
- Spiral bound manual lies flat when opened. Pages are non-glossy finish and heavy enough to be turned easily.
- Manual includes Table of Contents, Index, numbered pages, and indexing tabs
- Manual and quick reference card provide step by step instructions accompanied by illustrations
- Safety information is presented at the front of the manual
- Manual includes trouble-shooting information and directions for accession customer service and optional material
- Audiocassettes of the full manual and quick reference guide are available. A Braille diagram of the control panel is available.
- Border of oven opening is dark and provides contrast with light oven interior.
- A headphone jack in the front of the microwave