# 14

# *The Human Element*

## 14.1 THE USER INTERFACE

It is no use putting a heap of clever features into a device if the user is not comfortable with it. It is said that only a very few percent of videotape machines are ever programmed for automatic recording. So, why have the sales been so successful? Perhaps it is because a rental tape can be inserted into the slot and will start to play with no further instructions.

DVD players now perform the playing of rental videos—and they do not need to be rewound. It will be interesting to see how successful the hard-drive-based videorecorders will be in the long term. It will depend much on the simplicity of their programming.

### 14.1.1 What Do the Buttons Do?

Every one of the appliances that we take for granted was once a new product. There are museum-piece plaques that state; "This room is equipped with electric light." It must have been strange to look for the on/off control near the doorway, rather than a tap on the pipe of a gas lamp. But even today, all is not so simple. Which way do you move the switch to turn an electric light on?

An American will immediately say "up," but in Britain, Australia, and many other countries, the answer is "down."

*Essentials of Mechatronics*, by John Billingsley

It is obvious that each new product should try to build on the conventions that are already established in the mind of the user, but that does not always happen. Which way do you turn a faucet to increase the flow of water? Which way do you turn the knob of a radio to increase the volume?

"Which way" problems persist to this day. On a satellite or digital television receiver, it is not surprising that pressing the UP button on the remote will increase the channel number. But when the channel list is displayed on the screen, it is the DOWN button that increases the channel number because of our habit of writing larger numbers below smaller ones.

A succession of projects long ago on designing early digital controls for domestic cookers showed that the task of establishing the conventions was at least as challenging as writing the software. The operation had to be made totally intuitive. Nobody reads the manual in an appliance showroom, and that is where the purchasing decision is made.

The design task was actually even more complicated. The contract design work was being performed for the manufacturers of the electronic control box. They had to convince the cooker manufacturer that theirs was the controller to install in the new cooker range. The cooker manufacturer had to convince the stores to stock their brands of cooker and only then did the public get to see and try the new algorithms.

Let us start with the most fundamental function. How do you adjust the time? Even today the adjustment buttons of many clocks are designated "slow" and "fast." You hold the FAST button and watch the minutes and hours rip by. You release it some tens of minutes before the time you actually want. Then you press the SLOW button to let the minutes plod to the target.

But if impatience gets the better of you and the FAST button overshoots the target, you have to navigate another 24 h of adjustment.

So we designated the buttons "up" and "down." Clearly we needed to start the adjustment slowly and then speed up. But according to what algorithm? After numerous tests using the factory employees as guinea pigs, we settled on

(minute)—pause—(minute)(minute)(minute) until the hour is reached,
then (hour)—pause—(hour)(hour)(hour) . . .

Now we have to consider setting the cooking functions. Suppose that the current time is noon. You set the "ready time" for one o'clock. Then you enter "2 h" for the time that the meal should cook. When will the meal be ready? On some rival controllers, the answer would be "1:00 tomorrow." This was known as the "day factor error." Our simple remedy was patented and earned royalties and fees for infringement.

Increasing the "cook time" pushed the "ready time" correspondingly into the future, so that in the example above, a 2-h cooking time would give a 2 p.m. ready time. Selecting and advancing the "ready time" left the "cook time" unchanged, but wound up the "waiting time" before cooking would

start. Decreasing the "ready time" reduced the waiting time, but when this reached zero, any further reduction was blocked.

To set the "ready time" for 1 p.m. tomorrow, it was necessary to wind it forward by all 23 h, something hard to do by accident.

### 14.1.2 What Sort of Display?

Long ago, the seven-segment display looked fashionable, whether in shadowy LCD (liquid crystal display), red LED, or flashing vacuum fluorescent figures. Today a mobile telephone is not complete without a glowing display screen that can show a full-color photograph. As the prices converge, the simplicity of numeric displays will continue to lose its advantage.

A seven-segment display (actually eight, with the decimal point) is easy to drive from the simplest of microprocessors, especially those designed to give the appropriate output levels. In fact, only one digit is illuminated at any one time. One "digit driver" line selects the digit, either pulling low a set of cathodes of an LED display or pulling high the digit's anode if the display is vacuum fluorescent. Meanwhile eight segment drivers cause the appropriate segments to be illuminated.

The display is kept refreshed by a background routine that lights each digit in turn. From this the processor is diverted to attend to any input or control actions.

Any more sophisticated display is likely to have a controller dedicated to its needs. The system designer's task is then to send it the data to display in the appropriate form over the appropriate bus connection.

Another form of output might not seem to fit the term "display," but it is a valuable user interface. It is sound output. Computers use sound to interact in a way that is often much more effective than vision. There is the responsive "click" of an input key, through ring tones and the annoying "ping" that alerts you to an error, all the way to voiced instructions telling you to "Please hold, your call is valuable to us."

A display has three functions. The first is to "close the loop" between user and computer, so that the user is assured that the programmed function is exactly what is wanted, whether it is a dialed telephone number or a Sunday roast. The second is to convey information to the user, such as a caller's identity or the speed of a jogger. The third is to look attractive at the point of sale, something dear to the heart of the client.

### 14.1.3 What Sort of Input?

The concept of a keyboard is firmly embedded in the folklore of computing, whether the teletypes of the ancient machines or the two or three buttons on an everyday appliance. A very few devices, such as intelligent pacemakers, might be designed without user inputs but most have an interface of some sort or another.

Pushbuttons present no real problem except that of laying them out in a way that will make their purpose intuitively obvious to the user. Should they be placed on the appliance itself, or should they be located on a remote control "zapper"? How should they be labeled? The international market decrees that the user must be preeducated with a set of basic concepts. A solid square means "stop," a triangle means "play," and two lines mean "pause." But what do you do if your product is truly novel?

The display can come to the aid of keys by displaying a descriptive legend against them, as in a cashpoint machine. It can even display the legend inside an image of the keys, if they have been replaced by a touchscreen. Now the user can be led through a complicated menu—sometimes rather reluctantly—where the functions of the keys change with each press.

There are other forms of input besides keys. The most familiar device that can input a nonnumeric quantitative input is the computer mouse. Drag it across a screen icon, and you can set the playback volume or the screen contrast, with no thought of entering numbers. The mouse has some very special features.

On a PC, as the mouse is moved, the cursor moves with it. When the cursor is over the feature or value the user wants to select, tapping a key or a touchpad will execute the desired action. But there is no absolute relationship between the cursor and the location of the mouse on the surface of the desk, or of the finger "tickling" the touchpad that substitutes for the mouse on many laptops. They simply cause the cursor to move. It is the computer that tells the user what action will be performed if the selection is clicked, so that there can be no disagreement.

On the other hand, a graphics tablet reads coordinates from the pen that the user is holding and a calibration error can cause the wrong action to be performed.

Touchscreens are useful if they have big, chunky legends but have serious problem with fine detail. By definition, the user's finger is between the screen and the eye, so that even if a spot on the screen lights to show the measured location of the finger, it is likely to be hidden!

The joystick is another popular input, both for games and for the setup movement of numerically controlled machine tools. It has even appeared as a substitute for a mouse, in the form of a small blob in the middle of the keyboard of some laptop computers.

Sound should not be forgotten as an input medium. Phonebook enquiries now let a computer try to understand the speech of the user, although in many cases a human operator must be called to the rescue. With the price of memory and processor power becoming vanishingly small, voice will soon be an attractive option for many pocket gadgets.

Vision is also a star that is likely to rise. Already a picture of a keyboard can be projected onto a flat surface, where the view of the user's fingers tapping away is translated into keystrokes. Gestures can be recognized and who knows, voice input might soon be made more reliable by lip reading.

## 14.2 IF ALL ELSE FAILS, READ THE INSTRUCTIONS

My wife proudly unpacked her new digital camera. It had come with the special offer of a 256-Mbyte memory card. With the card installed, she switched it on and took her first photograph. Nothing happened, except that the word FORMAT appeared on the miniature monitor screen.

In the slim handbook, we found a statement that the memory must be formatted before use. For details, see the full manual on the enclosed CD. Eventually, long after the photographic subject had gone, the procedure for formatting the memory was found on page 107 of a 10-Mbyte PDF file.

### 14.2.1 Designing the Handbook

The handbook is no less a part of the user interface than any software routine, although if the interface has been designed professionally, it should never need to be consulted. Problems can arise from too much as too little information. The help files of a well-known operating system are a good case in point.

In the early days of computing, help files were written by the same enthusiasts who had written the software. They might have lacked subtlety and polish, but they answered the needs of the user to the best of the writer's abilities. Then as the industry formed into large corporations, it was clearly felt that the writing of help files was a waste of programmers' time. It was easy to imagine an army of stenographers filling in boxes of a "What can we find to tell them about this?" questionnaire with no real thought for the needs of the user.

There has to be a fine balance between telling the user how to go about changing a setting, why they should want to change it, and what sort of values they would want to change it to. The tip "By selecting COMPRESSION in the dialog box, the value can be changed" does nothing to help the blood pressure.

Nowadays the help system seems most concerned with setting up the playing of video clips, changing the screen saver or choosing a pleasant color scheme. There seems to be little concern with the "real nitty gritty." Relentlessly searching for a technical term will leave the user adrift in an ocean of Web files. Alternatively they have to resort to "developer network" help disks, consisting of two or more CDs crammed with so many tips and hints that to find anything is like looking for a needle in a haystack.

But think again, the user has changed. Who is buying the most computers? For every engineer trying to do something innovative, there are a hundred would-be authors of the great novel, accountants, secretaries, lawyers, and lonely hearts searching the Web. The geeks and nerds are a long way down the pecking order in the consideration of a company that has certainly been successful in making a dollar or two.

The danger with leaving the help file or handbook task to the engineer is that the vital step that will baffle the user is so instinctive to the engineer that it is just not considered. Imagine trying to open a door if you have never seen a doorknob. There is an old joke about a new lumberjack who has spent all day cutting down a single tree with a chainsaw. Then when the supervisor starts it for him, he asks, "What's that noise?"

Nothing can beat the close observation of new users who are handed the device and asked to put it to work. It is their first questions and their first reactions that count. If the product is well designed, they will become expert within minutes or mere seconds and will no longer be suitable guinea pigs for a second test.

## 14.3 IT JUST TAKES IMAGINATION

Hardly a day goes by without media tales of wonderful new devices. Refrigerators with plasma displays and barcode and tag scanners will order replacement food from the supermarket via the Internet. Electric blankets and air-conditioning can be turned on by telephone text messages. "Swallowable" robots take biopsy samples and transmit a video travelog of their journey through the gut.

Some bright ideas can be a huge success, while many others vanish without trace. To some extent marketing may be the reason, but eventually it all comes down to the human element. With the power of embedded computers, if you can imagine it, you can probably build it. But can you sell it?

There are evolutionary products where technology nudges along the answer to the user's need, step by step. "Personal music" once took the form of a "ghettoblaster" balanced bulkily on a shoulder. Then the "Walkman" brought relief to us all, reducing the blast of sound to a merely irritating "Tsk tikatika tsk tika tsk" from the headset of a neighbor in the subway. Tape was supplanted by the compact disk, which in its turn has fought a losing battle with semiconductor memory and MP3 data compression, in the form of the "iPod."

The incredible shrinking memory chip is taking over portable storage applications everywhere. In "thumb drives" it has made the floppy disk history and in the digital camera it has sent photographic film the way of the phonograph.

Sometimes a brand new "need" is discovered, such as the mobile telephone. Technology has lifted the capabilities and reduced the price to make it universally available, but huge money is being made from spinoff markets. However, did teenagers communicate before text messaging? How much is being spent on downloading ring tones and games? Yet other attempts at "technology push" such as Internet access from a mobile phone seem to have met with an uphill battle.

So, when you start to work on your "better mousetrap," perhaps with machine vision identification of the mouse, MEMS sensors and actuators to close the trap, plus a wireless message to a cellphone to tell you to collect the trophy, first consider the human aspects. How will you convince me that I should buy it? How will I learn to set it? Where in the handbook does it tell me what to use for bait?

### ... and finally

The last sentence had been typed, the last figure drawn, but the task was far from finished. The text has been subject to the scrupulous attentions of a meticulous copy editor and must be marked up for the final edit.

Squeezing the text onto a narrower printed page has meant that many lines of computer code have "word-wrapped". I hope that I have caught them all, but if your computer grumbles about code that you have typed in from the text, the fragments of "left over" lines caused by word-wrap may well be the problem. You should be able to download an undamaged version from the book's web page at http://www.EssMech.com.

If you find that any of the promised material is missing from the website, please drop me an email at john@essmech.com—put "Essentials of Mechatronics" in the subject line so that the spam filter does not trap it! I will make room on the website for interesting questions and suggestions, too.

I hope that this book has convinced you of one important fact. Mechatronics can be fun.