

**acuity** sharpness or keenness, especially when used to describe vision

to best access information in long-term memory. For example, by “priming” a subject with some fact that requires access to long term memory, the access time for closely related concepts can be improved. Finally, there are thousands of studies on the **acuity** of and variation in human sensory and motor capabilities. All of these studies have led to principles for:

- menu construction, related to the limits of short term memory;
- system design based on metaphors that activate areas of long term memory;
- the target size of buttons and icons, based on studies of motor skills;
- the use of visual and auditory cues, based on human sensory capabilities and limits.

Although these references are only the tip of a vast and growing field of research in human perception and use of data provided by computers, they represent the kinds of developments that are moving interactive system design from an art to an engineering science.

### Direct Manipulation Systems

**paradigm** an example, pattern, or way of thinking

As noted earlier, a direct manipulation system is one in which the user is able to select an object and then specify which actions are to be taken. This is in opposition to command line systems where the user would normally specify an action and then select an object upon which the action was to be performed. This fundamental **paradigm** shift caused a number of changes in how these systems were designed and implemented in code.

The basic programming paradigm had to change from the process-driven approach to an event-driven perspective. In earlier systems, the program’s main process would control what the user could do. Now, it was possible for the user to initiate a broad series of actions by selecting an “object”—a window, an icon, or a text box, for example. This required some method for collecting events and handling them. The X Window System on Unix was one of the early popular systems for doing this. Each graphical component of the interface was capable of producing one or more events. For example, a window might be opened or closed generating an event. Similarly, a button might be pressed, or the text in a text box might be changed. There are mouse events as well—such as when a mouse enters a window or moves over a button. These events are dispatched to a window manager. For Apple systems and all the Windows systems since Windows 95, this functionality is built into the operating system.

The programmer’s task is to display a coordinated set of components that can generate events. The programmer is also required to write code that will initiate some action when an event occurs. These code fragments are called event-handling functions. Once the programmer has defined the objects that might generate events and the code to respond to those events, the final programming task is to “register” the event handlers as having an interest in certain classes of events produced by certain objects. When those events occur, the window manager dispatches them to the appropriate event handler. In object-based and object-oriented programming environments, this task of handling events is made easier through object classes which associate default event-handling methods with specific classes of objects. For

example, the code for how the appearance of a button is changed when it is pressed may be provided as a default method of the button objects. Similarly, the class may provide default button release code. The programmer simply needs to add additional code that performs some application-specific action when the button is released.

## Visualization, Virtualization, and Agents/Embedded Systems

Throughout the 1980s and 1990s, there were numerous efforts to take advantage of the human ability to process information visually. At the simplest level, consider that a human looking at an image on a television screen has no problem in discerning a pattern that consists of millions of individual **pixels** per second, changing in both time and space. Or consider the example provided in Figure A. Ask yourself what pattern is represented by the following set of numbers: a set of X,Y pairs with the X value being the upper value in each column and the Y value being the lower value?

47	42	93	122	68	65	105	133	137
58	100	35	46	126	133	131	108	68

Even knowing they are pairs of X,Y coordinates, most people have trouble seeing a pattern in this numerical example. If however, these points are plotted, or visualized, a pattern emerges rather quickly as shown in Figure B. Visualization systems manipulate information at high levels of aggregation, making the information more accessible to users. The aggregates may be records, documents, or any other entity defined as an object. Working with large numbers of objects that have multiple attributes, we can map these attributes to the interface in such a way as to visualize the data or simulate some process. The visualization of abstract data to sensory interfaces is central to software including geographic information systems and **data mining** applications, among others.



In the 1990s, researchers began to experiment with extending interactive systems from symbolic interaction—icons, mice, and pointers—to virtual systems. In these systems, every effort was made to allow the user to explore a virtual world with little or no translation to symbolic form. Thus, with visualization techniques and new forms of input devices, such as data gloves, hand movements could be used to manipulate virtual objects represented graphically in a virtual world. This virtual environment was presented to the user via two display screens, each of which provided a slightly different perspective, giving the user a stereoscopic view of a virtual space that appeared to have depth. Work on virtual and artificial reality continues on a number of specialized fronts, including a field known as **telemedicine**.

**pixels** single picture elements on a video screen; the individual dots making up a picture on a video screen or digital image

Figure A.

**data mining** a technique of automatically obtaining information from databases that is normally hidden or not obvious

Figure B.

**telemedicine** the technology that permits remote diagnosis and treatment of patients by a medical practitioner; usually interactive bi-directional audio and video signals

**agents** systems (software programs and/or computing machines) that can act on behalf of another, or on behalf of a human

**embedded systems** another term for “embedded computers”; computers that do not have human user oriented input/output devices; they are directly contained within other machines

**pattern recognition** a process used by some artificial-intelligence systems to identify a variety of patterns, including visual patterns, information patterns buried in a noisy signal, and words patterns imbedded in text

**speech recognition** the science and engineering of decoding and interpreting audible speech, usually using a computer system

The next generation of interactive systems, represented by agents in embedded systems, will again change how humans and computers interact. Direct manipulation environments will still be around for many years to come. At the same time, we have begun to see both **agents** and **embedded systems** make their appearance. Embedded systems can be as simple as the analog sensor systems that open a department store door, or turn on lights when someone enters a room. At a more complex level, most cars being built today include air bag deployment systems and antilock brakes that operate invisibly by gathering data from the environment and inserting computer control between our actions and the environment. As air bag deployment systems become more complex, they react based not simply on acceleration data, but also based on the weight of the individuals occupying the seat and their relative position (leaning forward or back) on the seat.

As the information processing of sensory inputs becomes more complex, these embedded systems begin to act like agents. For example, programs that monitor typing activity and automatically correct spelling errors are beginning to mature. Although early versions frustrated sophisticated users, more advanced versions are demonstrating their ability to learn user preferences and new forms of errors to correct. The perceptive user will note that the most recent applications remember lots of things about user activity—which web sites they frequent, for example, or where they hold meetings and with whom they meet. In the next generation, programs will use these data stores to communicate on the user’s behalf with agents of other users.

In summary, new systems are emerging where the interface between the human and the computer system is becoming invisible. When the programs are very complex and act on behalf of the user, they are called “agents.” These agents make use of increasingly sophisticated methods of data acquisition. Agents are evolving from using stores of data acquired from user activity to acquiring real-time data based on new information including facial and gesture **pattern recognition** and **speech recognition**. Increasingly, these agents will perform tasks such as storing and retrieving files for the user and undertaking simple actions such as making or confirming appointments. The help feature in Microsoft’s *Office* software is an example of an active agent that observes user activity and offers help based on actions that suggest it may be needed, from formatting documents to correcting common spelling and grammatical errors. SEE ALSO GAME CONTROLLERS; GAMES; HYPERMEDIA AND MULTIMEDIA; MOUSE.

Michael B. Spring

### Bibliography

- Baecker, Ronald M., and William A. S. Buxton, eds. *Readings in Human-Computer Interaction: A Multidisciplinary Approach*. Los Altos, CA: Morgan-Kaufmann Publishers, 1987.
- Card, Stuart K., Thomas P. Moran, and Allen Newell. *The Psychology of Human-Computer Interaction*. Hillsdale, NJ: Lawrence Erlbaum Associates, 1983.
- Johnson, Jeff, et al. “The Xerox Star: A Retrospective.” *IEEE Computer* 22, no. 9 (1989): 11–30.
- Norman, Donald A. *The Psychology of Everyday Things*. New York: Basic Books, 1988. (Also published as *The Design of Everyday Things*, 1990.)
- Perlman, Gary, Georgia K. Green, and Michael S. Wogalter, eds. *Human Factors Perspectives on Human-Computer Interaction: Selections from Proceedings of Human Fac-*

*tors and Ergonomics Society Annual Meetings 1983-1994*. Santa Monica, CA: HFES, 1995.

Shneiderman, Ben. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 3rd ed. Reading, MA: Addison-Wesley Publishing, 1997.

Smith, David, et al. "Designing the Star User Interface." *Byte* April (1982): 242-283.

Weiser, Mark. "The Computer for the Twenty-First Century." *Scientific American* 256, no. 3 (1991): 94-104.

## Internet

The Internet is a computer network that was designed to interconnect other computer networks. Its origins lie in the ARPANET, an experimental network designed for the U.S. Department of Defense Advanced Research Projects Agency (ARPA) in 1969. The original ARPANET had some features that were unique in its day.

The first unique feature was that it supported peer to peer networking. In this system, each computer has the same rights and abilities as any other computer on the network. The commercial computer networks at that time were hierarchical, where some devices performed special control functions, and other devices had to wait for permission to transmit from the controller.

Another unique feature of ARPANET was that it was not designed with a particular application or set of applications in mind. The designers created a network whose uses were not fully specified. As a result, ARPANET was designed to be transparent to applications. This allowed new Internet applications to be developed by placing the necessary functions (usually computer software) in end user devices rather than in the network. Thus, new applications did not require changes to the network.

Yet another unique feature of ARPANET was that it allowed organizations to have operational control of their local networks while still allowing them to be interconnected. This made it possible for a computer at a Burger King restaurant to communicate with a computer at a McDonald's restaurant without forcing the management at either restaurant to give up local autonomy for the privilege of communicating with each other.

In the 1980s, ARPANET split into a military component and a civilian section. The civilian part became known as NSFnet, in acknowledgment of support from the National Science Foundation. Other developments in this decade included the development of **local area networks (LANs)**, which pushed peer to peer networking closer to many end users, and the microcomputer, or personal computer, which made it possible for many people to have dedicated computer access. NSFnet was limited by its charter to educational and not-for-profit organizations. Although commercial firms began to see the advantages of NSFnet, they were not able to participate fully in this new age of communications until NSFnet was **privatized** in 1993.

The Internet has grown in leaps and bounds since privatization, fueled by the emergence of a new application, the World Wide Web, and the resources of the private sector.

The Internet has become a change agent in many areas of the economy. Examples of this include retail sales, business to business transactions, tele-

### local area networks

**(LANs)** high-speed computer networks designed for users who are located near each other

**privatized** to convert a service traditionally offered by a government or public agency into a service provided by a private corporation or other private entity

### INTERNATIONAL INTERNET-FREE DAY

On Sunday, January 27, 2002, a British organization called for an International Internet-Free Day. As announced on the nonprofit DoBe.org web site, hosted by the Institute for Social Inventions in the United Kingdom, the event was held in an effort to motivate people to turn off their computers for a day, chat in person with family and friends, and go out and participate in activities such as listening to concerts and poetry readings, taking a walk, visiting a museum or art gallery, or just getting outdoors. Event organizers encouraged people to spend time participating in group activities to counter the social isolation they sometimes experience by communicating so often via the web.



The Internet allows easy access to a wealth of information from around the globe. In India, for example, Tibetan spiritual leader the Dalai Lama helped launch the web site of Kiran Bedi, the first woman to become part of the Indian Police Service.

phone and video carriage, and music distribution. In fact, few industries have not been touched in a significant way by the Internet. Many industries have reorganized themselves as a direct result of the economic changes brought about by Internet-based applications.

For the most part, computers on the Internet communicate via two communications protocols: the Transmission Control Protocol (TCP) and the Internet Protocol (IP). The role of finding a path through a complex network is left to IP. This is a “best effort” protocol, in that it does the best it can to deliver a packet to the desired destination, but makes no promises. Thus, if a portion of the network failed, IP would attempt to re-route around the failure if it could, but would not guarantee that all packets would survive intact. Many applications require stronger assurances than this, and that is the role of TCP. The TCP is a communications protocol that operates between two end devices, ensuring that the complete information that was transmitted arrives safely at the destination. If some of the information is lost by IP, TCP retransmits it until it is received correctly. Thus, the two protocols operate in tandem to provide a complete, reliable service to end users.

The Internet differs from telephone networks in that information is broken into packets, each of which is treated separately, much like a letter. The Internet allocates its resources to individual packets as needed. By contrast, the telephone network treats a telephone call as a stream of information,