User Interfaces

In computer science, we understand the *user interface* as the interactive input and output of a computer as it is perceived and operated on by users. *Multimedia user interfaces* are computer interfaces that communicate with users using multiple media, sometimes using multiple modes such as written text together with spoken language [May93a].

Multimedia would be without any value if applications did not use the various media at the user interface for input and output. Media determine not only *how* human-computer interaction occurs, but also *how well*. For example, to boot the first computers, the user had to enter a range of addresses through register switches and commands at a mainframe console. Punch cards were used for input and paper was the main form of output. *Text* was the only medium for interaction with terminals. Later, applications were controlled through text menus, which simplified user input. Nevertheless, the user had to adjust to the computer.

Graphical user interfaces – using the mouse as the main input device – have greatly simplified human-machine interaction. A large number of graphical commands are hidden to the users through the use of a *Window System* (e.g., *Presentation Manager*™, *GEM*, *NeWS*, *MS-Windows* or the *X Window System*™). There are also other software programs which achieve similar user interfaces as an X Window System. The computer has been adapted – at least in part – to the user.

Despite these advances, there are still many well known problems with current user interfaces. One problem is *computer interaction* which is still neither natural nor effective. Speaking is often more suitable for the situation than writing. Changes and commentaries can be made verbally, which is more effective (i.e., faster) than making changes and comments in electronic text. Reading and listening are not alternatives to each other; they complement one another (e.g., audio textbooks).

Another problem is the *specification of object movement.* A specification of movements using graphics or text is often much more difficult and complicated than using a motion video. For example, consider an electronic textbook about tennis. The individual movements and typical errors can be presented much more easily using motion video than graphics images, or even text alone.

The development goes toward more effective human-computer interfaces using new interactive devices, which is an area of research in the field of *virtual reality.* The goal is to provide interactive devices such as *data gloves and body suits* for input, and *holography, head-mounted displays and three-dimensional sound device* for output. These devices help to move objects in a 3D space.

14.1 General Design Issues

The main emphasis in the design of multimedia user interfaces is *multimedia presentation.* There are several issues which must be considered:

1. To determine the appropriate information content to be communicated.
2. To represent the essential characteristics of the information.
3. To represent the communicative intent.
4. To chose the proper media for information presentation.
5. To coordinate different media and assembling techniques within a presentation.
6. To provide interactive exploration of the information presented.

The objective of the multimedia presentation system should be the *appropriateness principle* [Nor91]: "The surface representation used by the artifact should allow the person to work with exactly the information acceptable to the task: neither more nor less."

14.1.1 Architectural Issues

An effective presentation design process should not only involve sequential flow of actions, but also parallel and interactive actions [SF91]. This means that there is a requirement for extensive feedback going on between the components making decisions about media and modalities. Additionally, the design includes a number of higher-level concerns, such as goals and focus of the dialogue, the user's context and current task, and media selection to represent this information in a way that corresponds to these concerns. A conceptual architecture with a knowledge base (lower part of the figure), used by an intelligent multimedia presentation system (upper part of the figure – both parts are separated by the black arrow), is shown in Figure 14.1 [RH93].

14.1.2 Information Characteristics for Presentation

A complete set of information characteristics makes knowledge definition and representation easier because it allows for appropriate mapping between information and presentation techniques. The information characteristics specify:

- *Types*

  Characterization schemes are based on *ordering information.* There are two types of ordered data: (1) *coordinates versus amount*, which signify points in time, space or other domains; or (2) *intervals versus ratio*, which suggests the types of comparisons meaningful among elements of coordinate and amount data types.

- *Relational Structures*

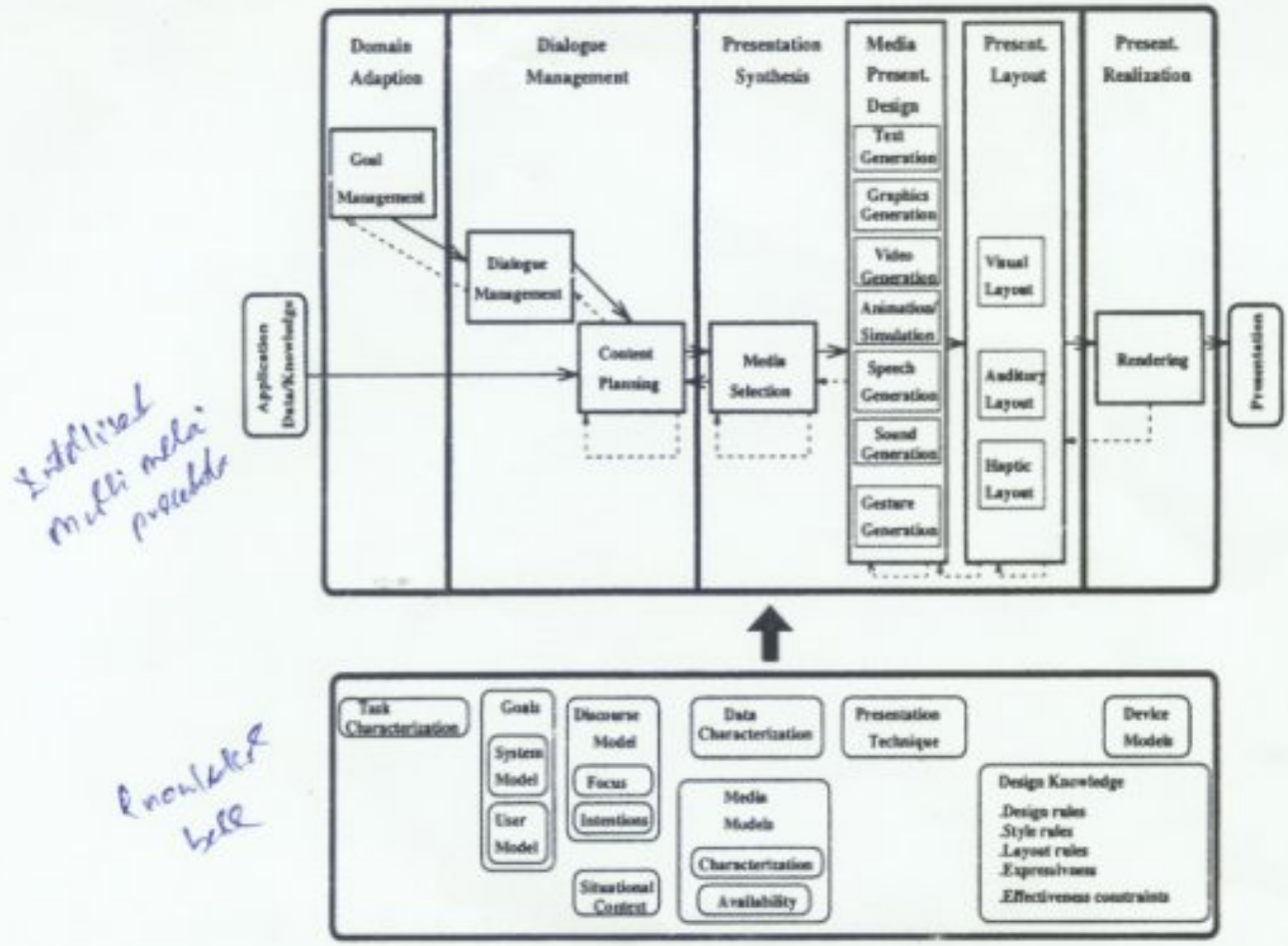

Figure 14.1: *Conceptual architecture of a multimedia presentation system [RH93].*

This group of characteristics refers to the way in which a relation maps among its domain sets (dependency). There are *functional dependencies* and *non-functional dependencies*. An example of a relational structure which expresses functional dependency is a *bar chart*. An example of a relational structure which expresses non-functional dependency is a student entry in a relational database.

- *Multi-domain Relations*

  Relations can be considered across multiple domains, such as: (1) *multiple attributes* of a single object set (e.g., positions, colors, shapes, and/or sizes of a set of objects in a chart); (2) *multiple object sets* (e.g., a cluster of text and graphical symbols on a map); and, (3) *multiple displays*.

- *Large Data Sets*

  Large data sets refer to numerous attributes of collections of heterogeneous objects (e.g., presentations of semantic networks, databases with numerous object types and attributes of technical documents for large systems, etc.).

14.1.3 Presentation Function

Presentation function is a program which displays an object (e.g., *printf* for display of a character). It is important to specify the *presentation function* independent from presentation form, style or the information it conveys. Several approaches consider the presentation function from different points of view. For example, one approach views the presentation function as a set of information-seeking goals [RM91], another approach considers it as a hierarchical representation of media-independent presentation goals derived from a plan-based theory of communication [May93b].

14.1.4 Presentation Design Knowledge

To design a presentation, issues like *content selection*, *media and presentation technique selection* and *presentation coordination* must be considered.

Content selection is the key to convey the information to the user. However, we are not free in the selection of the it because content can be influenced by constraints imposed by the size and complexity of the presentation, the quantity of information, limitations of the display hardware, and the need for presentation completeness and coherence.

Media selection determines partly the information characteristics described earlier. For *selecting presentation techniques*, rules can be used. For example, rules for selection methods, i.e., for supporting a user's ability to locate one of the facts in a presentation, may specify a preference for graphical techniques. Media must be chosen to be "adequate". For example, to present a course on how to play tennis, graphics and video are more suitable than text only. On the other hand, it may not be of great help to receive all electronic mail as audio data only because the receiver has very few opportunities to scan over the content; he/she must listen to most of

the received information.

Coordination can be viewed as a process of composition. Coordination needs mechanisms such as : (1) encoding techniques (e.g., among graphical attributes, sentence forms, audio attributes, or between media); (2) presentation objects that represent facts (e.g., coordination of the spatial and temporal arrangement of points in a chart); and, (3) multiple displays (e.g., windows). Coordination of multimedia employs a set of composition operators for merging, aligning and synthesizing different objects to construct displays that convey multiple attributes of one or more data sets. For example, the user interface shown in Figure 14.2 results from the composition of objects with attributes such as color, position, size and medium specification (text, graphics, image) (user interface taken from the NCSA Mosaic tool).

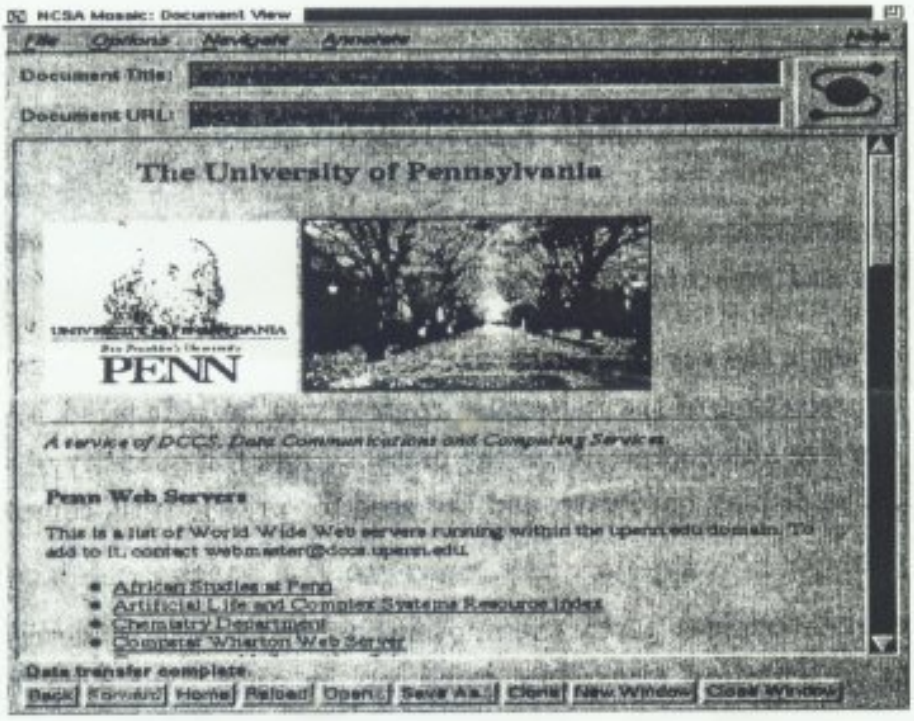

Figure 14.2: *User interface of University of Pennsylvania's Mosaic home page illustrating a result of coordination.*

14.1.5 Effective Human-Computer Interaction

One of the most important issues regarding multimedia interfaces is effective human-computer interaction of the interface, i.e., *user-friendliness.* We will discuss this property in detail in Section 14.6.

Here, we will just briefly enumerate the main issues the user interface designer should keep in mind: (1) *context*; (2) *linkage to the world* beyond the presentation display; (3) *evaluation of the interface* with respect to other human-computer interfaces; (4) *interactive capabilities*; and (5), *separability* of the user interface from the application.

14.2 Current Work

Although the topic of generating a user interface with several media is crucial for the success of multimedia systems and applications, there is still a lack of serious attention given to this issue. The current literature tends to be either very abstract or problem-specific.

A primary source of information is the *SIGCHI (ACM Special Interest Group for Computer-Human Interaction)* and the annual *Human Factors Society Conference.* A good overview for generating graphical interfaces is given in [FWC84], discussing matters such as classification of the interactions and classification of the actions performed. A joint work in the area of intelligent multimedia interfaces is presented in [May93a]. Issues discussed include presentation design, the communicative act of multi-sentential text in multimedia presentations and a presentation planner that composes different media together at the user interface.

Some authors worked on partial problems in user interfaces such as color mapping [Mur84], the size and position of windows among each other [Gai85, Gai86] and the use of icons in alternative window systems [Mye84]. Other authors consider input interface problems to provide the ability to interpret typed or spoken natural language utterances together with deictic mouse or data-glove gestures to resolve ambiguous references (e.g., "put that there") [NTDS89]. The most work to integrate