The Role of Graphics in User Interfaces

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During the 1980s Dr Ring was involved in the design and development of educational software and the teaching of courseware authoring and evaluation. During the 1990s he has been the driving force behind the establishment of a range of academic programmes in the field of Interactive Multimedia Technologies at Edith Cowan University. He is also involved in several research and development projects which are using leading edge interactive multimedia technologies that are aimed at the needs of industry as well as traditional education markets.

My 1986 Australian Educational Computing article entitled “Is a (computer) picture worth a thousand words?” examined the role of computer graphics in educational software. This 1996 article will discuss the role of graphics in graphical user interfaces (GUIs). The fact that digital data has no single physical form has led to the desire for the software component of user interfaces to be an illusion of substance and form (often referred to as the graphical user interface), allowing the user to treat elements on the computer screen as if they were real objects. The significant improvement in computing power over the last decade has resulted in the widespread adoption of graphical user interfaces by developers of operating systems and software products for desktop and laptop computers.

While the advent of interactive multimedia (IMM) products has provided richer forms of human-computer communication and interaction, many of these information and learning environments are quite complex with the result that many users are having difficulties handling the interfaces for these and other software products. This situation presents a challenge for interface designers as GUIs are typically more difficult to design and implement than more traditional interfaces and it is all too easy to come up with a poorly designed graphical interface which overloads users with information.

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My 1986 Australian Educational Computing article entitled “Is a (computer) picture worth a thousand words?” examined the role of computer graphics in educational software. In more recent times, Hix and Hartson (1993) have again answered the question in that title affirmatively:

Even in days of inflation, a picture is still worth a thousand words. The graph of a function is much easier to understand than its formula or a table of values; graphics help to turn data into meaningful information. Graphics promote the exploration and more importantly the understanding of complex domains. (p.85)

This 1996 article will discuss the role of graphics in graphical user interfaces (GUIs). The fact that digital data has no single physical form has led to the desire for the software component of user interfaces to be an illusion of substance and form (often referred to as the graphical user interface), allowing the user to treat elements on the computer screen as if they were real objects. The significant improvement in computing power over the last decade has resulted in the widespread adoption of graphical user interfaces by developers of operating systems and software products for desktop and laptop computers.

The conceptual basis for most GUIs was developed at Xerox’s Palo Alto Research Centre (PARC) in the 1970s. The major concepts which came out of the work at PARC, and which underpin the design of current GUIs, were: (1) the direct manipulation of graphics objects on the screen (with a mouse); and (2) the use of graphical metaphors of familiar real-world objects. PARC researchers attempted to build interfaces that addressed the three fundamental skills Bruner (1966) assumed humans use in understanding the world around them, viz: (1) enactive skills (manipulating objects, knowing where you are in space); (2) iconic skills (visually recognising, comparing, contrasting); and (3) symbolic skills (the ability to understand long sequences of abstract reasoning).

In addition to their use in representing two and three-dimensional objects and scenes, interface graphics are often used as a form of coding. Different forms of graphical coding are used to represent abstract processes, data and other invisible features of the interface. In some cases there is a more direct relationship between the graphics and the entities being represented such as when a rubbish bin is used for unwanted files, different image sizes are used to represent different
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The aspects that create the "look and feel" of graphical interfaces are the visual characteristics of interface elements and the images and interaction metaphors and themes used to convey meaning and function. Objects such as windows, icons, menus and buttons have become standard in today's user interfaces and they convey messages to the user about their functionality via their visual characteristics and their familiarity. In the words of Frederick Brooks, as quoted in Rheingold (1991),

"If mathematics is the Queen of the Sciences, Computer Graphics is the royal interpreter." (p.43)

Visual design skills are highly relevant to the process of interface design. They are required in routine tasks such as determining the appearance of generic objects like windows as well as more complex tasks such as an animated illustration in a simulated three-dimensional environment. Visual cues are particularly important in assisting users to understand the organisation of the interface, to show how information is related, to indicate the functionality of screen objects, to indicate what is possible in specific program modes and to clarify the navigation options available. Since reading is more demanding of human memory than perceiving, well-designed interfaces incorporate elements that give clues as to their use, usually by making them appear like objects in the real world. Graphic designers are key people in this task and they use a range of devices to aid user perception such as spatial depth, perspective, tonality, etc.

The graphic designer's role in the development of user interfaces is multifaceted: to support the product's metaphor visually; to develop a consistent overall look; to design a framework to maintain visual clarity; to specify a typographical style and format, including a standard writing style; to enhance the navigational schema visually; to design a visual map which displays the hierarchical organisation of information; and, to create the artwork required which illustrates the program's varied concepts.

file sizes, etc. Also, the display of quantative data via graphs continues to be used to facilitate the perception of aspects such as data trends and relationships. Graphical objects can be shared between the user and the system and the actions of both can have an effect on those objects.

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The application of principles of graphic design to user interfaces, both holistically and for each individual interface element, can enhance the potential of the interface to communicate information. If systematically applied, such principles can assist people to understand complex information. The communication of emotions also plays a part in interactions between a human and a computer via the user interface. Marcus (1990a) uses the term "visible language" when referring to all the graphical language techniques used to communicate the message or content and he considers it to include the following:

- layout: formats, proportions, and grids; 2D and 3D organisation
- typography: the selection of typefaces, fonts, type sizes and typesetting techniques
- colour, texture and light that convey complex information and pictorial reality
- imagery: signs, icons and symbols from the photographically real to the abstract
- animation: a dynamic display that is especially important for video-related imagery
- sequencing: the overall approach to visual storytelling
  - sound: abstract, vocal, concrete or musical sounds
  - visual identity: the additional, unique rules that lend overall consistency to an interface
  - animation: a dynamic display that is especially important for video-related imagery

Marcus points out that sound is included because it is becoming increasingly "part of the repertoire of the information designer of GUIs". The three principles espoused by Marcus are: (1) organise, by providing the user with a clear and consistent conceptual structure; (2) economise, by maximising the effectiveness of a minimal set of cues; and (3) communicate, by matching the presentation to the capabilities of the user. The first principle includes screen layout, relationships between interface elements and navigational schema. The second principle includes the notions of simplicity, clarity, distinctiveness and emphasis. The third principle includes legibility, foreground/background combinations, readability and spacing/typsetting.

Colour can also be a powerful graphics tool for communication if used correctly. Graphics designers need to be aware of several characteristics of colour that impinge upon the effectiveness of interface graphics such as colour consistency, simplicity, legibility, interactions and symbolism. Marcus (1990c) lists the following advantages for using colour to assist visual communication:
- emphasise important information
- identify sub-systems or structures
- portray natural objects in a realistic manner
- portray time and progress
- reduce errors of interpretation
- add coding dimensions
- increase comprehensibility
- increase believability and appeal
Message design, in the context of graphical interface design, refers to the use of patterns of media elements to modify the psychomotor, cognitive or affective behaviour of the user for the purpose of facilitating learning about, and efficient usage of, the user interface. Designers of messages are primarily concerned with how message form and structure influence the users’ information processing and perceptual organisation. Typical issues include the relative placement of objects on the screen and the way the eye travels over the screen in response to various techniques of visual composition.

Interface designers cannot be sure what a user will be looking at on a given screen at a given time, nor can they know how a message is being perceived. Fleming and Levie (1993) point out that this is why many messages are designed for "preattentive processing", an automatic neurophysiological process which operates on the retinal image and begins to organise it prior to the user consciously focusing attention on it. Designers should be aware of what these early perceptual processes are and of the factors which influence them. Messages are also designed for conscious "attentive processing" and an understanding of the principles that apply to this process, together with message design variables related to the perception of pictures, diagrams, charts, graphs, text, sound, animations and video, can be helpful in creating effective GUIs.

**User Interfaces for IMM Products**

The emerging area of IMM has raised new issues in interface design. IMM interfaces are often aesthetically pleasing and frequently offer the user sophisticated interactions along with easy-to-use cross-referencing and indexing. Another characteristic of many IMM products is the large amount of information accessible to the user. However, the advent of IMM has resulted in greater complexity of presentation and interaction methods, thereby increasing the number of interface decisions required of the user and the potential for user confusion. Also, IMM software typically uses a variety of media to engage the user with information via several sensory channels. The human brain has limited capabilities and can be easily overloaded with information. Hence it is important for interface designers to understand the memory and attention limitations of users and to know how to create meaningful and memorable mapping occurs naturally, is simple and easy to understand. Norman makes the point that highly intuitive mappings often involve a spatial relationship - a mapping between a user's mental model and some physical object or objects in the real world. Unfortunately, mappings with abstract IMM software environments are more complex and this is where the real challenge lies for interface designers. The presentation to the learner of a good conceptual model is central to this challenge. It allows the operations required of them to make sense, thus increasing the likelihood of the learner developing a functional mental model of the interface.

User disorientation is a significant problem needing to be addressed with IMM interfaces. This disorientation is felt by many users when interacting with IMM software products that employ a hypermedia-style design in which data is stored in networks of nodes connected by numerous semantic and structural links. User disorientation is often the price paid for the more complex navigational methods used by IMM products which use hypermedia approaches to the organisation of data. The use of visual cues in the interface to reveal complex organisational structure can assist in overcoming disorientation. Good interface designs make use of a variety of visual cues to enhance their interactivity as well as their appearance. Program structure and information organisation can be revealed with judicious use of design principles and rules.

**GUI Design Guidelines**

The GUI standards set by Apple and Microsoft represent two of the few sets of guidelines available to interface designers. Apple (1992) published interface design guidelines containing eleven principles for the graphical user
interface of the Macintosh operating system. They do not differ significantly from Microsoft’s (1993) guidelines for Windows and both contain relevant information for designers of user interfaces for IMM products. The first of Apple’s “principles”, metaphors, takes advantage of the learner’s existing knowledge of the world. With “command line” operating systems such as Microsoft’s MS-DOS, it was necessary for the learner to rely on either their memory or paper documentation to determine what options were available. Nowadays it is common, indeed expected, that a lot of information is available on the screen or accessible via a graphical interface such as those provided by the Macintosh and Windows operating systems. The memory requirements on the user are consequently less; users need merely look at the screen and access needed information via interface elements such as menus and icons. These visual aids make it much easier to recognize (rather than recall) what needs to be done. The interface designer’s goal is to come up with a conceptual model based on a familiar metaphor so that the learner can easily understand what is occurring or what is required.

As for Apple’s other ten interface design principles, direct manipulation refers to the immediate visibility of the effects of operations on objects; see-and-point refers to the sequence of selecting an object then choosing an action, consistency refers to the look and behaviour of screen elements; WYSIWYG (What You See Is What You Get) refers to printed images being identical to screen images as well as the idea of actions being immediately obvious on the screen, user control requires a balance between learner’s initiating actions and being guided and protected; feedback and dialogue refers to keeping the users informed as to what is happening; forgiveness refers to actions being reversible and warnings for actions that could result in data loss; perceived stability refers to the consistent placement and actions of interface elements such as icons and menus; aesthetic integrity refers to visual appeal and modelessness refers to the general principle of avoiding a multiplicity of user modes and where these are used, giving a clear visual indicator of the current mode.

A useful insight into the fundamental principles underlying GUI design is provided by Marcus (1992) who lists the following as “key components” of well designed interfaces:

- Easily grasped metaphor and idea or image that captures the essence of the system
- Appropriate organisation of data, functions, roles, and people in a task-oriented cognitive model
- Efficient navigation schema in the cognitive model, that is, the action relationships that enable reading and writing of these data, functions, tools, roles and people
- Quality appearance characteristics (the size, shape, colour, orientation, location, etc) of each visual element on the screen
- Effective interaction sequencing (the logical protocols for the visual elements) and their relationship to hardware input/output devices

Conclusion

Today’s multimedia environments offer a range of media elements for interface designers to employ: text; static graphics, such as illustrations, photographs diagrams, charts, maps, and icons; dynamic graphics (video and animations), such as simulations, cartoons, “walkthroughs” and virtual reality environments; and sounds, such as music, voice and concrete sounds. Within this broad range of media elements, graphics have the widest range of applications and play the most fundamental role in user interfaces. They are usually used to give the visual appearance of the interface a degree of coherence and are also used to support text and other media elements as part of the information presented.

The emergence of IMM software has made greater demands on interface designers. Gone are the days when most interfaces were based on a single screen with text and still graphics the only elements. Interactive multimedia products often demand a complex structure involving several key screens and other interactive modes such as sound and touch. The goal of an interface for an interactive software product is to focus and orchestrate the interaction with the user and to make visibly apparent the organisational structure of the product. Of all the media elements, graphics play the key role in enabling interface design teams to achieve this goal.

REFERENCES


