1 Introduction

What are Multimedia Systems?

Multimedia has become an extremely powerful selling point in today's home computer market. But what is "multimedia"? And is there more to this subject than the advertising hype would suggest?

A "multimedia computer" has come to mean a personal computer capable of displaying high-quality digital images, and playing digital sound and digital video with a satisfactory degree of realism. A suitable computer may have many potential uses, in education, business, industry, medicine and not least in entertainment.

In education, the ability of the multimedia computer to present information in a flexible and interesting manner has been exploited in developing materials for delivering the curriculum. The material is designed such that students are able to study independently, following their own interests (within the curriculum's constraints) and at their own pace. A major strength of providing computerised materials is that the expertise of the teacher is potentially available simultaneously to all of the students on an individual basis. This also has advantages in that the curriculum can be delivered automatically, leaving the teacher to concentrate on other time demanding tasks.

In business, multimedia applications have been used to visualise data and their inter-relationships. This has been of use in regulating the supply of goods and services, in visualising the structure of organisations, and so on.

An interesting example comes from the field of aircraft maintenance, where service manuals are available online to be browsed by the maintenance staff as they are working using a portable computer. Providing the information in a multimedia format is not novel, what is original in this application is that the computer is small enough to be worn on a belt-pack and the display is head mounted. The service engineer can then view the service manual as he or she is working on the aircraft.

Similar examples could be imagined in medicine, where a surgeon may choose to refer to online information during the course of an operation. Whilst this application could be imagined, it has not yet been implemented, for a range of practical and professional reasons. However, multimedia systems are finding applications in informing and training; informing the public of health issues and training doctors and surgeons. One of the more interesting examples is training surgeons in the use of keyhole surgery, once this was "on the job training", then simulators were used that mocked-up the abdomen, latterly the mechanical simulators have been replaced by software simulations in which the endoscope view is displayed and the manipulators are provided with tactile feedback.

The entertainment field provides the largest number and most familiar examples of multimedia systems. It is probably true that the home entertainment market has been one of the largest driving forces behind the development of affordable multimedia systems. This has occurred to such an extent that we now have many different types of peripheral device specifically for the home computer, for example, steering wheels and car-like pedals for interfacing to racing car simulators. It is also probably true that using the home computer for entertainment is its single largest use in some age groups.

The rapid development of the personal computer has facilitated these applications. Not many years ago, playing sound and video data would have required extremely expensive additional hardware since a standard desktop computer simply did not have the processing power to do these things. This hardware would have included additional storage, an additional graphics processor, a sound card and possibly a video decoder. Today, however, it is almost impossible to buy a desktop computer that is not capable of playing multimedia data. The typical home or workplace computer is now able to:

1. play sound with CD quality i.e. as good as is necessary for the sound to be of acceptable quality;
2. play video clips at broadcast quality without needing an additional video processor;
3. render graphical images with a high degree of realism within tolerable time spans;
4. render complex graphical scenes rapidly, giving the appearance of real-time motion through a virtual environment.

The ability to play multimedia data is a basic requirement for many of today's computer applications. The single characteristic of all of these multimedia applications is the integration and delivery of diverse data types. The application naturally uses the keyboard and mouse to receive information from the user, but is not restricted to using text to convey information to the user, rather the text is augmented by images, videos and sound clips.

But if our understanding of multimedia is restricted to the rendering of data on a desktop computer, we will have a very poor appreciation of the depth and breadth of this subject. In addition, multimedia should be understood to include the development of hardware and software that creates, manipulates or transmits more than one data type. The topic will include the multimedia we have experienced at home, but will also include human–computer interaction, manipulation of data types other than simple text and the vast range of applications that can make use of these technologies.

Some of these applications have already become available. They are still characterised by their delivery of multimedia, but most also include some data capture. For example, videoconferencing used to require dedicated communication channels and studio facilities, but with the advent of cheap digital cameras, the desktop computer can become a videoconferencing studio. The conferencing application still does very little in the way of sophisticated processing, it limits itself to capturing sound and image data, encoding, transmitting, receiving, decoding and displaying it. Whilst this is a significant improvement for communication between distant parties, it is still a conceptually simple application that has much scope for improvement. Similarly, applications exist that can capture and encode video data, in real time, and broadcast it over wide area networks, major terrestrial television news channels offer this service.

One of the more significant multimedia achievements has been speech understanding. Results of the first investigations into the problem were reported in the 1970s. Shortly afterwards the American DARPA (Defence Advanced Research Project Agency) announced a 5 year initiative whose goal was to deliver software systems capable of comprehending the natural speech of any individuals. It is a testimony to the complexity of the problem, that at the end of the 5 year programme, despite the involvement of major research institutions, the problem remained unsolved. The more advanced systems that were developed were only capable of decoding isolated words. It was only some 15 years later that IBM and others began to market what were essentially computerised dictation machines, but are able to decode continuously spoken words.

Other methods of human computer interaction have been suggested, some are being actively researched, others remain ideas for future work. Much current research is directed towards finding ways of emulating human communication. For example, if the problem of understanding speech can be solved, it must also be possible to discover how to lipread, to understand gestures or sign language. The response of *HAL*, the computer in *2001: A Space Odyssey* may not be far off, when it was asked "how did you know we were talking?" *HAL* replied, "I saw your lips move, Dave".

So far in this introduction, multimedia systems have been presented as those systems that deliver multimedia data, or enable multimedia communication between the computer and a human operator. A recent IEEE

report suggested that the subject should include these topics, plus the enabling technologies. Specifically, multimedia systems could encompass:

- Multimedia processing of text, speech, music, images, graphics, and video.
- Interaction among multimedia representations of signals.
- Compression, manipulation, and interactive access of multimedia signals.
- Human-computer interfaces, intelligent agents.
- Human and machine perception: audio, visual, and multi-modality.
- Applications: distant learning, tele-medicine, home-shopping, virtual reality, games.
- Databases: video-on-demand, digital library, multimedia servers.
- Multimedia communication: transport, synchronisation, protocols.
- Network issues: wireless, ATM, packet audio-visual services.
- VLSI implementation: architectures, audio/video codecs, low-power circuits.
- Standards: DAVIC, Java, MHEG, JPEG, MPEG, VRML.
- Emerging technologies: Internet, WWW, hypertext, and hypermedia.

The traditional view of multimedia introduced above, encompasses only a very small portion of the whole subject. In turn, the subject covers a wider range of topics than will be addressed in this book. Briefly, the book will discuss how multimedia delivery systems are designed and assembled, and how new approaches to multimedia interactivity are bearing fruit.

Multimedia Delivery Systems

A multimedia delivery system can be considered as any computer system designed to play multimedia data files, be they sounds, images, graphics, video clips or simple text. The system will also allow its user to navigate a path through the data. Such a system is typical of the "traditional" (if such a new phenomenon can have traditions!) examples of multimedia such as the programmes used for home entertainment, and the widespread educational software. The world wide web could also be considered as a multimedia delivery system.

A multimedia delivery system will have three fundamental components: the hardware hosting the system, the software delivering the content and the content itself. An appreciation of all components and their mutual relationships is necessary for the design of effective multimedia.

The data being presented by the multimedia system will include some or all of the different types of multimedia. The implementer of a multimedia system should be aware of the human perception of these elements in order to be assured of the quality of the data being presented. For example, it is useful to know the rate above which individual frames of an image sequence blur into continuous motion.

Developing multimedia titles is seldom the work of one person alone, software engineers and graphic designers will all be involved. Nevertheless, the design and implementation process will pass through well defined stages, and certain well documented models can be used in the design. These models will be examined.

It was stated above, that it would be difficult to purchase a home or workplace computer that was not suitable for use as a multimedia computer. Five years ago this was not the case. The designer of multimedia delivery systems must be aware of the hardware that is used in today's home computers, what alternatives are available and where those alternatives would be best used.

Multimedia Interactivity

Interactive multimedia systems are those that allow two way communication between the computer and its operator. In some cases the computer may not be recognisable as a computer. Some examples will amplify this concept.

Microsoft's EasyLiving project aims to develop ubiquitous computer interfaces that can be used in the home or workplace without the user having to sit in front of a workstation. Instead, the user is free to walk around the living space, the computer tracks the user via video cameras installed to monitor the entire space. Having located the user in some room, the system activates microphones, a keyboard and screen in that room, the user may talk to the computer or use the keyboard in that room.

Siemens have developed a GestureComputer and suggested a number of potential applications. The system tracked the users' hands and head and interpreted their motions appropriately. These two examples are simply alternative implementations of the computer keyboard and were intended to improve productivity by easing the communication bottleneck.

MIT developed a substantial application, the SmartRoom, to demonstrate the results of a number of research projects. Among the technologies involved was a module to track people in the room, to interpret their gestures and to provide feedback as appropriate to the task being performed.

A final, slightly trivial example was developed by Mitsubishi. They cited a survey that claimed that the two electronic innovations that most improved American's standard of living were the microwave oven and the television remote control. Mitsubishi set out to improve the remote control. They suggested using a multimedia system to monitor the viewer and interpret suitable hand gestures as control signals for the remote control.

These example systems are still largely in the research stage. However, they do serve to illustrate the fact that multimedia systems provide a richer set of communication channels between the user and the system.

The overall aim of these is to ease the problem of communication with a computer: using a keyboard is an acquired skill, whereas talking or making gestures is, for most people, an everyday occurrence.

What Topics does the Book Cover?

This book does not set out to cover all of the topics listed by the IEEE report quoted above. Instead, it presents the foundations of multimedia delivery systems and an overview of current research into multimedia interactivity.

The following three chapters cover the requirements and implementations of data coding algorithms for sound, images and video data; the methods of assembling multimedia presentations and the hardware platforms required of multimedia systems. These chapters do not set out to teach how to design and build multimedia programmes, rather the intention is to give an overview of the requirements of these systems and directions as to how to assemble the components.

The remaining chapters of the book present an overview of current research in multimedia human-computer interaction: speech understanding, gaze following, gesture recognition and motion following.

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