Workstations in Computer Animation

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Abstract

The purpose of this paper is to review the role of the computer graphics workstation in the field of computer animation. To achieve this, the paper initially overviews the development of the graphics workstation. Reference is then made to two application areas where this type of equipment has already been utilised for animation of complex systems.

In order to illustrate some of the hardware and software techniques involved in this environment; a case study of a short film sequence produced on a network of workstations is used.

Finally the paper takes a look at the future, with reference to direct video interfacing, distributed processing and the ways in which changing computer and display hardware may affect the use of the workstation in the application area of computer animation.

Introduction

Before the application of the computer graphics workstation to the field of animation is considered, it is necessary to define exactly what is meant by 'computer graphics workstation'. In its broadest sense the term covers virtually every computer based system which is capable of driving a graphics application, and it is certainly true that all devices in this category can be used to aid in the production of animated sequences. For the purposes of this discussion however the 'computer graphics workstation ' will be defined as a system in which the main processor, display subsystem and mass storage subsystem are integrated into what is essentially a single user system. The other criterion that will be applied is the screen resolution of the display subsystem. This should not be less than 1024x800 pixels. Another factor that should be considered is the processing power of the system. The generally accepted minimum for modern workstations is of the order of 2 MIPs with a maximum currently at about 8 MIPs. This is of course a fairly arbitrary rating considering the speed with which the technology is changing but is adequate for the purposes of this discussion.

It will be seen from the above definition that the PC and its clones are essentially excluded from the definition of a computer graphics workstation. This is not intended in any way to decry the uses that are being made of PC based systems in the generation of computer assisted images, or the use that this type of equipment is being put to as an interface for producing animated sequences. It was, however, felt that the use of PCs in this area is somewhat different to the use in which the more powerful stand alone workstation may be applied. It is not part of the object of this paper to discuss the pros and cons of the PC as a graphics workstation.

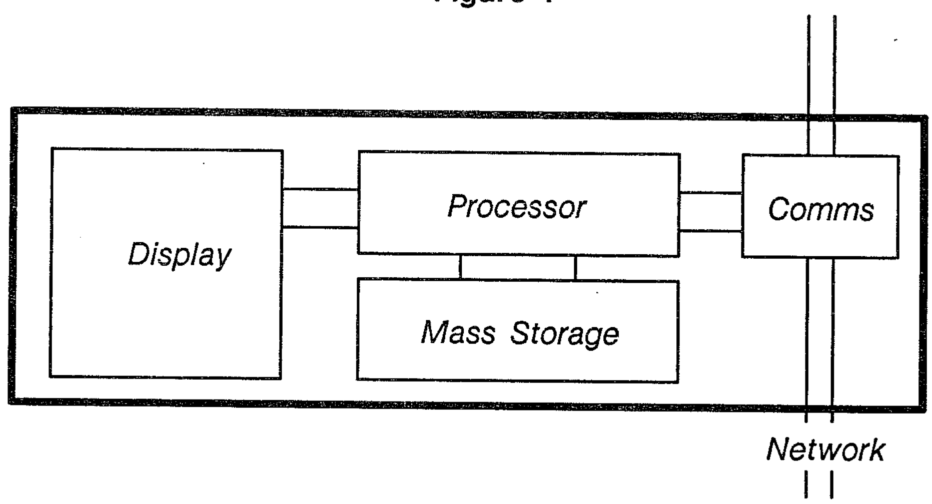
Development of the Workstation

The computer graphics workstation as broadly defined above has been developed largely over the last six years; although the Tektronix 4051 desktop computer fulfilled many of the basic criteria as long ago as 1975. Admittedly the technology of that period did not allow the processing power and mass storage capabilities that we now associate with the workstation; although the use of the Direct View Storage Tube permitted high quality graphics to be produced with what was then the best available microprocessor generally available.

The 4051 and its successors were used to produce animation sequences in the mid 1970's by photographing single frames on the screen. Control of the camera could be done by the 4051 through its IEEE interface and several programs were developed to take advantage of these capabilities. The sequences produced were monochrome, but as the systems developed the 4050 family of computers became front ends for more sophisticated colour oriented devices. Their use was mainly to generate the basic vector information; this was then transferred to a device which could produce the filled and coloured image necessary for such applications as TV titling and audio visual presentations.

The boom in microprocessor technology that happened in the late 1970s and early eighties, coupled with the increasing need for personal computing power for the technical professional, produced what is now seen as the computer graphics workstation. This device incorporates a high quality display, a fast and powerful microprocessor, several megabytes of memory and usually some form of mass storage device such as a winchester disk. These items taken together with a high speed communications interface make up the typical workstation as used by many Computer Aided Design applications(fig 1).

Figure 1



Typical Workstation Components

As the workstation has matured over the last five years, it has gained in power and capability. Specialised display processors and high resolution colour displays have combined to produce systems that are capable of generating photographics quality images. These display subsystems, backed up by microprocessors capable of up to 4 MIPs performance are approaching the boundaries of real time 3D solid graphics on a stand alone machine.

Although these workstations are capable of producing high quality images with excellent visual rendering, or able to generate moving 3D solids; they still fall short of combining all the computational and imaging power required to give a full animation in real time. For wire-frame pictures realistic animation can now be achieved, but for a fully rendered and animated image the background computation and foreground visualisation still need to be shared.

The development of the workstation in a fully networked environment has enabled the processing requirements to be shared around the network. This allows those systems which may specialise in the graphics rendering to concentrate on this aspect, while other devices handle the processor intensive calculations necessary for smooth movement and realism.

This does not mean that workstations cannot be used to generate sophisticated animated sequences; and an increasing number of users are now applying the commercially available workstation to the fields of title sequences and image generation. Simulation sequences which may not necessarily need to be in real time pose fewer problems; and these too are being produced on off the shelf devices.

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Animation applications

Another controversial area is of course the classification of animation. To the graphics artist animation is often a realistically moving three dimensional object, preferably with an equally realistic background. The discussion of realism and visualisation in computer animation is one that this paper intends to avoid. For the purposes of this discussion; animation is considered to span the field from simple wire frame simulation (e.g. robot arms) to the artistic image generation that is seen in some of the TV titles and commercials currently on show.

Application areas for animation where the workstation is now being actively used now include robot simulation where frame rates of up to 16 per second are now being achieved. This software is primarily wire frame but can allow full visualisation of single frames. Similarily, where wire frame is acceptable, some military simulations are in use: there is, however, little information available on these.

In the areas of solid modelling, some animation of the model is now feasible. This is mainly in terms of simple translation, to allow the designer to move around a shaded and lit object. This allows viewing from all angles and can be done currently in real time by using specialised hardware to handle the necessary rendering once the model has been produced.

Various imaging packages exist to allow realistic static views to be generated on a single workstation but the addition of movement to these is still largely a matter of recomputation for the next view and photography of single images in the classic cartoon film technique. Even so the new generation of workstations has brought down the time needed to produce the artwork by an order of magnitude.

The main restriction of the workstation is still the quantity of computation required to produce the number of frames needed for an animated sequence. This is particularily true where high levels of realism are expected, and also where complex physical interactions are being modelledinvolving techniques such as ray tracing, texturing etc. One approach to this problem is to utilise the networking abilities of the modern workstation to share the processing around multiple cpus. Another method would be to interface to a specialised processor server such as a parallel processing cpu to handle to computation and use the graphics capabilities of the workstations to produce the images locally. The first of these techniques is the one used to produce the case study sequence.

If we consider a typical network of workstations with perhaps one hundred nodes connected; the theoretical processing power available is equal to 100 times the power of each node. This means that if we assume 1 MIP per node there is a possible processing power of 100 MIPs. The problem is actually harnessing this capability. This is one area we shall consider in the next section.

The other method in which workstations may usefully be applied for animation work is when their high quality graphics capabilities may be harnessed to a super computing engine such as a CRAY. In this case, the majority of computational work may be done on the super computer, and the rendering of the complex three dimensional graphics may be performed on the workstation. The workstation may also be used for the video interface to conventional video tape systems.

Case study

The example that this paper considers is a problem in the modelling of interactions in a polymer system. The proposed solution to this particular case utilises both of the approaches outlined above.

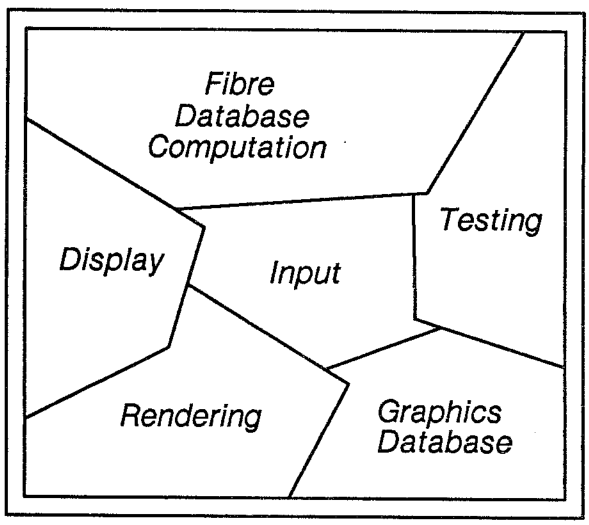
The problem itself is one of some mathematical complexity in that it is computing the interactions between fibres in a fluid medium. A three–dimension volume is defined and the movements of a given number of cylindrical fibres within this space are computed. To allow for a full visualisation of the interactions between the fibres requires that their positions are computed and displayed at millisecond intervals.

Previously, the problem has been solved for each timeslice and plotted out onto paper or transparent media. The computation is done on a traditional supercomputer. A display solution had previously been tried, but the limitations of communication lines and the quantity of data required to display each timeslice prohibited any major animation.

The proposed solution interfaces a high powered 3D graphics workstation to the existing supercomputer using an Ethernet link, and sending the necessary information to the workstation to allow each new timeslice to be rendered very quickly.

If we consider this application, it can be seen that the total process can be broken down into identifiable parts (Fig 2).

Figure 2



Parts of the Application

By applying the concept of Network Computing to this, the application can be split to allow the multiple tasks to be performed simultaneously on several processors, each of which may be specialised for a particular task. (Fig 3).

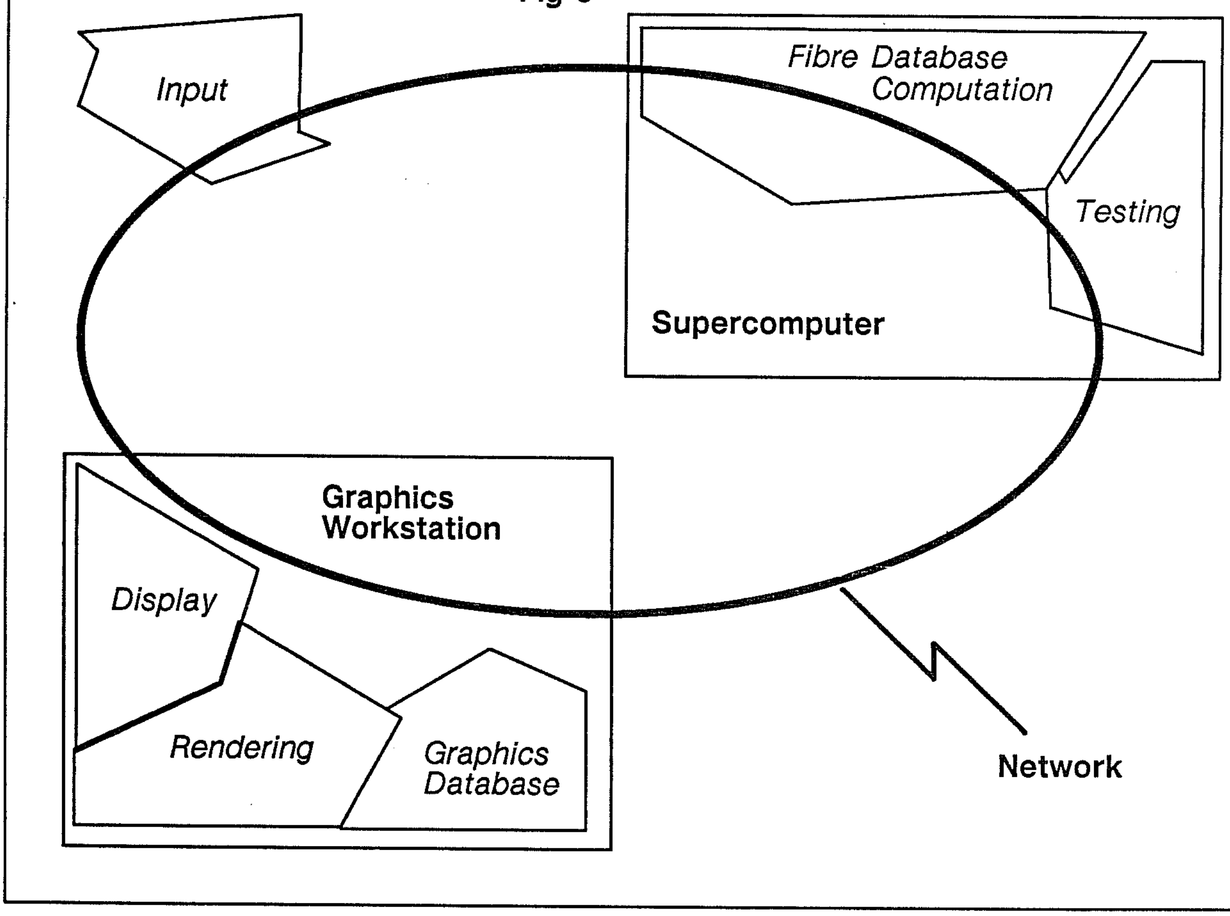
The application has essentially now been divided into two parts. The first part is the main algorithm for the modelling; this is computationally intensive and resides on the supercomputer. The second part is the visualisation software and graphics database; this resides on the workstation and takes advantage of the 3D capabilities that already exist.

The main database for visualising the fibres only needs to be transmitted once, thereafter the only data that is exchanged consists of a fibre id and change in position information. Since the main graphics is already on the workstation, new visualisations may be completed very quickly.

The current graphics software solution which is under evaluation for this visualisation has the additional advantage in that once the graphics database is generated, local viewing and manipulation may be done without reference to the main fibre database on the supercomputer.

The logical extension to this post processing capability is to add a pre–processing system which would allow data input and verification on a separate, low cost workstation also residing on the network. This would further reduce usage of the specialised resource of the supercomputer for what is essentially a trivial task.

Fig 3



Other facilities may be added into the network at later dates as technological advances are made. One such facility would be that of video interfacing. Ethernet video systems are now becoming available, but one interim solution would be a workstation based video interface such as that used at the University of Trondheim. This system allows for single frame recording onto conventional video tape systems for true animation sequences to be viewed in real time.

The splitting of applications such as this to allow maximising the use of available facilities is currently aided by the tools contained within the Network Computing System; but is still essentially a job for a specialised programmer. As the system develops, more automated tools will emerge to allow the normal applications programmer to take advantage of the this type of software solution.

Futures

Several developments are in progress to allow animation to become a much more usable application in a workstation environment. These are both in the area of hardware and software. At the hardware end of the system faster processors, specialised 3D hardware, new display technology and direct video interfacing are all in preparation. Where software is concerned, not only are better algorithms being developed to handle the rendering and manipulation of the image; but software to allow intelligent sharing of resources is under development.

The current graphics system that is being used for the above application will be superceded early in 1989 to allow much faster and more sophisticated rendering of the fibre interaction model. This workstation will also allow many more frames to be stored to allow real time playback of sequences on screen, independent of the necessity for transfer to video tape for short sequences. For long sequences; and ease of viewing; transfer to video is, of course, still important.

The improvements in workstation hardware and experience of local area networks can now be harnessed to allow true distributed processing on an integrated network of systems. By virtue of the differing abilities of a range of workstations, a network can utilise its resources to optimise any application. This optimisation is particularily true of animation where large databases, 3D graphics computation, imaging and interactive input all play an important part.

Network Computing Architecture is evolving from current workstation architecture to allow computing over an entire network from a single workstation. That workstation should have a standard user interface and window system so that the technical professional who is not highly computer literate may easily use the system. The X-window standard, for example, since it is based on a client/server relationship; allows for remote running of jobs and may well be a starting point for systems of this type.

Other developments that will largely influence the use of the workstation in this field include the ease with which the finished visualisations may be transferred to film or video tape. A new generation of video related devices is starting to emerge based on standard bus structures, and these should fulfill some of the need in this area. The use of optical discs should also have some effect at this end of the marketplace; both for recording and storing pictures and also for merging existing images with computer generated graphics.

Conclusion

In conclusion it seems reasonable to say that the workstation has now reached the level of power and maturity where it can be a useful tool for the production of animation sequences. Although a single stand alone system is still somewhat limited for complex animation, the top end systems are useable and a network of modern computer graphics workstations is powerful enough to produce high quality animation in a commercially cost effective way. Future developments will improve the situation and new ideas on the use of distributed networks should open up this capability to the industrial user.

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