

A Survey of Simulator Requirements

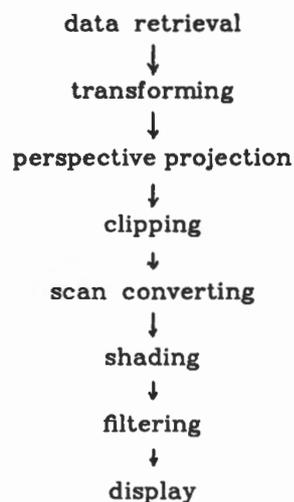
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INTRODUCTION

Simulators have been developed to train pilots, sailors or car drivers without the costs and risks of moving their real vehicles. To obtain high success in training, the simulators have to provide a high level of realism. The requirements of simulators and their CIG-system, especially the 'real time' requirement, result from this need for realism. 'Real time' means, the system has to react in less than 150 ms after the trainee has made an input.

On principle modern CIG-systems show the same structure as usual graphics systems:



This structure is reflected by the internal structure of the CIG system (Fig. 1). There exist some subsystems arranged in pipeline, doing the above mentioned task.

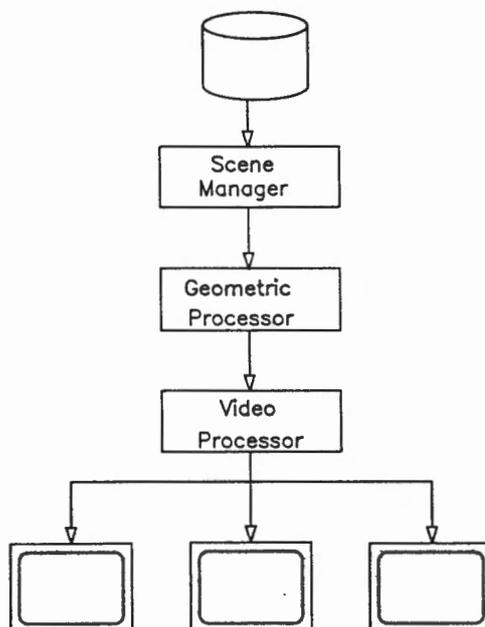


Figure 1: CIG system pipeline

SCENE MANAGER

The objects displayed by an CIG system are usually modelled with planar polygons. Some systems use quadric surfaces to define curved objects, but planar polygons are the main modelling primitives in today's systems. To render a fairly realistic scene more than thousand polygons have to be processed by the CIG pipeline. To increase the level of realism but not the number of primitives, textures generated synthetically or by digitizing a photograph can be mapped onto the primitives. Texture mapping is performed in such a way that each point of a primitive is always mapped into the same 2-D coordinate of the texture pattern. So the texture appears to the viewer in correct perspective as he moves around the object. To avoid aliasing effects in the texture, the pattern is stored in a pre-filtered manner.

The object description is stored in the data-base. The scene manager, the first processor in the pipeline, retrieves the required set of primitives from the data-base to produce the actual frame. Therefore it has to test whether a primitive is potentially visible in the actual field of view and has to provide the appropriate level of detail. 'Level of detail' means: every object is modelled several times by arbitrary number of primitives. The actual level is controlled by viewer's distance to the object.

In most high performance CIG systems the scene manager sorts the potentially visible primitives in an appropriate order to aid the hidden surface removal procedure.

Additionally the scene manager is responsible for the processing load of the pipeline. It avoids overloading the system, resulting in catastrophic losses of the imagery, by gradually reducing the amount of details and objects less relevant for the actual training phase.

The needed performance of the scene manager varies from 1 MIPS for applications with slower changes of the scenes to 40 MIPS for sophisticated, i.e. military and/or flight applications. These requirements are met by minicomputers or advanced microcomputer systems or by microprogrammable off-the-shelf multiprocessor systems respectively.

GEOMETRIC PROCESSOR

The geometric processor computes the 3-D transformations and the perspective projection of potentially visible primitives. It clips the primitives at the boundaries of the actual field of view and further on it computes the colour gradients of polygons needed in the smooth shading procedure.

The processing requirement of geometric processors in modern CIG systems is on the order of 60 MIPS. This requirement can be met by microprogrammable off-the-shelf array processors or custom-designed microprogrammable multiprocessors.

VIDEO PROCESSOR

The video processor scan-converts the projected primitives into the frame-buffer. It computes the colour value for each pixel taking into account hidden surface removal, smooth shading, translucency and special effects as fog, reflection, refraction and anti-aliasing. Translucency may not be considered as a special effect because it is not only needed for simulating translucent objects like glass windows, but also for gradually level-of-detail switching:

Each object is modelled at several levels of detail. The appropriate level is controlled by viewer's distance. The abruptly coming into view of objects, the popping, and the abruptly changing of the level of detail has to be avoided. This can be done by the following procedure: An object chosen for coming into view is initially fully translucent. The closer the object comes to the observer the more the translucency is decreased until the object is fully opaque. If this level has to be detached by an other level of detail, the actual level is slowly faded out and the new level faded in by reducing respective increasing the translucency.

The processing performance required for the video processor is 10000 MIPS. This performance is only reached by special purpose hardwired multi-processors.

DISPLAY SYSTEM

The display system of a CIG system consists of several colour monitors. The frames the monitors have to display consist of 1000 scan-lines with 1000 pixels each. The colour of each pixel is determined by 24 bit data. The monitor up-date-rate is 20 until 30 Hz in interlaced mode, that means every 15 until 25 msec the CIG system has to provide a new half of a frame.

A typical flight simulator system consists of three monitors (one front window, two side windows) and covers a field of view of about 120 degrees horizontal and 40 degrees vertical. This results in an angular resolution of 4.8 arc minutes per line pair. Necessary for military and desirable for other purposes is an angular resolution of 1 arc minute, the limit of human visual acuity.

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