Position Paper : Ubiquitous Computational Steering

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1 Introduction.

Consumers can already buy 3D graphics accelerators for their home computers, and Intel estimates that by the year 2000 80 % of all PCs will have 3D graphics. A key question is: the PC is ubiquitous, 3D graphics is about to become ubiquitous, can scientific visualization be made ubiquitous too ?

Computational steering is a form of scientific visualization in which end users are continuously provided with visual feedback about the state of a simulation, and can change parameters of the simulation on the fly. The benefit of computational steering is that insight to the simulation is enhanced; end-users can easily navigate through parameter spaces, and test various cause/effect scenarios, etc. Will computational steering ever become ubiquitous ?

Current Practice Well known examples of computational steering have been successfully demonstrated in the areas of atmospheric sciences, molecular modeling, computational fluid dynamics, computer aided design and engineering. These examples bring together various aspects of high performance computing, data management and interactive 3D computer graphics.

Analysing these examples, the following observations can be made:

- *high end technology.* The technology used is based on a small cluster of high performance compute/data servers linked with high speed networks to high-end UNIX graphics workstations.

- *user constituency.* Users are scientists or engineers who are specialists in the field they are studying. In addition, the number of users during a session is usually limited to one or a small group of specialists.

- *development environment.* The available tools are quite low level and require a high learning curve to use. Developers need to know the details of the simulation, data management, and computer graphics in order to develop computational steering applications.

- *user interface.* User interfaces are tailored towards the user constituency; hence very specialized towards the problem at hand. Interface are usually fixed and do not allow users to experiment with different views on their data.

- *3D interaction.* 3D interaction with 2D input devices is still very cumbersome. This has lead to studying new interaction techniques based on 3D widgets, or using more sophisticated display and interaction devices (eg. VR).

Ubiquitous Computational Steering. In ubiquitous computational steering a large number of users will connect/disconnect 3D PCs to ongoing simulations running remotely on compute servers. We believe that there are many opportunities for ubiquitous computational steering. Some examples are: interactive weather broadcasting, interactive electronic scientific magazines/journals and education books (which go beyond interactive 3D browsing), and the dissemination of knowledge at national laboratories.

Due to the rapid growth of 3D technology, we do not believe that the PC itself will be the factor that prohibits bringing computational steering to the consumer (0.5 Gflop and Reality Engine graphics capabilities in a laptop footprint with PC price points are just around the corner). More importantly, the following problems need to be addressed:

- *bandwidth.* This is almost an unsolvable problem, since more bandwidth is necessary as CPU performance increases. Perhaps adequate compression or multi-resolution schemes will provide an outcome.

- *user constituency and user interface* Users may or may not be specialists in the application field. Non-specialists may be interested in different information than specialists. Hence, the type of information that can be controlled must vary per user.
  Also, the type of information that will be presented and the desired representations will vary per user. Ideally, users will be able to customize the 3D interface.

2 Position.

We postulate our position as a list of concrete issues:

1. 3D and interactive 3D can provide added value to the consumer market, and goes beyond the possibilities provided by the current 2D consumer market (which is dominated by page description presentation, SGML, PDF, HTML).

2. Ubiquitous computational steering has many potential applications. We believe that a consumer market for "science on demand" could exist. [1]

3. For technology, the available bandwidth will cause bigger problems than the capabilities of the individual PC. The underlying observation is that processor speed and graphics power capabilities growth rates are higher than growth rates in bandwidth of wide area networks.

4. Due to the diverse user constituency of the consumer market, the type of information that will be presented to and steered by must be tailored towards the specific needs and desires of the user. In addition, we believe that users must be able to customize their own representations.

5. It is not clear what input and display capabilities the ubiquitous 3D PC will have. 3D interaction and direct manipulation will always be severely compromised if the ubiquitous 3D PC is limited to 2D input and display devices.

In addition, we list our worries:

1. Our institute (a research Center for Mathematics and Computer Science) have installed 120 SGI desktop workstations. Oddly enough, only the visualization and multimedia researchers make use of the 3D graphics capabilities. All other researchers use 2D capabilities and tools, even though they work on 3D problems.

2. Computational steering will need to be as attractive as 3D PC games, otherwise ubiquitous computational steering will not go beyond the entertainment market. This would be a missed chance.

[1] Science on demand – analogous to video on demand – is loosely defined as remotely being able to access scientific information. There could be many forms: from purely informative to educational.