Cogito: a system for computer-aided visualization - presented at SIGGRAPH '96 -

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Abstract

We contend that the computer can aid the creative endeavour of visualization beyond image production. Our system will allow users to effectively find personally meaningful visualizations amongst all those available.

Introduction

The exact nature of visualization in the computer age has been contentious. That visualization "offers a way to see the unseen" [4] is true whether it is done through a computer monitor or the mind's eye. Interpretation of computer-generated imagery must be supplied by the viewer even when all the decisions regarding image content are not.

The collaborative effort between mathematicians and visualization specialists at Simon Fraser University has resulted in the development of successful visual tools (e.g. [6]) for mathematical communication and discovery. What insight might be possible if the mathematicians could produce effective visualizations working directly with a computerized tool? The tool we propose here gives the user control over image content by enabling choice of content from a wide variety of possibilities, in a way that is consistent with models of human discovery [3]. Inventive thought required for discovery is based on the combination of elemental ideas and the selection from results. Einstein called this process "combinatory play". Interestingly, it is echoed in the Latin verb "cogito", for "to think", which etymologically means "to shake together".

Bertin [2] described a visual expression of the discovery process by distinguishing three successive forms of graphic application in decision making: matrix analysis of the problem (questions are defined); graphics information-processing (answers are discovered); and graphic communication (answers are communicated). Bertin noted that some parts of this process can be automated easily, while the creative parts could never. We agree that creativity cannot be computerized, how-

ever we contend that the computer can act as an aid to creativity, by combining problem elements and presenting alternatives to the user.

Description

The space of all available representations is determined by the data, and the functions which operate on the data, as supplied to the system. It is constructed from combinations of the visual representation elements (including data, shape, and others).

The user may choose to limit the search space before any images are created, which corresponds to Bertin's notion of matrix processing. One may also configure the space in order to give direction to the search process. The system can be left without user guidance to present images taken from the entire search space. In this case, however, the user may soon be overwhelmed by the amount of available choices and find it difficult to arrive at useful visual representations. A better strategy for exploration is to pursue a particular direction with each search and perform many searches. The operation of the tool depends on the user's input.

We propose a flexible visual interface, the core of which is reminiscent of Sims' [1] system. The interface (see Figure 1) will display a subset of alternative representations, generated from the current data, with which the user can interact. The dynamic nature of the tool is a difference from other systems, like SageTools [7]. The search of the whole space of alternatives is driven by a genetic algorithm, with the user providing the fitness function through his or her selection. At each step the user may choose one or several promising representations, to define the search space for the next iteration. New alternatives are presented by performing crossover operations to recombine the visual elements of previous selections. Individual elements may also be mutated through parameter modification. The result of the iterative search process will be one or more distinct representations which may be linked and used in concert to study the problem at hand.

Accessible with each representation is a generation history, including all parameter values associated with each element, which may be edited directly. Successful representations can be saved and used as "genetic material" for other visualizations.

Artificial intelligence techniques have been applied, in part, as a way to manage the space of alternatives for the user [5]. We contend that the user will not be overwhelmed with the choices implied by this model. Rather, we feel that the system will allow the user to quickly dismiss useless representations and focus on those possibilities which are meaningful, some of which might not have even been otherwise considered.

Conclusions

We claim that this exploratory approach to visualization is effective in fostering discovery. It allows each user the freedom to create meaningful visual representations, in a way which does not require programming of the system. It can also provide the foundation for communicating those representations and insights to a broader community by allowing a particular representation to be

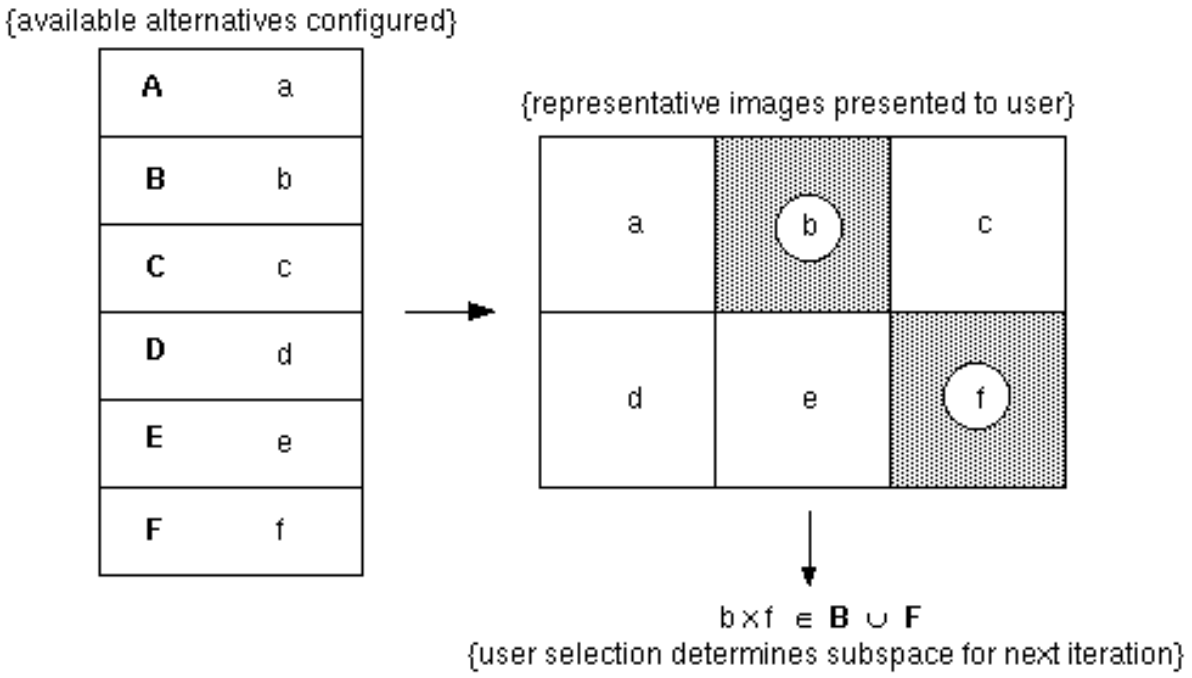

Figure 1: Schematic look at the interface: the space of available alternatives is grouped according to user-specified criteria. Each group (A – F) has a representative element (a – f) which is displayed to the user. The subspace for the next search iteration is based on the user selection (b and f).

modified easily or assembled quickly from components; and by permitting the inclusion of other computerized tools as additional layers in the system.

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