BOUNDARY MATH RESEARCH PROPOSAL

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OVERVIEW

Boundary Mathematics (BM) facilitates several fundamental research advances. One has great economic potential.

HISTORY

I have spent the last 15 years exploring the advantages of mapping the mathematical semantics of strings onto higher-dimensional representational spaces. For limited computational domains, these maps have yielded substantial algorithmic performance improvement. An evolutionary theme to this work has been to expand the conceptual bases of BM both toward the silicon architecture of the computer and toward the cognitive architecture of the human computer user. The long-term goal is to find common ground for Human-Computer Interaction. An emergent goal along this path is to construct a formal foundation for cyberspace. My most current facilitating project is the formation of a company to build

DEFINITION

Boundary Mathematics (BM) is

> a theory of representation in which higher-dimensional structures (containers, blocks, networks,...) carry mathematical and functional semantics, and
>
> a theory of computation in which non-representation (void-based concepts) has functional utility.

These characteristics make BM tricky to implement on register-based computer architectures. But the following performance features make BM particularly desirable:

Computational efficiency: use of the void makes representation more efficient and converts most computational steps from rearrangements to erasures.

Visualization: use of space makes representation visual and redefines many computational steps from rearrangement to direct observation.

Parallelism: containers naturally partition independent and dependent processes, providing a parallel control strategy.

RESEARCH/DEVELOPMENT TOPICS

Several specific technologies contribute to the BM engine design.

Equational Logic: as a computational approach containers are of particular advantage, fitting well with equational logic styles. The disadvantages include that BM is abstract and unfamiliar, that it is very innovative, and that seems to require ultra-fine-grain parallelism. Each of the computational advantages of BM suggest a research project. I have partially developed each.

Topic 1: Theory of Representation

Explore various maps between BM concepts and standard mathematical structures. Maps to number theory, database theory, and the theory of recursion are currently interesting.

Topic 2: Visual Programming

Develop two and three dimensional spatial representations for programs. Visual transformations map to program transformation.

Topic 3: General Purpose Computer

Build a silicon board which uses BM parallelism to drastically improve cost/performance ratios of current high-end cpus.

THE SMART SPATIAL ENGINE

We have been developing a computational engine based on advanced techniques in silicon, logic, and graphics. Initial prototypes and models suggest that the Smart Spatial Engine (SSE) will deliver at least two orders of magnitude cost/performance improvement.

The silicon substrate is a highly modified Content Addressable Memory which provides order arithmetic (=, >) for many kilobytes of data per clock cycle (currently 50 MHz), yielding terabit performance from conventional chip manufacturing techniques.

The representational substrate is Boundary Mathematics, providing extremely efficient state transformation operations, greatly reduced computational instruction sets, and a unified representation of logical, numerical, and graphic information.

The mathematical substrate is equational first order logic using pattern comparison as axiomatic basis and computational instruction set

The computational substrate is match-and-substitute over an equational first order logic. Equalities, inequalities, and orderings model principles of conservation, invariance and constraint. The engine's application of transformations is reactive, scriptable and adaptive.

The interactivity substrate is spatial in three dimensions, multi-modal, directly interactive and potentially friendly to human thought and modeling.

CONCLUSION

In current environments of symbolic information overload, human interaction with information must be spatial, intuitive, natural. BM demonstrates spatial computation improves even symbolic performance. This innovative technology could redefine our expectations from computation. The graphic substrate features real-time collision detection and depth complexity elimination while rendering at ten million polygons/second.