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Image Matrix Processor for Volumetric Computations Final Report CRADA No. TSB-1148-95

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Disclaimer

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DISCLAIMER

Image Matrix Processsor for Volumetric Computations

Project Accomplishments Summary
CRADA No. TSB-1148-95

Date: September 5, 2000 Revision: 3

A. Parties

The project is a relationship between the Lawrence Livermore National Laboratory (LLNL) and Advanced Research and Applications Corporation (ARACOR).

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B. Background

The development of an Image Matrix Processor (IMP) was proposed that would provide an economical means to perform rapid ray-tracing processes on volume "GigaVoxel" data sets.

Three-dimensional (3D) projection rendering and image reconstruction are examples of ray-tracing processes. Volume reconstruction and direct volume visualization provided an important capability for the identification, and comprehension of features within 3D data sets. Volumetric reconstruction and visualization have been demonstrated to provide a unique and powerful analysis capability for industrial non-destructive evaluation (NDE) and medical imaging technologies, such as: computed tomography (CT), ultrasonics (UT), infrared (IR) imaging and magnetic-resonance imaging (MRI), and scientific visualization of modeled 3-D fields, for example, the computation of fluid dynamics.

Economical reconstruction and visualization computers were lagging the existing requirements of these technologies and modeling methods by orders of magnitude.

Imaging systems, such as industrial CT, provided 3D data sets and reconstructed images that could be as large as 10 GB in size. This posed a requirement for technology in the near term that would provide an economical solution with two or three orders of magnitude improvement in performance over existing mid-priced computers.

The Image Matrix Processor (IMP) was a specialized computer architecture designed to accelerate numerical computations associated with difficult 3D image processing problems. Just as an array (or vector) processor accelerated the computation of one-dimensional arrays, the IMP accelerates computations in two and three dimensions.

C. Description

This was a multi-phased project. The objective of the first phase of the IMP project was to evaluate the practicality of implementing a workstation-based Image Matrix Processor for use in volumetric reconstruction and rendering using hardware simulation techniques. Additionally, ARACOR and LLNL worked together to identify and pursue further funding sources to complete a second phase of this project.

To meet our objective, we designed components for a "virtual workstation" to simulate the behavior and measure the throughput of an IMP-based workstation. In this effort, we determined the best method for analyzing and modeling the behavior of the digital systems required in the IMP design. The method used for this work was a standard IEEE VHDL hardware description language. This hardware description language was used to describe the IMP hardware for the purpose of simulation, modeling, testing, design, and documentation. The VHDL language provided a hierarchical representation of the functional details of the proposed IMP design. That is, components were not described at the gate or transistor levels for simulation, but rather at the behavioral and data path design levels. The more detailed hardware description was to be developed in a future phase of this work.

The study of data throughput of the IMP virtual workstation required the development of a data converter. The data converter translates computed tomography raw data sets to a format that can be read by the VHDL hardware description code. This converter provides a means to use actual data acquired on a tomographic system in evaluating the data depth, data flow, and computational accuracy for various scenarios of an IMP virtual workstation design. The data converter also translates the VHDL data, after reconstruction, to a format that can be evaluated using standard tools. These tools are what we currently use to analyze a tomography data set. This allows us to compare current reconstruction methods to data that is reconstructed on the IMP.

ARACOR, with help from LLNL, acquired funding from the National Science Foundation for the second phase of this work. Unfortunately, the NSF funding was delayed for 12 months due to government budget delays. ARACOR had a schedule that could not tolerate this delay and decided to change their direction. The second phase of the LLNL CRADA was not funded and the work was terminated.

D. Expected Economic Impact

ARACOR was planning to develop a high-resolution, volume (cone-beam) Computed Tomography system as a product for laboratory and educational use. This product required an extremely fast reconstructor. Computers that could provide the necessary speed for reasonable reconstruction times were available at the time of the CRADA, however, they cost $300,000 or more. To keep the price of this cone-beam CT product at a minimum, ARACOR wanted to reduce the price of the reconstructor by developing the IMP.

This project was the first step in determining the practicality of implementing an IMP based workstation. This work developed the individual components required for the IMP simulation. Future funding was required for the second phase that would have performed a fully integrated simulation of the IMP. The third phase of the work would be to develop a prototype of the hardware to verify the simulation work.

We were successful in acquiring a NSF grant for the second phase; however, due delays in the government budget for the year this was to be funded, the allocation was delayed for 12 months. ARACOR had a schedule that could not delay, and opted for a different solution to this problem. Unfortunately, without the second and third phases of the LLNL CRADA being performed, the expected economic impact could not be quantified.

E. Benefits to DOE

This project supported the defense programs missions in both advanced scientific computing and the factory of the future. For example, production line volume x-ray tomography would become a reality if the CT reconstruction times were significantly reduced. Additionally, this technology could greatly improve applications requiring rendering and volumetric visualization. However, as mentioned above, the second and third phases of this work were not funded; therefore, these benefits are not quantified.

F. Industry Area

Semiconductors, computers, medical imaging, and industrial imaging.

G. Project Status

This project was completed in September 1996.

H. LLNL Point of Contact for Project Information

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I. Company Size and Point(s) of Contact

Aracor has annual sales of less than $10 million. The company employs less than 50 people.

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J. Project Examples

There are no project examples available.

K. Subject Inventions / Generated Information

There are subject inventions./generated information.

This small value contractual mechanism generated a software code called CONVERT. This code translated results from LLNL's RECON and VIEW codes into a format so that the simulator code (VHDL) could use these results.

L. Release of Information

I certify that all information contained in this report is accurate and releasable to the best of my knowledge.

for Kathy Kaufman
Karena McKinley, Director
Industrial Partnerships
and Commercialization

10/26/00
Date

Release of Information

I have reviewed the attached Project Accomplishment Summary prepared by Lawrence Livermore National Laboratory and agree that the information about our CRADA may be released for external distribution.

Jolyon Browne, Technical Contact
ARACOR

10/3/2000
Date