FINAL REPORT
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BETWEEN
BROOKHAVEN SCIENCE ASSOCIATES
AND
PHYSICAL OPTICS CORPORATION

Project Entitled: Three Dimensional Holographic Archival Memory

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Title:

Three Dimensional Holographic Archival Memory

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Industry participant:

Physical Optics Corporation

Industry participant PI:

Fedor Dimov

Project objective:

Determine the usefulness of the three dimensional holographic Archival Memory for the storage of RHIC and other High Energy and Nuclear Physics data.

Significant accomplishments:

To address the DOE need for the storage and handling of terabyte of nuclear physics data, Physical Optics Corporation (POC) developed a new multi-terabit, 90° recording geometry 3D holographic archival optical memory storage and search system. In contrast to state-of-the-art memory approaches, 3DHAM handles the data through highly parallel optical processing in conjunction with highly redundant hologram multiplexing. The 3DHAM system advantages also stem from its unique 3D volume-recording medium, which theoretically has a significantly greater data density than disk-based systems.

Phase II of the project produced a 3DHAM system with the following capabilities:

1. Highly stable recording of thousands of holograms in a 90° geometry in 1cm³ lithium niobate (LN) crystal.
2. Parallel data searching via a correlation method, and a mixed content and index addressable method.
3. Retrieving stored data as holograms without crosstalk

3DHAM was successfully tested by recording thousands of holograms. Search and image retrieval capabilities were demonstrated.

Significant problems:

Significant problems POC faced during this project were related to the following:

1. Various technical issues prevented shrinking the device size to less than ~2ft
2. Correlation-based search technique precision needed to be increased.
3. Correlation camera pixel numbers needed to be increased to handle larger amount of data
4. Permanent data storage methods needed to be improved.
5. LN crystal sensitivity needed to be improved to reduce stored data recording time.

A significant problem from the BNL perspective was the fact that the level of abstraction in particle physics data as commonly stored is such that holographic search techniques on 3DHAM stored data

seem to offer no significant advantage over database type searches in conventional storage. This does not negate the potential higher storage density advantage of this development but was less than originally hoped for by the BNL participants. Holographic searches of 3DHAM data may work for data less drastically abstracted than that of particles physics such as genetic code representations for example.

Industry benefits realized:

With the completion of this Phase II project the promise of using volume holography to deliver high performance optical storage systems comes closer to fruition. The results of Phase II clearly demonstrate significant increase in the storage capacity. This should encourage developers of this media to put more effort into improving their dynamical range and efficiency. 3DHAM could have significant utility in the electronics industry, as well as government laboratories, universities, and medical institutions. This optical data storage system will contribute to U.S. photonic and computer technology leadership.

Laboratory benefits realized:

Built 3DHAM data storage system is one more step toward using the full theoretical limit of 3D recording media. Developed high-precision alignment techniques, high quality imaging, hologram recording schedule with fast shutters, increased life time of stored data, developed GUI will further benefit to the laboratory research in holographic data storage.

Recommended follow-on work:

POC contacted FORESIGHT, a company suggested by the DOE, regarding commercialization assistance. In their (FORESIGHT's) opinion 3DHAM has a great potential when compared to other data storage systems, nevertheless, the insufficient parameters of 3D media impose limitations on the amount of stored data as revealed during this project. Possible reduction of the CCD cameras pixel size and lithium niobate crystal thermal fixing techniques may solve some problems.

Potential benefits from pursuing follow-on work:

In conclusion, POC believes the feasibility of 3DHAM is proven and the next step is the miniaturization of the system. They believe that progress in micro-optics, CCD sensors, and micro-positioning systems can make it possible to build shoebox size multi-terabit holographic data storage systems base on lithium niobate crystals.