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Accelerating Computer-Generated Hologram Computations for Digital Holographic Video Systems

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Abstract. Holography reached a major turning point due to the introduction of digital holography by Computer-Generated Holography (CGH). However, one of the major obstacles of the CGH technique is a huge amount of calculation (for example, MxNxOxP calculations for MxN 3D object points and OxP digital hologram resolution). In this paper, we propose a parallel computing approach to accelerating long-running computations of the CGH application to provide high resolution digital holograms. To speedup CGH computations, a sequential version of a CGH program is parallelized as Message Passing Interface (MPI) applications and an entire computation will be assigned among different computational nodes. For all the experiments, we will use a supercomputer which is a 60-node heterogeneous CPU/GPU cluster. Our experimental results indicate that parallel processing has the potential to become a powerful tool for computationally-intensive CGH applications.

Keywords: Digital Hologram, Message Passing Interface, Parallel Program

1 Introduction

Recent trend of the 3D image/video is heading to a perfect realistic 3D without restriction in viewing angle, wearing glasses, etc. It can be realized by hologram [1] which has been gathering more attention recently by that reason. However, in order to achieve large image size with wide viewing angle and full parallax effect, holograms with large pixel count are required [2]. Generation of such holograms is computationally expensive and remains one of the main challenges to make holographic 3D display technology.

CGH has the ability to correctly record and reconstruct a light wave for a 3D object. Assuming that a 3D object is composed of N point light sources, the formula for computing a CGH is expressed as [3]:

$$I_\alpha = \sum_j^N A_j \cos(k\sqrt{(px_\alpha - px_j)^2 + (py_\alpha - py_j)^2 + z_j^2}) \quad (1)$$

where, α or j indicates a particular point on the hologram or 3D object respectively, k is the wave number of the reference wave defined as $2\pi/\lambda$, p represents the pixel pitch

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of the hologram, and (x_α , y_α) and (x_j, y_j, z_j) represent the coordinates of the hologram and 3D object respectively.

We propose a parallel computing approach to accelerating long-running computations of the CGH application to provide high resolution digital holograms.

2 Implementation & Discussion

We have designed and implemented a Message Passing Interface (MPI) application to show the applicability of parallel computing in digital holographic systems. MPI is a standardized library specification for message-passing on both massively parallel machines and on workstation clusters [4]. As our implement environment, we have used a computer cluster which consists of a 60-node heterogeneous CPU/GPU cluster. Each compute node of the cluster runs two Intel Xenon processors with 8 cores each (a total of 16 cores), Four GPUs, 128GB RAM, and Red Hat Enterprise Linux 6.3. The nodes are connected by InfiniBand (40Gbit+).

Figure 1 provides the overall flow of the proposed parallel computation. The root node in the MPI program makes a 2-dimensional image array from a 3D object and sends the image array to all participant processes using the `MPI_Bcast` operation. `MPI_Bcast()` is one of the standard collective communication techniques and is used to send out the same data to a parallel program, or to all processes. Each process carries out CGH computation to calculate some pixels of a digital hologram with the broadcasted image array data. Once all computations have completed, `MPI_Gather` takes individual computation results from all processes and gathers them to the root process. Finally, the root process generates a digital hologram from the collected data.

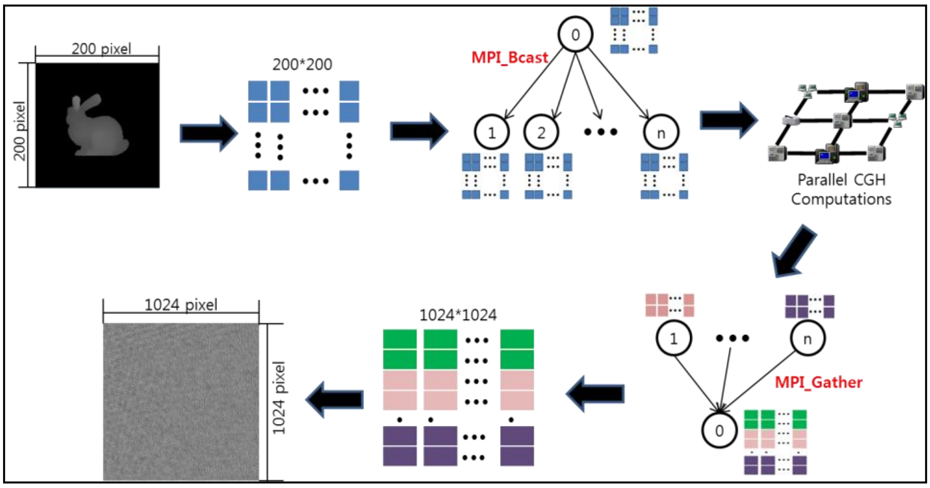

Fig. 1. High-level overview of the parallel computation process to generate digital holograms. The parallel MPI program calculates a digital hologram from a 3D object using MPI collective operations, `MPI_Bcast` and `MPI_Gather`.

As seen in Figure 2, we measured the execution time for five cases by varying the number of participating cluster nodes. As expected, the execution time tends to speed up as the number of cluster nodes increases.

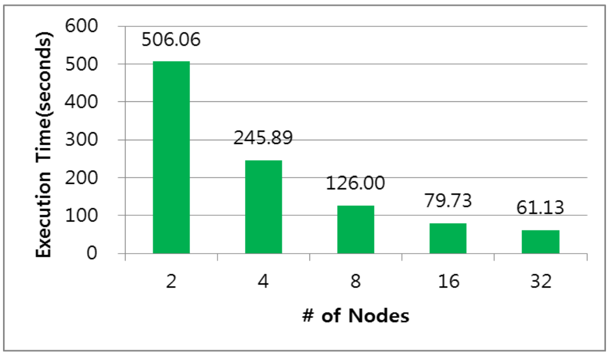

Fig. 2. Execution time of calculating computer-generated holograms in the compute cluster. x-axis: the total execution time, y-axis: the number of nodes in the computer luster.

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References

1. Benton, S. A. and Bove, V. M. Jr.: Holographic Imaging, John Wiley & Sons, Inc., Hoboken, NJ (2008)
2. Xu, X. W., Solanki, S., Liang, X. A., Pan, Y. C., and Chong, T. C.: Full high-definition digital 3D holographic display and its enabling technologies," Proc. SPIE 7730, 77301C (2010).
3. Choi, H. J., Seo, Y. H., Jang, S. W. and Kim, D. W.: Analysis of Digital Hologram Rendering Using a Computational Method. Journal of information and communication convergence engineering, vol. 10, no. 2, pp. 205--209 (2012),
4. The Message Passing Interface (MPI) standard, http://www.mcs.anl.gov/research/projects/mpi/.

