ID5130 Course Project Outline

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Project title:

Create a **Octree Data Structure** and use it for implementing Parallelized **Bilateral Filter** which is commonly used in Image Denoising and a MPI-Based **Collision Detection** Algorithm.

Abstract:

In the realm of parallel computing, harnessing the power of data structures tailored to specific applications is paramount for achieving efficient and scalable solutions. This project delves into the utilization of octree data structures, exploring their potential in two distinct applications: **image denoising** through a parallelized bilateral filter and parallelized collision detection using Octree data structure.

The octree, a hierarchical tree structure widely employed in **computer graphics** and computational geometry, serves as the cornerstone of our endeavors. Firstly, we embark on implementing an **OpenMP** parallelized bilateral filter for image denoising. The bilateral filter, known for its ability to **preserve edges** while effectively reducing noise, is integrated with the octree data structure to expedite computation. By exploiting the **spatial coherence** of neighboring pixels and the octree's hierarchical nature, the filter operates efficiently across multiple threads, significantly enhancing denoising performance. We demonstrate how the octree facilitates the partitioning of image data, enabling concurrent processing of disparate regions and thereby accelerating denoising tasks.

Subsequently, our project extends the utility of octrees to the domain of collision detection through an **MPI-based** Linear Octree algorithm.

Collision detection, crucial in **simulations**, gaming, and robotics, demands meticulous handling of spatial relationships between objects. Leveraging the hierarchical organization of the octree, we design an MPI parallelized approach for efficient collision detection across distributed-memory systems. Each MPI process is tasked with managing a subsection of the octree, with inter-process communication facilitating information exchange regarding object positions and collision results. This distributed scheme enables scalable collision detection, catering to scenarios with large-scale environments and numerous interacting entities.

Through these applications, we underscore the versatility and efficacy of octree data structures in parallel computing paradigms. The bilateral filter exemplifies how octrees can expedite image processing tasks by exploiting spatial coherence, while the Linear Octree collision detection algorithm showcases their role in facilitating scalable simulations through distributed-memory parallelism. Furthermore, we discuss the **challenges encountered** during implementation, including load balancing, communication overhead, and synchronization issues, and elucidate strategies employed to mitigate these obstacles.

In conclusion, this project offers insights into the symbiotic relationship between octree data structures and parallel computing methodologies. By leveraging octrees, we demonstrate tangible improvements in performance and scalability across diverse domains, paving the way for enhanced efficiency in image processing and simulation applications. Our findings underscore the significance of tailored data structures in unlocking the full potential of parallel computing systems, heralding advancements in computational efficiency and scalability.