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MULTIPROCESSING AND PARALLEL COMPUTING

Milestone 1

Enhancing Traffic Sign Recognition Performance Using CUDA-Accelerated Hough Transform: A Comparative Study with C Implementation

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I. Abstract

This study enhances a Traffic Sign Recognition (TSR) application by applying the Hough Transform algorithm through CUDA parallel computing, with an emphasis on execution time comparisons against traditional C implementations. TSR is critical for the reliability of autonomous driving systems, necessitating precise and rapid detection of traffic signs. The problem addressed is the inefficiency of CPU-based TSR systems, which struggle with real-time processing due to limited parallelization capabilities. By leveraging CUDA's GPU-accelerated architecture, this project seeks to significantly reduce computation time by parallelizing the shape detection process. The methodology involves integrating CUDA with a MATLAB application that already performs HSV-based masking and extended border tracing, facilitating direct execution time comparisons between the CUDA-enhanced and C implementations for the Hough Transform Algorithm. This comparative analysis aims to demonstrate the potential of CUDA in accelerating TSR systems, potentially setting a new benchmark for future automated driving technologies.

II. Description Of The Project

This project aims to enhance the performance of Traffic Sign Recognition software by implementing the Hough Transform in CUDA, explicitly focusing on shape detection. The Hough Transform is a technique for detecting geometric shapes, such as circles and lines, which are seen in traffic signs. By utilizing CUDA, the project leverages the power of the GPU's Single Instruction, Multiple Threads (SIMT) architecture.

A vital aspect of this project is the comparison of the CUDA-enhanced Hough Transform against its C implementation counterpart. Traditional CPU-based implementations, while effective, often need to catch up in real-time scenarios due to their limited parallel processing capabilities. However, GPUs can handle numerous operations in parallel, increasing computational speed. This project will measure the performance improvements gained through CUDA optimization.

The optimization achieved through this project is particularly valuable for automated driving systems, where rapid and accurate traffic sign recognition is crucial. In such systems, the ability to quickly and reliably identify traffic signs, especially for automated vehicles. Efficient traffic sign recognition contributes to autonomous vehicles' overall performance and reliability. This can also provide feedback to drivers with their blind spots, assuming they could not see the sign.

III. PROPOSED ALGORITHM

The proposed system will utilize CUDA to parallelize the **Hough Transform algorithm**, which is used for detecting edges or shapes in images. By breaking down the image into smaller segments, the system can process these segments in parallel, speeding up the computation. Each segment of the image will be managed by a separate thread within the GPU. This parallel approach takes full advantage of the GPU's SIMT architecture, which should yield a better time compared to its C counterpart. Both the C and CUDA versions will be integrated into a MATLAB application, as shown in Figure 1, which employs HSV for binary masking and extended border tracing—processes that will not be parallelized. The input for the Hough Transform will be the segment of the image that was edge-traced- an array of pixels. Its output will be coordinates of points and lines that show what shape it is, as seen in Figure 3.

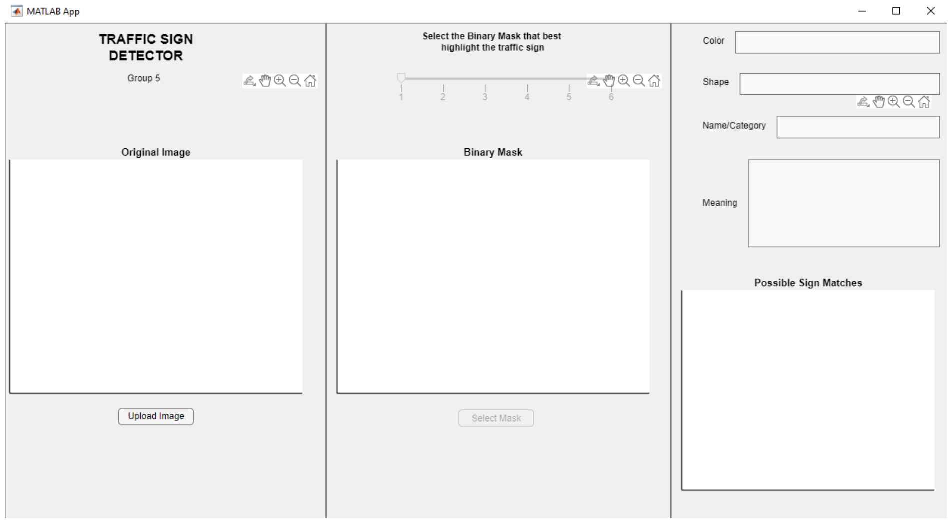

Figure 1. MATLAB Application of Traffic Sign Recognition

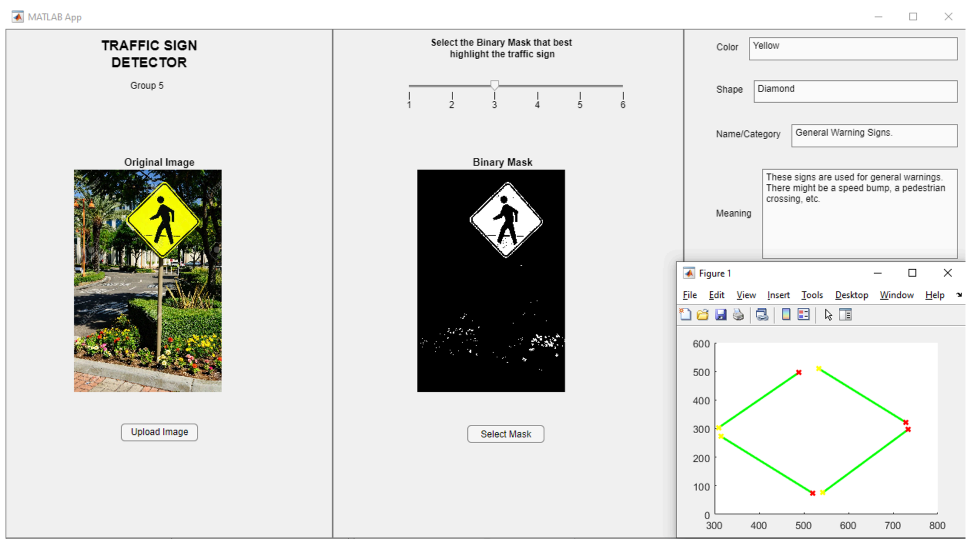

Figure 2. MATLAB Application of Traffic Sign Recognition with Image Input

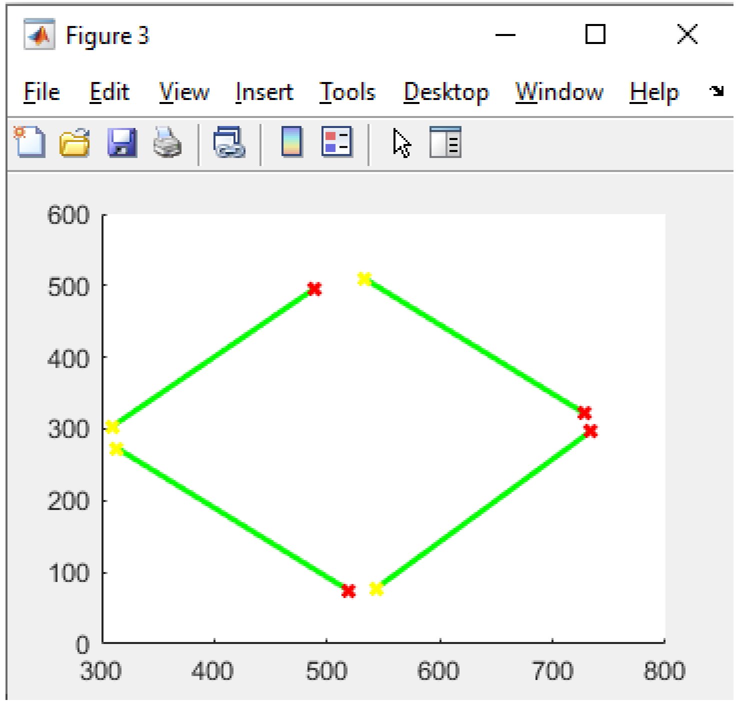

Figure 3. Hough Transform output visualization

In terms of SIMT utilization, each thread will execute the same instructions on different data segments. This means that the Hough Transform computations will be uniformly distributed across the GPU threads and by doing so, the system can handle large images more effectively. With CUDA's parallel processing capabilities, the proposed algorithm aims to achieve better performance and accuracy compared to traditional CPU-based implementations.

IV. Proposed Milestones

A. Milestone #2

For the mid-project milestone in week 10, the group has decided to complete the actual implementation of the Hough Transform using CUDA and C. This milestone will serve as an avenue to assess the progress and integration of the parallel processing capabilities within the project framework. A short project demonstration will be recorded as proof of the group progress in this project.

B. Milestone #3

For the final milestone in week 13, the group plans to consolidate all final deliverables into a single GitHub repository. This repository will include the project demonstration video link, source codes, discussions, execution time comparisons, and conclusions. Additionally, the original C and CUDA implementations will be optimized and fully-integrated into the MATLAB application for this milestone, ensuring a comprehensive demonstration of the project's capabilities and enhancements.

V. References

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