ABSTRACT

KEYWORDS: interconnection networks, mesh, torus, twisted torus, parallel processing, FPGA, GPU, supercomputer, parallel processing arrays, line scan camera, edge detection, soccer ball, object tracking, image processing, computer vision

We proposed and developed parallel processing algorithms (and corresponding hardware) to speed-up two image processing applications - edge tracing and tracking of a linearly moving object - using the connecting properties of the interconnecting network. Further, we used a twisted Rectangular Torus-based interconnection network to improve the performance of such parallel processing applications.

First, we developed *three* contour tracing algorithms (Adapted and Segmented (AnS) algorithms), adapting three major families of contour tracing algorithms (pixel-following, vertex-following, and run-data-based-following algorithms) for the mesh and torus-connected architectures. These algorithms used distributed data processing for tracing contours which exploited the specific interconnect properties of torus network. We simulated these algorithms on a two-dimensional torus-connected multiprocessor model. Using a Python environment, we achieved a speed-up of 468 times (considering clock ticks) over single-processor systems. Our implementation on Tesla K40c and Quadro RTX 5000 GPUs showed a speedup of 194 (and 47 respectively) compared to the existing parallel processing contour tracing implementations.

Second, we implemented our developed algorithms on a Zynq-7000 FPGA-based platform, building a hardware accelerator based on our Adapted-and-Segmented (AnS) algorithms. This implementation used a mesh-interconnected multiprocessor architecture and was much faster than existing methods - 55 times faster (if input-output overheads were excluded) and 12.5 times faster (if input-output overheads were included).

Third, we developed an efficient and cost-effective system for tracking linearly moving objects in sports fields using a Panning Line-Scan Camera and

Lens (P-LSCL) setup. We introduced a novel angle of motion prediction algorithm based on edge tracing, specifically designed for tracking a white football in a football game within a stadium (with artificial grass as a uniform green background) which is 1.15 times more accurate, O(n^2) times less complex, and only 1/6th of the cost of current methods.

Fourth, and last, we enhanced the connectivity properties in Rectangular Torus (RT) networks by introducing twists to reduce the Average Inter-node Distance (AID). We proposed a methodology for implementing twists in RT networks, studying the Average Inter-node Distance as a function of the twist (t-shift) in one dimension. This methodology can be used for mapping *any* Rectangular Twisted Torus network onto a 2D VLSI chip, potentially enhancing performance and connectivity in parallel processing systems.