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SPECIAL ISSUE

Parallel architecture for accelerating affine transform in high-speed imaging systems

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Abstract Affine transform is widely used in the high speed image processing systems. This transform plays an important role in various high speed applications like Optical quadrature microscopy (OQM), image stabilisation in digital camera and image registration etc. In these applications, transformations of image consume most of the execution time. Hence, for high speed imaging systems, acceleration of Affine transform is very much sought for. In this paper, the pipelined architecture implementation of a proposed inherent parallel algorithm for Affine transform has been presented. The acceleration of the image transformation will help in reducing the processing time of high speed imaging systems. The architecture is mapped in Field programmable gate array (FPGA) and the result shows that the proposed algorithm is almost 4 times faster than the conventional algorithm while retaining the image quality. Using the proposed algorithm, an image of size 1,920 × 1,080 can be transformed with a frame rate of 540 frames per second and the multiplane image synthesis for image stabilisation on the same digital image can be performed with a frame rate of 65 fps.

Keywords Affine transform · Optical quadrature microscopy · Multiplane image stabilization · Digital camera · Parallel processing · FPGA

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1 Introduction

Affine transform consists of various operations such as rotation, scaling, shearing and translation. This algorithm is very computationally intensive as it involves matrix multiplication of trigonometric functions and interpolation. In high-speed imaging systems, the Affine transform plays an important role. The transform is applied on each and every pixel location of the image to obtain a transformed image. Due to this, when the size of the image increases, the computation time of the transform also increases. A parallel algorithm will help in faster processing of the transform and also faster implementation of the high-speed imaging systems. Some of these applications are mentioned below where faster processing of the Affine transform is required.

Optical quadrature microscopy (OQM) performs a phase unwrap to obtain the structure of objects being studied. Generating phase information in real time is a challenging problem. Real-time phase unwrapping would allow researchers to visually inspect samples as they are being positioned on the microscope. Before unwrapping, an Affine transform is applied to the data, which adds an additional latency of 3 s to the process when implemented in CPU and 0.2 s in Graphics processing unit (GPU) [18]. This hinders the real time unwrapping of the microscopic images. Our proposed inherent parallel algorithm will speed up the Affine transform process so that the latency in generating a visual display for the quadrature microscope using phase unwrapping can be eliminated.

Image stabilisation technique prevents photos becoming blurred in digital cameras by reducing the effect of camera shake caused by hand movement, slow shutter speeds or when using a long telephoto lens without a tripod. The multiplane image stabilisation provided by the high-speed imaging system used in Sony digital cameras, captures several frames that do not have blur (for e.g. 8