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Retinal Fundus Image Enhancement using accelerated parallel implementation on GPU

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Abstract— Retinal fundus image enhancement is a good technique to disclose the concealed specifics of a retinal image. Retinal image enhancement is used to elucidate issues such as, noise, and degradation. There are several image enhancement techniques. This paper presents acceleration of retinal image enhancement using parallel implementation of histogram equalization on GPU. GPU has enormous parallelism inherent in its architecture. In this work accelerating the retinal enhancement is discussed. The technique of histogram equalization was used in previous works for retinal image enhancement on CPU. In this work, retinal images are being enhanced by histogram equalization implemented on GPU.

Keywords— Retina, Image enhancement, GPU, Fundus Image, Parallel Processing, histogram, histogram equalization

INTRODUCTION

Graphics Processing Unit (GPU) is a dedicated electronic hardware designed to swiftly handle and modify memory to accelerate the formation of images in a frame buffer for output to a display. GPU can be used along with a CPU to accelerate scientific and engineering applications. There have been elementary level works on image enhancement using histogram equalization. These works have been done on CPU. This work implements this basic task of histogram equalization on GPU for enhancing the retinal image. The basic idea in this work is to accelerate the image enhancement.

OVERVIEW OF SOME RELEVANT WORKS

In a field which traditionally has relied on the trained eye of a specialist to make diagnoses from a qualitative perspective, a transition is underway: computer-aided diagnosis is now possible with digitized imaging. By developing algorithmic methods which are reliable, reproducible and unsupervised, comes with the presentation of a powerful tool which aids in the collection of data, assist researchers to further their understanding of the condition, and ultimately help with the critical diagnosis of various types of human diseases [K].

Several algorithms were introduced for image contrast enhancement, each having advantages in making it suitable for specific purposes. One of the primary algorithm suggested by Zimmerman and Pizer [A], is Histogram Equalization.

Enhancement of images broadly classified as non-uniform illumination correction, color normalization and contrast enhancement. Most used techniques for color normalization is histogram equalization in image [B].

In order to enhance retinal images, many techniques have been used by different authors. In recent studies, the histogram technique was used for the first step of image enhancement in retinal image segmentation [C, D, E]. Additionally, contrast limited adaptive histogram equalization (CLAHE) was performed on retinal images to enhance local contrast [D, F, G]. A recent study used CLAHE to improve contrast and correct non-uniform background to extract boundary of optic disk [H].

One study compared some contrast enhancement and illumination equalization techniques for vascular segmentation in retinal images. In this study, the performances of preprocessing techniques in vascular segmentation were evaluated by calculating the value of the area under receiver operating characteristic curve. The adaptive histogram equalization was found to be the most effective technique and improved the segmentation of the vessel in the retina [I].

In [J] fundus region detection is proposed, using binarization and mathematical morphology. Then nonlinear diffusion segmentation is applied for encapsulation of the variation in exudates and lesion boundary pixels. Region props and color histogram methods are used to detect the optic disc.

Sanchez Torres and Taborda implemented optic disk (OD) detection and segmentation method for retinal image based on evolution strategy (ES) realized on GPU using CUDA (Compute Unified Device Architecture) [L].

RETINAL FUNDUS IMAGE ENHANCEMENT

Increase in blood pressure, Diabetes, and tension is producing rupture of retina and blood vessels leading to retinopathy. Retinopathy is extreme impairment to the retina. The enhancement of retinal image is of pronounced attention since it could be cast-off as a non-intrusive diagnosis in present ophthalmology. The morphology of the retinal blood vessel and the optic disc is a vital cursor for evaluating the presence and severity of retinal diseases such as diabetic retinopathy, hypertension, glaucoma, vein occlusion and neo-vascularization. However to evaluate the span and of retinal blood vessel or the outline of the optic disc, manual method is used by ophthalmologist, which is mostly time intense and tending to human error, unambiguously when the vessel construction are elaborate or a large number of images are acquired to be labeled by hand. Therefore, a reliable automated technique for retinal blood vessel and optic disc segmentation, which preserves various vessel and optic disc features is attractive in computer aided-diagnosis.

A precise description of the boundaries of blood vessels makes exact measurements of these features possible. Blood vessel appearance is a vital pointer for various diagnoses, including diabetes, hypertension, and arteriosclerosis. Veins and arteries have several noticeable features, including diameter, color, and denseness. Artery–vein crossings and formations of small vessels can also serve as diagnostic indicators. These dimensions may then be useful to a multiplicity of tasks, comprising diagnosis, treatment evaluation, and clinical study. In this paper we describe an accelerated method to enhance retinal fundus images. With this technique, eye care specialists can hypothetically screen larger populations for vessel abnormalities. Precise measurements may be more easily recorded, for instance, for evaluation of treatment or for clinical study. Interpretations constructed upon such a technique would also be more methodically reproducible. This could prevent and reduce vision impairments; age related diseases and many cardiovascular diseases as well as dropping the time and cost of the screening.

When a large number of retinal images are to be mass evaluated an accelerated technique for retinal image enhancement is of great interest. Thus, there is a need for a consistent and accelerated technique for retinal image enhancement. In the following segment, we briefly introduce accelerating of retinal image enhancement.

THE USE OF GPU IN ACCELERATING RETINAL IMAGE ENHANCEMENT

It is always desired to get better speeds to implement algorithms. The use of GPU gives speed up in the enhancement process. GPU have several cores for handling parallel tasks. GPU can be compare to a large number of small kids who are going to do a task. CPU however is a large grown up who is going to do the same task alone. It is of less surprise GPU can perform well.

In this work, STARE and DRIVE Retina image DATABASE was used to implement the GPU accelerated enhancement. The enhancement step applied was to remove the salt and pepper noise in the retna image. The image with salt and pepper noise before enhancement is given in fig 1.1. The image of enhanced image is given in fig 1.2.

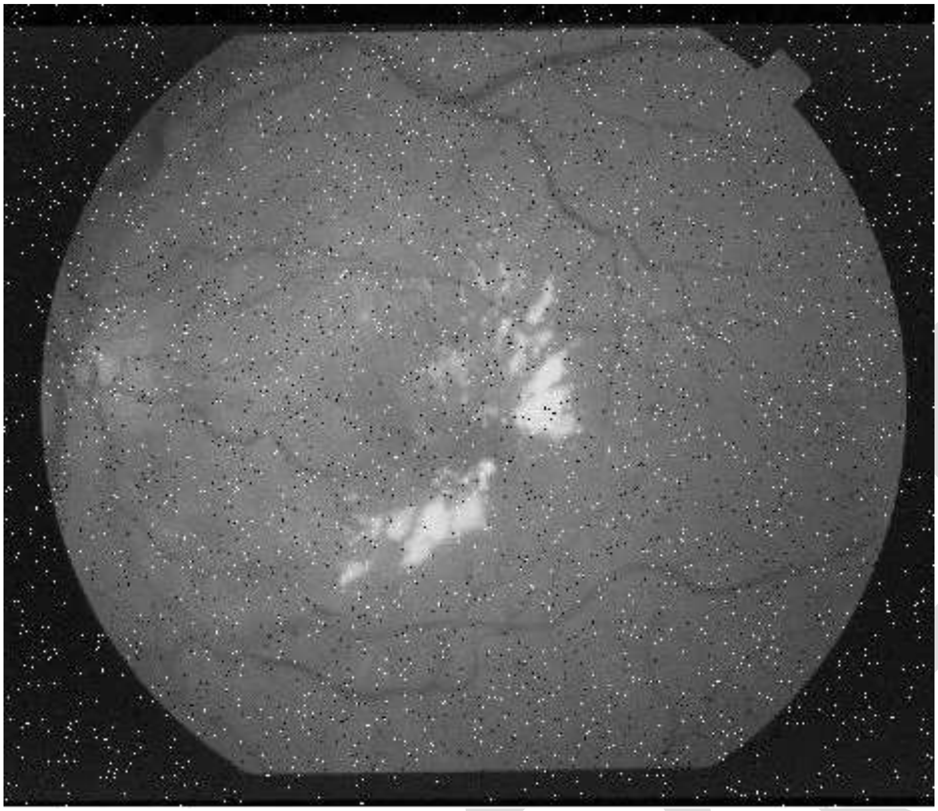

Fig. 1.1 The Retinal image with salt and pepper noise before enhancement

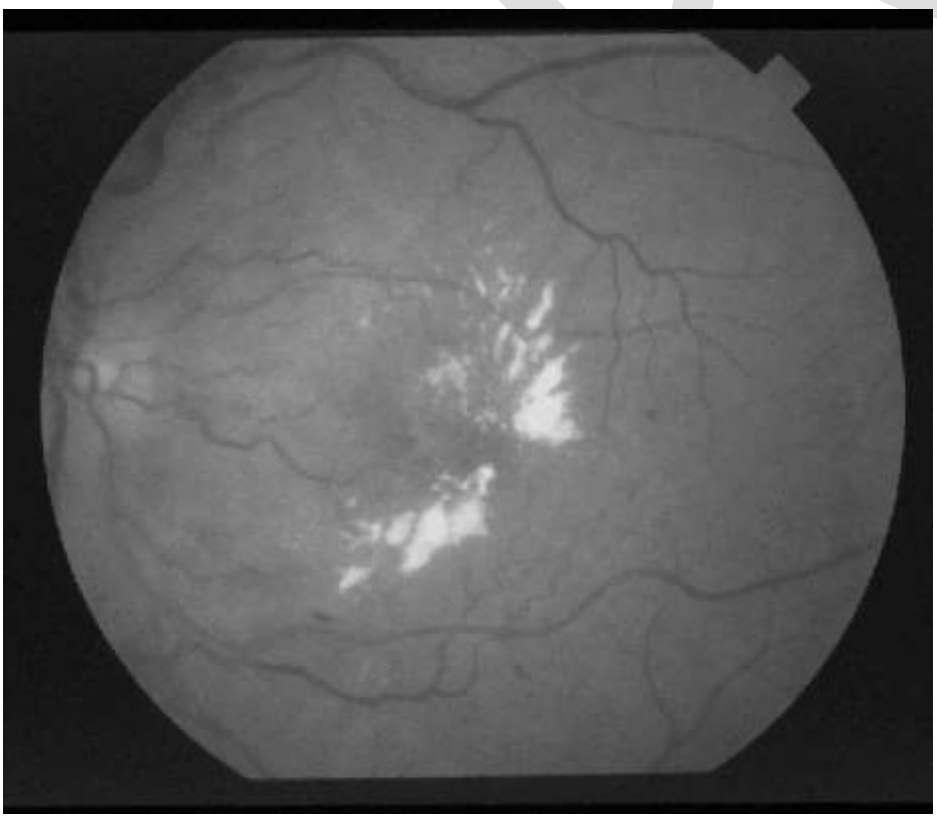

Fig. 1.2 Retinal image after enhancement

RESULT

The image enhancement as shown in fig. 1.2 was implemented on CPU and GPU. The enhancement process was to apply

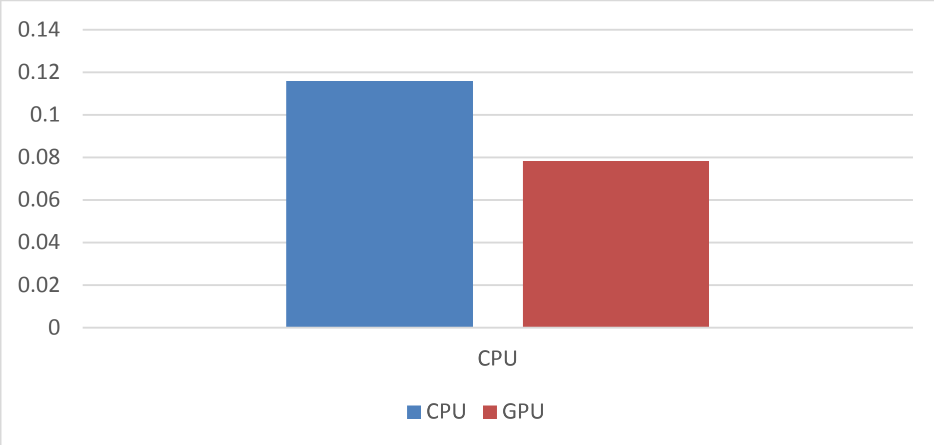

Fig. 1.3 Comparison of execution time of image enhancement on CPU versus GPU

The comparison of execution time of image enhancement on CPU versus GPU is given in fig 1.3. It indicates that running algorithm in parallel on GPU is faster. The time of execution on CPU is 0.1157 seconds and on GPU is 0.0781 seconds.

CONCLUSION

It is always better to accelerate the processing tasks and algorithms by utilizing parallel implementations and harnessing the power of GPUs to the most extent in this direction. Retinal image enhancement when clubbed with the power of GPU can bring a new strength for analyzing a very large database of retinal fundus images. There are several methods to be explored to harness the effectiveness and power of GPUs. When a large number of retinal images are to be mass evaluated an accelerated technique for retinal image enhancement is of great interest. Thus, there is a need for a consistent and accelerated technique for retinal image enhancement. In this work this aspect of retinal image enhancement was dealt with good results. In future, we would try new techniques applied on enhancing retinal image on GPU.

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