The Improved SIFT Algorithm Based on Rectangular Operator and Its Parallel Implementation

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ABSTRACT

The SIFT algorithm is one of the most widely used algorithm which bases on local feature extraction. But it could not meet the requirement of the real-time application due to the high time complexity and low execution efficiency. In order to improve these drawback, the authors optimized the SIFT algorithm by using the Gaussian convolution scale of adaptive scale space. The authors also provided the executive process of the improved SIFT algorithm on the MapReduce programming model and compared its performance in terms of the stand-alone and cluster environment. The experiment result showed that compared to the traditional algorithm, the improved algorithm had high execution efficiency, good speedup, scalability and is suitable for massive amounts of image data processing.

KEYWORDS

Feature extraction, Hadoop, Heilongjiang Institute of Technology, Northeast Forestry University, Parallel, Rectangle Operators, SIFT

INTRODUCTION

Image feature extraction played a critical role when processing images. The main applications of image feature extraction were target identifying and tracking. It was necessary to select the proper local features in order to identify the target accurately (Lowe, 1999). Scale Invariant Feature Transform (SIFT) (Lowe, 2004) was used to extract local features. SIFT feature kept no changes regardless of scale zooming, rotation and lighting changes. But the application of SIFT in real time environment was limited due to the drawback of high complexity and time consuming. So many researchers are working on the improvement of SIFT algorithm.

Regarding SIFT self-improvement: Sinha (Sinha, Frahm, Pollefeys, & Genc, 2007) proposed a feature point extraction algorithm based on OpenGL, which had a ten times increase in speed. Zhang et al. (Zhang, Ma, Zhang, & Xu, 2014) employed the fuzzy K-means algorithm to improved SITF and improved RANSAC algorithm to eliminate false matching points after matching with PCA-SIFT and FKPCA-SIFT. From the experimental results, it can be seen that FKPCA-SIFT can keep the high matching accuracy for image. Herbert Bay proposed SURF (speedup robust features) in 2007 (Bay, Tuytelaars, & Van Gool, 2016) and replace the complex Gaussian filter in SIFT.

Regarding CPU hard drive speed up: One commonly algorithm used to speed up the image feature extraction was Multi-Core CPU. Q. Zhang designed two parallel SIFT algorithm and got a 6.4 times speed-up in 8-core CPU (Zhang, Chen, Zhang, & Xu, 2008). Feng et al. (2008) implemented

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the parallel SIFT algorithm on 16-cores machine/CPU and got 11 times speed up. Although both task gained certain speedup, there were gaps to the desired effect. Zhang (2009) enervated SURF of the layered parallel algorithm (P-SURF) on multi-cores CPU. This algorithm had a smaller parallel granularity. However, the issue was a larger synchronization overhead because there would be a process of data synchronism at the end of each phase. In order to decline the synchronization overhead and unbalanced load, Shigeto & Sakai (2011) improved parallel algorithm removed the previous synchronization process and paralleled the calculation of the integral image in previous integral image. Therefore, they gained 6 times speedup on 16-cores machine but still not so satisfied.

Regarding GPU hardware speedup: GPU could assist CPU to complete the calculation of high degree parallelism. SIFT and SURF had part of related work on GPU. Lindeberg (2012) presented a fast algorithm based on the CUDA of scale invariant features transform. But the result did not indicate a critical question: whether the data transfer time was included in the SIFT conduction time. Heymann et al. (2007) completed another version GPU SIFT and got 20 frames per second processing speed on QuadroFX340. These researches showed that GPU could accurate the image retrieval algorithm. But consider the strong calculation power of GPU/CPU, there is still a big gap to the best ideal result.

The research above improved the function of SIFT feature extraction on algorithm self-optimization or architecture Based on CPU/GPU. However, there was still a big gap between testing result and idealized value. With the developing of the internet, the number of images, videos and multimedia are increasing rapidly. It is showed (Tseng, Lin, & Hsu, 2010) there were 60 hours videos that were uploaded to the internet every minute on the video website like YouTube. Flickr and Facebook had 6 billion and 200 billion images respectively. With the exponential increasing of the size of data, in order to manage the data effectively the data should be processed in distributed environment (Cho, Cha, Gawecki, & Kuo, 2013).

This paper deeply analysis the principle of SIFT algorithm first. Second, the authors optimized the SIFT algorithm based on the rectangular operator. Finally, the authors presented the execution flow of SIFT algorithm on MapReduce and performed the stand-alone and cluster testing. The experiments result showed: comparing to the traditional algorithm, the improved SIFT algorithm had higher execution efficiency, better speedup, scalability and is suitable for massive amounts of image data processing.

THE PRINCIPLE OF THE SIFT ALGORITHM

SIFT (Scale Invariant Feature Transform) (Lowe, 2004) is one of the most commonly used algorithm of image feature extraction. SIFT algorithm is widely used in image retrieve area. The major implement are image and video classification, video monitoring and automatic medical system. There are three main process in SIFT, including locating feature points, calculating feature points, describe feature points.

LOCATING FEATURE POINTS

The authors used $I(x,y)$ to represent an image. In different scale space, the image can be represented as $I(x,y,\sigma)$.

$$I(x,y,\sigma) = I(x,y) \bullet G(x,y,\sigma) \tag{1}$$

$G(x,y,\sigma)$ is the Gaussian kernel

The difference Gaussian pyramid is established by using the formula (2):

$$D(x,y,\sigma) = (G(x,y,k\sigma) - G(x,y,\sigma)) \times I(x,y) = L(x,y,k\sigma) - L(x,y,\sigma) \tag{2}$$

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