A paralleled algorithm based on multimedia retrieval

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Abstract
With the rapid development of the computer and the Internet technology, the multimedia data has become one of the main data of the current computer processing. But due to the large amount of the information that was contained in the multimedia data, the current multimedia retrieval algorithm cannot carry out the multimedia data retrieval very well, so many multimedia applications are far from practical application. According to the parallel study of the multimedia retrieval algorithm based on the local features, this paper can not only promote the current multimedia applications, but it also can provide a series of effective references for the system structure design of these applications in the future.
Key words: MULTIMEDIA, RETRIEVAL, PARALLEL, ACCELERATION

Introduction

With the continuous development of the computers and the network technology, the users can conveniently use various resources of computers and networks, which also makes the original computing intensive computer services (such as scientific calculation, military simulation, etc.) change gradually into the data intensive computing service [l] (such as search engine, video website etc.). Although the current data service system (such as Baidu search engine, Google search engine etc.) has a strong data retrieval ability, which can identify for the data that the users require quickly and accurately [2]. But with the advent of the WEBZO technology and its development, the interaction between the users and the networks becomes more and more closely, and more and more users start to share their photos and videos, which, therefore, the retrieval designed for various types of multimedia information have been used more and more widely. The main purpose of the multimedia retrieval algorithm is the extraction of the characteristic information which is the representative of these images and can easily be expressed. Then through the comparison of the feature information, we can carry out the images matching and images retrieval (usually the similar characteristics stands for the similar image). Therefore, how to extract the features that can express the image information from the images and to make sure that these images can be correctly matched is one of the most coral steps in the multimedia retrieval algorithm. According to the different description methods of the image information features, the current multimedia algorithm mainly divided into two kinds: the multimedia retrieval algorithm based on global features and the multimedia retrieval algorithm based on local features. Multimedia retrieval algorithm based on global features [3], multimedia retrieval algorithm based on local features [4]. At present, we still have some variant of SIFT algorithm: RIFTI [6] can change the elliptic area in an image into a circular area, through which it can achieve a stability better than SIFT rotation and affine; When the GLOH [5] is in the description of the characteristics, it enhances its uniqueness and robustness of the characteristics by a more fine-grained description. Besides, the use of the principal component analysis can reduce the dimension of the character. But these algorithms are only for a certain application requirement, which can improve the performance of its related applications. The two parallel algorithms of SIFT are proposed in the paper [7] in allusion to the multi-core system, and in the 8-core CPU and the 32-core simulator, it is implemented on the corresponding algorithm; bibliography [8] will put the parallel algorithms to the 16 nuclear CPU and the 64 nuclear simulator, and a detailed analysis of the SIFT algorithm has been made on the influence of the usage of the RAM, the overall line and the expenses for the overflow programs.

Although the parallel algorithm on the above has achieved some acceleration on the extraction algorithm of the local image features, but they do not make a system analysis on the local feature extraction algorithm of parallel method. In this paper, mainly through the systematic analysis of the SIFT parallel algorithm as well as a variety of parallel algorithm of SIFT parallel and its evaluation, we can find out the most suitable method for parallel at present; at the same time, we can provide reference of the parallel design for the parallel system structure based on the multimedia retrieval algorithm in the future.

Analysis of SIFT algorithm

The steps of the SIFT algorithm and other local image feature extraction algorithm are roughly the same, which can mainly be divided into two steps: the feature point detection and the feature point description. The specific steps of the algorithm can be further divided into the following steps:

(1) Establish the image of Pyramid Gauss In order to ensure the stability of the telescopic image, the SIFT algorithm will firstly obtain the information of the image in each expansion range before the input of the image information and then put the description into a Pyramid structure. Each layer of the Pyramid is known as an octave, and each octave image is based on the last octave of the image. The image width and height is reduced by half, and these octave will have been reduced until the width or height is less than 16 pixels, so as to guarantee that the SIFT algorithm can find the required reference telescopic scope. As the Pyramid model is the extension range of a discrete transform, while the SIFT algorithm require a continuous stretching transform so as to find the telescopic scope of its reference. So between these two octave Pyramids, the SIFT algorithm adopts the method of Gauss filter, and establishes a lot of layers, which are known as the Gao Sizi layer intervals. Finally, the Pyramid structure of the image in the SIFT algorithm are as shown in Figure 1

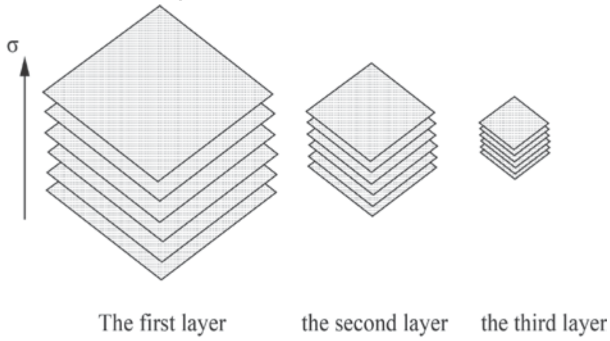


Figure 1. The complete Pyramid structure of the image in the SIFT algorithm

In Figure 1, between the different intervals in the same octave, we adopt the method of Gauss filter, and make the image of the interval gradually close to the fuzzy effects of the next octave until the blur effect is the same as the next octave image. In this way, the entire Pyramid structure contains more image stretching range of information. Therefore, the extracted characteristics of the SIFT algorithm has a very good stability for the scaling transformation. In the detailed calculation, with the same octave and different intervals, the SIFT algorithm can use the following formula to carry out the Gauss filter:

$$L(x, y, \sigma) = G(x, y, \sigma) * I(x, y)$$

Among them, $I(x, y)$ is the corresponding coordinates value in the original image, and in SIFT, it is generally referred as the octave. The value of the image in the first interval is: $G(x, y, \sigma)$. It is the Gauss function that the Gauss filtering inputs in it, the detailed calculation method is as shown in the following formula:

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}}$$

$L(x, y, \sigma)$ is the image which is obtained by the Gauss filter. In the SIFT algorithm, it is mainly the first interval in addition to the other image intervals, wherein the G parameters stands for the filter width Gauss filtering, which directly influence the fuzzy degree of the results of the Gauss filter. When we make the detailed calculation, each octave can be divided into several intervals, which can be defined by the users themselves. Because when the fuzzy degree of the Gauss filter is the same as the next octave fuzzy degree, it will stop the Gauss filtering of the current octave, and as a result, the octave will be divided into more intervals, and correspondingly, the telescopic range will cover more information and the characteristics in theory will be more accurate.

(2) The establishment of the image pyramid of the difference of Gaussians

After the establishment of the image pyramids of the Gaussians, the SIFT algorithm needs to calculate the difference of Gaussians with the help of the Gauss Pyramid. In the actual calculation, the process is very simple. We need simply to subtract the images of these two consecutive intervals.

(3) To find the feature points of the image by the extreme in the Pyramid

After having the pyramid of the difference of Gaussians, we only need to find the corresponding extreme points in the Pyramid, which is the position of the feature points in the corresponding images. The specific method of calculation is to compare each point with the surrounding 26 points (8 points in the same interval and 9 points in both the upper and lower intervals). If it is extreme, then the point is the candidate feature points. This will ensure that no matter it is in the plane or it is in a telescopic stereo space, these feature points will have a better representative significance.

(4) The direction of the calculation feature points

After finding the features points' position of the images, the SIFT algorithm will then compute the main direction of these feature points, so it can match the various rotating and transforming of the images. When we carry out the specific calculation, the SIFT algorithm will firstly calculate the direction E and the gradient M of the points around the feature points according to the following two formulas:

$$m(x, y) = \sqrt{[L(x+1, y) - L(x-1, y)]^2 + [L(x, y+1) - L(x, y-1)]^2}$$

$$\theta(x, y) = \tan^{-1}((L(x, y+1) - L(x, y-1)) / (L(x+1, y) - l(x-1, y)))$$

(5) The description of the feature points

When the main direction of the characteristic points have been finished, the SIFT algorithm will extract the feature values based on these feature points, and eventually they will be used to describe the characteristics of these points. The SIFT algorithm is used to describe the characteristics of the method and it is similar to the calculation of the feature points' direction, which also obtains the characteristic value through the statistics of the direction and gradient around the feature points. Figure 2 shows how to get the characters of the feature points through the statistics.

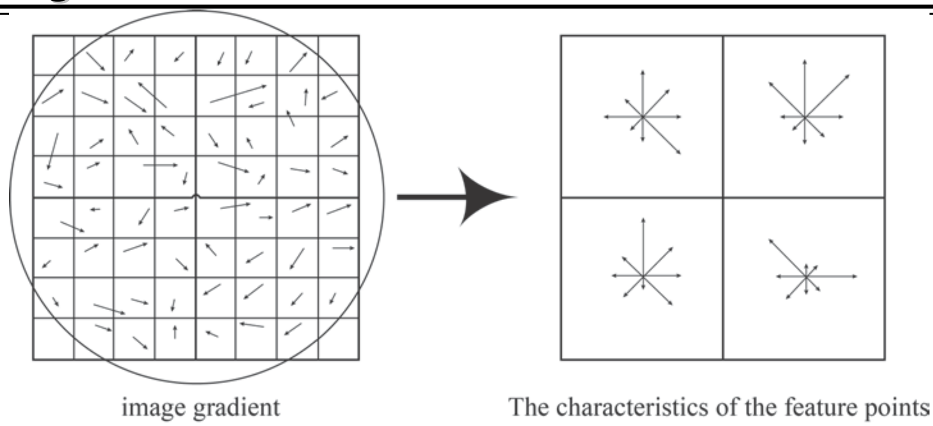


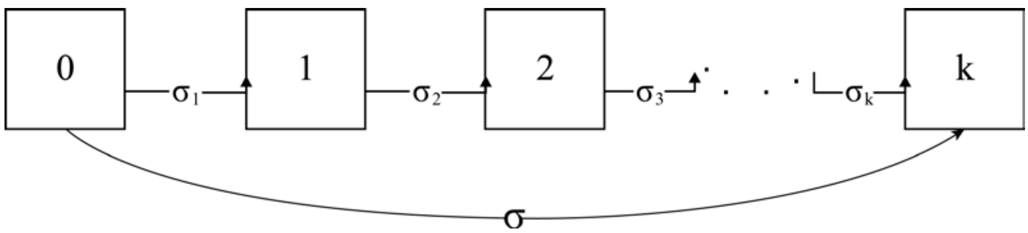
Figure 2. Calculation of the feature value of the feature points

Parallel design and implementation of the SIFT algorithms

The interval parallelism of the image will make analysis of the SIFT algorithm and will implement the corresponding parallel speedup methods. In order to be able to assign work to the average individual workflows that are to be executed in parallel, we need firstly understand the distribution of the SIFT algorithm of the time calculation. The time distribution of the *build_gauss_pyr* function and the *seale_spaee_extrema* function on each layer of the pyramid is performed in accordance with the distribution of the pyramid shape.

In order to realize the parallel speedup of the *build_gauss_pyr* function, we need try to eliminate the dependent relations between the original intervals. In the realization of the original SIFT algorithm, the previous Gaussian calculations usually use an interval as the original image. In order to eliminate the dependencies between the intervals, this article will change the Gaussian calculations into the original image of the first interval with each octave. The following formula shows the equivalence between the two calculations relationship

$$\sigma^2 = \sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \cdots + \sigma_k^2$$



Considering the successive a_l, a_2,…a_k times' Gaussian transforms, which is equivalent to one time from O layer as the parameters. The direct filter and the filter parameters with a previous relationship between the parameters will meet the square and equal relationships. So, we only need to change the parameter of the Gaussian filter so as to eliminate the dependency between the original intervals and make sure that each of the Gaussian filters regards the Interval as the original image. However, since the original purpose that we change the previous interval into an interval previously calculated is to reduce the value of A and enhance the speed. So if we change the method into the first interval calculation method, it is bound to bring a certain time overhead. Through the experimental tests, we will increase the Gaussian filter calculation time by 10% if we change the Gaussian mode to the original way. Compared with the parallel acceleration effect, the little performance lose is cost-effective in general.

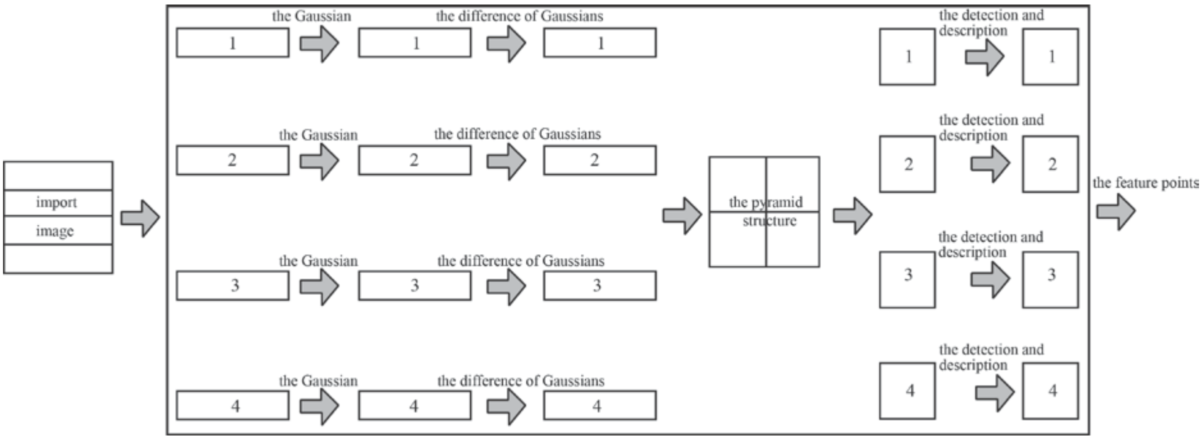


Figure 3. The flowchart of the parallel block SIFT algorithm

When we use the SIFT algorithm in the Gaussian calculations, considering that the need for more memory copy operations and cut sideways Mito method can guarantee the demarcated images on the memory is still continuous, so it is selected in the calculation of the Gauss sideways to cut three knife method for image block. While when we make the feature point detection, because the cut knife method can maintain the ratio of the original image information, the feature point detection method will make a description of each division cut back method. This paper finalized the image block division scheme, Figure 3 is a flowchart of the SIFT Algorithm when we make parallel sub-block division.

Parallel experimental test

When we make the experiment, the test machine used in this paper is the Intel E7310 processor, which has a total of 16 independent1.6GHz computing core; and each core has a 64KB instruction cache and 64KB data cache. At the same time, the 16-core nuclear shares a 16MB of second level cache. The machine has a total of 32G of memory, and the operating system is Debian. Table 1 has listed the main parameters of the test machine

Table 1. The main parameters of the test machine

The number of the processor cores	16
The type of the processor cores	Intel® E7310® 1.6GHZ
Instruction cache	64KB*16
The first level data cache	64KB*16
The second level data cache	16MB（share）
Memory size	32GB
Operation system	Debian Linux

The test data set includes a total of three data sets, the first data set are eight test images. Because this eight pictures have a wide range of applications in the field of computer vision, so each picture has a certain representative image feature. This article select these 8 pictures as a basis for a parallel effect analysis; the second data set, a total of 48 pictures, is used as a small test batch input set, and these 48 pictures are transformed from the eight pictures of the first data set. In addition to the image feature representation, but it is also able to measure the processing speed of the corresponding methods in parallel image shed; the third data set, a total of 2400 pictures, from which some pictures come from its image test set 2, which are mainly used as the test images during a large number of the image processing. The paper use this to assess the effect of the final parallel SIFT algorithm performance.

(1) The basic acceleration effect

In this section, we will adopt a variety of methods to test the acceleration effect of the parallel testing when the SIFT algorithm is in the case of 4-core. First of all, we will use the image test set 1 to test the previous parallel test methods, and obtain the acceleration effect of the respective parallel method under the different image characteristics of the SIFT algorithm. Figure 4 shows the acceleration effect of the SIFT algorithm hierarchical parallel and the block parallel to the 8 pictures in image test set 1.

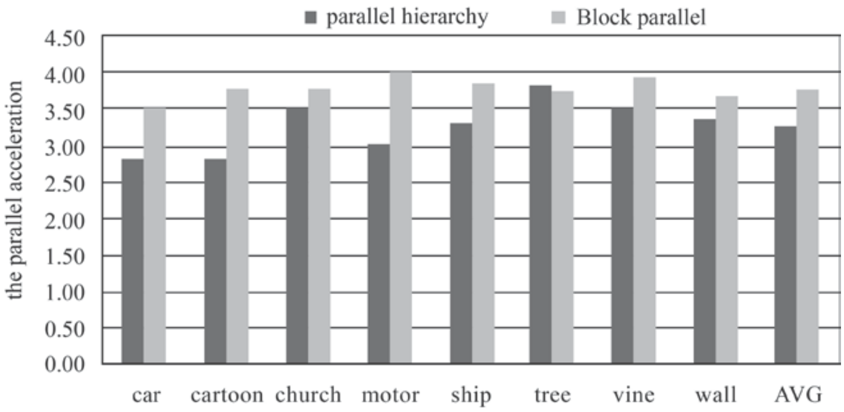


Figure 4. The acceleration effect of the image test set 1

In Figure 4, AVG is the average value, if it is not particularly pointed out, all the average value refers to the geometric average value.

Among them, we did not list the parallel flow lines results, mainly because the parallel flow lines do not have any effect on one picture. This article will regard these 8 images as a whole and put them into the pipeline acceleration. Finally, we can get the acceleration effect of 3.38 times. It can be seen from Figure 4. In general, the effect of the block parallel is the best. The 8 images in the image test set 1can reach a total of 3.82 times of the acceleration. While the parallel effect of the layered parallel is the worst, which only obtains 3.26 times of the acceleration. The distance between the two methods is relatively large. The parallel lines acceleration can reach 3.38 times, which is between the layered parallel and the hierarchical block. Seen from each test image, it is basically based on the method of the block parallel. However, for the tree picture, the parallel effect of the parallel layered approach is best. This is mainly because this tree picture has a large number of the feature points on the first layer, which allows this article layers evenly distribute the task of feature points to each flow line. In this way, we can achieve a better acceleration effect. Of course, the parallel effect of the block parallel method is still excellent, which can reach 3.78 times.

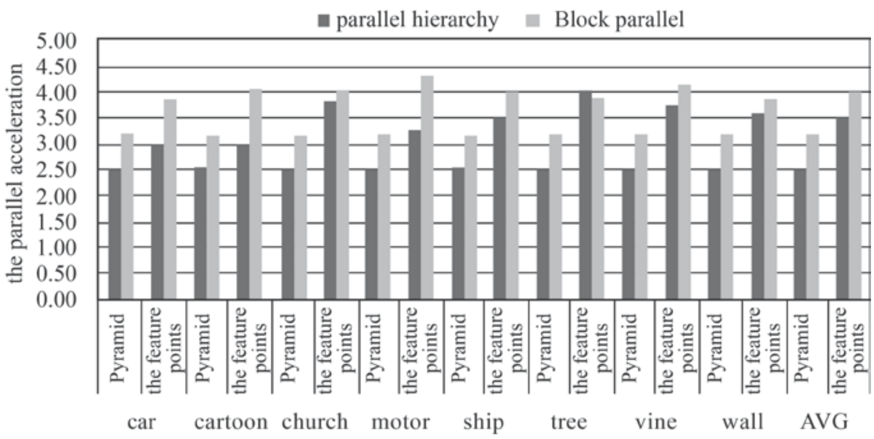


Figure 5. Parallel accelerated distribution of the image test set 1

Because in the SIFT algorithm, the establish time of the Gaussian pyramid will also takes a large number of time, this paper analyzed the images in the set of the image test 1, in which it analyzes the acceleration effect of the two parts separately, including the establish of the Gaussian pyramid and the feature points extraction. Figure 5 is the result of the test.

(2) Optimization of the feature points' parallel description

Compared with the flow parallel and the block parallel, the effect of the hierarchical parallel is less satisfying, which can only reach an acceleration of 3.28 times, while the parallel block can reach the ideal acceleration of 3.8 times.

Through the parallel stratified analysis, we find that the layered parallel has an obvious imbalance task during the stage of the stratified feature point's description. After testing, we can find that when the feature point was described, the flow line that is responsible for the second layer task needs to perform the tasks that are usually more than 30% of the total, which makes this flow line become the bottleneck of the whole process, and lead to the final results of a declined parallel effect. In order to enhance the effect of the layered parallel and the hierarchical parallel, this paper modified the original effect of the layered parallel. When we make the feature point detection, the flow line that is in charge of the second layer has a task about 25%, which is quite balanced. And the unbalanced situation mainly occurs during the period when we describe the feature points. Consequently, this article will use the method of the task chain allocation during the period of the feature point description instead of the original layer division based on the feature points. This will ensures that when we make the description of the feature points, we have a better task balance. However, compared with the original method, this method would require more flow line synchronization to ensure the correctness of the feature points inputting. Figure 6 has added the effect when we have modified the hierarchical parallel of the 2 test image set.

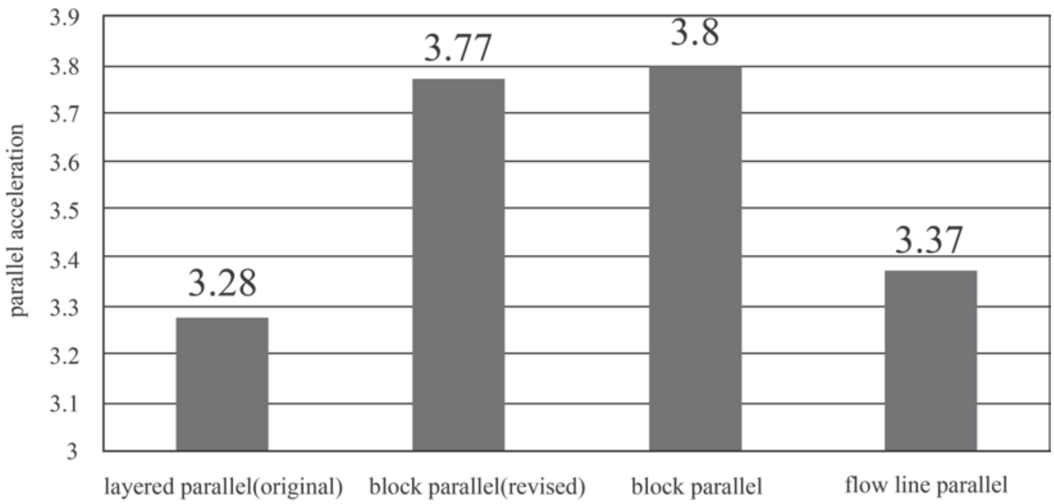


Figure 6. The effect after modifying the hierarchical parallel of the 2 test image set

In Figure 6, the hierarchical parallel (original) is the hierarchical parallel approach that has not been modified; while the stratified parallel (revised) is the stratified parallel algorithms that has been modified in the stage of the feature points' description. Figure 6 shows that, when the division of the tasks that are described in the feature points are modified, the layered parallel effect has been significantly improved, and the acceleration will upgrade from 3.28 times to 3.77 times, which is about the same as the block parallel of 3.8 times. So we can see that the parallel effect has been greatly improved after we have distributed the tasks of the feature points more rationally. It has proved that when we make the parallel algorithms, the balance of the task distribution in each flow line is of vital importance to the effect of the parallel.

(3) Scalability analysis of the parallel method

Thanks to the development of the current multi-core technology, the resources of the current parallel multi-core platform have become more and more rich. The parallel method in this paper has a quite good effect on a 4-core parallel. But whether these methods can achieve a better result or not when the number of the nuclei increases is still an unknown problem. Consequently, we have made a scalability analysis about the previous parallel method in this paper. Figure 7 shows the two kinds of the acceleration effect of the hierarchical parallel when the nuclear extended from 4-core to 8-core and 16-core.

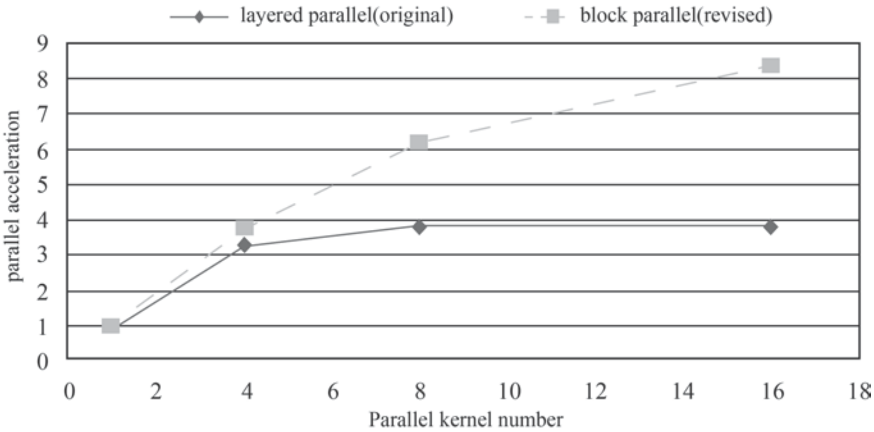


Figure 7. Scalability of the hierarchical parallel

The figure shows that the scalability of the hierarchical parallel before modifying is very poor. The acceleration of the increased parallel nuclear is very small, which is mainly due to the sub-layer of the first octave takes a very large proportion in the SIFT algorithm, usually more than 20% of the time scale, which makes the flow line that is responsible for the first octave become the bottleneck of the whole process. The other flow lines are all waiting for the execution of these flows, thus reduces the overall performance. In contrast, the scalability of the layered parallel approach would be better after the modification, mainly because of the better balance of the task allocation during the period of the feature points' description. What is more, the proportion of time we use to describe the feature points is relatively large. So when concurrent auditor increases, the parallel effects of the feature point's description that accounts for most of the time can obtain a better promotion.

Conclusion

Firstly, we have made a parallel analysis of the current multimedia-image features extraction algorithm that is widely used -SIFT algorithm, and we have identified the parallel elements in the SIFT algorithm as well as the corresponding elements in parallel parallelism; then, we have analyzed the advantages and disadvantages of the various parallel methods, including the layered parallel, the block parallel and the flow parallel; Finally, we have realized all these parallel methods, and we have found the parallel effects of these parallel methods through the experiment tests.

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