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Algorithm-Oriented SIMD Computer Mathematical Model and Its Application

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ABSTRACT

This paper has designed a professional and practical SIMD computer mathematical model based on the SIMD physical machine model combined with the variable addition method. Furthermore, the model is applied in image collection, processing, and display operations, and a SIMD data parallel image processing system is finally established by absorbing the parallel computing advantages of the mathematical model. In addition, the data-parallel image processing algorithm is introduced and the convolutional neural network algorithm is optimized to promote the significant improvement of the main performance such as the accuracy of the application system. The final experimental results have shown that the highest accuracy of the data-parallel image processing algorithm reaches 93.3% and the lowest error rate reaches 0.11%, which proves the superiority of the SIMD computer mathematical model in image processing applications.

KEYWORDS

Convolutional Neural Network Algorithm, Data Parallel Image Processing Algorithm, SIMD Computer Mathematical Model, SIMD Data Caching Model, SIMD Image Parallel Processing System

INTRODUCTION

Single instruction, multiple data (SIMD) is a stream technology in the computer field. It is different from the previous instruction that can process operands only one by one, but can process multiple operands simultaneously to realize the synchronous processing of calculation instructions. SIMD can also diversify to increase throughput, thereby saving a lot of time lost in the registration process. Computers with SIMD characteristics also realize parallel processing in data processing and operations, and they solve complex computer problems efficiently. SIMD computers are also suitable for solving tasks that require a large number of matrix operations.

However, the theoretical knowledge framework of SIMD computers is not mature enough, and its construction on the physical machine and mathematical models still has a defect in that it is only theoretical and lacks practical evidence. Therefore, according to the parallel operation characteristics of SIMD computers, in this paper we first explain how to construct a physical machine model with a more rational structure. On this basis, the state transition in the model is analyzed comprehensively, and an advanced SIMD computer mathematical model is constructed. Moreover, to improve the scientificity of applying the mathematical model to the actual operation process, this paper shows

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how to improve the key performances, such as image processing and detection accuracy for data-parallel image processing algorithms.

This paper discusses the following innovations:

- The physical machine model is rationally designed before the construction of the SIMD computer mathematical model, thus laying a solid theoretical foundation for the construction of the mathematical model.
- The convolutional neural network algorithm is introduced to optimize the data-parallel image processing algorithm, reducing the experimental sample error and improving the data classification accuracy.

Related Work

The construction of computer mathematical models has the full theoretical support for the practical application of computers. Therefore, many computer researchers have conducted in-depth research on the improvement of computer mathematical models. For example, Miura et al (2017) expounded on the importance of the spatial buffer mechanism in the field of brain cell research and proposed a novel spatial buffer computer mathematical model to analyze the buffer characteristics in the brain cell environment. These researchers verified the performance of the model by simulation experiments.

Li et al (2020) first expressed approval for the development prospects of wireless sensor technology and proposed a reasonable computer mathematical model for the current technical difficulties this technology poses. In addition, efficient area coverage algorithms were combined to solve it. The simulation experiments of Li et al (2020) have shown that the model has good performance.

Bian et al (2021) proposed a processing method based on SIMD technology to solve the parallel computing problem of multicore processors and also expounded on the advantages of this method as well as the future optimization direction. Hong et al (2018) wrote a brief overview of the development process of SIMD architecture, and to reflect the parallel operation function of SIMD in the construction of computer mathematical models, proposed a method of rewriting the SIMD loop code to enhance the practicability of SIMD. The aforementioned related research on computer mathematical models has greatly enriched the theoretical knowledge of model construction and played an important role in the improvement of the functions of different types of computers. However, the above studies focus on only the construction of computer theoretical models; they ignore the measurement of the actual application effect of the model.

The SIMD computer mathematical model plays an important role in image processing, and the image processing algorithm is also an indispensable, important method in this process. Many scholars have conducted in-depth research and discussion on this process in recent years. For example, Saussard, et al (2018) have scientifically described the current status of driver assistance systems, and they have proposed a feasible solution to combine image processing algorithms with the system and enable it to run in real environments. They revealed relevant implementation problems and specific implementation steps that have been solved by this scheme.

Lazarov et al (2017) conducted a detailed review of commonly used traditional image processing algorithms and introduced the main features of inverse synthetic aperture radar (ISAR) technology. Then, focusing on the problem that ISAR images are easily affected by factors such as shadow occlusion during the identification process, these researchers proposed an improved image processing algorithm for ISAR images. Shen et al (2020) explained the design concept and mechanism of thick plates in detail, described the deformation process of thick plates, introduced an image processing algorithm to improve the accuracy of the grid diagram design of the thick plate, and proved the unique advantages of the designed grid diagram.

Moness et al (2021) described the characteristics of the physical conditions required by today's young athletes in swimming and introduced image processing algorithms for anthropometric measurements of swimmers. Using experimental data, these researchers then demonstrated how the algorithm improves image accuracy.

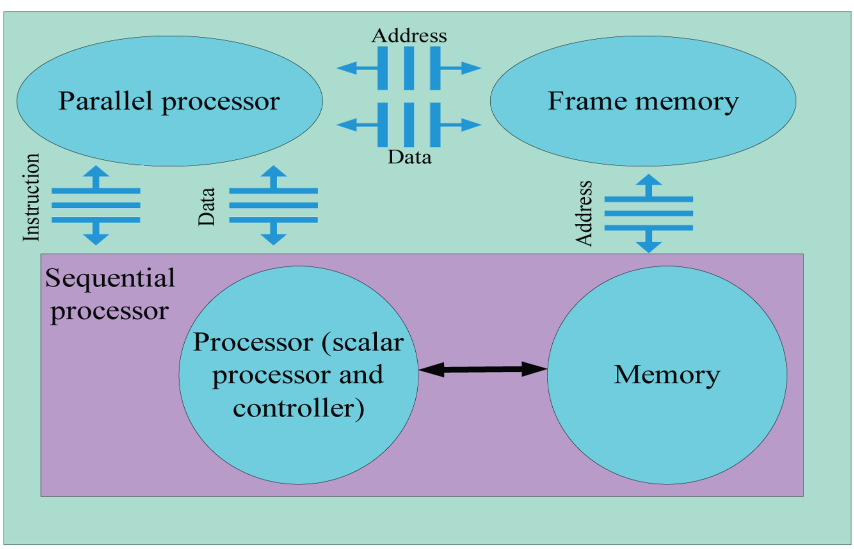
Hore et al (2019) described the commonly used filter structures and their functions in detail and proposed an image processing algorithm that can enhance contrast to solve the problem that computational operations in two-dimensional filters need to occupy high memory. Hore et al (2019) also analyzed the possible results of the algorithm. Liu et al reviewed the existing research on the application of internet technology to the problem of garbage classification. On this basis, Liu et al (2020) proposed a new type of garbage classification system, proposed an original image processing algorithm in the design of the software components of the system, and proved the accuracy performance of the algorithm by experiments. The above research on image processing algorithms has effectively broadened the application field of the algorithm. However, the performance of the above algorithms in image classification accuracy is relatively general, and it is difficult to meet the accuracy requirements of large-scale image processing systems.

ALGORITHM-ORIENTED SIMD COMPUTER MATHEMATICAL MODEL AND ITS APPLICATION SYSTEM CONSTRUCTION

An SIMD computer is a type of computer divided according to the concept of instruction and data flow. It has the advantage of processing vector units over other computer types. When you are manipulating vectors, any instruction in the computer can operate on more than one unit of data. Therefore, SIMD computers are the first choice for specialized computing. In this paper, we studied in depth the concept of an SIMD computer and its application. First, we described how the model of an SIMD computer is designed. This model plays an important role in building a professional computer mathematical model. SIMD computer models generally fall into two categories. Considering the strict requirements of the physical structure of the SIMD computer mathematical model designed in this paper, we selected a suitable physical machine model to study. Its specific structure is shown in Figure 1.

In Figure 1, the SIMD computer physical machine model consists of three parts: frame memory, serial processors, and parallel processors. The most important part is the serial processor, which is the core processor in the entire physical machine-running process. The serial processor exchanges real-time information with

Figure 1. Composition of SIMD computer physical machine model



the parallel processor and frame memory. Among them, the serial processor and the frame memory transfer only address information, whereas the parallel processor can simultaneously exchange information between data and instructions. The parallel processor can process, control, and store information simultaneously. The three components of the SIMD computer physical machine model interact with each other and carry out effective information transfer, thus forming a powerful grid interconnected SIMD computer.

After the model design is completed, the SIMD computer mathematical model is constructed based on the data parallel image processing algorithm. In this paper, we probabilistically analyzed the state transition of the model using the supplementary variable method and established a standardized SIMD computer mathematical model.

Let $y(r)$ be the state representation of the computer system at time r. Since $\{y(r), r \geq 0\}$ does not belong to the Markov process, this paper introduces advanced variable $z_i(r)$ to supplement the time when the system remains in state i, $i = 1,2$. From the above expression, it can be deduced that:

$$x(r) = \begin{cases} y(r), & y(r) = 0 \\ (y(r), z_1(r)), & y(r) = 1 \\ (y(r), z_2(r)), & y(r) = 2 \end{cases} \tag{1}$$

Formula (1) shows that $\{x(r), r \geq 0\}$ belongs to the Markov process in the generalized range and can be deduced as follows:

$$q_0(r) = Q(y(r) = 0) \tag{2}$$

$$q_i(y, r) = Q(y(r) = i, y < z_i(r) \leq y + dy), i = 1,2 \tag{3}$$

Among them, dy represents the amount of change in y. $q_0(r)$ represents the possibility that the system would remain in the state of 0 until time r. $q_i(y, r)$ represents the possibility that the parallel operation time is y when the system remains in state i at time r.

At this time, according to the characteristics of the SIMD computer system, $q_i(y, r)$ is added to the restriction condition $y > r$, and the occurrence rate of the system leaving the i state is defined as (Zhao, T., et al, 2018):

$$\begin{aligned} \sigma_i(y)\Delta r &= Q(y < z_i(r) \leq y + \Delta r \mid z_i(r) > y) \\ &= \frac{Q(y < z_i(r) \leq y + dy)}{Q(z_i(r) > y)} \\ &= \frac{dL_i(y) / dy}{1 - L_i(y)} \Delta r, r = 1,2 \end{aligned} \tag{4}$$

In formula (4), $\sigma_i(y)$ is a non-negative and measurable function form, and its value range is $0 < \sigma_i(y) < \infty$.

Then, the state transition of the system after Δr time is deduced. Let η_1 be the error rate of the system hardware, and η_2 be the error rate of the system model. $\sigma_i(y)$ represents the probability of parallel operation for the above errors when the system remains in state i, which can be obtained from the full probability formula:

$$q_0(r+\Delta r) = q_0(r)(1-(\eta_1+\eta_2)\Delta r + o(\Delta r)) + \sum_{i=1}^{3}\int_0^{\infty}\sigma_i(y)q_i(y,r)\Delta r dy + o(\Delta r) \tag{5}$$

$$q_i(y,r) = q_i(y,r)(1-\sigma_i(y)\Delta r + o(\Delta r) \tag{6}$$

Combining formulas (5) and (6) and letting $\Delta r \to 0$, we deduce that:

$$\begin{cases} \dfrac{d_{q_0}(r)}{dr} = -(\eta_1+\eta_2)q_0(r) + \sum_{i=1}^{2}\int_0^{\infty}\sigma_i(y)q_i(y,r)dy \\ \dfrac{\partial q_i(y,r)}{\partial y} + \dfrac{\partial q_i(y,r)}{\partial r} = -\sigma_i(y)q_2(y,r) \end{cases} \tag{7}$$

$\frac{\partial q_i(y,r)}{\partial y}$, $\frac{\partial q_i(y,r)}{\partial r}$ respectively represent the partial derivative of $q_i(y,r)$ with respect to y and r. Finally, the variation law of the derivative with time on the boundary of the solution area in the SIMD computer system and the initial default condition are deduced. Let $q_i(0,r)$ be the possibility that the system is just set to or transformed into the i state at time r; that is, the possibility that the system leaves the state of 0 at time r. The specific expression is:

$$q_i(0,r+\Delta r)\Delta r = \eta_i q_0(r)\Delta r + o(\Delta r) \tag{8}$$

At this time, if $\Delta r \to 0$, the variation law of the derivative on the boundary of the solution area with time can be obtained:

$$q_1(0,r) = \eta_1 q_0(r), q_2(0,r) = \eta_2 q_0(r) \tag{9}$$

Under the same circumstances, if the state measurement is carried out from the time when the system enters the normal operation state, the initial default conditions of the system can be obtained:

$$q_0(0) - 1, q_1(y,0) = q_2(y,0) = 0 \tag{10}$$

According to the above formula, the final SIMD computer mathematical model representation can be obtained:

$$\begin{cases} \dfrac{d_{q_0}(r)}{dr} = -(\eta_1+\eta_2)q_0(r) + \sum_{i=1}^{2}\int_0^{\infty}\sigma_i(y)q_i(y,r)dy \\ \dfrac{\partial q_i(y,r)}{\partial y} + \dfrac{\partial q_i(y,r)}{\partial r} = -\sigma_i(y)q_2(y,r) \\ q_1(0,r) = \sigma_1 q_0(r) \\ q_2(0,r) = \sigma_2 q_0(r) \\ q_0(0) = 1, q_1(y,0) = q_2(y,0) = 0 \end{cases} \tag{11}$$

Application System Construction of an SIMD Computer Mathematical Model

After constructing a scientific and practical SIMD computer mathematical model, we apply the model to image collection and processing operations. The parallel operation function is added to the image convolution operation, which can not only easily obtain the image convolution result but also ensure the accuracy of the result, thereby greatly promoting the process of image convolution operation. Therefore, the SIMD computer mathematical model has very good adaptability to image processing operations. In the whole process of image processing technology optimization, the core concept of the SIMD computer mathematical model is first applied to the image convolution processor. This processor provides a solid foundation for the construction of the subsequent parallel image processing system. The processor is constructed as shown in Figure 2.

Figure 2 shows the structure of the image convolution processor based on the concept of the SIMD computer mathematical model, which is mainly composed of four parts: the storage system and the three parts of control, processing, and interface (Al-Sudany, S. M., et al, 2020). Among them, the storage system exists as a large data container for data reception, effective information storage, and reasonable classification of image data. The control component controls the operation of each unit in the processor by issuing key control information. The processing component implements SIMD processing for the information to be operated so that unnecessary cost loss in the operation process can be reduced. The function of the interface component is to collect and transmit data, as well as reasonably process the signals sent and received.

After the SIMD convolution operation is performed on the image, a data cache model that can store and optimize the reorganization of the data must be designed so that the processed image data can be received and distributed appropriately. The number of times the memory is accessed is controlled within a reasonable range, and the connection of the image convolution processing results is finally completed. The general structure of the data cache model based on the SIMD computer mathematical model is shown in Figure 3.

Figure 2. Image convolution processor under the SIMD computer mathematical model

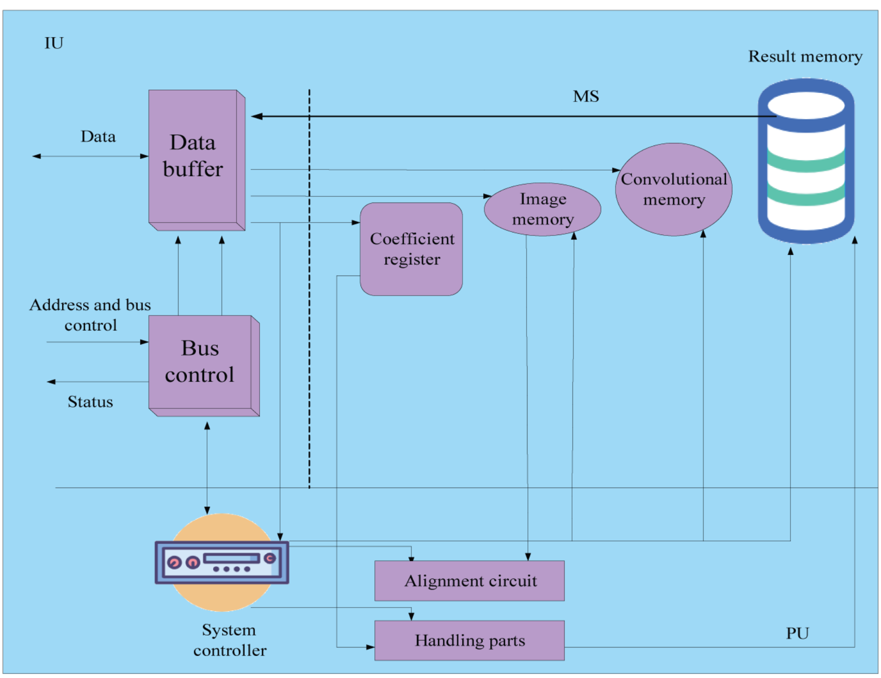
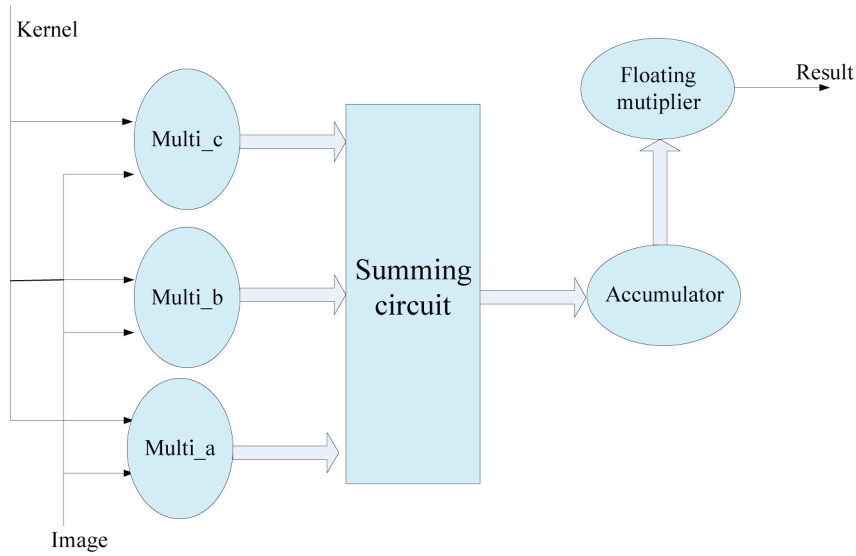


Figure 3. SIMD data cache model



As the data cache architecture in Figure 3 shows, the operation process of the model is roughly as follows: The image convolution result obtained by the operation of the convolution processor is put into the kernel storage container, and then the result is divided into three lines of data to perform data writing operations, respectively. These three lines of processed data are then integrated and superimposed. Finally, a floating multiplier is used to calculate the final image data result (Lai, B. C., et al, 2019). Through this step, the memory use can be greatly improved, and it is obviously helpful for image data integration.

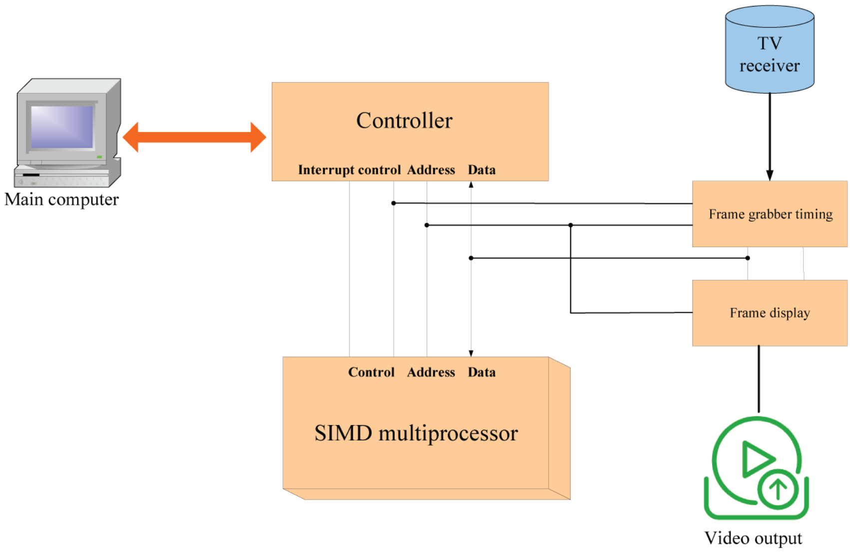
After the above optimization preparation operations are completed, the proposed SIMD computer mathematical model is applied to the final image processing design. Applying this model makes the system have better data parallel processing capabilities on the basis of traditional image systems. The speed of image collection, processing, and display is greatly improved, and the original to-be-processed image data is subjected to several scientific operations to present the best image visual communication effect. The components of the system are shown in Figure 4.

From the analysis of the image processing system based on the SIMD computer mathematical model in Figure 4, the system is mainly composed of a host computer, an image controller, a data receiver, an SIMD parallel processor, and a data display. The core system component is a processor device with parallel operation that integrates the SIMD computer mathematical model. The processor interacts with the controller for key information such as control information, addresses, and data. Moreover, all information can be operated in parallel, thereby accelerating image processing and saving a lot of time and cost for subsequent image display operations. In addition, the processor can be divided into various subprocessors with specific functions, such as edge judgment processing, to enhance the operation efficiency of the entire system through parallel processing.

Data Parallel Image Processing Algorithms

In this paper we use the data-parallel image processing algorithm to scientifically optimize the image analysis and processing process of the image processing system proposed in this paper. The first step is to define the edge determination operation in image processing (Nasirullah, A. A., 2020). The edge point is defined as the point where the degree of change of the image to be operated is extremely fast.

Figure 4. SIMD image parallel processing system



Usually there is more than one white pixel around the black edge point, which makes the pixel basis item (l,m) meet the following conditions:

$$\begin{cases} v(l,m)=0, k(l,m)=1 \\ k(l,m)=[v(l,m)\oplus v(l\pm 1,m)]or[v(l,m)\oplus v(l,m\pm 1) \end{cases} \tag{12}$$

The edge direction derivative of the image $g(y,z)$ with non-discontinuous characteristics should meet the requirement of being the maximum value in the local range. Therefore, the edge can be determined by the slope of this image along the edge direction of r (Amrutha, U., 2020). Let k_1 and k_2 denote the slope parameters, respectively, both of which are used to calculate the slope of $v(l,m)$ in two vertical directions. The modulus and direction of the slope vector are expressed as follows:

$$k(l,m)=(k_1^2(l,m)+k_2^2(l,m))^{1/2} \tag{13}$$

$$\varepsilon(l,m)=\tan_{-1}(k_2(l,m)\,/\,k_1(l,m)) \tag{14}$$

Among them, ε represents the angle of the edge direction. The calculation process of $k_1(l,m)$ and $k_2(l,m)$ usually uses the slope parameter and the operation relationship between the pixels. The modulus value of the slope vector can also be converted into Formula (15):

$$k(l,m)\approx\mid k_1(l,m)+\mid k_2(l,m)\mid \tag{15}$$

In a uniform area of the image, assuming that $k(l,m)$ has a larger value range than the threshold s, then $v(l,m)$ can be represented as an edge point (Al-Marakeby, A., 2020). All the points are joined together to form a linear representation $d(l,m)$:

$$d(l,m)=\begin{cases}1,(l,m)\in H_k\\0,(l,m)\notin H_k\end{cases} \tag{16}$$

Among them, $H_k=\{(l,m);k(l,m)>s\}$. By establishing $d(l,m)$, the final edge position can be established.

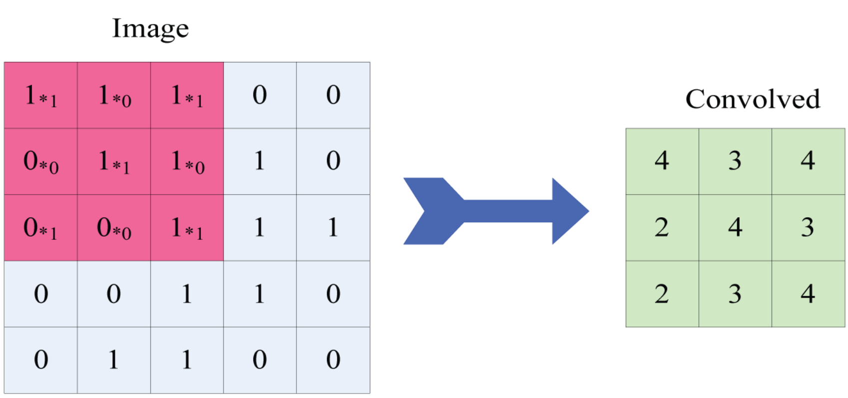
We use the convolutional neural network correlation algorithm model to improve the above data-parallel image processing algorithm. The convolutional neural network has always been a key algorithm in the field of image recognition, and it has a fairly stable performance in data classification. In the convolutional neural network, the model structure is divided into three types: the layer structure used in the output process, the layer structure used in the convolution process, and the layer structure used in the aggregation process (Wang, X., et al, 2017). The convolutional layer is one of the most important parts of the convolutional neural network, which is mainly used to obtain the data information of the previous layer. Its convolution operation is shown in Figure 5.

In the convolutional layer, before you select a suitable function with an activation function to perform the band filtering operation, it is necessary to learn the relationship corresponding to the features of the previous layer. The composition of the convolutional layer can be expressed by Formula (17):

$$y_p=\int\prod_{i=0}^{I-1}\prod_{h=0}^{N_i}(j_{hi,p}*y_{h,p-1}+c_{i,p}) \tag{17}$$

In Formula (17), y_p represents the feature correspondence display map of the p-th layer of the convolutional layer, and the resolution of the map is changed by the downward sampling function to strictly limit the increase or decrease of the number of features (Ren, S., et al, 2017). At the same time, the size of the corresponding area in the input process can also be increased, and the feature correspondence display diagram can be displayed by Formula (18):

Figure 5. Schematic diagram of convolution operation



$$y_p = \prod_{i=0}^{I-1} \int \chi_{i,p} down\_s(y_{i,p-1}) - c_{i,p} \tag{18}$$

Among them, χ represents the weight of the downward sampling process, and $down\_s()$ represents the function expression of the downward sampling. Then, the feature correspondence is divided into squares with side length a that do not affect each other, and the feature representation in each square is averaged. In addition, each feature correspondence is reduced by a factor element of a.

The next step is to select an appropriate activation function to enhance the learning ability of the entire network model. Considering the high demand of the image processing system designed in this paper for the convergence speed of the network, we select the ReLU function for nonlinear processing (Evo, I. & Avramovi, A., 2017). Its function expression is shown in Formula (19).

$$f(w_s) = \begin{cases} w_g, w_g > 0 \\ 0, w_g \leq 0 \end{cases} \tag{19}$$

Among them, w_g represents the input data, and the activation layer of the ReLU function needs to consider only the size of w_g. If the input value is less than or equal to 0, the gradient of this layer would become 0; otherwise, if it is greater than 0, the gradient of this layer would not be changed. However, this function is also prone to failure to activate at high speed. Therefore, we choose the Leaky ReLU function, a variant of this function, to solve the above problems. The expression of the Leaky ReLU function is shown in Formula (20):

$$f(w_p) = \begin{cases} w_p, w_p \geq 0 \\ \eta w_p, w_p < 0 \end{cases} \tag{20}$$

The input data is represented by w_p. After the feature correspondence display graph with two-dimensional space is made one dimensional by means of tiling, the graph is represented as the input of the structural layer with the fully connected property as shown in Formula (21):

$$y_p = \int (\varphi_{p-1} y_{p=1} - c_{p-1}) \tag{21}$$

In Formula (21), φ_p represents the attribute parameter of the input weight, and c_p represents the offset. Typically, convolutional layers are max-pooling layers. These layers reduce the size of feature maps by dividing them into blocks and replacing the entire block with its maximum value.

The SIMD Computer Mathematical Model Applied to an Image Processing System

To explore the design effect of the SIMD computer mathematical model proposed in this paper and the performance of applying the model to image processing operations, we conducted professional data analysis in the form of a questionnaire survey and experimental simulation for these two parts. We first invited professional researchers in SIMD computer design and development to evaluate the SIMD computer mathematical model designed in this paper. The researchers conducted a comprehensive comparison of the model from four different properties of the mathematical model. The evaluation results are shown in Table 1.

From the characteristic evaluation results in Table 1, you can see that four professionals in the field of SIMD computer research gave a very high evaluation to the model. The average score for all four features of the model remains above 4.25. Among them, the practicality of this model has been widely recognized. All four researchers gave it a full score, which shows that the model has the most prominent features of practicability, and it is highly feasible to apply the model to the actual environment.

Therefore, we applied the proposed SIMD computer mathematical model to two digital signal processing technologies with strong compatibility, and analyzed the practicability of the model in the actual operating environment. The model is first combined with a finite impulse response filter (FIR). Different FIR scales are selected to explore the comparison of FIR running time before and after combining the mathematical model. The specific data comparison is shown in Figure 6.

In the data comparison in Figure 6, the FIR based on SIMD technology has a significant optimization in running time compared with the traditional FIR. Among them, as the scale of FIR continues to increase, the gap between the running time of the two also continues to widen. When the FIR scale is 960×1920, the running time of the traditional FIR reaches 1242.08 μs, while the running time of the improved SIMD-FIR is only 617.32 μs. The gap between the two reaches the maximum value, which indicates that the SIMD computer mathematical model has a very good role in promoting signal processing.

Table 1. Characteristic evaluation of the SIMD computer mathematical model

Characteristic	Researcher				
	R1	R2	R3	R4	Mean
Scientific	5	4	5	5	4.75
Innovative	4	4	4	5	4.25
Practicality	5	5	5	5	5
Comprehensive ability	4	4	5	4	4.25

Figure 6. FIR running times before and after combining SIMD computer math models

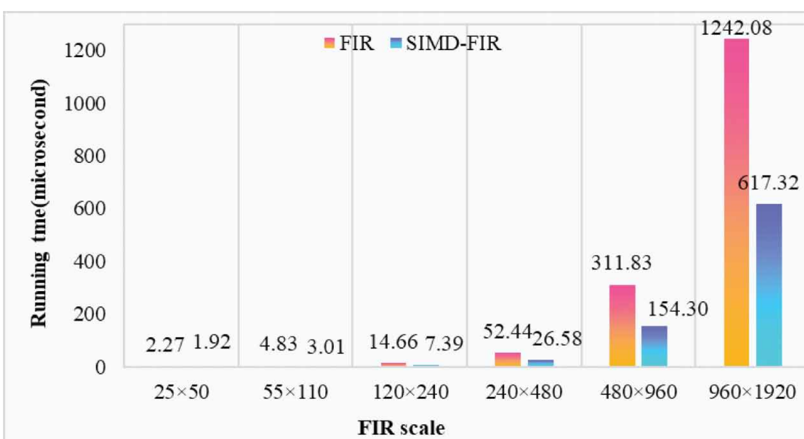


Figure 7 shows the runtime optimized performance of the SIMD computer mathematical model applied to another digital signal processing technique, the fast Fourier transform (FFT). In this experiment, different FFT points are also selected for comparative analysis.

Figure 7 shows the powerful advantage in the running time of the FFT after the SIMD computer mathematical model is improved. Among the different FFT points selected in the experiment, the running time of SIMD-FFT is less than that of traditional FFT. Among them, when the number of FFT points reaches the maximum value of 1920, the running time difference between the two also reaches the maximum value of 171.63. This further proves the powerful practicability of the SIMD computer mathematical model in the actual operating environment.

According to the running time data before and after the combination of the SIMD computer mathematical model and two digital signal processing technologies in Figures 6 and 7, we focus on analyzing the running time optimization ratio of the model for the two technologies. We also explore how the speed optimization ratio changes as the FIR size and the number of FFT points change significantly. In addition, the structure and composition of the SIMD computer mathematical model can be further adjusted according to the final data comparison.

Table 2 shows the runtime optimization performance of the model for these two signal processing techniques for different FIR scale and FFT point numbers. Among them, when the FIR scale increases from a small scale to a large scale, its speed optimization ratio increases greatly. When the FIR scale

Figure 7. FFT runtime before and after combining SIMD computer math models

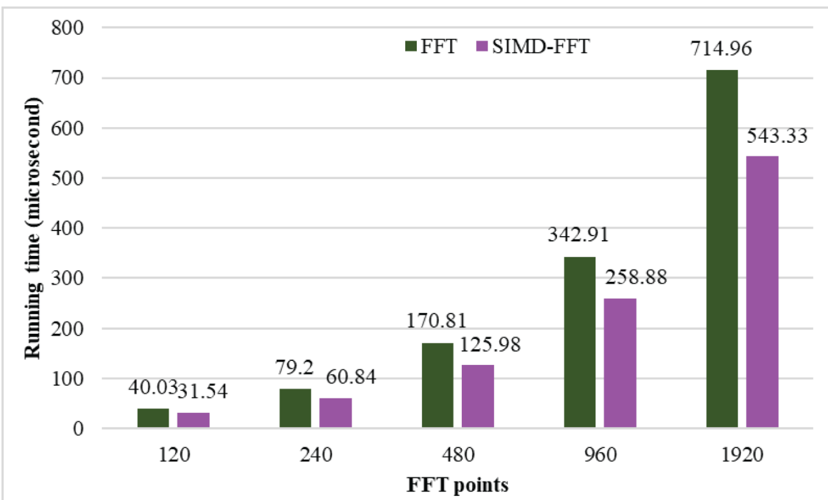


Table 2. The speed optimization ratio of the SIMD computer mathematical model for the two technologies

FIR scale	Speedup ratio (%)	FFT points	Speedup ratio (%)
25×50	15.4	120	21.2
55×110	37.7	240	23.2
120×240	49.6	480	26.2
240×480	49.3	960	24.5
480×960	50.5	1920	24.0
960×1920	50.3		

is 25×50, its speed optimization ratio is only 15.4%. When the scale is increased to 480×960, the speed optimization ratio is increased to 50.5%. In the change of FFT points, the increase of FFT points has little effect on the speed optimization ratio, and the maximum difference of the speed optimization ratio is only 5.0.

After verifying the practicability of the SIMD computer mathematical model proposed in this paper in the actual environment, we analyzed the performance of the SIMD parallel image processing system designed in the field of image processing and display. First, we launched a questionnaire survey to the aforementioned four researchers about the design quality of the system, and each question was scored between 0 and 10 points. Table 3 shows the questionnaire evaluation results of the four research scholars.

In Table 3, the four researchers expressed a high degree of affirmation for the system's performance on all four issues. Among them, the SIMD computer mathematical model has the highest average score in the evaluation of the degree of embodiment of the system, reaching 9.75 points, and the lowest average score is the system structure design and overall system evaluation. However, it also reached a high level of 8.25 points, which shows that analyzing the system from a professional perspective has a very good design concept and that the SIMD computer mathematical model plays an important role in the system.

In addition, we also conducted simulation experiments to explore the important performance of the system; that is, the error rate, which is used to evaluate the detection effect of the system on image data. In this paper, the original image processing system without SIMD computer mathematical model optimization is selected as the control group, and a large number of image samples are selected to enhance the scientificity of the experiment. The experimental results are shown in Figure 8.

It can be seen from the data analysis in Figure 8 that the SIMD parallel image processing system proposed in this paper has a better image detection effect. Among them, in the whole testing process, the miss rate of this system is always lower than that of the original system, and the miss rate declines faster. This intuitively reflects that the system has excellent performance in image detection. At the same time, it can also be concluded that the SIMD computer mathematical model proposed in this paper has sufficient advantages in the field of image detection and processing.

Application of Data Parallel Image Processing Algorithms

In this paper we tested the key performance of the data-parallel image processing algorithm used in image data processing, such as error control and accuracy, to verify the optimization degree of the algorithm applied to image processing for image rendering. To improve the classification effect of image processing algorithms, this paper proposed a convolutional neural network algorithm to optimize image data classification. This paper compared the error performance between the convolutional neural network algorithm and the commonly used image classification algorithm BP neural network algorithm. A total of 210 image samples to be processed were selected, and two control experiments were carried out to strengthen the professionalism of the experiment. The errors of the two algorithms are shown in Figure 9.

Table 3. System performance questionnaire of SIMD parallel image processing system

Question	Researcher				
	R1	R2	R3	R4	Mean
Image processing method	9	9	9	10	9.25
System structure composition	8	8	9	8	8.25
The level of representation of SIMD computer mathematical models	10	10	9	10	9.75
Overall system evaluation	8	9	9	7	8.25

Figure 8. Missing rate results for both systems

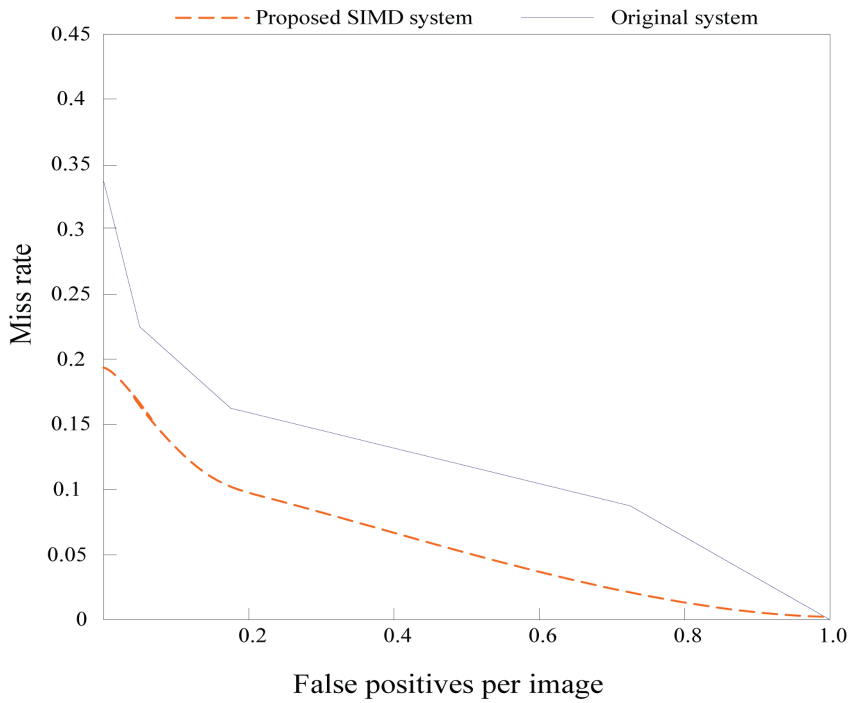


Figure 9. Comparison of two error data rates for the two algorithms

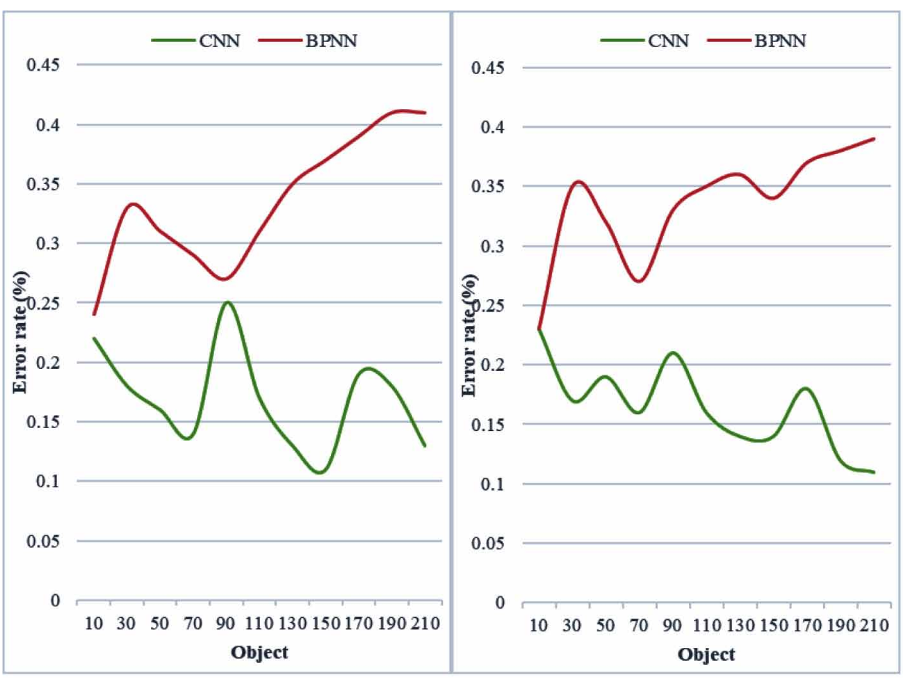


Figure 9 shows that the image processing optimization algorithm adopted in this paper has a stronger error control ability, and its error rate performance is always lower than that of the BP neural network algorithm. Among them, the error rate of the convolutional neural network algorithm is generally distributed between 0.1% and 0.2%, and the lowest error rate is 0.11%. In contrast, the lowest error rate of the BP neural network algorithm is only 0.23%.

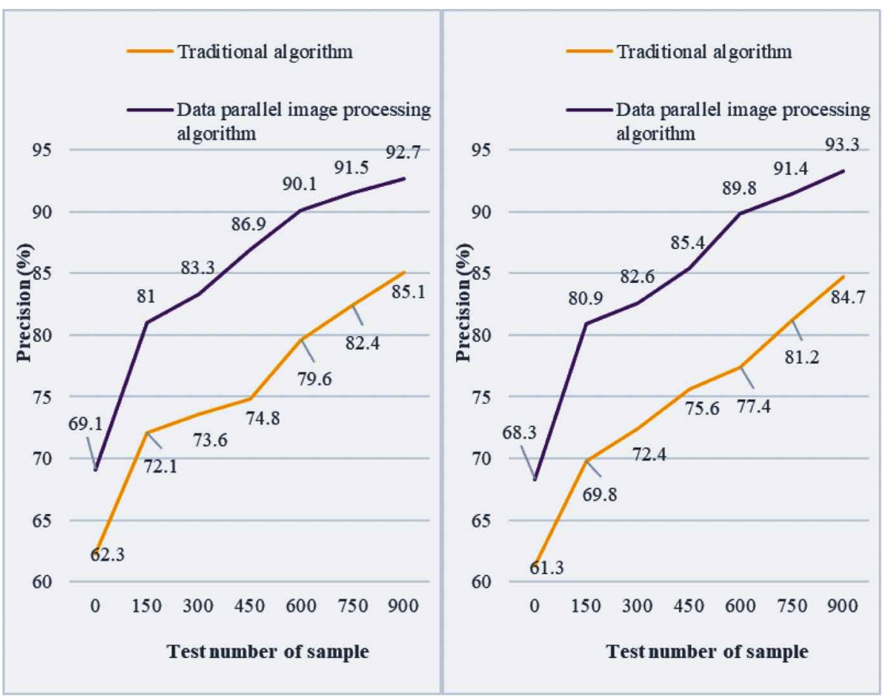
Finally, this paper compared the optimized data-parallel image processing algorithm with the traditional image processing algorithm. To explore the final performance of the algorithm after optimization by the SIMD computer mathematical model and the convolutional neural network, we selected the image classification accuracy as the performance measurement of the two algorithms. At the same time, to improve the accuracy of the experimental data, we expanded the experimental sample capacity to 900 and two control experiments in the same environment were taken. The final image classification accuracy is shown in Figure 10.

Figure 10 shows the results of two precision experiments between the data-parallel image processing algorithm and the traditional image processing algorithm. Among them, the highest accuracy of the data-parallel image processing algorithm reached 93.3%, while the latter's highest accuracy was only 85.1%. The accuracy gap between the two is large, and the accuracy results of data-parallel image processing algorithms have always been in the leading position. This demonstrates the unique advantages of data-parallel image processing algorithms in image processing and classification.

CONCLUSION

The construction of the SIMD computer mathematical model has a significant role in promoting the application of an SIMD computer in the fields of signal processing and image detection. Because the traditional computer mathematical model focuses on model construction and algorithm injection only, it does not test the actual application effect of the model. This leads to the following result: the

Figure 10. Two accuracy comparison results for the two algorithms



computer mathematical models designed are often at the theoretical level. This paper has incorporated SIMD computer system characteristics. Through the design of the physical machine model, a SIMD computer mathematical model that is more suitable for actual needs is constructed, and the model is applied to the field of image detection and processing, thereby creating a high-speed SIMD image parallel processing system. In terms of algorithms, this paper was oriented to data-parallel image processing algorithms. In addition, on this basis, it was optimized by combining the convolutional neural network related algorithms to improve the image accuracy performance of the algorithm. The SIMD image parallel processing system supported by this optimization algorithm has a breakthrough innovation in image processing.

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