Multi-source remote sensing image big data classification system design in cloud computing environment

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Abstract: Due to the problems of poor classification and time-consuming in traditional multi-source remote sensing image big data classification system, it cannot meet the standard requirements for image big data classification in related fields. To solve the above problems, the multi-source remote sensing image data classification system under cloud computing environment is optimised. Following the line string transmission protocol architecture, relevant information is processed, transformed and fused. Data are transported to the host through protocol transmission. Based on above principle, the system hardware and software are designed. Detailed, designing hardware system refers to designing image sensor interface and system processing interface. The design of the system software part can be divided into two parts, including the two-wire serial protocol formulation and the image big data classification algorithm that provides users with initialisation operations. At the same time, the image is sharpened and the pixels are improved. Experimental verification results show that the system has good processing effect and short time consumption.

Keywords: cloud computing environment; multi-source remote sensing; image big data; classification system.

Reference to this paper should be made as follows: Tong, X-Y., Guo, C. and Cheng, H. (2020) 'Multi-source remote sensing image big data classification system design in cloud computing environment', *Int. J. Internet Manufacturing and Services*, Vol. 7, Nos. 1/2, pp.130–145.

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1 Introduction

In the late 21st century, with the development embedded system in China, multi-source remote sensing image processing successfully transferred to the computer system platform. Using multi-source remote sensing image big data led to an increase in feature dimensions. The redundancy and noise brought by this can reduce the efficiency of the image big data classification process. When redundancy and noise reach a certain load limit of the system, system stopped running or image data were lost. Data packet loss caused confusion of image big data classification, which in turn led to a decrease in classification accuracy. Therefore, it was necessary to design a multi-source remote sensing image big data classification system under cloud computing environment (Kang and Lee, 2016; Liu et al., 2013b). The system used microprocessor and memory electronics as core. The operation of the system can realise real-time control and remote monitoring of image big data classification.

Multi-source remote sensing image big data classification research was a subject of informatics research and the scope of research in this topic was wider. Accompanied by the rapid development of computer technology in China, image big data classification made great progress both in principle and application (Chen et al., 2016; Yan et al., 2017). With the influence of large-scale integrated circuits and programming, image processing system design was also constantly innovating and improving. The high density in cloud computing was an array of programmable logic controllers that logically arrange the cells in the structure. Using a cloud computing environment in your system can provide logical access and provide lower power. This mainly included input, output, configuration logic modules and programmable connection resource modules.

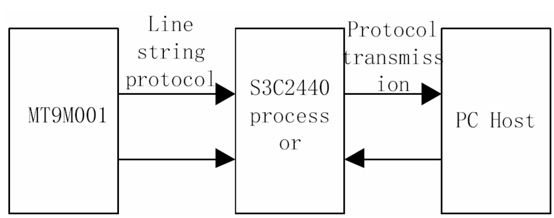
Multi-source remote sensing image big data classification was a process of converting image signals classified by big data into digital signals. This process can broaden the application of real-time image processing. However, traditional systems had problems such as poor processing effect and long time-consuming. They cannot meet the high standard requirements for image big data classification in various fields (Yang et al., 2018; Li et al., 2017; Liu et al., 2013a).

Based on the above problems, a multi-source remote sensing image big data classification system for cloud computing environment was proposed. Under the cloud computing environment, the overall structure of the multi-source remote sensing image big data classification system was designed. Follow the line-string transmission protocol architecture processing system block diagram to process, transformed and integrated related information. The system hardware and software were designed based on the protocol transmission method. The image sensor interface and system processing interface were designed for the hardware part of the system. The experimental verification results showed that the system can efficiently classify all multi-source remote sensing images in the cloud computing environment. And the classification time was short, which can meet the standard requirements for classification of image big data in related fields.

2 System overall structure design

The multi-source remote sensing image big data classification system design structure block diagram in the cloud computing environment was shown in Figure 1. Its main components included MT9M001 model sensor, ARM processor and PC host.

Figure 1 Processing system block diagram



It can be seen from Figure 1, the system followed the string transmission protocol. It used MT9M001 model sensor to transmit frame data, line data and pixel data to the S3C2440 processor. It went through the processor for related big data processing, transformation and fusion, and transmits data to the image processing host through protocol transmission. Based on this principle, the system hardware and software were designed.

2.1 Multi-source remote sensing image big data classification system hardware design

The core part of the hardware architecture of multi-source remote sensing image big data classification and processing system was composed of chip, field programmable gate array and integrated circuit. Such as, memory, in-and-out memory devices, and flash, etc. (Zhang et al., 2017). The integrated circuit was mainly responsible for assisting the core circuit to perform related processing functions. Flexible circuit board assembly with random access memory, which can be used to store data and intermediate results of multi-source remote sensing image data classification processing. The execution function stored in the Flash was fused with the configuration data assembled by the flexible circuit board, which facilitated the field-programmable gate array to efficiently process signals. The system comprehensively considered the effectiveness of the multi-source remote sensing image big data classification processing system and designed the system scale and debugging difficulty. The hardware block diagram design was shown in Figure 2.

Figure 2 Hardware block diagram

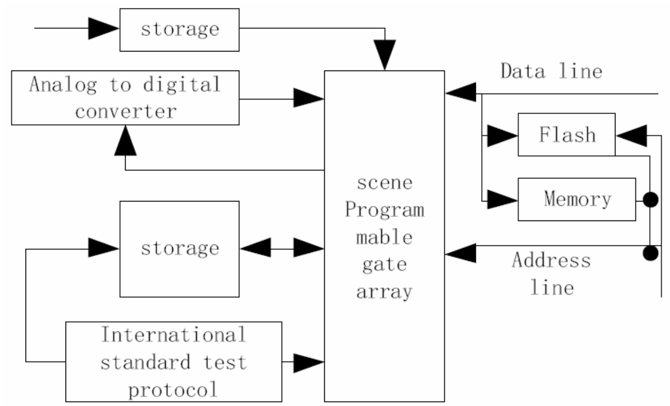
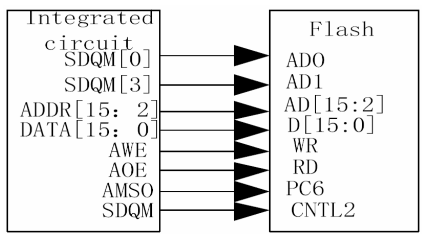


Figure 2 showed that the system hardware structure configured the memory to have a unified 4 GB address access space. It used 48-bit address addressing, which included internal memory and external memory as well as address-access space for all intrinsic resources. And it occupied part of the system's address space alone. The external memory read data through the interface bus. The interface was a seamless connection interface, which can accommodate up to four simultaneous DRAMs and five asynchronous storage devices.

Memory design needed to consider the storage speed, type and size of multi-source remote sensing image data. Besides, there were something need to do, including inspecting whether it can meet the computing needs, extending the size of the external memory and using synchronous dynamic random-access memory to buffer the image data. Synchronous dynamic random access memory compatible with the peripheral component interconnect standard can be setup to four address space storage blocks with connected attributes, each of which was 128 MB in size. For this purpose, direct access to 512 MB of RAM can be performed (Yang et al., 2016). Each memory block can be independently configured to facilitate single and continuous physical address space access in the memory of the system kernel. Asynchronous memory interface selected dual-port memory, which can be used as multi-source remote sensing image big data to transfer from the memory to the internal structure of the system. It decided the image data transmission mode through the direct memory access control register, selected Flash as the memory basic integrated circuit, and connects with the flash interface. Detailed information was shown in Figure 3.

As shown in Figure 3, after the system was powered on, internal data can be accessed from the flash with direct memory access and run at full speed in the internal program. There were many interfaces in the external hardware of the multi-source remote sensing image big data classification system. The more critical interfaces included image sensor interface, timing counter interface, terminal controller interface, processing interface of embedded system, DNA controller interface, etc. Among them, the image sensor interface and the embedded system processing interface were key interfaces. The following two interfaces were designed.

Figure 3 Integrated circuit and flash interface

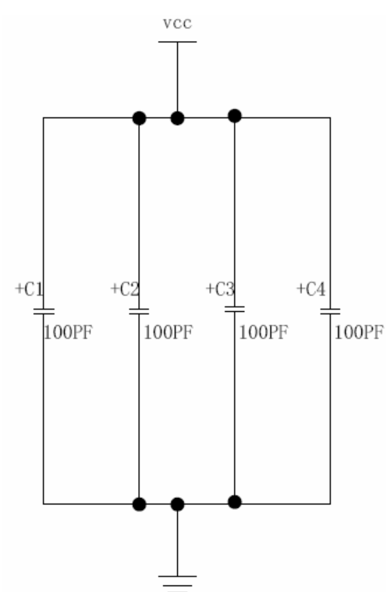


2.1.1 Image big data classification sensor interface design

We adopted MT9M001 model 16-inch black and white image sensor with 1.5 million pixels. Its sensing performance fully met the needs of industrial monitoring and multi-source remote sensing image processing (Li et al., 2016; Liu et al., 2015). In addition, the sensor can also process the greyscale image. When the greyscale image was returned to the host PC, the image big data can be directly classified, which can reduce the complexity of the system from the colour space to the greyscale space. The sensor design also provided a variety of data output methods for use by different users. This can meet the programmable gradation correction, provide a convenient MT9M001 model sensor working mode and real-time control for the line serial interface bus.

The MT9M001 model image sensor circuit board design was shown in Figure 4.

Figure 4 Image sensor board design

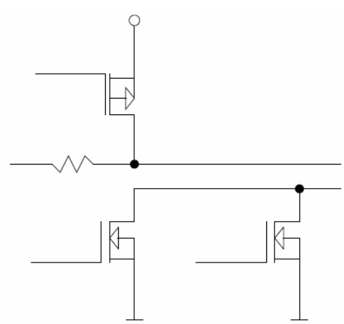


Because the sensor output image data was a 10-bit system, for this purpose, 8-bits of data were input during image data classification. First, the first two bits of data in the sensor were discarded, then PCB layout and 3D designs were performed (Yu et al., 2017; Fernnádez et al., 2017). Finally, the input signal, output signal, data bus and address bus were connected. The complex programmable logic device (CPLD) was used as a multi-source remote sensing image big data sensor control device and the data was buffered by a static random access memory (SRAM). In the system hardware design, because the sensor was affected by the size of the circuit board, the circuit was also subject to certain restrictions in the design, and the position of the components had also changed accordingly.

2.1.2 Image big data classification embedded interface design

S3C2440 processor was a processor based on ARM architecture, the main frequency was 350 MHz, the highest frequency can reach 550 MHz. The SDRAM processor was automatically integrated inside the CPU and four-channel DMA was used to directly access the memory. It used a three-channel universal asynchronous receiver transmitter (UART), an SD interface, and an eight-channel 10-bit A/D converter to facilitate system development (Diazgomez and Ortizcorredor, 2017). The distributed system infrastructure (Hadoop) was an open source organisation that works on the principle of parallel computing for large-scale data sets (greater than 1 TB). Under this principle, the architecture (Hadoop) can implement the fault tolerance and scalability of image big data classification and form a solid distributed image big data classification interface. The structure was shown in Figure 5.

Figure 5 Distributed image big data classification interface design



According to Figure 5, the image big data classification interface design can realise the fault tolerance and scalability of image big data classification. According to the above image sensor interface and the embedded system processing interface in the cloud computing environment, the design of the hardware part can be completed.

2.2 System software design

The design of the system software can be divided into three parts, which are the two-wire serial protocol that provides users with initialisation operation, the design of image big data classification algorithm and the implementation steps of multi-source remote sensing image big data classification. The system driver was mainly responsible for the initialisation of the hardware device. Besides, it can provide the user with operating hardware device interface. Then it can convert the data collected by the driver and initiate communication to the PC host if necessary (Cai et al., 2018; Rauber et al., 2017; Yang and Liu, 2014).

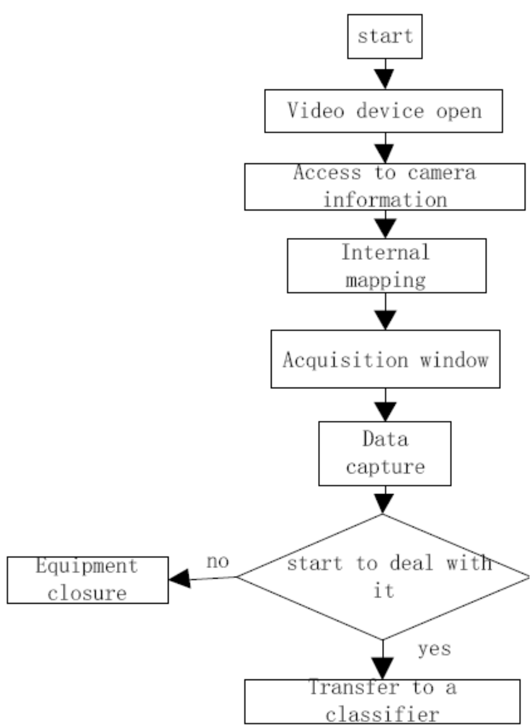
2.2.1 Multi-source remote sensing image big data classification two-wire serial protocol

Multi-source remote sensing image big data classification two-wire serial protocol driver was a chip-driven communication protocol that enabled the chip registers in the image to be set efficiently. Two pins were the data pin and the clock pin. The specific protocol is described below.

When the clock crystal oscillation frequency SCLK was too high, the data started to be transmitted when the serial data SDATA was switched from the high level to the low level (Boccaletto et al., 2017). The most critical step in the design of the system software section was to capture the data from the camera chip and transferred it to the memory module for reading. In order to realise the real-time transmission of data, it was necessary to read the data through the map software and connected a certain section of the user's memory with the memory of the image processing device to directly operate the data.

In the transmission process, all the data was read by using the map software, which can greatly reduce the long data classification time for multi-source remote sensing image data, and thus improved system efficiency. The multi-source remote sensing image big data processing flow was shown in Figure 6.

Figure 6 Multi-source remote sensing image big data processing



The data collected by the driver were converted and organised. In order to reduce the amount of calculation and program design time, in the digital image big data classification process, the colour image was converted to a greyscale image for processing. Since the camera chip can only output a greyscale image chip, for this reason, the user did not need to specially convert the colour image and the greyscale image in the system, and acquired the data to be processed according to the two-line serial protocol. In the two-wire serial protocol, if the image data of the system was successfully extracted, it provided a scientific basis for the cloud computing environment image big data classification algorithm.

2.2.2 Cloud computing environment image big data classification algorithm

Image big data classification algorithm, firstly, using cloud computing environment interval quantisation can be used for sampling equidistant rectangular grid. There were usually two kinds of sampling and quantisation results, which were the grey-scale image array sampling method and the spatial domain quantisation method.

1 Grey-scale image array sampling

   Elements in an image array were collectively referred to as pixels. Usually in experimental TV images, the grey level of the image processing was in the form of an integer power. The greyscale data of the image was limited in the cloud computing environment. It selected the 8–12-bit matrix and converted the greyscale image into a binary image during the processing (Flantua et al., 2016). Generally, it was represented by two grey levels, black and white, and the digital image can be represented by a bit matrix.

2 Spatial domain quantisation

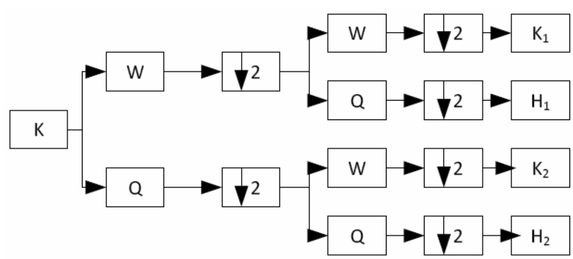
   For the digital image processing, the spatial domain quantisation method was used for each pixel set in the image, and a series of processing methods can satisfy the output standard of a certain image. This image big data classification advantage was repetitive and can be applied to images to facilitate streamlined processing.

To process multi-source remote sensing image data in the cloud computing environment, it was necessary to select a verifiable algorithm according to the hardware structure of the system to achieve the processing capability. Because the work environment was relatively complicated, in order to solve this problem, noise reduction processing and image sharpening processing were needed to enhance the processing efficiency. Sampling methods using greyscale image arrays can reduce the average fuzzy reflection in the neighbourhood. All signals in the slow-changing part were processed into low-frequency signals and converted into images. All signals in the fast-changing part were processed into high-frequency signals and converted into images. For anti-interference pulse and point noise had a good inhibitory effect, can achieve efficient image processing.

Based on the principle of multi-source remote sensing image big data classification, the classification of multi-source remote sensing image big data was carried out below. The multi-source remote sensing images in practical applications were mostly images with low quality. If you do not clarify it, it will result in the classification of multi-source remote sensing image data. Wavelet transform can be used for image processing. Since the image was a two-dimensional signal, a two-dimensional wavelet transform mechanism was used in the process of wavelet analysis (Ravi and Khare, 2016; Kim and Lim, 2017). The intensity of signal changes can be enhanced in space or in time and frequency domain, becoming a multi-level wavelet coefficient. According to the wavelet characteristics, the characteristics of the coefficients were analysed, and the image processing technology was used to perform inverse transformation to obtain the desired target image. For the classification of multi-source remote sensing image big data, we must first reconstruct it.

Starting from an A × A multi-source remote sensing image. A was a power of two, which was the size of the original multi-source remote sensing image. With the increase of the power, the image size will also increase, which in turn will reduce the resolution of the image and be extended according to the two-dimensional wavelet method. At each transformation level, the image will be decomposed into 4 uniform-sized modules. Any one of the four modules was obtained from inner image processing of the wavelet image in the original image (Ewa et al., 2016; Lahsasna and Seng, 2017). After sampling and selecting in different directions, the multi-source remote sensing image was decomposed, as shown in Figure 7.

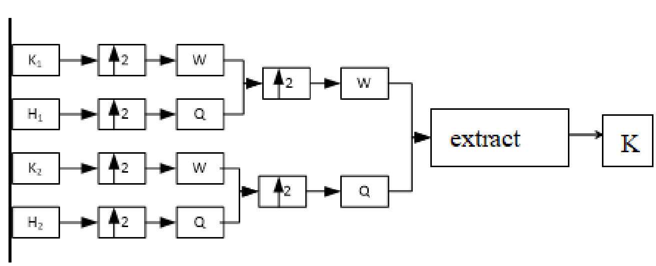
Figure 7 Multi-source remote sensing image decomposition



Fuzzy multi-source remote sensing image actually decomposed in Figure 7. K represents a low frequency coefficient, H represents a high frequency coefficient, W represents a low pass decomposition filter processing, and Q represents a high pass decomposition filter processing. The downward arrow indicates the data extraction mode of interlaced or interleaved data. However, the even-numbered rows or columns are retained and decomposition starts from zero.

The reconstruction steps for low-quality multi-source remote sensing images were inverse processes of decomposition, similar to the decomposition process. The specific reconstruction steps were shown in Figure 8.

Figure 8 Multi-source remote sensing image reconstruction

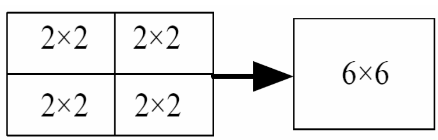


As shown in Figure 8, the up arrow of this step represented the column or row interpolation, leaving only the odd columns or rows and inserting a 0 value in them.

The multi-source remote sensing image big data classification mainly used the Gaussian model to perform effective big data classification processing on massive multi-source remote sensing images, thus providing a basis for image applications in different fields. The details were as follows.

For massive multi-source remote sensing image big data, in the process of image big data classification, the contrast of pixels in the image was relatively low. Therefore, it was necessary to use a discrete transform method to enhance the above images, so as to improve the contrast of the images and ensure the accuracy of the classification of large images. According to discrete transformation correlation theory, the correlation between different neighbourhoods in the image can be obtained and the enhancement parameters of the image can be obtained. According to the correlation between different neighbourhoods of images, a matrix composed of multi-source remote sensing image enhancement parameters can be obtained (Taheri et al., 2017; Varatharajan et al., 2017). The above matrix conversion process can be represented by Figure 9.

Figure 9 Multi-source remote sensing image enhancement coefficient matrix conversion process



According to the image enhancement coefficient conversion process, the feature points in the target image can be divided into four different categories, i.e., G_0, G_N, F_P, and F_K. The following formula can describe the energy relationship between the above different feature points.

$$E_N = \frac{G_N}{G_0},\ E_P = \frac{G_P}{G_0 + G_N},\ E_J = \frac{G_J}{G_0 + G_N + G_P} \tag{1}$$

The set of multi-source remote sensing images can be described by $Z = [z_1, z_2, \ldots, z_{M\times N}]$ The following results can be obtained by equation (2).

$$z_{(n-1)\cdot M+m} = \frac{1}{f_z \times f_a} \sum_{\Sigma\in\beta_{m,n}} K_B \tag{2}$$

In equation (2), $z_{(n-1)\cdot M+m}$ can be used to describe the average grey value of subunit $\beta_{m,n}$ in a multi-source remote sensing image. The corresponding prior probability can be described by $p(z)$. f_z is used to describe the efficiency of remote sensing image extraction under big data classification system. The density of conditional probability can be described by $p(z|y)$. The corresponding posterior probability can be calculated according to equation (3).

$$P(y \mid z) = \frac{p(y \mid z)P(y)}{p(z)} \tag{3}$$

According to the above explanation, it is possible to obtain the image grey difference as equation (4).

$$P(Z)=\sum_{k=1}^{P}\chi_k Q_k(Z) \tag{4}$$

In equation (4), the number of images in the Gaussian model can be described by P, the Gaussian grey distribution can be described by $P_k(Z)$, and the ratio of $P_k(Z)$ can be described by χ_k. The characteristics of the image in the above Gaussian model can be calculated by equation (5).

$$T(\rho)=\frac{1}{n}\sum_{v=1}^{n}N\left(Z_v,\rho\right)=-\frac{1}{n}\sum_{v=1}^{n}\ln p\left(Z_v,\rho\right) \tag{5}$$

The Gaussian model for multi-source remote sensing image big data classification can be established according to equation (6).

$$\begin{aligned}
&P\left(k\mid Z_v,\rho\right)=\frac{\chi_k P_k\left(Z_v\right)}{\sum_{m=1}^{P}\chi_m P_m\left(Z_v\right)}\\
&\chi_k=\frac{1}{V}\sum_{v=1}^{V}P\left(k\mid Z_v,\rho\right)\\
&w_{km}=\frac{\sum_{v=1}^{V}P\left(k\mid Z_v,\rho\right)z_{vm}}{\sum_{v=1}^{V}P\left(k\mid Z_v,\rho\right)}
\end{aligned} \tag{6}$$

According to the Gaussian model constructed above, large-scale classification of multi-source remote sensing images can be performed.

$$p^{*}=\arg\max P(m\mid Z) \tag{7}$$

According to the method described above, a Gaussian model can be established, and a large data classification of multi-source remote sensing image data can be realised according to the model.

3 Experiment

In order to verify the rationality of the multi-source remote sensing image big data classification system design under the cloud computing environment, the following experiments were conducted.

3.1 Experimental environment settings

The test hardware was tested under the PC host environment. The specific environment settings were shown in Table 1.

Table 1 Experimental environment settings

Equipment	*Model*
CPU	AMD Turion 64 X2
Frequency	1.65 GHz
Video card	NVIDIA GeForce Go7500(MHz)
RAM	512 MB

The software environment for experimental testing was Visual C++ 6.0 programming under Windows 8 operation. Since VC++ can remove tedious operations for program design and bring great convenience, it can greatly increase the efficiency of program design, facilitate the maintenance and expansion of follow-up systems and was extremely open.

3.2 Experimental results and analysis

The image big data classification system designed by this paper had certain weighted fusion attributes. The images obtained for this purpose were all desiccated, and the weights were all one. In general, 5 × 5 window was the best effect of filtering noise reduction. Therefore, the median filter of the 5 × 5 window was selected, and the image diagram obtained through multi-source remote sensing was shown in Figure 10.

Figure 10 Multi-source remote sensing image diagram (see online version for colours)

In order to make the verification result more reliable, the traditional processing system compared with the text processing system for image big data classification results, the results were shown in Figure 11.

Figure 11 The two systems compare the results, (a) the system of this article (b) traditional system (see online version for colours)

(a)

(b)

As shown in Figure 10 and Figure 11, the original multi-source remote sensing was a building in a certain area, and adopted an overhead view to transmit the diagram to a computer. The use of this system for multi-source remote sensing image processing was completed in the cloud computing environment can effectively deal with all the images, while the traditional system cannot handle all the images, the effect was poor.

The classification of the image in the original image schema was based on the classification time of the image big data and the time was counted. Comparing results between traditional processing systems and our optimise system were shown in Table 2.

As shown in Table 2, with the increase of the number of experiments, the time spent by the traditional system processing was stable at about 5.5 s, and the time spent by the system processing in this paper was gradually reduced and stabilised at about 2.8 s.

Therefore, our proposed method can effectively process all images with less time and higher usability.

Table 2 The two systems deal with the time-consuming comparison of multi-source remote sensing image classification

Experiment times	*Traditional system*			*The system of this article*		
	30% image	*60% image*	*All images*	*30% image*	*60% image*	*All images*
1	3.0 s	2.5s	5.5 s	2.4 s	1.2s	3.6 s
2	2.8 s	2.7s	5.5 s	2.2 s	1.3s	3.5 s
3	3.5 s	3.0s	6.5 s	2.0 s	1.5s	3.5 s
4	3.2 s	2.8s	6.0 s	2.1 s	0.9s	3.0 s
5	3.1 s	2.7s	5.8 s	1.9 s	0.8s	2.7 s
6	2.9 s	2.6s	5.5 s	1.8 s	1.0s	2.8 s

3.3 Experimental results

According to the experiment content, the experimental conclusion can be drawn. Using this system to process multi-source remote sensing images was completed in the cloud computing environment, and its hardware defects were fully improved, all images can be effectively processed, and the time was short, and the final stability was about 2.8 s. The traditional system cannot process all the images, the effect was poor and took a long time and finally stabilised at about 5.5 s.

4 Conclusions

The cloud computing environment was mainly used in multi-source remote sensing image data classification and was considerable system engineering. First of all, we needed to analyse the overall structure of the image and design the principle of the framework. In the image domain applied to the cloud computing environment, it was necessary to connect the cloud to the platform to implement the controllable layer image big data classification service of the cloud computing environment, thereby realising the advantages of infinite resources of the cloud platform. Through experimental verification, we can draw a conclusion that the design of the system is reasonable, the processing effect was good and the time was short. Which provided an effective way for many scholars to study.

Acknowledgements

This work was supported by High School Provincial Quality Engineering Project of Anhui Grant no. 2016ckjh224, the Excellent Top Talent Cultivation Project of Anhui High School Grant no. gxyqZD2017141, Nature Science Research Project of Anhui High School Grant no. KJ2017A560 and Scientific And Technological Innovation Team Grant no. Wzykj2018A02.

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