

Research Article

Automatic Recognition of Financial Instruments Based on Anisotropic Partial Differential Equations

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In this paper, anisotropic partial differential equations are used to conduct an indepth study and analysis of automatic recognition of financial bills. Firstly, it obtains the invoices of the group enterprise, uses scanning technology and related image recognition technology to capture, process, compress and slice the paper bill content, and then carries out data identification and verification of the image. It classifies the obtained electronic data information into bills, converts it into electronic information related to bills according to the corresponding categories of the bill template, and stores it in the bill table of the database to achieve the management operation of formatted electronic files. After categorizing the bills according to the electronic information of bills to match the business scenarios, financial journal vouchers can be generated according to the preconfigured voucher templates of the corresponding business scenarios, and the financial journal vouchers are converted into voucher messages using XML technology. Finally, we use agent technology to design middleware for heterogeneous financial systems to realize the function of communicating voucher messages to each other in different business systems. The system automatically extracts the key information of invoices through OCR technology and performs real-time verification and cyclical feedback to the verification results to the suppliers. The system has realized the intelligent management of the power company's VAT invoices, thus greatly enhancing the efficiency of VAT invoice verification and settlement. The automatic tax invoice recognition system adopts a network structured tax invoice recognition model, which eliminates the cumbersome steps of character decomposition and character classification in traditional OCR character recognition. After several trials, it has obtained better experimental results in terms of recognition accuracy, with an accuracy rate of over 93% in the recognition of tax invoice data set.

1. Introduction

Tax bills such as receiving and paying invoices are the basis of proving economic acts, which are the evidence that can be verified by the financial personnel of enterprises and institutions, meanwhile, have the functions of clarifying responsibilities and accounting for taxpayers; for the state taxation department, they are a kind of evidence for auditing and determining responsibilities [1]. In daily economic life, various economic activities of individuals or enterprises and institutions will generate many tax bills, and the scale of quantity of tax bills has increased dramatically. At the same time, with the continuous development of information tech-

nology, all walks of life are storing the traditional paper documents electronically [2]. Increase the contrast between the background and the target to simplify the processing algorithm; simplify the complexity of the visual system and reduce the overall cost of the entire system. The prosperity of modern industry, commerce, and daily economic activities has prompted the frequent use of invoices and other tax documents to be urgently recorded and kept by information technology, which means that the work of regular manual processing and management of tax documents is handed over to calculation and completion. The traditional way of manually entering the information of tax bills into the computer system cannot meet the requirements of people

in the face of the rapid growth of tax bills, and the error rate is high and the timeliness is poor [3]. The manual processing method is not compatible with the fast developing and information-based society. Therefore, utilizing information technology to improve the information processing ability, operating efficiency, accuracy of tax invoices, and realizing automatic identification of tax invoices is an effective solution to the problem. Ordinary VAT invoices are still the legal bookkeeping documents for commodity transactions. In the finance department, invoice reimbursement is often a relatively large workload business, and the heavy and tedious work of invoice processing will be a major problem for all relevant organizations. The information on invoices must be identified, extracted, stored, and other processings for subsequent approval. Many invoices made out every day, which take a lot of human resources and time costs to complete these tasks. Moreover, as the working hours of employees increase, the accuracy of invoice information entry will also be decreased. The invoice automatic recognition algorithm can enter invoice information in real-time, which helps to improve the company's office automation and speed [4].

Machine vision makes the automated processing of invoices possible. Its main purpose is to use a computer to simulate the visual function of the human eye to extract useful information from the image, process and understand, and finally, apply it to the actual inspection. Camera, lens, and other devices composed of the image acquisition system can capture images, using the camera's USB data line, and you can achieve real-time transmission of images from the acquisition system to the computer and then use the subsequent programming software processing and the results obtained for analysis and practical use. Machine vision has unique features such as rapid information acquisition and systematic automation of processing information. In current automated production, it is used extensively in areas such as part identification, work condition monitoring, and quality monitoring. Machine vision systems are noncontact measurements and can reduce wear and tear on delicate parts, thus enhancing the safety of the system [5]. The business management function of the automatic entry preprocessing system is mainly composed of four subfunctions: priority management, task management, operation monitoring, and parameter management. The priority management subfunction is mainly to sort the priorities of the tasks currently running in the system to ensure that the business process of the system can be dynamically adjusted in real time according to the actual situation. The system has a high degree of flexibility, when the application of inspection results changes, and the software will be able to adapt to new needs after the corresponding upgrade changes. With the continuous development and innovation of digital image processing technology, people's visual requirements for images are becoming higher and higher; so, how to improve the visual quality of images has gradually become a research hotspot in the field. In the process of image acquisition, transmission, and storage, due to the quality of the sensor and the impact of many factors such as the outside world will inevitably be affected by various types of noise interference, which makes the image quality that is impaired, resulting in the postprocessing of

the image more difficult, it is important to remove the noise in the image.

The image is often interfered by various factors during its output, processing, or circulation process, resulting in noise. The image is affected by noise that will make the visibility of the image low, the image as a whole or local become blurred, the details of the characteristics are difficult to identify and interfere with people's access to image information and judgment, and it will have an impact on the subsequent image processing. Therefore, the role played by image denoising technology in today's social life is self-evident, and the study of image denoising methods also has profound significance and practical value. As far as the image signal is concerned, noise is an unwanted signal present in the image, and the noise signal can cause trouble when people process the image. The noise in the image generally exists in the high-frequency region, and the edge structure features of the image itself also exist in the high-frequency region; so, some traditional denoising methods will also erase the edge features of the image when eliminating the image noise, making the image details and textures and other information lost, and the image visibility is reduced. To address the shortcomings of these traditional denoising methods, it is important to find a denoising method that can consider the image details and texture and edge structure information while effectively removing the noise.

2. Current Status of Research

The selected threshold is compared with the gray value of each point in the image and based on the result of the comparison, the image is divided into two regions, background, and target. An et al. had good processing results for images with obvious separation of target and background and grayscale histograms with bimodal peaks. However, for images with uneven illumination and high noise, the binarization effect is not ideal, the algorithm requires the processing of each pixel point on the image, which is computationally large, and many scholars have also proposed improved algorithms [6]. Sun proposed a method that combines the spatial distribution characteristics of the image with the maximum interclass variance for problems such as uneven illumination in the image, which improves the rate of the algorithm operation [7]. The representative tool used in traditional methods for feature extraction is the Hough transform, by using the Canny edge detection operator to extract the edge pixels in the image, then using the cumulative probability Hough line transform to detect straight lines and finally selecting the edge line of the document from all the detected lines, the point where the four lines intersect can be recognized as the vertex of the document [8]. Sakano used Hough transform to find the top, bottom, and both boundaries of the license plate, respectively, and completed the localization of the license plate, which has similarity with the card ID localization theory [9]. It can be found that the Hough transform is only applicable to the case where the background of the localized target is simple, the contour edges are clear and complete, the deformation is not large, and the robustness of the method rapidly decreases under uncontrollable factors

such as complex background fusion, unreasonable parameter settings, or excessive perspective deformation [10]. In the practical application environment, not only the background of the image is complex but also the foreground is affected by different lighting conditions. Relying on preprocessing and complex adjustment of relevant parameters, it is very difficult to extract the edge contour of the localized target among many interfering straight lines, and the detection of straight lines or circles also occupies a lot of memory space of the processor, which affects the detection speed. In addition, there is a traditional method based on digital morphology for detecting connected regions of the edge of the document, i.e., using an erosion operation to noise reduce the card and then an expansion operation to connect the disconnected contours of the document [11].

Kuffour introduced the tensor matrix in the diffusion coefficients and proposed the anisotropic tensor diffusion model, and the design scheme was given in the literature [12]. Due to the flexibility and versatility of the anisotropic diffusion model, many scholars are still studying and innovating it in recent years. Muir et al. applied the anisotropic diffusion method to the study of the image pixel model [13]. Sturluson et al. successively proposed a denoising model based on Demon's algorithm, a denoising model based on rescaling equations, and a threshold-seeking filtering model, making the improved anisotropic diffusion method improved in terms of denoising performance and edge protection ability [14]. Optical character recognition (OCR) refers to the use of electronic devices (e.g., scanners or digital cameras) to scan the pixels on paper [15]. In the process of scanning characters on paper by electronic devices (such as scanners or digital cameras), determining their shape by detecting dark and light patterns, and then translating the shape into text using character recognition methods, that is, for characters in print or signature mode, the characters in the paper document are converted into a black and white dot matrix image file using optical recognition, and then the characters in the image are converted into text format using recognition software for further editing by character processing software [16]. How to eliminate errors, reduce errors, or use auxiliary information to improve the recognition of the correct rate is the most important topic of OCR. How to judge whether an OCR software or technology is good or not, mainly depends on the accuracy and speed of its recognition information. When dealing with practical noise problems, we first think of denoising by filters, such as median filters, mean filters, geometric mean filters, and Wiener filters, because they are easy to understand and implement, but for complex noise, the denoising effect of filters is not good. To meet the requirements of fast computation and better denoising, many classical denoising methods proposed since then, such as Fourier transform-based denoising methods and wavelet transform-based denoising methods. Due to the continuous development of numerical computing, partial differential equations have been applied to image denoising with very good results. The classical denoising models based on partial differential equations are anisotropic diffusion models.

The research goal of this paper is to remove the tedious steps such as character decomposition and character classification in traditional OCR through deep learning algorithms in the field of artificial intelligence and to unify the character feature extraction and character classification to deep learning algorithms to further improve the speed and accuracy of character recognition. It analyzes the existing character image positioning and preprocessing methods, removes the tax form background, locates the tax form area, realizes the tax form data block extraction, and identifies the tax form content from a single line of text date. Modeling, optimizing, and adjusting the network structure are used to improve the correct rate of recognizing characters. This paper focuses on the requirement analysis, system design, and implementation of tax bill content recognition system, design, and implementation of the tax bill content recognition system. According to the actual needs of the customer for tax bill content recognition, the content recognition system is divided into functional modules, and each functional module is designed and finally coded for implementation.

3. Analysis of Automatic Recognition of Financial Instruments for Anisotropic Partial Differential Equations

3.1. Improved Design of Anisotropic Partial Differential Equations. In the partial differential equation approach to image processing, usually, the equation being solved carries the partial derivatives of the unknown function. The function generally contains more than one independent variable. When the number of equations and unknown functions is more than one, they can also be represented by a system of equations, and several typical partial differential equations are described below.

$$\frac{\partial^2 I}{\partial t^2} = \alpha^2 \Delta I - F(x, t). \quad (1)$$

The equation can be used to solve some common fluctuation problems in optics, acoustics, and mechanics in life, and when $n = 1$, the equation can be used to represent the vibration of a string or the one-dimensional propagation of an acoustic wave, when the equation expression is:

$$\frac{\partial^2 I}{\partial t^2} = \alpha^2 \frac{\partial^2 I}{\partial x^2} - F(x, t). \quad (2)$$

With the continuous research on image processing technology, increasingly mathematical theories and methods have been applied to the field of image denoising, the most typical of which is the variational energy generalized function minimization method. At the same time, the noise can be processed more intuitively. Tilt correction can restore the angle of scanned and photographed tax bill images, laying the foundation for subsequent image processing. The method first constructs the energy general function that meets the image requirements, then uses the variational theory to find the corresponding variational partial differential

equation, and finally introduces the time parameter for numerical solution to achieve the best processing of the target image [17]. The denoising method based on the variational theory usually needs to consider the properties of the target image, then seeks the most ideal energy general function form by studying these properties, represents the contents of the image by the spatial parametrization, and finally obtains the corresponding partial differential equation for solving to obtain better denoising performance. With the continuous research on image processing technology, increasingly mathematical theories and methods have been applied to the field of image denoising, the most typical of which is the variational energy generalized function minimization method. The method first constructs the energy general function that meets the image requirements, then uses the variational theory to find the corresponding variational partial differential equation, and finally introduces the time parameter for numerical solution to achieve the best processing of the target image. The denoising method based on variational theory usually needs to consider the properties of the target image, then seeks the most ideal form of energy general function by studying these properties, represents the contents of the image by spatial parametrization, and finally obtains the corresponding partial differential equation for solving to obtain better denoising performance, as shown in Figure 1.

For anisotropic media, it is necessary to consider the local variation in the direction of the gradient, and the diffusion coefficients can be expanded into a tensor matrix, using the diffusion tensor as the diffusion term.

$$D = \begin{pmatrix} a & c \\ b & d \end{pmatrix}. \quad (3)$$

The spatial distance between pixels determines the null domain filter coefficient, and the coefficient value decreases with increasing spatial distance. The similarity between pixels determines the value domain filter coefficient, and the more similar the pixel values are, the larger the coefficient value is.

In the flat region of the image, the value domain filter coefficient is close to 1. At this point, the null domain filter plays a decisive role, and the bilateral filter is transformed into a Gaussian low-pass filter to smooth and denoise the image. In the edge region of the image, the interpixel variability is more obvious, when the value domain filtering coefficient is close to 0. The value domain filtering plays a decisive role, and thus the edge region of the image can be maintained. This is mainly because the WHT model confuses the wavelet coefficients and noise coefficients in the high-frequency components, resulting in insufficient noise elimination and loss of edge details of the image. Nonlocal mean filtering (NLM) is proposed by Bauds based on bilateral filtering, which can effectively use redundant information in digital images. Instead of simply processing a single-pixel point, this filtering algorithm selects and processes a larger block of pixels, and sometimes, the block is even the whole image [18]. The method can obtain the similarity between pixels more accurately and thus obtain weight coefficients with higher accuracy.

$$\text{NLM}(v(j)) = \sum_{j \in I} w(i, j)v(j), \quad (4)$$

$$\sum_{j \in I} w(i, j) = n. \quad (5)$$

Transform domain threshold denoising algorithms mainly contain Fourier transform, wavelet transform, and curvilinear transform. These methods filter out the noise based on the difference between the noise signal and the useful signal in the transform domain. The wavelet transforms or wavelet transform is used to decompose the image to be denoised into coefficients at different resolutions, set the threshold and filter the coefficients, and use the selected coefficients to complete the reconstruction of the image. In addition to the denoising model obtained by the above variational method, there is also a denoising model derived from the perspective of the Gaussian smoothing operator.

$$\begin{cases} \frac{\partial I(x, y, t)}{\partial t} = \Delta I, \\ I(x, y, t) = I_0(x, y), \\ \frac{\partial I(x, y, t)}{\partial_n} = 1. \end{cases} \quad (6)$$

The heat diffusion equation is based on the physical model of a partially heated iron tube, which slowly diffuses its heat as it conducts heat until the temperature of the entire tube is uniform. The application of this model to image denoising is analogous to the diffusion of noise to achieve a uniform grayscale across the image. Let the original image be $I(x, y, 0)$ and $I(x, y, t)$ be the diffusion image at time t and the thermal diffusion model be

$$\begin{cases} \frac{\partial I(x, y, t)}{\partial t} = \Delta I(x, y, t), \\ I(x, y, 0) = I(x, y, 1), \end{cases} \quad (7)$$

$$G_\sigma(x, y) = \frac{x^2 - y^2}{2\sigma^2}. \quad (8)$$

To use a finite difference method in a partial differential equation problem, the continuous problem must first be discretized by doing a ratio operation on the difference of the function between two adjacent points and the distance between these two points and then taking partial derivatives of the variables in the resulting function. In the general case, for the convenience of the partial derivative narrative, the difference notation is used to denote the different difference methods, and the first-order forward and backward difference methods, as well as the second-order central difference method, can be expressed by the following equation.

$$\left| \frac{\partial I}{\partial x} \right|_i^n = \frac{I_i^n + I_{i-1}^n}{\Delta x} + o(\Delta x). \quad (9)$$

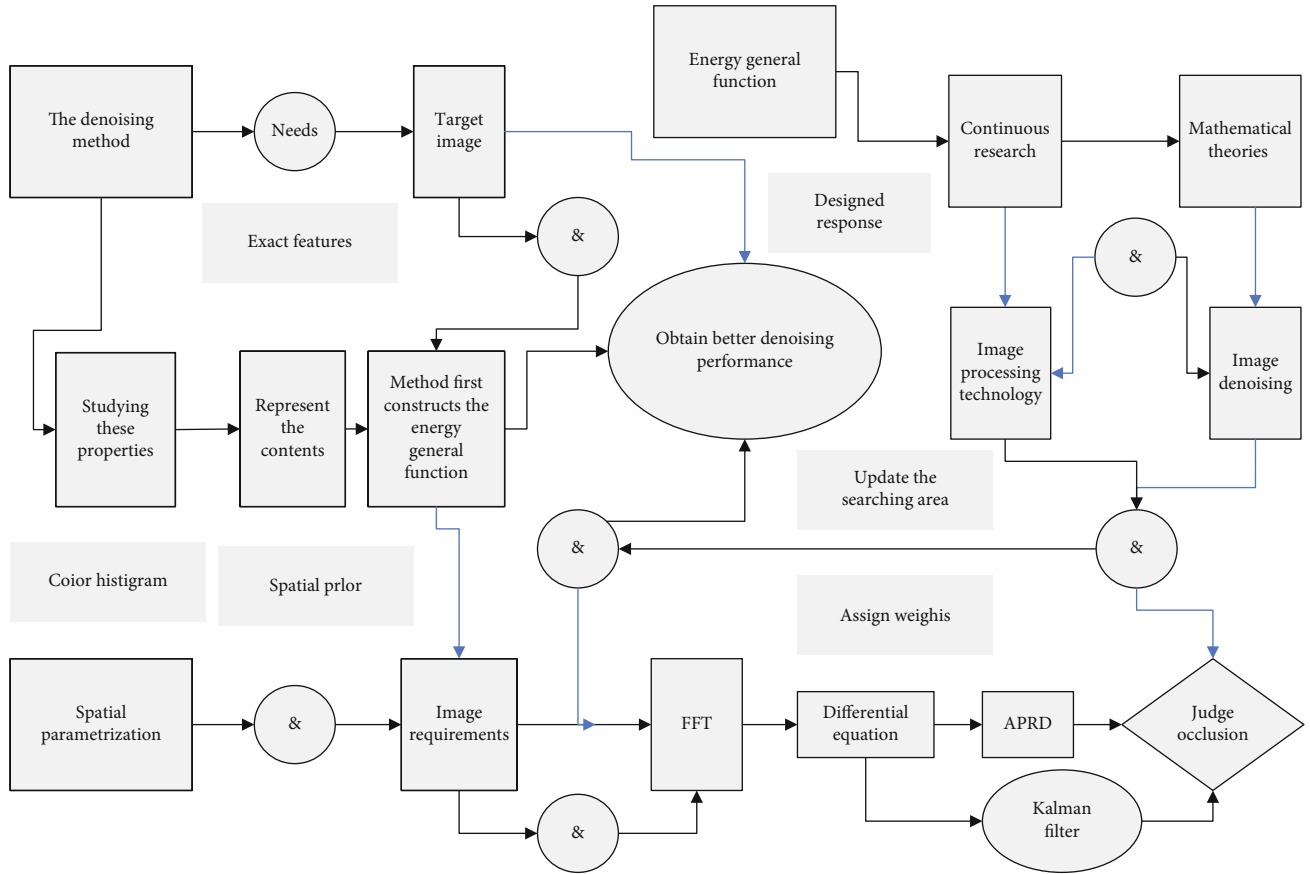


FIGURE 1: Improved framework for denoising anisotropic partial differential equations.

Then, the partial derivative of the forward differential can be expressed as

$$\frac{\partial I}{\partial x} = \Delta I(x, y, t). \quad (10)$$

Forward differencing is a method of first-order precision, and it can be derived that backward differencing is also of first-order precision. Among them, 11 characters were recognized incorrectly, and the overall recognition rate was 94.9%. Compared with the 90% recognition rate of conventional neural networks, there is a significant increase. This functional module mainly wants to perform electronic image processing on the content of paper bills. The user selects a tax bill information that needs to be modified in the bill information display interface, clicks the modify button, the interface jumps to the detailed information display interface, and the user can modify the information other than the main key and save it. The system provides input validation function to prevent wrong input, such as tax numbers can only input numbers and limit the length. If the modification is saved successfully, it prompts the modification success message and returns to the bill information display interface. If the modification is saved unsuccessfully, a pop-up message is prompted for unsuccessful modification. By querying and other operations, display the qualified bill information in the bill information display interface, select the bill infor-

mation that needs to be deleted, and click the delete button to delete the tax bill information that has been entered into the database. If the deletion is successful, the message of successful deletion is given, and if the deletion is unsuccessful, the message of unsuccessful deletion is given. The statistical analysis information such as the number of tax bills saved in the database is displayed in real-time, as shown in Figure 2.

A partial differential equation is an equation in which there is an unknown function related to more than one variable or a relationship between the corresponding unknown function and the partial derivatives of more than one variable. The establishment of the method implies a certain physical meaning, and a filtering model that meets the requirements usually derived based on the corresponding physical meaning. Such methods are based on taking the original noisy image as the initial condition and iteratively deriving the solution of the PDE model and applying it to the image denoising process, and the core of the method is to establish an effective diffusion model based on the relevant information of the target image. Since Gaussian filtering cannot distinguish the noise and edge information of the image in the process of image processing, it makes the image edges oversmoothed in the process of image denoising, and then the phenomenon of image blurring occurs.

3.2. Analysis of Automatic Recognition of Financial Instruments. To some extent, the design and selection of

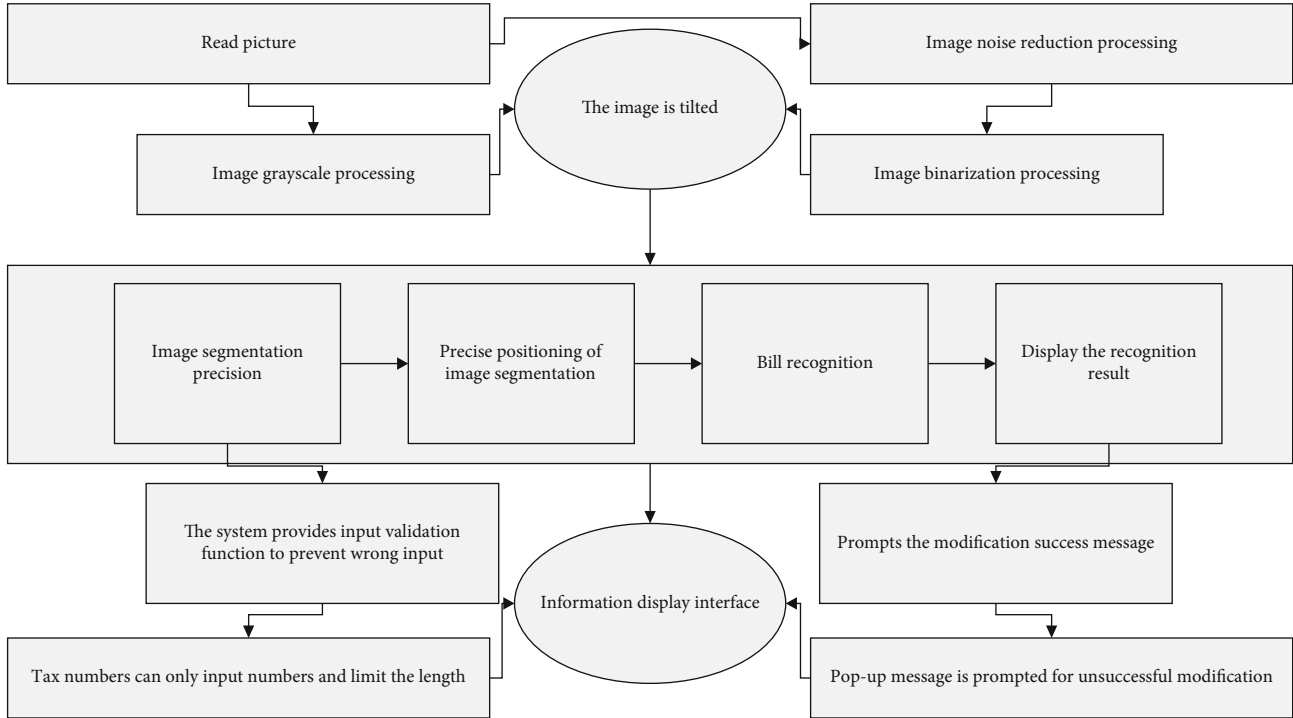


FIGURE 2: Flow chart of bill identification business.

the light source are some of the factors that determine how good a vision system is, and the right light source can reduce the complexity of the processing algorithm. The role of light sources in vision systems is mainly to make the target area stand out from the background, to facilitate the extraction of the key information we need, to increase the contrast between the background and the target to simplify the processing algorithm, to simplify the complexity of the vision system, and to reduce the overall cost of the whole system. The object itself can emit fixed frequency electromagnetic waves, and we call it a light source, emitting electromagnetic waves including visible and invisible light [19]. Light sources are divided into natural light sources and artificial light sources. While realizing the automatic entry of financial vouchers, the original images of the generated financial vouchers can be associated to realize financial electronic file management. Natural light sources are mainly sunlight, some self-luminous bacteria, and some marine luminous organisms. The business management function of the automatic financial voucher entry preprocessing system consists of four main subfunctions: priority management, task management, operation monitoring, and parameter management. The priority management subfunction is mainly responsible for prioritizing and processing the existing running tasks of the system to ensure that the business processes of the system can be dynamically adjusted in real-time according to the actual situation. The task management subfunction is mainly responsible for formulating the corresponding task content to complete the corresponding business functions. The operation monitoring subfunction is mainly responsible for monitoring the running tasks of the system to avoid the occurrence of unexpected situations.

The parameter management subfunction is responsible for maintaining and optimizing the relevant parameters of the enterprise in the system process to achieve the special business needs of different enterprises, as shown in Figure 3.

The system designed and developed in this study has many users, and the scale of information data carried by the system is also large, which requires the system to have the performance and characteristics of being able to handle a large amount of information data at the same time. Based on the above reality, during the design of this system, the system's operation capacity and level need to be optimized and upgraded to continuously improve the information data processing speed of the system. To ensure that the system can respond to at least eight hundred users' requests for data and information within three seconds, and at the same time, the accuracy of the information and data response rate must be 100%. In addition, it is also necessary to ensure that the system can read, query, and manipulate 400 items of user information data in one minute and must ensure that the completion rate of information data processing is 100%, and on top of that, it must ensure that the level of central processor resources used by the whole system during the working period does not exceed 60%. According to the above system design and development performance needs, the MVC hierarchical framework should be used to ensure that the information data and manipulation behaviors in each module within the system can be balanced to promote the stable operation of the whole system, as shown in Table 1.

In the process of bill preprocessing, the operations of grayscale, noise removal, image binarization, image skew correction, and image pinpointing are mainly performed

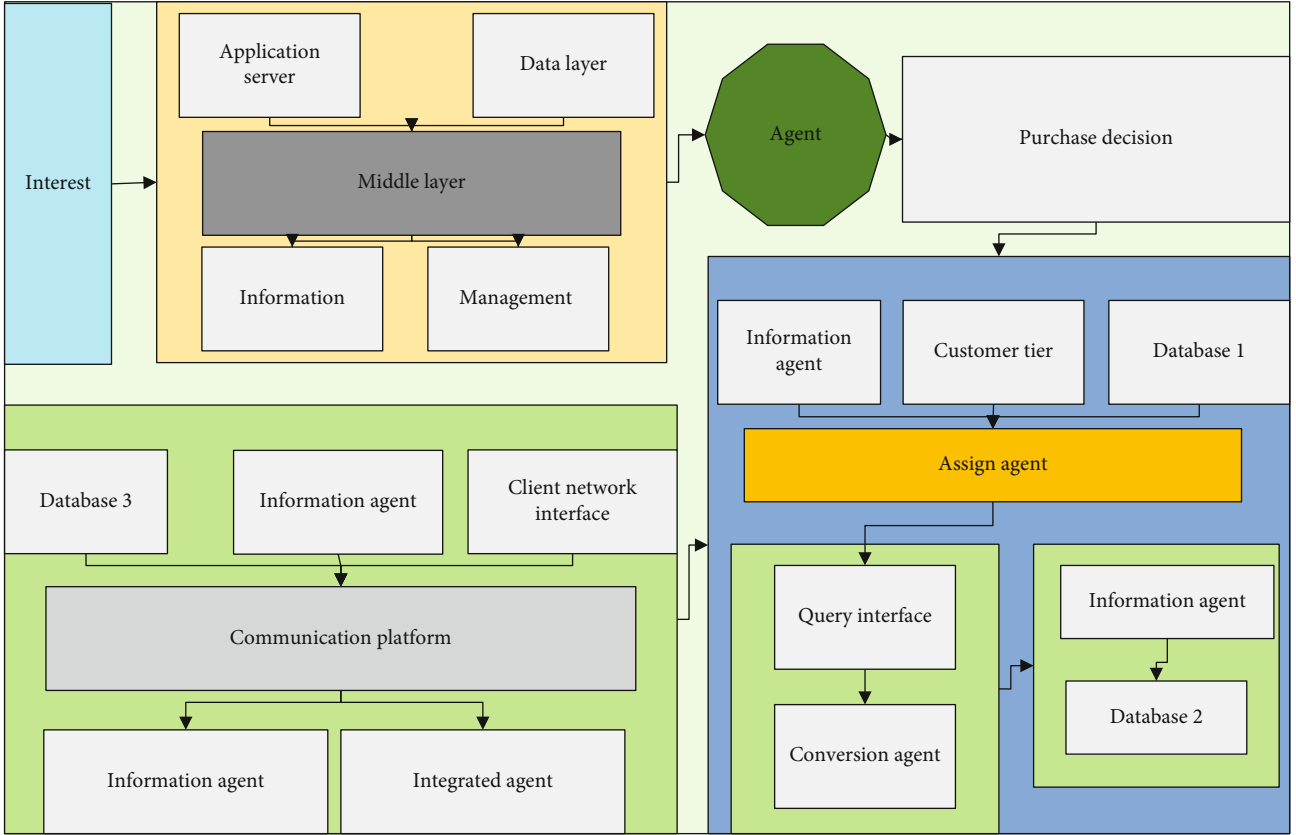


FIGURE 3: Heterogeneous data integration module.

on tax bill images. Image grayscale mainly converts color images into grayscale images, and grayscale is good for filtering important information of images and subsequent more accurate image processing. Image denoising mainly removes the image noise, restores the image quality, and enhances the image visual effect, so that the image quality can be maximized and restored. Binarization is the process of graying out the image after noise reduction, transforming it into a black and white image, thus reducing the amount of data to be processed and making it more intuitive to deal with noise. Tilt correction can restore the angle of the scanned and photographed tax bill images, laying the foundation for subsequent image processing. Image precision positioning, i.e., image layout analysis, is to segment and position each part of tax bills. Through tax bill layout analysis, the information of tax bills to be extracted can be positioned reasonably, precisely, and efficiently, which plays a crucial role in the subsequent tax bill recognition. Grayscale image is the image without color information, image grayscale is the color image after computer processing into a grayscale image, and grayscale processing of tax bill picture is the basis of subsequent tax bill recognition and can effectively improve the speed and accuracy of tax bill recognition [20]. According to the theory of three primary colors, the grayscale processing can be realized by adjusting the image R , G , and B values.

$$\begin{cases} I_{\eta\eta} = \frac{I_x^2 I_{xx} - 2I_{xx} I_{xy} I_{yy} + I_y^2 I_{yy}}{I_x^2 - I_y^2}, \\ I_{\xi\xi} = \frac{I_x^2 I_{xx} + 2I_{xx} I_{xy} I_{yy} + I_y^2 I_{yy}}{I_x^2 - I_y^2}, \end{cases} \quad (11)$$

$$I_{\eta\eta} - I_{\xi\xi} = I_{xx} + I_{yy}. \quad (12)$$

The common grayscale algorithms are the maximum method, which adjusts the R , G , and B values to the maximum of them; average method, which adjusts the R , G , and B values to the average of the three; and weighted average method, which gives different weights to the three according to the actual needs and then adjusts the R , G , and B values to the weighted average of the three. Call OpenCV library functions to achieve image grayscale processing.

$$E(I) = \int_0^1 (I - I_0) dx dy, \quad (13)$$

$$G_\sigma(x, y) = \frac{x^2 + y^2}{2\sigma^2}. \quad (14)$$

The quality of the tax bill image is easily disturbed by the realistic factors in the process of shooting and

TABLE 1: List of design tables.

Number	Table name	Describe
1	Table 1	Original voucher automatic identification content storage table (approval form\invoice content)
2	Table 2	Electronic image storage of original voucher, original voucher paste sheet, printing stub, supply department approval control table
3	Table 3	Original document-financial document comparison list
4	Table 4	Original document electronic picture storage (temporary table) invoice interface source data
5	Table 5	Business document integrity control configuration table: strict control 1 nonstrict control 0 (check in the financial voucher generation stage)
6	Table 6	Original document-financial document comparison list
7	Table 7	Corresponding to the different types of documents in the configuration table
8	Table 8	Original voucher automatic identification content storage table (approval form\invoice content)
9	Table 9	Original document approval record form

scanning, causing the problem of too much noise, as well as in the process of scanning and collecting and transmitting through the tax bill scanner, because of the interference of electronic originals, which makes the noise of the image more and affects the clarity of the image, and the above problems have an impact on the recognition of the image. For better recognition of tax bills, the noise needs to be removed, and the clarity of the image needs to be improved. Thus, the security of the system is strengthened, and the system has strong flexibility. When the application of the detection result changes, the software can be upgraded and changed to adapt to the new demand. The filters often used in the process of image noise reduction are median filter, mean filter, Gaussian filter, Wiener filter, and other different methods. The principle of the median filter is to first mask the image pixels and then replace the current pixel with a pixel of intermediate size after reordering the size of the pixels within the mask. The adaptive median filter, which is more optimized than the median filter, can adjust the size of the mask window adaptively according to the interference level of the noise points, which is a unique feature of the adaptive median filter, and retains the edge information of the image to a large extent; so, it has obvious advantages, as shown in Figure 4.

The signal-to-noise ratio is used in a wide range of applications; so, there are various definitions of signal-to-noise ratio in different fields; however, there is also a wide range of definitions and calculations in the same field. In general, the image signal-to-noise ratio is equal to the ratio of signal to noise, and for the characteristics of the specific object of this paper, the ratio of character integrity before and after image processing used to define this paper.

$$\frac{W}{w} = \frac{L^2}{f}, \quad (15)$$

$$\text{SNR} = \ln \left[\frac{\sum_{i=1}^M \sum_{j=1}^N g(i, j)}{\sum_{i=1}^M \sum_{j=1}^N [g(i, j) + f(i, j)]^3} \right]. \quad (16)$$

Compared with the ordinary structure tensor we can find the difference between the two, the bilateral structure

tensor directly performs the gradient operation on the image to be processed without Gaussian pre-filtering and uses the bilateral weight function instead of the Gaussian kernel function when performing the integrated gradient information processing. It is with these two improvements that the bilateral structure tensor can better reflect the local structural information of the image and facilitate the image denoising process later. The bilateral structure tensor can distinguish the geometric structure information of the image more accurately, but for anisotropic diffusion filtering, there are still shortcomings in using the bilateral structure tensor alone; so, it is necessary to construct the diffusion tensor by using the bilateral structure tensor to achieve the different intensity of diffusion processing for different structural regions.

4. Analysis of Results

4.1. Improved Performance Results for the Identification of Each Anisotropic Partial Differential Equation. In analysis of the experimental results, as seen in Figure 5, although the image processed by the PM model has a certain effect of noise removal, the image as a whole appears a certain degree of blurring, and when combined with the magnification effect of the figure can be seen, the image lost a large number of textural details such as the lines on the clothes and the font of the ship, and this is due to the PM model used to detect the gradient of the edge is susceptible to the influence of noise, resulting in the image of the detail information such as corner points and spikes that are similar to the modal value of the gradient are ground out during the image smoothing process. The image processed by the YK model for denoising will leave some obvious isolated noise points on the image due to the fourth-order partial differentiation method used for image smoothing. The TV model has some denoising effect on the image, but the local magnification effect can be seen that the image processed by the TV model produces a step effect on the head and hull of the person, which is because the TV model in the flat area of the image. Noisy signals can cause trouble when people process images. The noise in the image generally exists in the high-frequency area, and the edge structure characteristics of the image itself also exist in the high-frequency area. Therefore, some traditional denoising methods will also erase the edge characteristics of the image when removing the image

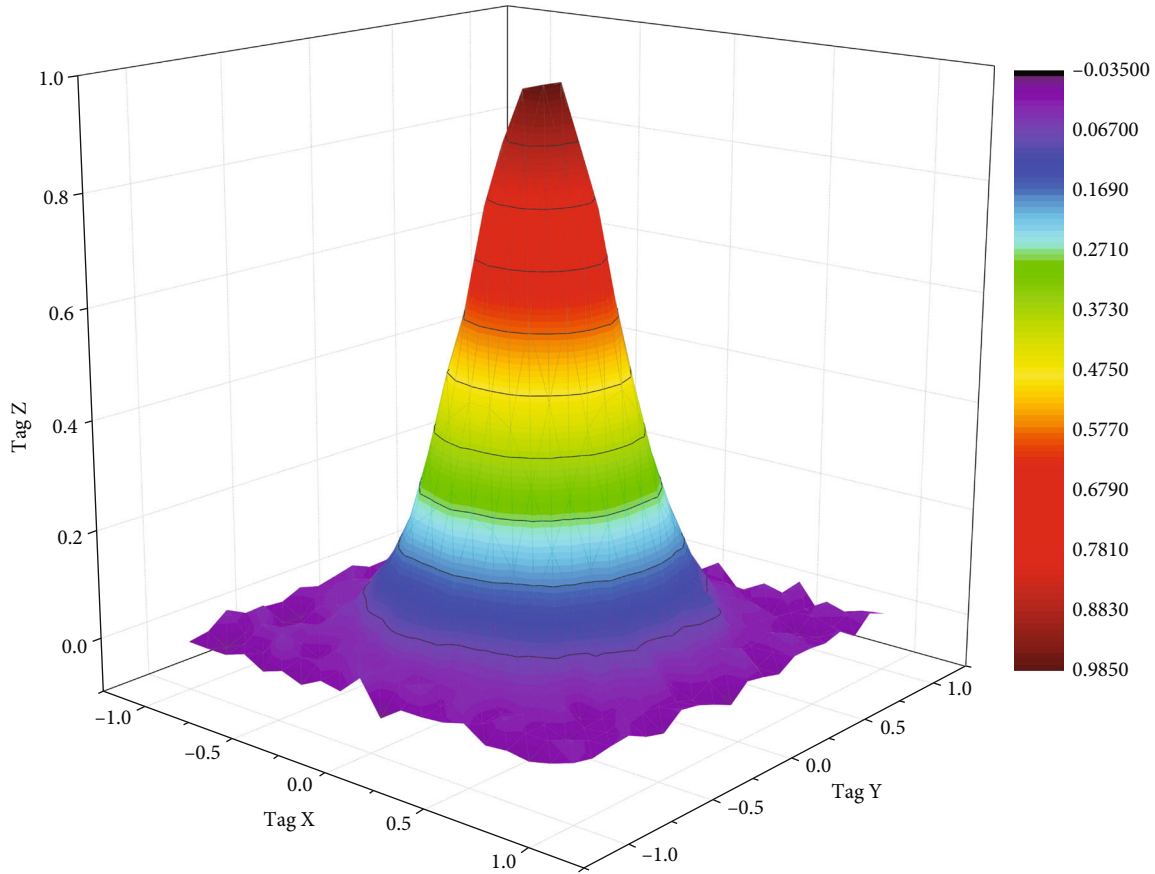


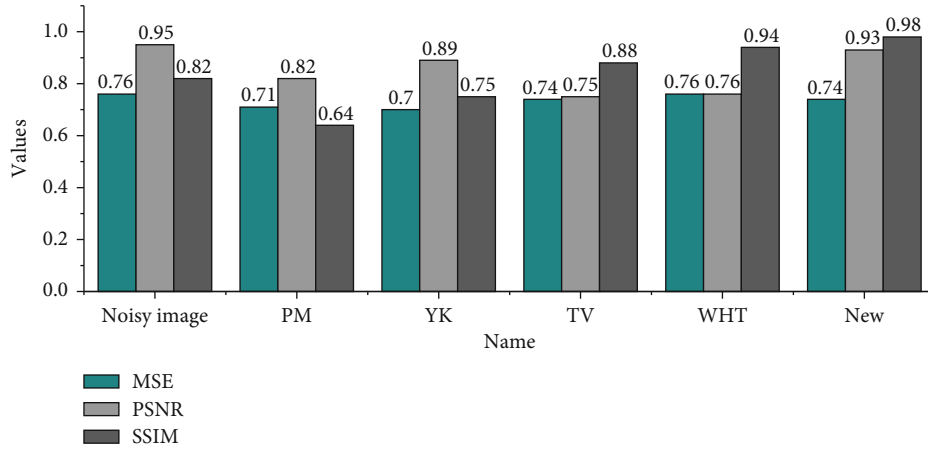
FIGURE 4: Distribution of pixel weights under Gaussian kernel function.

noise. The true gradient direction and the tangent direction perpendicular to it cannot be found. The image denoised by the WHT model is not satisfactory in terms of noise removal results, and the protection of edge textures is not adequate, mainly because the WHT model confuses the wavelet coefficients in the high-frequency component with the noise coefficients, resulting in less complete noise removal and loss of edge details in the image. Finally, the image after the denoising process using the new model is more effective in noise removal and better visibility compared to the previous model. This is because the new model can suppress the step effect in the flat areas of the image to effectively remove the noise and protect the detailed information and structural features in the corresponding edge areas, which makes the outlines of the people and the ship clearer in the denoised image, and the textures on the costumes and the words on the ship are preserved more completely.

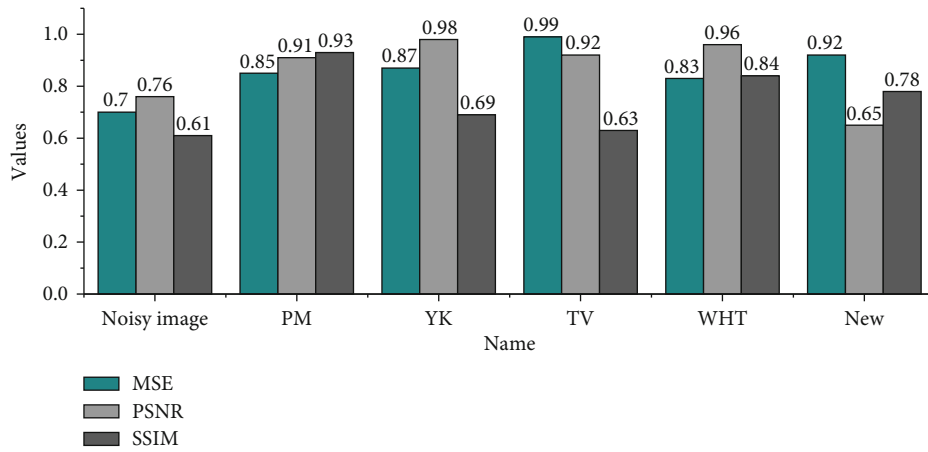
Figure 6 shows the comparison of the PSNR values of each model under different noise variances, which shows that the new model has a higher peak signal-to-noise ratio than the other models under each noise variance, which proves that the noise removal performance of the new model is more superior than the other models. Moreover, the PSNR values of PM, YK, TV, and WHT models decrease significantly as the noise variance increases, which indicates that the above models are not stable enough to deal with random noise. The PSNR values of the new model fluctuate less with

the increase of noise variance, which can reflect the high stability of the new model in noise handling.

The classical full variance denoising method is investigated with the development of variational denoising methods and the functions of the ROF model, and a higher-order full variance improvement method is proposed to suppress the step effect in flat areas of the image given the problem of “step effect.” In addition, according to the situation that it is difficult to protect the texture information in the edge regions of the image, a weighted adaptive full variance denoising model is proposed. Then, use the variational theory to find the corresponding variational partial differential equation and finally introduce the time parameter for numerical solution to achieve the best processing of the target image. The new model combines the advantages of the classical full variance segmentation method and the high-order full variance segmentation method to effectively remove the noise while suppressing the step effect in the flat regions of the image and protecting the detailed texture information in the edge regions. Compared with some traditional denoising models, the new model has superior noise removal performance, a higher definition of the denoised image, and better protection of edge information and detailed texture. At the same time, the peak signal-to-noise ratio, as well as the structural similarity, is significantly improved, and the effectiveness and stability of denoising are more excellent.



(a) Barbara



(b) Boats

FIGURE 5: Comparison of images after denoising using each model.

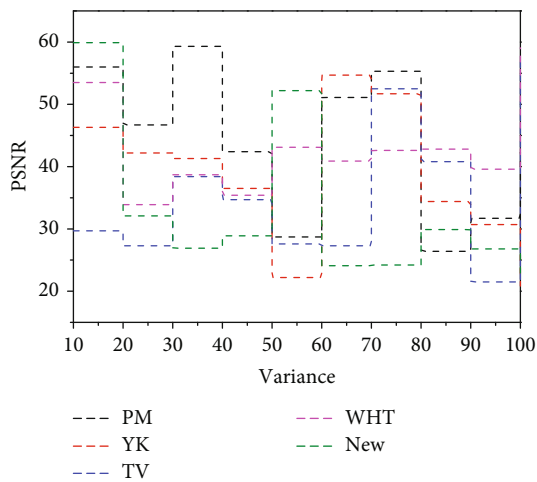


FIGURE 6: Model result.

4.2. Results of Automatic Recognition of Financial Instruments. After the location of the character recognition region is determined, the next step is single character segmentation

and recognition. For character segmentation, there are usually projection methods and correlation coefficient methods. The projection method is easy and fast but has low accuracy; the correlation coefficient method has high accuracy but requires specifying a series of templates and is inflexible. Since invoices have different specifications and their font sizes and colors vary, it is difficult to specify a uniform template; so, this paper uses the progressive segmentation method to segment characters based on the projection method: firstly, the projection method is used to obtain the coarse boundary of a single character from the outside to the inside, and then the effective point traversal is performed from the inside to the outside to obtain the exact boundary. The closest interpolation algorithm means that a floating-point coordinate is obtained by using the inverse transformation method; then, it is rounded and after that, an integer type coordinate is obtained. That is, it takes the closest upper-left corner of the floating-point coordinate and obtains the value of the pixel to which it corresponds. The nearest neighbor interpolation algorithm is not only simple and intuitive but also eliminates the need for computation. However, it has its drawback that the quality of the resulting image is not high. In the four regions of the pixel to be sought,

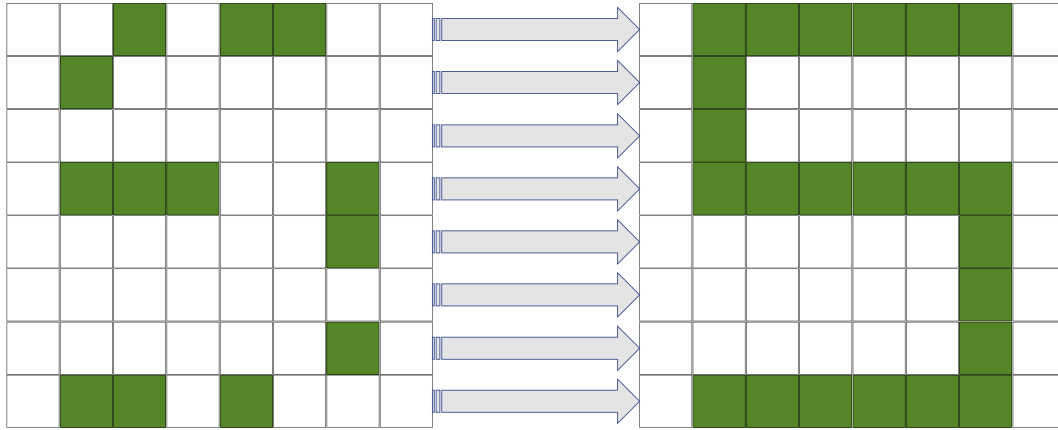


FIGURE 7: Image boundary fill.

we assign the gray value of the nearest neighboring pixel to the corresponding coordinate of the pixel to be sought, as shown in Figure 7.

In this paper, simulation experiments are tested for 10 invoices containing 216 characters and 20 number strings, of which 11 characters are incorrectly recognized, with an overall recognition rate of 94.9%. Compared with the recognition rate of 90% of the conventional neural network, there is a significant increase. This functional module is mainly intended to electronically image the contents of paper-based vouchers. Since the automatic financial voucher entry preprocessing system is mainly designed based on B/S architecture, the invocation and control of the capture device in this system are mainly implemented through an ActiveX control. The value domain filter coefficient is close to 1, and the spatial filtering plays a decisive role currently. The bilateral filter is transformed into a Gaussian low-pass filter to smooth and denoise the image. In the edge area of the image, the difference between pixels is more obvious. At this time, the range filter coefficient is close to 0, and the range filter plays a decisive role; so, the edge area of the image can be maintained. The control can be installed as a browser control, and the image capture device connected to the computer can be called through the browser to capture the image. After the image has been captured, the module performs image processing, image slicing, image reorganization, and other operations to obtain a highly recognizable image of the ticket.

This function module mainly checks the content of the data that has been identified. This function module is mainly to check the content of the ticket that has been entered. The main content of the check is divided into the following two main aspects: for the integrity of the data entered to check and for the accuracy of the data entered to check. The act of verification is done by the system together with the review post personnel. The system first checks whether there are any abnormalities in the recorded image content and whether the screening data content correctly identified. When the abnormal ratio of content data exceeds the budget threshold during the verification process, the input is transmitted to the review post personnel for manual data verification to effectively improve the accuracy of data identification, as shown in Table 2.

TABLE 2: Equipment statistics.

Equipment name	CPU frequency/GHZ	Memory capacity/GB	Disk capacity/GB
Main server	8.19	2.54	8.32
Ticket server	14.35	13.11	11.16
Database server	10.95	10.72	4.52
Other servers	11.78	3.89	3.7

After completing the image acquisition, financial voucher entry can be performed according to the different practical business requirements of different management systems. Before financial voucher entry, it is necessary to categorize bills and match business scenarios according to the electronic data information, generate electronic financial vouchers, and store them in the database according to the preprogrammed financial voucher templates of the corresponding scenarios and realize automatic financial voucher entry while correlating the original images of the generated financial vouchers to realize electronic file management of finance. According to the above simulation, environment in the system information data average corresponding period can fully demonstrate whether the above perfect algorithm can enhance the operation of the system server, and during the actual test, take a ladder method to build a variety of types of information data associated thread and then use the above multithreaded information data to pass data demand to the server, waiting for its response. During the subperiod, the information data response period of the whole system is calculated and finally, the average response period of the information data of the above system is made into a graph.

5. Conclusion

In this paper, the basic theory and numerical algorithm of partial differential equations are first analyzed, and then a high-order full variance improvement method is proposed for the problem of step effect in the classical full variance denoising model. If the modification is saved successfully, a message indicating that the modification is successful is

displayed, and the bill information display interface is returned. If the modification is not saved successfully, a prompt message of unsuccessful modification will pop up. Then, the edge protection ability of the high-order full variance model is improved, and a weighted adaptive full variance denoising model is proposed, which adaptively uses the high-order full variance method in the flat region of the image to suppress the step effect of the image in the process of removing noise; the classical full variance method is used to denoise the edge region of the image, to retain more structural features and detailed texture information of the image. The proposed deep learning-based tax bill content recognition model, i.e., the recognition model of each anisotropic partial differential, is more advantageous in terms of accuracy, speed, and size of image character recognition, with simple model parameter settings, simple network structure but high recognition efficiency, and easy to extend and only needs to determine the coordinates of tax bill region to recognize all types of tax bill content. In the recognition of real tax bills, both the steps of character decomposition and character classification in traditional OCR are omitted; furthermore, the accuracy rate is higher. This paper implements an automatic tax bill recognition system based on each anisotropic partial differential model, manages the information of recognized tax bills in the database, and provides functions such as query, modification, and deletion. It is convenient for the personnel of customer units to manage tax bills effectively.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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