Journal of Autonomous Intelligence (2024) Volume 7 Issue 4
doi: 10.32629/jai.v7i4.1470

ORIGINAL RESEARCH ARTICLE

Artificial intelligence assisted on seal design: Taking stable diffusion as an example

Xu Huang

International College, Krirk University, Bang Khen District, Bangkok 10220, Thailand; NJ_huangxu@163.com

ABSTRACT

In view of the possible problems of seal design, such as slow design speed, large error rate of seal identification, weak standardization and poor user satisfaction, how to use AI technology to solve these problems and improve the efficiency and automation of seal design is the focus of this research. This article used web crawlers and stable diffusion to collect exquisite seal images as the data source for research, and used median filtering to denoise the collected images. After graying the image using the weighted average method, histogram equalization is used for image enhancement. This article combined artificial intelligence technology and digital certificates to construct an electronic seal, and inputs the constructed electronic seal into the stable diffusion for further processing to obtain the final designed seal. The experiment showed that when the number of seals to be designed was 1, the time required to use stable diffusion for design was 1.11 seconds. At the same time, the average score of seal evaluators designed by stable diffusion in this article was 9.5 points (out of 10 points). With the help of artificial intelligence and stable diffusion, the study on seal design can improve the efficiency and accuracy of design, show good performance and stability in handling complex design tasks, and provide an effective solution to the limitations and efficiency of traditional seal design methods. At the same time, it also enhances the innovation and diversity of design, reduces the design cost, and improves the accuracy and efficiency of automated authenticity identification.

Keywords: seal design; artificial intelligence; electronic seal; stable diffusion; median filtering

ARTICLE INFO

Received: 28 November 2023
Accepted: 18 January 2024
Available online: 5 February 2024

1. Introduction

The seal, as a legal document for confirming the identity and behavior of a legal person, has always played an important role in people's daily lives. A unit or mechanism, regardless of size, must have at least one. At present, there are problems with seal design, such as slow design speed, high error rate in automatic authenticity identification of seals, weak standardization, and poor user satisfaction, which seriously restrict the development of seal design. With the development of Artificial Intelligence (AI) technology, it has had a positive impact on many industries, including the seal design industry. Through image processing technology, AI can help identify and analyze different seal patterns, colors, and text, thereby helping seal designers better carry out seal design. This solves the current problems in seal design, helps designers quickly generate multiple design solutions, reduces manual design time and effort, and improves design efficiency. At the same time, details can also be adjusted and optimized to improve the delicacy and accuracy of the seal, and improve the design quality. Stable diffusion is an artificial intelligence technology used for image creation, which can be used in research on seal design.

The core issue of this paper is how to use artificial intelligence technology, especially the Stable Diffusion model, to assist the seal design. The main goal of the study is to improve the efficiency, innovation and degree of automation of seal design. Stable diffusion can generate new images with similar patterns and features by learning a large amount of image data. In seal design, this tool can be used to design various seal patterns with inconsistent styles.

Electronic seals are a security technology that has emerged with the development of information technology[1]. It is mainly used to solve the issue of the validity of electronic document seals, verify the identity of the signatory of the electronic document, and ensure the accuracy and reliability of the document content. Shen Guangpeng proposed a digital watermarking algorithm based on Features from Accelerated Segment Test (FAST). He utilized an open source computer vision class library to extract FAST corner features of electronic seal images, and separated their pixel values, greatly improving feature extraction efficiency and detection accuracy[2]. Wang Zhenyu et al.[3] proposed a high-precision Chinese seal recognition system based on deep learning technology. When using this system, users only need to input a seal image into the system, and the system would automatically recognize the seal and report relevant information in real-time. Sun Bin et al.[4] proposed a method based on graphic matching to recognize characters in seal images, which utilized local features of nodes and edge pairs for calculation. Le Wei et al.[5] believed that with the widespread use of electronic seals, their traceability and security were receiving increasing attention. By designing electronic seals, the security of transmitted data can be improved. Alimehaj, Vlera et al.[6] developed an electronic seal using local digital certificates based on the characteristics of authentication and trust service regulations. Overall, there have been some research achievements in the design of electronic seals, but there are also problems such as slow design speed and low accuracy of seal recognition, resulting in poor user satisfaction. For this purpose, this article would utilize artificial intelligence technology and solve the problems existing in stable diffusion.

Wenjing X et al.[7-8] focused on artificial intelligence technology is widely applied in the fields of art and design. By utilizing computer vision technology, computers can automatically generate artworks, helping them learn patterns and styles from many artworks, and generate new works based on this. Zhao et al.[9] focused on the integration of artificial intelligence and art in the development of intelligent art, and proposed the process of their collision and fusion. This effectively improves the presentation effect of art design and increases user satisfaction. Verganti, Roberto et al.[10] proposed a framework for understanding design and innovation in the era of artificial intelligence. He discussed the meaning of design and innovation theory and found that AI has profoundly changed the practice of design, improved the speed of design, and made users more satisfied. Sun Yan et al.[11] summarized the problems in the application of artificial intelligence in the cultivation of art and design professionals, and evaluated the promoting role of artificial intelligence from aspects such as teaching content and teaching methods. This effectively demonstrates the promoting role of artificial intelligence in the cultivation of art and design professionals, helping to better promote the development of art and design. Terzidis, Kostas et al.[12] conducted research on the intentionality presented by artificial intelligence in art and design. He mainly discussed that if people only focused on the results of the artistic process, the artist's intentionality had no relevance. Stark, Luke et al.[13] found that artists often develop a sense of unfamiliarity with the audience, as well as the critical distance of contemporary artificial intelligence technology. This can help artists design more excellent works of art. Wang Chenghao et al.[14] provided a new solution for the application of artificial intelligence painting generation by combining the stable diffusion method with network user interface technology, which can generate smoother and more coherent images. Wenjing Xu et al. [15]Machine learning and human emotions are the two most important aspects of interactive and high-quality art design, and artificial intelligence and machine learning are more successful in cultivating students' creative talents than traditional learning methods, and in the evolution and creation of interactive and intelligent digital art, artificial intelligence and machine learning are playing a highly active role, showing the effectiveness of

art design systems based on artificial intelligence. Chiu Min-Chi et al.[16] used the fine-tuned ResNet50 model to develop an art learning system (DL-ALS) based on deep learning to help students identify and classify works of art, aiming to cultivate students' accurate appreciation knowledge and artistic creation ability, and use artificial intelligence technology to provide instant feedback and personalized guidance. Li Yurong et al.[17] believes that the vast majority of AI image generation software uses an image processing algorithm called Stable Diffusion. This algorithm uses a large number of commercial illustrations as a data set, and its ability to imitate the illustration style in the data set is very amazing. Discuss the advantages and disadvantages of the Stable Diffusion algorithm compared to human creation, and the impact of algorithm abuse on the aesthetic environment of Internet illustration. In summary, using artificial intelligence technology for artistic design can effectively improve the speed of design, help better design, and improve user satisfaction.

Some researchers suggested using basic computer algorithms for seal design in the early trials. Despite the fact that this approach streamlines the design process somewhat, the constraints of rules and specifications frequently result in designed seals that lack creativity and beauty. An increasing number of academics are attempting to use deep learning technology to seal design as a result of its rise. The quick advancement of artificial intelligence (AI) during the last ten years has transformed numerous industries. AI application gives designers more creative and practical tools, particularly in the realm of design. We want to address the issues of low efficiency and inadequate creativity in the conventional seal design approaches by implementing deep learning and other AI technologies.

With the rapid development of AI technology, AI painting has attracted wide attention from the art and design circles. In the field of art and design, the rise of AI has brought many new opportunities and challenges. And Stable Diffusion is the latest application software in AI painting, applied to the seal design, can effectively solve the current seal design slow, normative and low user satisfaction, can be based on the user's preferences and demand, provide personalized seal design advice, help designers to better meet the needs of customers. This paper presents a new method, using artificial intelligence technology, especially the Stable Diffusion model, to assist in seal design. This method not only improves the efficiency of the design, but also opens up a new approach of seal design. This paper details how to apply the Stable Diffusion model to the seal design process and provides specific implementation steps and techniques. In general, the research covers both technology and application, using Stable Diffusion model for seal design; applying AI technology to the actual seal design work. All studies aimed to fully explore in depth the auxiliary role of AI in seal design.

The general procedures for doing the research are as follows: First, the goals and issues of the research are outlined, and it is decided whether or not artificial intelligence can help with seal design. Next, decide which AI model is best suited for training and learning to fulfill the requirements of seal design, such as Stable Diffusion. Gather and handle seal data, gather a lot of information about seal design, and preprocess the data; next, research how artificial intelligence can help with seal design; and lastly, carry out experimental analysis.

2. Data collection and processing of seal design under artificial intelligence

The meaning of a seal is a mark printed with special words or symbols, which can be used to identify an individual's identity or as a proof of trust Li et al.[18]. The seal element has great aesthetic value, and it involves steps such as color, size, shape, and text processing during the design process. In the process of designing seals, it is necessary to learn the rich cultural connotations of seal carving art Wang, J., Yang Y[19]. In the long history of development, seals have undergone countless modifications and innovations by literati and literati. This is not only a reference in form and meaning, but also a profound understanding of its beautiful tradition. It is necessary to perfectly combine traditional aesthetics with modern culture.

2.1. Image digital input

The content of artificial intelligence technology is very rich, including computer vision technology. The

continuous development of computer vision technology has made images an important means of receiving and disseminating information from the outside world Wiley V et al.[20,21]. At the same time, with the rapid development of computer technology, the richness of image content expression and the convenience of transmission all meet the requirements of contemporary people for information technology visualization. Digital information can be better visualized, reflecting the importance of images. The input of digital images is a prerequisite for modern digital imaging. The basic schematic diagram of the image acquisition system is shown in **Figure 1**.

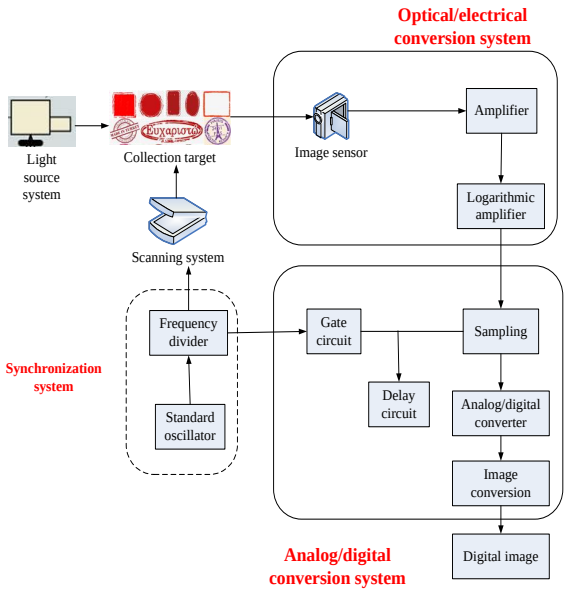

Figure 1. Basic schematic diagram of image acquisition system.

As shown in **Figure 1**, it can be divided into five parts: light source system, synchronization system, scanning system, optical/electrical conversion, and analog/digital conversion system. The light source system provides sufficient light for image acquisition and for the next step of optical/electrical conversion. The optical/electrical converter is responsible for converting optical signals from circuits corresponding to the characteristics of the measurement model into electrical signals and providing powerful processing to match analog-to-digital conversion.

2.2. Data collection

Seal design data collection refers to the process of obtaining information on the shape, size, font, color, and other aspects of a seal from practical application scenarios, and utilizing this information for seal design. This article would collect seal design image data uploaded by users by accessing online seal design websites, and automatically retrieve image data from these websites through a crawler program. There is also a large amount of image data related to seal design obtained through keyword search. At the same time, this article uses stable diffusion software to generate seal images and design seals through textual descriptions. Stable diffusion is an open-source artificial intelligence image design model that can create matching images by writing descriptive text Lee et al.[22,23]. Stable diffusion can also design a massive number of seal design models by studying many seal design materials, accumulating rich seal design styles and styles. The collected data is shown in **Figure 2**.

Figure 2. Partial data collected.

2.3. Data preprocessing

Because stable diffusion has powerful image processing capabilities. It can be combined with image preprocessing technology to better adjust and process the image of seal design in detail. This article uses image processing technology to denoise and enhance the seal images collected based on stable diffusion, in order to ensure the best effect of the seal in practical use.

2.3.1. Image denoising

People refer to the many factors that affect the understanding and recognition of information in images as image noise Zhang K et al.[24]. Image noise is some interference information present in image files. Due to limitations in recording equipment and lighting, stored images inevitably contain some noise, which can seriously reduce image quality Sun, X et al.[25]. There are many methods for denoising, and this article would use median filtering to denoise the collected images. The principle of median filtering is to replace the original pixel values with the median of each point in a certain area of a digital image Yildirim M et al.[26,27]. This filter is very good at eliminating salt and pepper noise. Its advantage is that it not only runs fast, but also preserves the edges of the image while removing noise, effectively overcoming its drawbacks. The specific expression is as follows:

$$h(a,b) = med\{g(a - n/2, b - n/2), \cdots, g(a + n/2, b + n/2)\} \quad (1)$$

Among them, $\mathrm{med}\{g(a - n/2, b - n/2), \cdots, g(a + n/2, b + n/2)\}$ are the medians of each pixel in a square template with an area of n × n, and $h(a, b)$ is the smoothed image. The comparison of the effects of median filtering on the original image is shown in **Figure 3**.

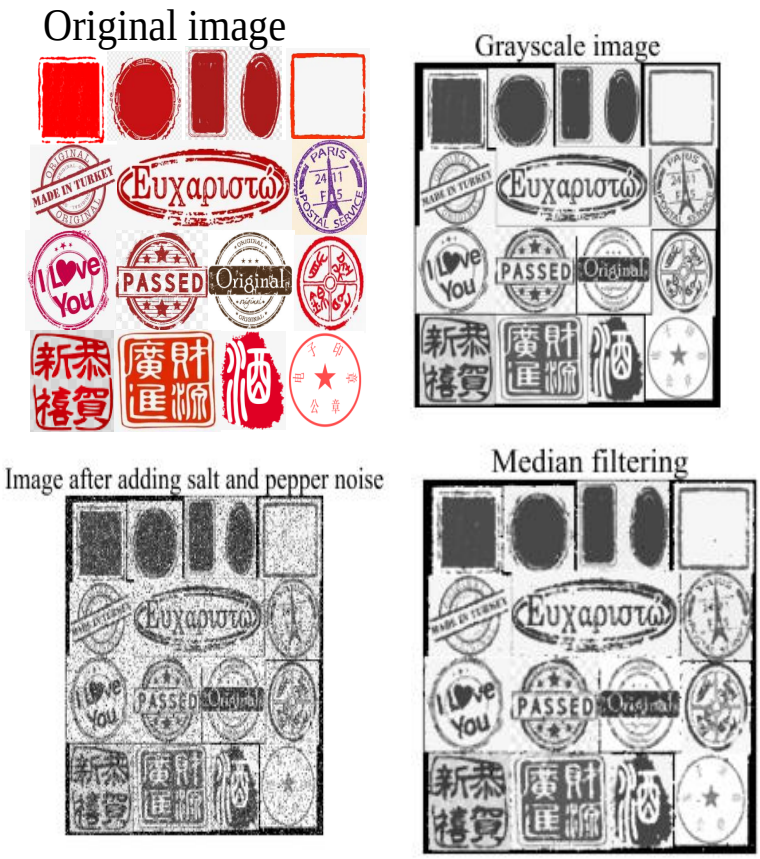

Figure 3. Comparison of the effects of median filtering on the original image.

2.3.2. Image contrast enhancement

In the process of studying seal images collected using stable diffusion, if the seal image has a background, it would affect the overall authentication and design of the seal. In order to reduce interference and improve recognition efficiency and accuracy, it is necessary to extract and segment seals to create ideal seal image recognition conditions. A color image is created by the grayscale values of multiple channels. In color space, the weighted average method is a commonly used image graying method Vartiainen E et al.[28], and its principle is as follows:

$$g = 0.299 * R + 0.587 * G + 0.114 * B \quad (2)$$

Among them, R, G, and B are the component values of each channel in the color image, and g is the converted grayscale value.

Due to the uneven strength of the force on the paper, the color of the seal may vary. The image of the seal placed in the air for a long time may fade or disappear, and the color of the seal is not an inherent feature. So first, it is necessary to grayscale the seal image. In addition, the clarity of the seal image is affected by external lighting, and histogram equalization can improve the contrast between the foreground and background, distinguishing between symbol and non symbol regions. This article would use histogram equalization to further grayscale seal images.

The histogram equalization transformation widens the histogram distribution of the seal image, expands the grayscale span, and increases the contrast between light and dark Dyke RM et al.[29,30]. Assuming that the size of the seal image $h(a,b)$ is N × N, the grayscale level is 0, 1, t−1, and n_i represents the number of grayscale values.

Firstly, calculate the grayscale histogram value of the input seal image, and normalize the histogram to

control the grayscale value within (0,1). The probability of i pixel occurrence is as follows:

$$Q(s_i) = \frac{n_i}{N * N}, i = 0,1,\cdots,t-1, \qquad 0 \le s_i \le 1 \tag{3}$$

Perform cumulative integral distribution transformation on the normalized histogram generated in the previous step:

$$r_i = W(s_i) = \sum_{j=0}^{i} Q(s_j) = \sum_{j=0}^{i} \frac{n_i}{N * N}, i = 0,1,\cdots,t-1, \qquad 0 \le s_i \le 1 \tag{4}$$

The final image grayscale value obtained after transformation:

$$h(a,b) = \begin{cases} 255 * r_i(a,b) & i = 1,2,\cdots,255 \\ 0 & i = 0 \end{cases} \tag{5}$$

The comparison before and after histogram equalization is shown in **Figure 4**. The first line in **Figure 4** is the grayscale image obtained after processing the original image, and next to it is the histogram after equalization of the grayscale image. Because the strength of each person's stamp is different, the image of the stamped seal is usually incomplete. The second row is the equalization map and the equalization histogram, where the brightness contrast between the marked area and the background area is more pronounced.

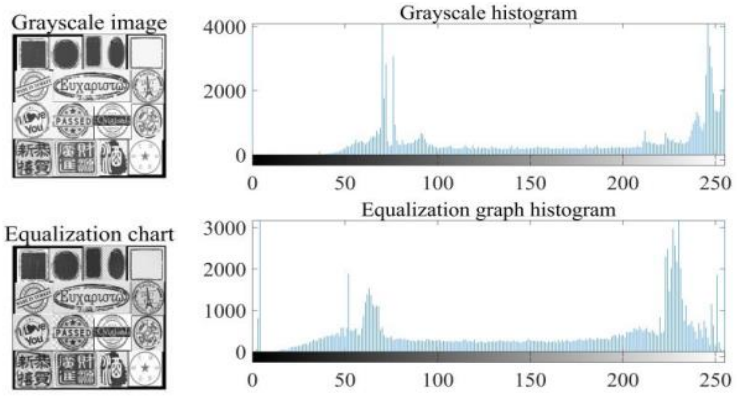

Figure 4. Comparison before and after histogram equalization.

2.4. Feature extraction

Shape characteristics are the external characteristics of a product that do not change with the color of the product image. Therefore, in many image retrieval, image features exhibit adaptability that color and texture cannot achieve. The FAST feature detection algorithm is currently the fastest detection algorithm and is widely used for object feature extraction Wei C et al.[31]. This means that if a pixel in an area has enough different points from its neighbors, it may be a corner. Considering grayscale images, if the grayscale value of a point is less than or greater than enough points in its neighborhood, it is the grayscale value, so the point may be a corner.

This article compares the grayscale image values around feature points. If the grayscale value of a circle of pixels around the test point differs significantly from the grayscale value of the candidate point, it can be considered that the candidate point is a feature point. Use coordinates to represent (L_a, L_q) in a two-dimensional image:

$$H_{q-a} = \begin{cases} x, & L_a \le L_q - t\ (darker) \\ y, & L_q - t < L_a + t\ (similar) \\ z, & L_q - t \le L_a\ (brighter) \end{cases} \tag{6}$$

Among them, t is the threshold (usually t = 10); L_a is the grayscale of any point in the image, and the

grayscale of the center of the circle is L_q. The FAST feature detection algorithm can detect many unique features with a high matching rate, and the matching speed is the fastest compared to previous versions. The specific feature extraction of seal images is shown in **Figure 5**.

Figure 5. FAST feature detection algorithm feature extraction.

2.5. Summary

This work is focused to examining the auxiliary function of artificial intelligence (AI) in seal design, especially through the implementation of the Stable Diffusion model. The following components are the key ways in which the research innovation work and distinctive traits are highlighted in this paper:

1) Innovation in research methods A text-to-image latent diffusion model called the Stable Diffusion model was employed in this study as a research tool. The Stable Diffusion model may produce seal styles with a great degree of diversity and creativity when given text descriptions as input. This approach increases design efficiency while simultaneously giving seal designers more room to express their creativity.
2) An original viewpoint on privacy protection the importance of seal privacy is emphasized in the study. Insofar as privacy is concerned, the generated seals are not exact replicas of the original images because the Stable Diffusion model relies on text input. This novel viewpoint offers a fresh concept and approach for privacy protection in seal design.
3) The principle of user demand-oriented design the function of user demand in seal design is the main topic of this study. Through user research and experimentation, in-depth understanding of users' individual demands and expectations of seal design. The created seals are more in line with the real application circumstances because to this user-oriented design idea, which also increases user happiness.

3. Artificial intelligence under electronic seal aided design

Electronic seals, also known as electronic signatures, digital seals, etc., are visualizations of digital signatures and can be understood as digitization of seals and manuscripts. Their functions are similar to handwritten signatures used in manuscripts Yang, Y et al.[32,33]. Most electronic seals are used in electronic documents and need to be sent in a network environment, which makes the design of electronic seals more complex. Electronic seals are usually constructed by software systems and disk key signatures, and the security technology used by software systems is mainly digital signature technology. The specific architecture diagram of the electronic seal is shown in **Figure 6**.

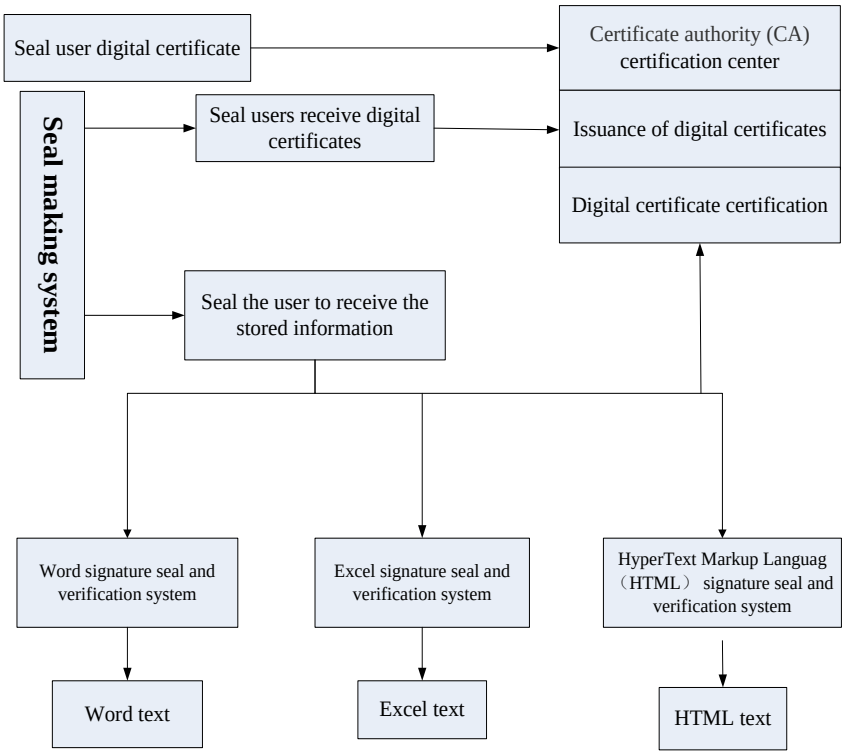

Figure 6. Electronic seal architecture diagram.

The user signature software in electronic seals is made using artificial intelligence technology, and the results can be used as independent signatures or easily combined into office software and web pages. The components commonly used in electronic seal systems are shown in **Table 1**.

Table 1. Components commonly used in electronic seal systems.

Serial number	Name	Function
1	Watermark	Encapsulation watermark related operations
2	Button	Two versions of word and excel are provided, and the toolbars and buttons inserted into office are realized. The signature control is called through this control.
3	Sign	Two versions of word and excel are available, including the main signature operation and document verification operation
4	Seal storage plug-in	A graphical interface when signing is provided to help users choose the seal and the storage location of the seal.
5	Universal Serial Bus (UBS)—Key	The development interface of USB smart cards is usually provided by the manufacturer
6	Certificate Authority (CA)	Encapsulate certificate-related operations

3.1. Design requirements for electronic seals

The unique requirements and expectations of users for seal design through survey, interview, and observation. For instance, the characteristics, features, or designs that users desire, as well as the situations in which the seal will be utilized. And allow them to apply the Stable Diffusion model for the design, inviting a specific number of people to take part in the seal design experiment. We are able to comprehend consumers' experiences and sentiments regarding AI-assisted seal design by gathering user comments, thoughts, and ideas during the experiment. evaluating customer satisfaction with the seals produced by the Stable Diffusion model in light of user experiment findings. To examine customer input, both quantitative and qualitative analysis can be applied. The traditional hand produced seals and the seals created using the Stable Diffusion model were compared to assess the variations in look, style, innovation, and other aspects. We can gain a better grasp of the features and benefits of AI-assisted design through comparative trials. and put the seals produced by the

Stable Diffusion model to the test in real-world application situations. Apply the created seal, for instance, to contracts, business cards, letters, and other documents to see how it functions and looks in real life. The applicability and practicability of AI-assisted seal design can be further confirmed by application trials.

When designing seals, the needs of target users can be analyzed from three dimensions: functionality, appearance, and emotion to determine their individual and common needs. This article regards user needs as the main feature of seal design, and at the same time, special designs are made according to different user needs to meet the personalized needs of customers. From a functional perspective, electronic seals are transformed from traditional seals. Therefore, they should not only have the basic functions of traditional seals, but also have some advanced skills for users to use. Starting from the visual dimension of the product, the appearance of the product usually includes colors, materials, and packaging, which are the interactive media when people use seals. Users obtain important information such as product functions and usage methods from the perspective of the product, and gain practical experience during use.

3.2. Production of electronic seals

In this article, an electronic seal is an image file that contains user personal information. Personal information is the signature of the creator on the user information identity, used to verify the similarity between electronic seals and digital certificates. Meanwhile, when a user signs a document, the electronic seal must include the user's signature information on the document to verify its authenticity. Therefore, this article divides electronic seals into two parts: one is to store the CA signature of user files, and the other is to store the user's signature on paper. In order to achieve the binding of electronic seals and digital certificates, it is necessary to change the content of the digital certificate, add extensions to the digital certificate, and store the electronic signature certificate on the electronic seal. The modified digital certificate content is shown in **Table 2**.

Table 2. Digital certificate content.

Serial number	Classification	Specific content
1	Version	Identify the version number of the certificate
2	Serial Number	The unique identifier of the certificate assigned by the issuer of the certificate
3	Signature Algorithm	Used to illustrate the signature algorithm used in this certificate
4	Issuer Name	The identifiable name of the issuer
5	Validity Period	The period of time when the certificate is valid
6	Subject Name	Identifiable identification of the certificate owner
7	Subject Public Key	The public key value of the subject and the identifier of the public key algorithm
8	Issuer Unique Identifier	Unique identifier of the certificate issuer
9	Subject Unique Identifier	Unique identifier of the certificate owner
10	Extension	Extension item, which stores the CA's signature information for the electronic seal

To ensure the legality and uniqueness of electronic seals, electronic seals and digital certificates must be bound. The so-called uniqueness refers to the electronic seal being only applicable to one legitimate user. The specific binding is as follows:

Firstly, the seal issuer allows users to apply for document h and extract the user's identification information (ID) from it; then, the user's identity information ID is calculated to obtain the abstract f_1 of the identity information, and the private key K_{R1} is used to sign the f_1 information Q_1, namely:

$$f_1 = f(ID), Q_1 = Qig(f_1, K_{R1}) \tag{7}$$

Secondly, embed Q_1 into the region L_1 of the seal image to obtain the seal image region L_1' containing

identity information, namely:

$$Embed(Q_1, L_1) = L_1' \tag{8}$$

Finally, read the L_1' information in the seal image area, perform calculations on it, and obtain the summary f_2 of L_1', namely:

$$f_2 = f(L_1'), Q_2 = Qig(f_2, K_{R1}) \tag{9}$$

The bound electronic seal has the sender's signature on the user's personal information, and the digital certificate contains the detailed information of the electronic seal. Due to the sender being a trusted party, the signed information is also trustworthy, and the user's personal information is unique in the system, thus ensuring the uniqueness and security of the electronic seal. The purpose of adding detailed information about electronic seals to electronic certificates is to verify whether the electronic seal has been tampered with during use, ensuring the integrity of the electronic seal. The implementation process is shown in **Figure 7**.

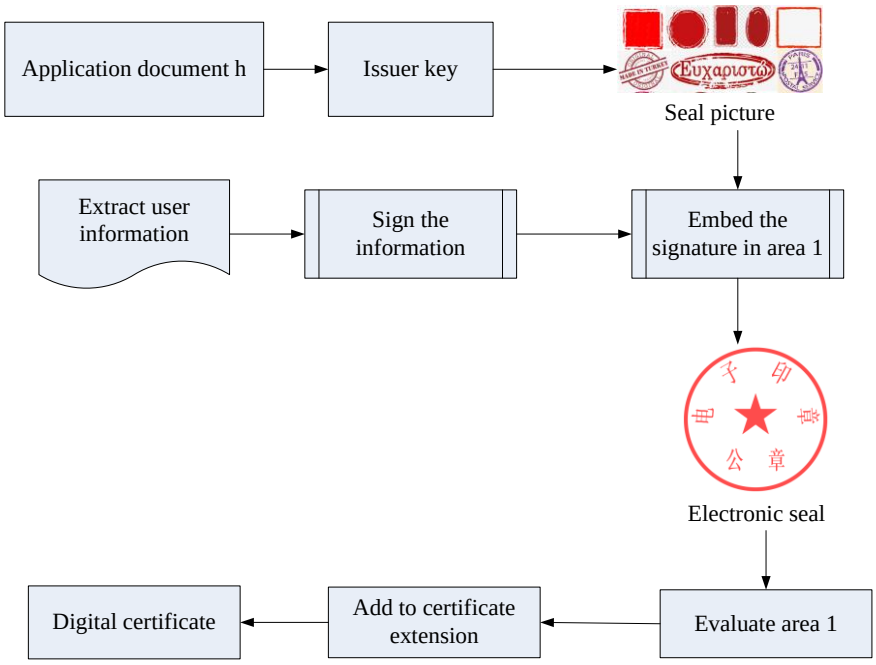

Figure 7. Binding process between electronic seals and digital certificates.

Through the above work, it can help to better utilize the stable diffusion tool to design electronic seals. The design steps are as follows: the firstly is to use stable diffusion to determine the width and height of the seal. Generally, it set the width and height to the same size, so that the seal image appears circular or square. The second is to design the color of the seal, setting the foreground and background colors of the electronic seal image. The third is the border of the electronic seal. It sets the width of the seal border. The width is usually 4 pixels. Finally, there is the main text of the seal, which includes text surrounding the seal border.

Stable diffusion is an image generator based on the Diffusion model, which gradually mixes with real data to generate samples and create new images Shchetinin EYu et al.[34,35]. Stable diffusion is excellent in terms of image production quality and speed, creating high-quality and useful images while maintaining a certain level of innovation. Stable diffusion also has powerful word processing capabilities[36]. It can design and sample the text in the seal well, ensuring that the font, size, spacing, and other aspects of the text complement the overall design of the seal. This article uses text description, combined with contour method, to extract the outer layer of the model. It preserves the main features and expands them, reducing the proportion of secondary features and emphasizing primary and secondary features. Overall, the image of seal design needs to be filled but not overcrowded, pursuing simplicity without being rigid. It adopts a circular stamp and often uses arcs and curves to prepare the image, as shown in **Figure 8**.

Figure 8. Text seal constructed based on stable diffusion.

Through the above research on electronic seals, this article combines the stable diffusion tool to design an electronic seal with parallel graphics and text. The juxtaposition of images and text is the fusion of images and text on the same printing surface. Although the styles of images and text are different, the content is mostly real images, with smooth text. There is no deliberate difference between the text and images, as shown in **Figure 9**.

Figure 9. Image and text seal constructed based on stable diffusion.

Stable diffusion can also make customized adjustments to seal design based on user needs. For example, users can upload their own images or text to incorporate into seal design, thereby creating more personalized and customized seals, as shown in **Figure 10**.

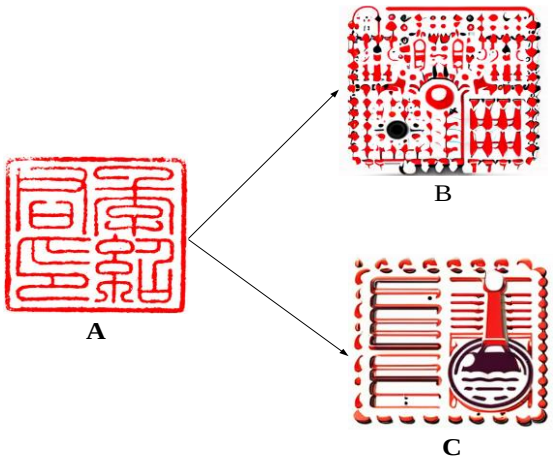

Figure 10. Personalized seal constructed based on stable diffusion.

As shown in **Figure 10**, this article inputs A from the figure into the stable diffusion and generates seals B and C based on the user's description. This effectively meets the personalized needs of users. In summary, the artificial intelligence technology represented by stable diffusion in this article has played an important auxiliary role in seal design.

4. Experiment of seal design on stable diffusion

This article utilizes computer vision technology in artificial intelligence technology to preprocess images of some data collected through the Stable Diffusion (SD) tool and web crawlers, and constructs a seal design method. It helps to better denoise and enhance the image strength of the collected seal images, extracting the main features that need to be paid attention to when designing electronic seals. The effective combination of computer vision technology and stable diffusion tools has accelerated the speed of seal design through textual

descriptions. In order to further demonstrate its speed in seal design, it was compared with AI painting software such as Generative Adversarial Networks (GANs) Sun L et al.[37], Diffusion Models (DMs)[14], Variational Autoencoders (VAEs), and Deep Dream Generators (DDGs) Rani S et al.[38] for the time required for seal design. The specific comparison is shown in **Figure 11**.

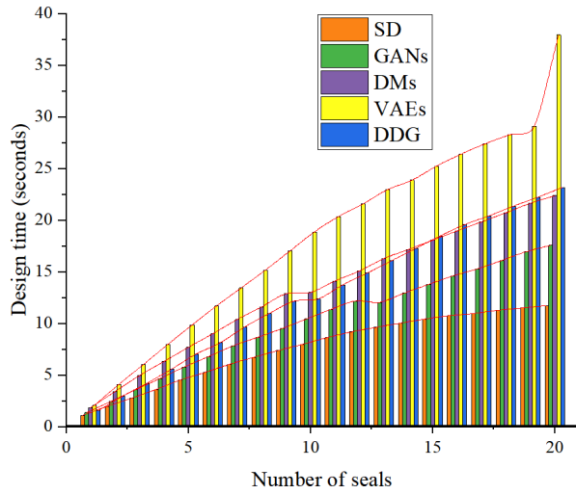

Figure 11. Comparison of the time required for seal design using different software.

In **Figure 11**, the x-axis represents the number of seal designs, and the y-axis represents the time required for the design. As shown in **Figure 11**, the time required for seal design using SD in this article is much shorter than that required for seal design using other software, and the design speed is faster. Among them, using GANs for seal design in this article requires more time than SD, but it is less than DMs, VAEs, and DDG. The time required for seal design using VAEs is more than that required for the other four software designs. When the number of seals to be designed is more than 14, using DMs for design requires more than SD and GANs, but less than VAEs and DDG. When the number of seals to be designed is 13 or less, using DMs for design requires more than SD, GANs, and DDG, but less than VAEs. When the number of seals to be designed is 1, the time required to use SD for design is 1.11 seconds. It takes 0.27 seconds, 0.75 seconds, 0.97 seconds, and 0.46 seconds less time than using GANs, DMs, VAEs, and DDG for design, respectively. When the number of seals to be designed is 20, the time required to design using SD is 11.74 seconds. It takes 5.84 seconds, 10.64 seconds, 26.22 seconds, and 11.44 seconds less time than using GANs, DMs, VAEs, and DDG for design, respectively.

For electronic seal design, in addition to the need for fast design speed, the security of electronic seals is also very important. Electronic seals have the function of anti-counterfeiting, and printing them in documents can play an important role in verifying documents. The probability of electronic seals being attacked and cracked by others varies depending on the software or system used in this article. This article uses stable diffusion and other artificial intelligence technologies to design electronic seals, and the designed seals have high security measures. It is not easy to avoid forgery and modification, and can ensure the security of electronic documents and the security of data during communication. This article uses stable diffusion to design multiple electronic seals and test them. It would obtain a seal cracking rate, and the lower the cracking rate, the higher the security of the designed electronic seal. In order to make the measures more scientific, this article conducted 100 experiments. The obtained 100 experimental results were compared with the cracking rate of electronic seals designed based on software such as GANs, DMs, VAEs, and DDG. The specific comparison results are shown in **Figure 12**.

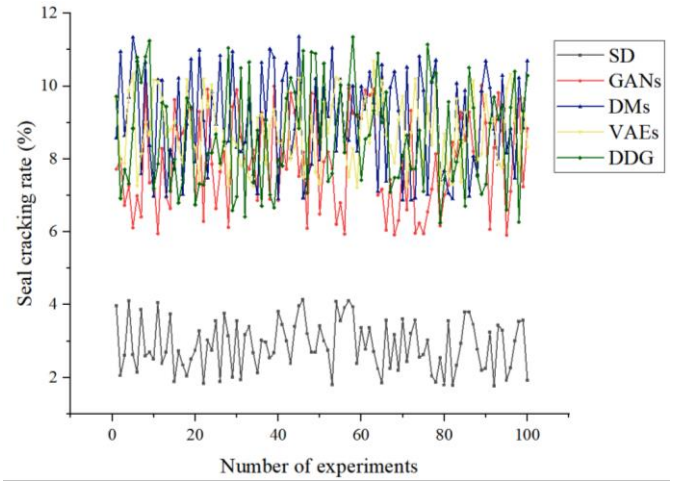

Figure 12. Comparison of electronic seal cracking rates among different software designs.

In **Figure 12**, the x-axis represents the number of experiments, with a total of 100 conducted, and the y-axis represents the seal cracking rate. As shown in **Figure 12**, the cracking rate of electronic seals designed using SD is much lower than that of seals designed using the other four software designs. This also indicates that the seal designed by the method studied in this article has higher security. The cracking rate of seals designed using SD is below 4.15%, while the cracking rates of seals designed using GANs, DMs, VAEs, and DDG are above 5.9%, 6.86%, 7.21%, and 6.24%, respectively. The average cracking rate of using the seal designed by SD for 100 experiments is 2.89%. Their cracking rates are 5.04%, 6.14%, 5.87%, and 5.74% lower than the average using GANs, DMs, VAEs, and DDG, respectively.

This article uses stable diffusion to design seals, which can be described through graphics and text to design more personalized seals and meet the personalized needs of users. At the same time, the designed seal has a better display effect, stronger image clarity, and higher user satisfaction. In order to further concretize users' satisfaction with seals designed based on stable diffusion, this article selects 50 evaluators to rate seals designed based on stable diffusion. The scoring value is 1–10 points, and the higher the score, the higher the satisfaction of the evaluator. It would compare the obtained results with the seal scoring results based on software designs such as GANs, DMs, VAEs, and DDG. The specific comparison results are shown in **Figure 13**.

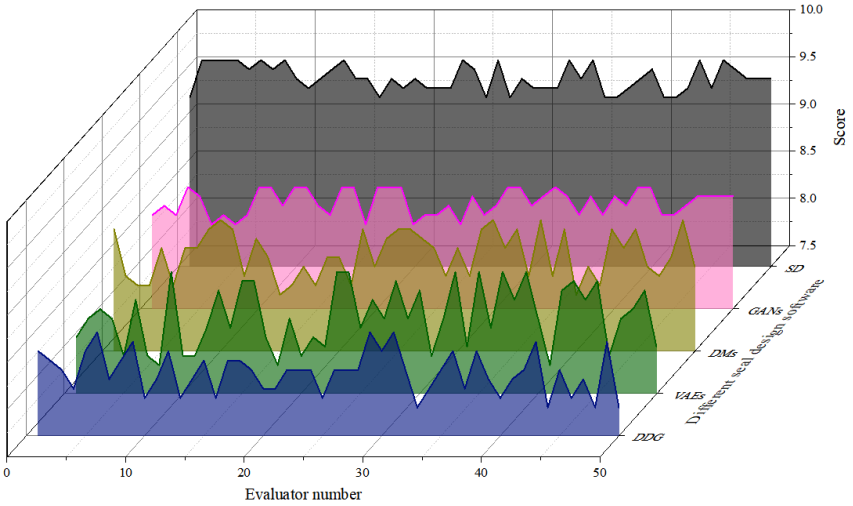

Figure 13. Rating of seal evaluators based on different software designs.

In **Figure 13**, the x-axis is the evaluator's number, and the y-axis is the score. The z-axis is a different seal design software. As shown in **Figure 13**, for seals designed using SD, the score given by the evaluator is

higher than that of seals designed using other software. Using SD for seal design not only provides high security and fast design speed for the designed seal. The overall presentation effect is better, resulting in higher satisfaction for evaluators. Among them, the seal evaluator designed using SD scored above 9.29 points. Seals designed using GANs, DMs, VAEs, and DDG are rated below 8.81 points, 8.91 points, 8.81 points, and 8.61 points, respectively. The average score of the 50 evaluators selected in this article for the seal designed using SD is 9.5. It scores 0.9 points, 1 point, 1.2 points, and 1.3 points higher than the seals designed using GANs, DMs, VAEs, and DDG, respectively.

5. Conclusions

Stable diffusion is an artificial intelligence technology used for image generation, which can be applied in auxiliary research of seal design. It can be achieved by learning a large amount of image data and generating new images with similar styles and features. In seal design, this technology can be used to generate seal patterns of various styles and features. Through stable diffusion, designers can input specific images or samples, and then have artificial intelligence systems learn and generate similar seal designs. This helps designers gain more inspiration and creativity, while also helping them generate diverse design solutions more quickly. The following results are mainly obtained:

1) From the perspective of the time required for seal design, the use of Stable Diffusion model can significantly shorten the design time. Traditional seal design requires designers to create by hand, which is not only time-consuming, but also needs to have certain professional knowledge and skills. Through the Stable Diffusion model, designers can generate a variety of seal styles in a short time, improving the design efficiency.
2) In terms of seal privacy, the Stable Diffusion model has certain advantages. Since the model is based on a text-to-image latent diffusion model, the generated seal style is based on the input text description rather than being generated directly from the real image. This indicates that the created seals are not connected to any specific person or organization, hence providing a certain level of privacy protection.
3) The majority of users expressed satisfaction with the seals produced by the Stable Diffusion model, according to data from user surveys and comments. According to these users, artificial intelligence-designed seals are beautiful, varied, and able to satisfy the majority of real-world application requirements. To better suit the requirements of particular sectors or usage, some users have drawn attention to the fact that the generated seal style still needs to be modified.

Conflict of interest

The author declares no conflict of interest.

References

1. Liang H, Yuan G, Yang Y, et al. The Evolutionary Game of Electronic Seal Usage Behaviour Supervision From the Perspective of Credit and Penalty. IEEE Access. 2018, 6: 57751-57762. doi: 10.1109/access.2018.2872322
2. Shen G, Wang T. Design of digital watermarking algorithm for electronic seals based on image characteristics. Computer applications. 2020; 1-3. doi: 10.11772/j.issn.1001-9081.2019081441
3. Wang Z, Lian J, Song C, et al. CSRS: A Chinese Seal Recognition System With Multi-Task Learning and Automatic Background Generation. IEEE Access. 2019, 7: 96628-96638. doi: 10.1109/access.2019.2927396
4. Sun B, Hua S, Li S, et al. Graph-matching-based character recognition for Chinese seal images. Science China Information Sciences. 2019, 62(9). doi: 10.1007/s11432-018-9724-7
5. Le W, Moros-Daza A, Jubiz-Diaz M, et al. A Blockchain Prototype for Improving Electronic Seals on Container Shipping Operations. Sustainability. 2023, 15(14): 11341. doi: 10.3390/su151411341
6. Alimehaj V, Halili A, Dervishi R, et al. Analysing and comparing the digital seal according to eIDAS regulation with and without blockchain technology. International Journal of Information and Computer Security. 2021, 14(2): 171. doi: 10.1504/ijics.2021.113174
7. Wenjing X, Cai Z. Assessing the best art design based on artificial intelligence and machine learning using GTMA. Soft Computing. 2022, 27(1): 149-156. doi: 10.1007/s00500-022-07555-1

8. He C, Sun B. Application of Artificial Intelligence Technology in Computer Aided Art Teaching. Computer-Aided Design and Applications. 2021, 18(S4): 118-129. doi: 10.14733/cadaps.2021.s4.118-129
9. Zheng X, Bassir D, Yang Y, et al. Intelligent art: the fusion growth of artificial intelligence in art and design. International Journal for Simulation and Multidisciplinary Design Optimization. 2022, 13: 24. doi: 10.1051/smdo/2022015
10. Verganti R, Vendraminelli L, Iansiti M. Innovation and Design in the Age of Artificial Intelligence. Journal of Product Innovation Management. 2020, 37(3): 212-227. doi: 10.1111/jpim.12523
11. Sun Y. Application of Artificial Intelligence in the Cultivation of Art Design Professionals. International Journal of Emerging Technologies in Learning (iJET). 2021, 16(08): 221. doi: 10.3991/ijet.v16i08.22131
12. Terzidis K, Fabrocini F, Lee H. Unintentional intentionality: art and design in the age of artificial intelligence. AI & SOCIETY. 2022, 38(4): 1715-1724. doi: 10.1007/s00146-021-01378-8
13. Stark L, Crawford K. The Work of Art in the Age of Artificial Intelligence: What Artists Can Teach Us About the Ethics of Data Practice. Surveillance & Society. 2019, 17(3/4): 442-455. doi: 10.24908/ss.v17i3/4.10821
14. Wang, C, Chung, J. Research on AI Painting Generation Technology Based on the [Stable Diffusion]. International Journal of Advanced Smart Convergence. 2023; 90-95. doi: 10.7236/IJASC.2023.12.2.90
15. Xu, W, Cai, Z. Assessing the best art design based on artificial intelligence and machine learning using GTMA. Soft Computing. 2023: 149-156. doi: 10.1007/s00500-022-07555-1
16. Chiu MC, Hwang GJ, Hsia LH, et al. Artificial intelligence-supported art education: a deep learning-based system for promoting university students' artwork appreciation and painting outcomes. Interactive Learning Environments. Published online July 13, 2022: 1-19. doi: 10.1080/10494820.2022.2100426
17. Sun Y, Yang CH, Lyu Y, et al. From Pigments to Pixels: A Comparison of Human and AI Painting. Applied Sciences. 2022, 12(8): 3724. doi: 10.3390/app12083724
18. Li, X., Zou, C., Yang, G., & Liu H. SealGAN: Research on seal elimination based on generative confrontation networks. Journal of Automation. 2021; 47(11): 2614-2622. doi: 10.16383/j.aas.c190459
19. Wang, J., Yang Y. Experimental research on the identification of high-imitation photosensitive seals. Chinese Judicial Appraisal. 2022; 123(4): 60.
20. Wiley V, Lucas T. Computer Vision and Image Processing: A Paper Review. International Journal of Artificial Intelligence Research. 2018, 2(1): 22. doi: 10.29099/ijair.v2i1.42
21. Khan A, Laghari A, Awan S. Machine Learning in Computer Vision: A Review. ICST Transactions on Scalable Information Systems. Published online July 13, 2018: 169418. doi: 10.4108/eai.21-4-2021.169418
22. Lee, SH, Song, KS. Exploring the possibility of using ChatGPT and Stable Diffusion as a tool to recommend picture materials for teaching and learning. Journal of the Korea society of computer and information. 2023; 28(4): 209-216. doi: 10.9708/jksci.2023.28.04.209
23. Fujii Y, Ito H, Miura A, et al. Fast discharge–charge properties of FePS3 electrode for all-solid-state batteries using sulfide electrolytes and its stable diffusion path. Functional Materials Letters. 2021, 14(03): 2141005. doi: 10.1142/s1793604721410058
24. Zhang K, Zuo W, Zhang L. FFDNet: Toward a Fast and Flexible Solution for CNN-Based Image Denoising. IEEE Transactions on Image Processing. 2018, 27(9): 4608-4622. doi: 10.1109/tip.2018.2839891
25. Sun, X., Fu, P., Sun, Q. A noise estimation method for hyperspectral remote sensing images selected from isotropic homogeneous areas. Data collection and processing. 2018; 33(5): 809-817. doi: 10.16337/j.1004-9037.2018.05.005
26. Yildirim M. Analog circuit implementation based on median filter for salt and pepper noise reduction in image. Analog Integrated Circuits and Signal Processing. 2021, 107(1): 195-202. doi: 10.1007/s10470-021-01820-3
27. Perrot G, Domas S, Couturier R. How separable median filters can get better results than full 2D versions. The Journal of Supercomputing. 2022, 78(7): 10118-10148. doi: 10.1007/s11227-021-04233-1
28. Vartiainen E, Masson G, Breyer C, et al. Impact of weighted average cost of capital, capital expenditure, and other parameters on future utility-scale PV levelised cost of electricity. Progress in Photovoltaics: Research and Applications. 2019, 28(6): 439-453. doi: 10.1002/pip.3189
29. Dyke RM, Hormann K. Histogram equalization using a selective filter. The Visual Computer. 2022, 39(12): 6221-6235. doi: 10.1007/s00371-022-02723-8
30. Wang X, Chen L. Contrast enhancement using feature-preserving bi-histogram equalization. Signal, Image and Video Processing. 2017, 12(4): 685-692. doi: 10.1007/s11760-017-1208-2
31. Wei C, et al. Fast image stitching algorithm based on improved FAST-SURF. Journal of Applied Optics. 2021, 42(4): 636-642. doi: 10.5768/jao202142.0402001
32. Yang, Y., Zhang, R., Xu, P., et al. Improved U-Net for the division of archives and seals of the Republic of China. Computer applications. 2023; 43(3): 943. doi: 10.11772/j.issn.1001-9081.2022020218
33. Zheng, J., Qi H. The application of CNC machining technology in seal processing. Journal of Jilin Institute of Chemical Technology. 2022; 39(2): 26-30. doi: 10.16039/j.cnki.cn22-1249.2022.02.007
34. Shchetinin EYu. Brain-computer interaction modeling based on the stable diffusion model. Discrete and Continuous Models and Applied Computational Science. 2023, 31(3): 273-281. doi: 10.22363/2658-4670-2023-31-3-273-281
35. Raubickas, Emilis, and Grazina Tautvydiene. Vaizdu generavimas naudojant dirbtinio intelekto modelį STABLE

DIFFUSION. Business, New Technologies and Smart Society. 2023; 1(1): 82-87. doi: 10.48550/arXiv.2210.04885
36. AI Application to Generate an Expected Picture Using Keywords with Stable Diffusion. Journal of Artificial Intelligence Practice. 2023, 6(1). doi: 10.23977/jaip.2023.060110
37. Sun L, Chen P, Xiang W, et al. SmartPaint: a co-creative drawing system based on generative adversarial networks. Frontiers of Information Technology & Electronic Engineering. 2019, 20(12): 1644-1656. doi: 10.1631/fitee.1900386
38. Rani S, Jining D, Shah D, et al. The Role of Artificial Intelligence in Art: A Comprehensive Review of a Generative Adversarial Network Portrait Painting. Lecture Notes in Networks and Systems. Published online 2023: 126-135. doi: 10.1007/978-3-031-50330-6_13