Design of Laser Holographic Digital Image Compensation Resource Cloud Storage Platform

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Abstract Aiming at the problem of image quality affected by laser holography distortion caused by laser diffraction, a cloud storage platform for laser holography compensation resource is designed. Users are sent by the data access layer database access engine laser holographic digital image compensation resources storage after the request to the application of the interface layer, application interface layer in information management, platform, operation and monitoring in the interface to select the corresponding interface to cloud storage software layer, the layer through the HDFS distributed database storage technology to complete compensation resources storage, access, management and response of the laser holographic digital image compensation request, including compensation through image compensation module is complete. All data will be sent to the hardware facilities layer, which will send user demand data to the user interface and save it in the storage server to realize data cloud storage. Experimental results show that the platform can effectively compensate the laser holographic digital image, and the image quality after compensation is high, and the storage time is only 511 ms when the storage capacity is 3000 M, with high storage performance.

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1 Introduction

Holographic digital storage technology is a large-capacity storage technology born with the development of science and technology. This technology uses a photosensitive medium as a storage carrier to realize data storage based on laser interference technology [1]. With the continuous development and improvement of holographic digital storage technology, holographic digital storage technology has been applied in many different fields. Holographic digital storage technology is a technology that combines computer technology, spatial light modulator technology, and image processing technology [2]. Images obtained by laser holographic digital technology can display a large amount of image information. Therefore, through laser holographic digital technology The acquired images have special visual effects [3].

Laser holographic digital image (CCD) is an entity image amplified by laser. When observing the entity through a laser microscope, the image will be distorted due to laser diffraction, which affects the quality of laser holographic digital image [4]. Therefore, an effective laser holographic digital image is designed. Compensation for the resource cloud storage platform is of great significance.

Cloud storage is a new mode of storing data through the Internet. It is a new concept based on the development of cloud computing. Cloud storage integrates various technologies such as distributed processing, grid computing and parallel processing. A new storage technology. The development of cloud storage technology has changed the traditional network storage model. With the continuous development of informatization in my country and the popularization of the Internet, traditional storage methods can no longer meet the ever-expanding amount of information and data. With the increase in the amount of information transmission [5], people pay more and more attention to the security of information transmission. As a storage method with high security, the storage method has gradually become popular in human life. Design a cloud storage platform for laser holographic digital image compensation resources to solve the shortcomings of traditional laser holographic digital image compensation resource storage platforms such as poor security, small capacity and lack of interaction ability, improve the quality of laser holographic digital images and have high real-time data storage and data storage query function.

2 Cloud Storage Platform Design

2.1 Cloud Storage Platform Architecture

The overall architecture of the laser holographic digital image compensation resource cloud storage platform is shown in Fig. 1.

As can be seen from Fig. 1, cloud storage management is located at the central node of the overall architecture, and the central node and resource nodes are in a cluster relationship. The platform's resource storage services are provided through

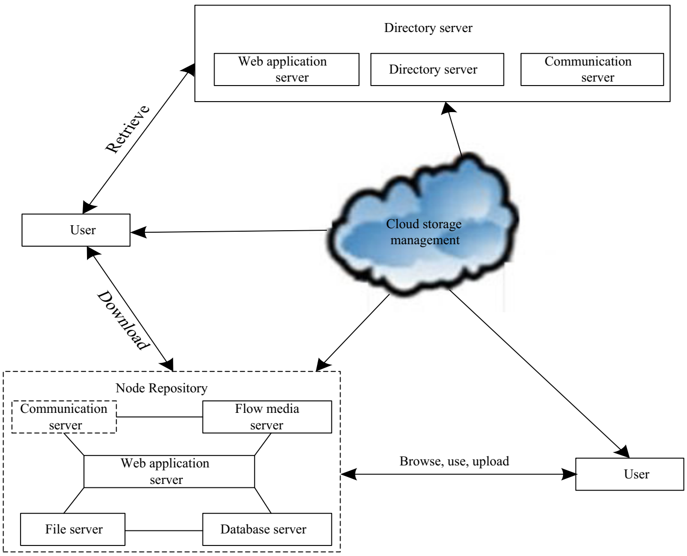

Fig. 1 Overall architecture of cloud storage platform

the node resource library [6], and resource information is sent to the central node. Nodes implement cloud storage management. The laser holographic digital image compensation resource cloud storage platform mainly uses HDFS technology as the main technology for the operation of the cloud storage platform.

Through the application interface layer, the functions of information management, platform operation and monitoring of various businesses in the cloud storage platform are realized. The storage, access, management of laser holographic digital image compensation resources and laser holographic digital image compensation are realized through the cloud storage software layer [7], and the cloud storage software layer is realized by HDFS distributed database storage technology. Hardware facilities such as storage servers and network storage are managed through the hardware facility layer.

After the user sends a resource storage request in the database access engine of the data access layer, the data access layer calls the corresponding interface through the application interface layer and transmits the request to the cloud storage software layer, and the cloud storage software layer completes the relevant instructions according to the user's requirements [8], and Send the required data to the hardware facility layer, send the final result to the user interface through the hardware facility layer, and save the cloud storage of the realization data in the storage server. The digital resource public service retrieval technology is selected and applied to the application interface layer [9] to improve the accuracy of the cloud storage platform to find information in massive information.

2.2 Cloud Storage Software Layer Implementation

2.2.1 HDFS Distributed Database Storage Technology

The cloud storage software layer of the system selects the distributed architecture of Hadoop and uses the HDFS distributed database storage technology to realize the storage and management of laser holographic digital images.

The HDFS distributed database storage technology has the advantages of high fault tolerance and matching with various hardware devices. The HDFS distributed database is used to store the unprocessed laser holographic image data set in the cloud storage platform.

The HDFS distributed database storage technology is a storage technology based on the Hadoop architecture. It manages resource data through the Hadoop architecture, and uses the resource data to perform file system naming, customer read and write requests, data block creation, deletion, replication and other commands [10].

Read the uncompensated laser holographic digital image data from the HDFS distributed database, and divide it into small data sets, process the data of each small data set in parallel through the laser holographic digital image compensation technology [11], and store it after all processing is completed. to a distributed data platform.

The laser holographic image compensation resource cloud storage platform uses the network to realize the compensation, storage and access services of laser holographic digital image resources. Therefore, an encryption system is set up in the HDFS distributed database to ensure the security of data storage and access [12].

Let the input attribute set of the platform be ξ, set the random number λ_j, satisfy each attribute of the laser holographic digital image $i \in \xi$, form the key through the random number λ_j, group and decrypt the platform data through the key:

$$\xi = g^{\frac{\alpha+\lambda}{\beta}}, \forall j \in \xi \tag{1}$$

In formula (1), g represents the generator of the prime number group, and the decryption process of the data belongs to the recursive process, so the intermediate function formula is as follows:

$$\begin{aligned} \eta_x &= \frac{E(D_i, C_x)}{E\left(D_i', C_x'\right)} \\ &= \frac{e\left(g^{\lambda} \cdot H(i)^{\lambda}, g^{q_x(0)}\right)}{e\left(g^{\lambda_i} \cdot H(i)^{\lambda}, g^{q_x(0)}\right)} = e(g)^{\lambda q} \end{aligned} \tag{2}$$

In formula (2), E represents encryption operation, D represents small decryption operation, and C represents ciphertext, $H(i)$ represents the hash function, which $i \in \xi$ means that the decryption packet is realized at that time, and $i \notin \xi$ means that the decryption packet fails at that time.

2.2.2 Laser Holographic Digital Image Compensation

The laser holographic digital image is an enlarged real image. The deviation caused by the distortion of the laser holographic digital image is compensated by the image compensation module [13], and a clear and high-quality laser holographic digital image is obtained. The cloud storage software layer image compensation module in the cloud storage platform compensates The process is as follows:

$$\phi_{MO}(m,n) = \exp\left[\frac{i\pi}{\lambda d_1}\left(m^2\Delta x_i^2 + n^2\Delta y_i^2\right)\right] \tag{3}$$

In formula (3), x represents the abscissa, y represents the ordinate, m and n represent the parameters corresponding to the abscissa and ordinate respectively, $d_1 = d_i - f$, d_i represents the distance between the laser digital holographic image and the laser microscope, and f represents the focal length of the laser microscope.

By $\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i}$ expressing the relationship between the object and the image, it can be known that the quadratic phase factor formula in the laser holographic digital image is as follows:

$$\phi_{MO}(m,n) = \exp\left[\frac{i\pi}{\lambda C}\left(m^2\Delta x_i^2 + n^2\Delta y_i^2\right)\right] \tag{4}$$

Combining formula (3), formula (4) and the relationship between objects, we can get:

$$\frac{1}{C} = \frac{1}{d_i}\left(1 + \frac{d_0}{d_i}\right) \tag{5}$$

It can be seen that the conjugate term of the quadratic phase factor of formula (3) needs to be placed before the reproduction of the digital holographic image [14], so as to compensate the phase distortion caused by the laser microscope. Using the digital phase mask to represent the conjugate term, we can get:

$$\phi(m,n) = \exp\left[-\frac{i\pi}{\lambda C}\left(m^2\Delta x_i^2 + n^2\Delta y_i^2\right)\right] \tag{6}$$

According to formula (6), it can be known that the phase distortion can be compensated by selecting the optimal parameter d_0,d_1, that is, the optimal parameter C.

In the holographic digital storage device, the distance between the laser holographic digital image and the laser microscope is fixed, and the value obtained from the object-image relationship is also fixed. The above analysis shows that the distortion fringes in the phase can be eliminated by adjustment, and the laser holographic digital image compensation can be realized. [14].

Holographic digital storage devices usually realize holographic image reading through reference light. The reference light R_D formula is as follows:

$$R_D(k,l) = A\exp\left[i\frac{2\pi}{\lambda}\left(k_x k\Delta x + k_y l\Delta y\right)\right] \quad (7)$$

In formula (7), k_x, k_y both represent the vector component in the reference light.

In the process of reading the laser holographic digital image, the reference light needs to be realized in the Fresnel integration [15], so the reproduced laser holographic digital image changes when the value changes, which affects the compensation phase distortion results. It can be seen that in order to ensure the quality of phase distortion compensation, the reference light needs to be moved outside the Fresnel integral. The specific process is as follows:

The formula for the properties of laser modulation is as follows:

$$\begin{aligned}&\zeta_\tau\left[\exp(i2\pi vx)f(x)\right] = \exp(i2\pi vx_i)\times\\&\exp\left(-i\pi v^2\tau^2\right)\zeta_\tau[f(x)]\left(x_i - v_x\tau^2, y - v_y\tau^2\right)\end{aligned} \quad (8)$$

In formula (8), τ and f and represent the two-dimensional parameters of the Fresnel transform and the frequency of the light wave respectively; are the adjustment coefficients of the length and width of the laser holographic digital image.

The wavefront reproduction formula is:

$$\begin{aligned}&\psi(x_i, y_i) = -i\phi(x_i, y_i)\cdot\exp(i2\pi d/\lambda)\\&\cdot R'(x_i, y_i)\zeta_\tau[I](x_i, y_i)\end{aligned} \quad (9)$$

In formula (9),$\psi(x_i, y_i)$ and $\phi(x_i, y_i)$ respectively represent the wavefront reproduction phase and the phase of the holographic digital image; and respectively represent the reference light correction coefficient and the recorded holographic digital image.

The discretization formula (10) can be obtained:

$$\begin{aligned}&\psi(m,n) = AR'(k,l)\phi(m,n)\exp\left[\frac{i\pi}{\lambda d}\left(m^2\Delta x_i^2 + n^2\Delta y_i^2\right)\right]\times\\&FFT\left\{I(k,l)\exp\left[\frac{i\pi}{\lambda d}\left(m^2\Delta x^2 + l^2\Delta y^2\right)\right]\right\}\end{aligned} \quad (10)$$

In formula (10),d and λ represent the reproduction distance and wavelength of the holographic image, respectively, Δx and Δy represent the sampling interval of the holographic plane, and represent the phase mask and the corrected reference light, respectively. The corrected reference light formula is as follows:

$$R'(k,l)=R_D(k,l)\cdot\exp\left\{-\frac{i\pi\lambda}{d}\left[\left(\frac{k_x}{\lambda}\right)^2 + \left(\frac{k_y}{\lambda}\right)^2\right]\right\} \quad (11)$$

3 Experimental Results and Analysis

In order to detect the laser holographic digital image compensation resource cloud storage platform designed in this paper to compensate the laser holographic digital image and the storage validity, the software of seafile v6.2.11.0 is used to build the platform of this paper, and the platform of this paper is used to compensate 5 laser holographic digital images. The detection platform compensates for the validity of the laser holographic digital image.

Five initial laser holographic digital images were selected in the experiment, as shown in Fig. 2.

The digital image of laser holography after compensation using the platform in this paper is shown in Fig. 3.

Comparing Figs. 2 and 3, it can be seen that the original laser holographic digital image has poor image quality due to the light diffraction generated by the laser microscope, while the five laser holographic digital images compensated by the platform in this paper have bright colors, clear boundaries, and the image quality is improved is larger, which verifies the compensation effect of the platform in this paper.

The time used to compensate 5 images is shown in Table 1.

From Table 1, it can be seen that the time used to compensate the five laser holographic digital images using the platform in this paper is all less than 900 ms, which shows that the platform can quickly and effectively compensate the laser holographic digital images, and has high real-time performance.

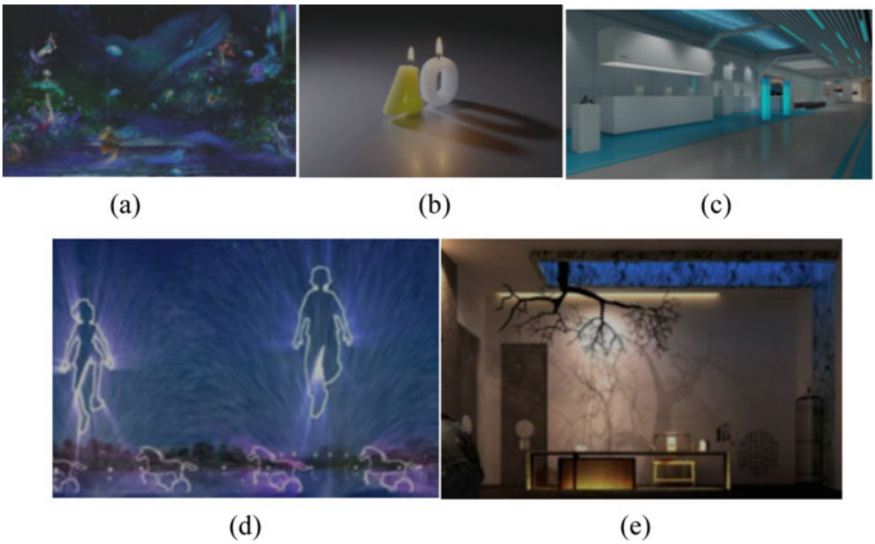

Fig. 2 Original laser holographic digital image

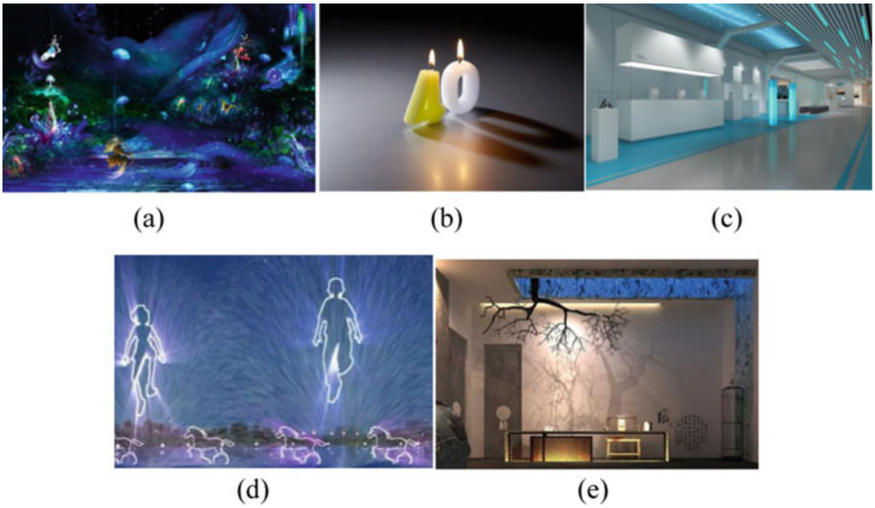

Fig. 3 Original laser holographic digital image

Table 1 Compensation time for 5 laser holographic digital images

Image name	Encryption time/ms	Decryption time/ms	Compensation time/ms
A	105	214	853
B	123	205	796
C	115	186	847
D	136	235	736
E	141	307	804

The storage performance of the platform in this paper is further tested, and the storage performance of the three platforms is set to continuously store 1000 100 kb laser holographic digital images. The comparison results are shown in Table 2.

The experimental results in Table 2 show that the CPU occupancy rate of the three platforms for storing laser holographic digital images increases with the increase of the number of images, but the CPU occupancy rate for storing laser holographic digital images using this platform is the lowest for different numbers of images., when using this platform to store 1000 100 kb laser holographic digital images, the CPU occupancy rate is only 2.33%, which verifies the storage performance of this platform.

Table 2 Comparison of CPU share of different platforms

Laser holographic digital image quantity/piece	This article platform%	Big data platform%	Dynamic encryption platform%
100	1.25	1.83	1.76
200	1.42	2.05	2.11
300	1.53	2.33	2.45
400	1.61	2.41	2.67
500	1.58	2.62	2.81
600	1.71	2.73	2.93
700	1.81	2.96	3.17
800	1.93	3.15	3.35
900	2.01	3.25	3.47
1000	2.33	3.65	3.72

4 Conclusion

In order to effectively improve the poor image quality of laser holographic digital images due to laser diffraction, a cloud storage platform for laser holographic digital image compensation resources is designed, the HDFS distributed database storage technology is applied to the cloud storage platform, and a large number of experiments are carried out to verify the performance of the platform. Effectiveness, the experimental results show that the use of this platform can not only effectively compensate the laser holographic digital image, but also make the compensated laser holographic digital image high in definition, bright in color, large in storage space, high in efficiency, and less time-consuming. The storage platform has great advantages.

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