CAD Drawing Teaching Assistant System of Civil Engineering Based on Digital Technology

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Abstract. The traditional civil and architectural CAD drawing teaching aid system, under the application of traditional technology, does not have accurate calibration and data switching functions, resulting in poor communication capabilities, classification capabilities and tracking capabilities of the system, affecting the overall teaching performance of the system, so Based on digital technology, design a new CAD drawing teaching aid system for civil engineering. In the system hardware design, the SDRAM circuit and RS323 bus circuit are redesigned. In the system software design, the system CAD drawing calibration mode is optimized, and the system switching algorithm is set based on digital technology. The experimental test results show that the MOS value, MAE value and RMSE value of the system designed this time are lower than that of the teaching aid system under traditional technology, indicating that the data switching of the system is smoother and the classification deviation is smaller. In general, this time. The design system has better tracking performance for CAD drawing data. It can be seen that digital technology is more suitable for drawing teaching aid systems.

Keywords: Digital technology · Civil architecture · CAD drawing · Teaching assistant system

1 Introduction

CAD drawing teaching assistant system solves practical problems of CAD drawing teaching by means of mechanization and automation, and provides real teaching means for students' drawing. However, due to the relatively backward technology used in the traditional teaching auxiliary system, the performance of the system is gradually difficult to meet the teaching requirements under the influence of external environment noise and massive heterogeneous data. Therefore, taking the digital technology as the innovation point, the CAD drawing teaching assistant system of the whole department is designed. The hardware of CAD drawing teaching assistant system is designed by SDRAM circuit and rs323 bus circuit; the calibration task is carried out according to the similarity of image features. Therefore, the calibration mode of CAD drawing is set through the similarity index. A large number of drawing data sets are divided and processed according to the time characteristics by using the sliding window to generate

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data sequences in different time domains; then, the time information redundancy fusion method is used to extract the frequency domain features, and the attribute change rule is obtained through the optimal estimation. The data sequence is processed twice to get the fused data. Finally, in the state space, the vector with associated features is fused with the multi-sensor information fusion technology to fuse the drawing information in the space to calibrate the information, set up decision-making instructions, complete the design of CAD drawing teaching assistant system of civil engineering based on digital technology. The effectiveness of the system is verified by simulation experiments.

2 Hardware Design of CAD Drawing Teaching Assistant System

2.1 Design SDRAM Circuit

Digital signal processor is abbreviated as DSP, which is a microprocessor specially used for rapid signal processing. As the main processor of the maneuvering target tracking circuit board, it directly affects the library information tracking function of the resource integration system. Therefore, considering the system's calculation accuracy, calculation speed, hardware resources and power consumption and other factors, select the DSP chip according to the functional requirements of the auxiliary teaching system. The I/O working voltage of the processor is 3.3 V, and the core voltage is 1.6 V. Through non parallel energy-saving configuration, the automatic management of information is realized, which meets the requirements of power consumption of integrated system. Considering the factors such as hardware resources, speed level and development tool support, FPGA chip is selected to replace the field programmable gate array in the original CAD drawing teaching assistant system, and a high-performance programmable logic is set to complete the circuit function of complex sequence and combination logic [1, 2]. In the process of target tracking, the teaching system needs a large capacity of storage space to store a large amount of drawing information, and needs to use the space to filter the collected information resources. Although the selected DSP solves the problems of the system to a certain extent, due to the limited storage space of DSP itself, SDRAM chip is added on the basis of the above hardware selection. The SDRAM model selected in this study is mt48lc4m16a2tg, which provides 64 MB memory for the teaching assistant system. The chip has four memory blocks, each with a capacity of 16 MB and a total of 16 bit bus. According to the actual specifications of the chip, connect SDRAM address line a [0:9] with DSP address bus a [1:10], and connect A10 with sda10, a11 with A12, and then connect data bus d [0:15] with DSP data line D [0:15]. Let the block selection signals BA0 and BA1 of A12 and A13 be connected with A13 and A14 of DSP. Then the connection between SDRAM and FPGA chip is established through SDARS, SDCAS and sdwe signal lines. Using this circuit to store target information, it is convenient to integrate the image resources in the process of drawing teaching after the end of target tracking.

2.2 Design of rs323 Bus Circuit

When the system receives drawing information, there are synchronous transmission data and asynchronous transmission data. Therefore, it is necessary to design the RS323 bus circuit to ensure that the system can receive all different types of information. The RS323 interface has 9 pins or 25 pins. In this study, the RS323 with 25 pins was selected and tested at 50, 100, 600, 1200, 2400, 4800, and 9600 and 19200 baud rates respectively. Whether the selected RS323 allows a 2500pF capacitive load, and on the basis of expanding the communication distance, ensure that the hardware has the ability to suppress noise and other interference information. Figure 1 below is the RS323 transceiver circuit structure diagram designed this time [3].

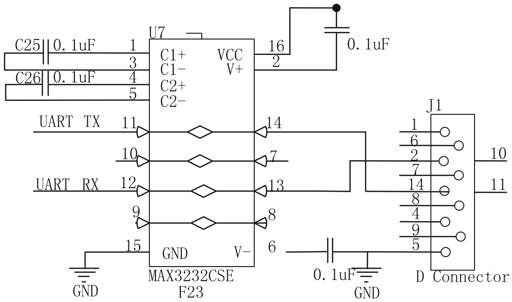


Fig. 1. RS323 transceiver circuit

Considering the connection between the system and the computer, in the RS323 bus circuit designed, the MAX3232 chip is used as the transceiver chip of the hardware. The selected chip has dual channels, and its proprietary low dropout transmitter output stage, through two receivers and two drivers, realizes data transmission and reception at a data rate of 240 kps, ensuring the working efficiency of the auxiliary teaching system. So far, the hardware design of the CAD drawing teaching auxiliary system for civil engineering is completed.

3 Software Design of CAD Drawing Teaching Aid System for Civil Engineering Based on Digital Technology

3.1 Set System CAD Drawing Calibration Mode

When assisting CAD drawing teaching, it is necessary to perform calibration tasks based on the similarity of image features, so the system CAD drawing calibration mode is set through the similarity index. This index can be represented by $sim(x, y)$, where x and y represent the basic parameters of student drawing and system calibration standards. In terms of calculation form, the following calculation requirements need to be met:

Let the similarity index be a real number between [0, 1], so $sim(x, y) \in [0, 1]$. When the two parameters are completely similar, then $sim(x, y) = 1$; when the two references are completely different, there is $sim(x, y) = 0$ [4]. At the same time, the similarity index has symmetry characteristics, so there is $sim(x, y) = sim(y, x)$. According to the above calculation requirements, combined with its decreasing function relationship, assuming that the change degree between the similarity index and the calibration gap is represented by $\lambda^{-dis(U,V)}$, the influence of students' CAD drawing parameters on the similarity index can be described by the following formula:

$$F(x, y) = \frac{f(x) + f(y)}{|f(x) - f(y)| + 1} \tag{1}$$

In the formula: $f(x)$ and $f(y)$ represent the standard level of x and y respectively. When $F(x, y) > 1$ is not in line with the similarity index value range, so divide F by 2 times the layer depth H to keep the influence of layer factors on the conceptual similarity within the range of [0, 1], and obtain a new calculation result:

$$F(U, V) = \frac{f(x) + f(y)}{2H \cdot (|f(x) - f(y)| + 1)} \tag{2}$$

According to the above calculation formula, the similarity between the two parameters increases with the increase of concept level, and the hierarchical difference between the two parameters is enlarged, which makes the similarity between calibration data gradually decrease. Therefore, the degree of change between the two elements is obtained:

$$dis(x, y) = f(x) + f(y) - 2\varphi(F(x, y)) \tag{3}$$

In the formula: $dis(x, y)$ represents the distance between two parameters; $\varphi(F(x, y))$ represents the minimum classification level of the two parameters [5]. Quantify the influence of calibration distance and level factors on the similarity index, so we get:

$$K_1(x, y) = \frac{\lambda^{-dis(x,y)} \cdot h_{x,y}}{2H \cdot (dis(x, y) + 1)} \tag{4}$$

The sum of $f(x) + f(y)$ is the level of $h_{x,y}$. At the same time, the logarithmic function is introduced and the nonlinear function is used to evaluate the similarity:

$$K_2(x, y) = \log_2\left(1 + \frac{|ud(x) \cap ud(y)|}{|ud(x) \cup ud(y)|}\right) \tag{5}$$

In order to avoid the infinite value of x and y, 1 is added to the true number part of logarithmic function to make it take the value of 0. Therefore, through the above calculation process, the similarity calculation model is designed, and parameters b_1 and b_2 are added to adjust the similarity index:

$$sim(x, y) = \begin{cases} b_1K_1 + b_2K_2 \; x \neq y \\ 1 \; x \neq y \end{cases} \tag{6}$$

According to the above calculation formula, the design of the similarity calculation model is realized. Use the similarity model to calibrate the drawing, so the calibration algorithm is set to control the calibration of the model. Control the calibration of the similarity model according to the basic connotation of deep learning and the basic characteristics of drawing elements. Use the deep structure and learning ability of the deep learning network to track the effective features of the drawing data in a hierarchical manner, and use the recognition signal to determine whether the drawing data comes from the same target. In the process of deep learning network training, the label signal data is input into the self coding network to achieve the task of nonlinear depth feature extraction, and then these depth features are mapped to the recognition class by softmax function. The purpose of this design of teaching assistant system is to provide more accurate data for students' architectural drawing. Therefore, according to the characteristics of back propagation, in the process of data iteration, the weights of deep learning network are optimized to realize image calibration [6]. It is known that the verification signal makes the characteristics of the third hidden layer similar. Therefore, a loss function is used to set the model calibration algorithm based on deep learning, as follows:

$$P\left(sim_i, sim_j, s_{ij}, \alpha\right) = \begin{cases} \frac{1}{2}\left|sim_i - sim_j\right|^2 \ s_{ij} = 1 \\ \frac{1}{2}\max\left(0, \mu - \left|sim_i - sim_j\right|^2\right) \ s_{ij} = -1 \end{cases} \tag{7}$$

In the formula: sim_i and sim_j are the calculation results of the similarity index of the two elements of the model; $s_{ij} = 1$ means that the two data belong to the same image; $s_{ij} = -1$ means that the two data do not belong to the same image; μ means different architectural drawing requirements; $\alpha = \{\mu\}$ means deep learning After verifying the loss function, the parameters to be learned. The deep learning process is completed through pre-training and fine-tuning, and the back-propagation algorithm is used to control the similarity model. The following codes are some of the key codes when the algorithm performs retrieval tasks:

```
def cos(vector1,vector2):
dot_product=0.0
normU=0.0
normV=0.0
for U,V in zip(vector1,vector2):
dot_product+=U*V
normU+=U**2
normV+=V**2
if normU==0.0 or normV==0.0
return None
else
```

Use the above code to run the basic calibration procedure of the calibration algorithm to optimize the system's calibration capability [7].

3.2 Setting System Switching Algorithm Based on Digital Technology

According to the characteristics of digital technology, the data fusion process of auxiliary teaching system is designed. Firstly, a large number of drawing data sets are divided and processed by using sliding window according to the time characteristics; Secondly, time information redundancy fusion method is used to extract frequency domain features, and the attribute change law is obtained by optimal estimation. In this stage, the data sequence is processed twice, that is, the operation is carried out in the system measurement space.

In the attribute space, according to the feature vector of the data sequence, find out the external and internal relations between the data. Finally, in the state space, multi-sensor information fusion technology is used to fuse the drawing information calibration information in the state space with the vector with associated characteristics, and the decision instruction is set according to the fused data [8].

According to the process described above, it is assumed that sliding window a contains N data, which is the basic drawing data of $\left[c_i, c_{i+1}\right]$ certain set among multiple drawing sets, and the data sequence composed of the data is described by $\{z_n|n = 0, 1, 2, \ldots, N-1\}$. The data at this time is divided into different data sequences according to the current sliding window, and these data sequences are defaulted as the basic unit of system processing to ensure the internal correlation of the data while also reflecting the characteristics of the drawing data under the current time window. When the system performs data collection and calibration tasks, mechanical and environmental noise interference has a great impact on the drawing data. Therefore, the default sensor data contains real data and noise data. The known noise $u_i(c)$ can not be predicted and unknown, so it is assumed that noise $u_i(c)$ satisfies Gaussian distribution, and its variance and mean value can be determined according to the actual working environment. It is known that there is a certain law for the change of attribute measurement in time and space. This study uses function $g(z)$ to express the law, but the law is complicated and objective, and the mathematical formula of function $g(z)$ is difficult to directly determine. Therefore, assuming that the environmental noise is additive noise, the real data is mixed with noise and sent to the receiving end in the form of data stream $\{\ldots, z_i, z_{i+1}, \ldots, z_n, \ldots\}$. The data received by the server also appears in the form of data stream. The physical environment at this time can be simplified as the model shown in Fig. 4 [9].

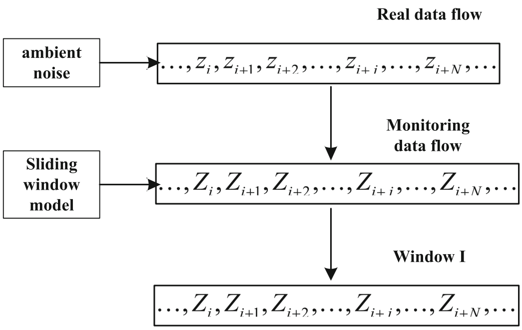


Fig. 2. Data flow and sliding window model

According to the model in Fig. 2, the system monitoring data with multiple sensors is abstracted into the following form. For the convenience of visual observation, the default number of architectural drawings that the system can calibrate at one time is three, then:

$$\begin{cases} A(c) = \beta(c) + u_\beta(c) \\ B(c) = \theta(c) + u_\theta(c) \\ C(c) = \gamma(c) + u_\gamma(c) \end{cases} \tag{8}$$

In the formula: $A(c)$, $B(c)$, and $C(c)$ respectively represent the calibration values of the three images; $\beta(c)$, $\theta(c)$, and $\gamma(c)$ represent the actual parameters of the image; $u_\beta(c)$, $u_\theta(c)$, and $u_\gamma(c)$ represent the image noise during the calibration process. The server divides the data according to the time window to get the function:

$$g(c) = g_0(c - c_0) + g_1(c - c_1) + \cdots + g_i(c - c_i) + \cdots = \sum_{i=0}^{\infty} g_i(c - c_i) \tag{9}$$

In the formula: $g_i(c - c_i)$ represents the true value of the property when the window time is $[c_i, c_{i+1}]$. On the entire time axis, the data sequence is divided according to the sliding window, and each data sequence is represented by $g_i(c - c_i)$. However, because $g_i(c)$ is only a continuously changing physical property, a discrete sequence after sampling in time, the sampling frequency is taken as the frequency at which the sensor collects data, and $g_i(c)$ can be expressed according to the following formula:

$$g_i(c) = \sum_{n=0}^{N-1} g_i(z) \cdot \lambda(z - c_n) \tag{10}$$

Therefore, in order to obtain the real basic data of building image, $g_i(c)$ can be estimated. Since $g(c)$ is continuous in time, the frequency domain characteristic of analog value $g_i(c)$ can be used as the feature of time window [10–12]. So far, under the application of digital technology, the design of civil architecture CAD drawing teaching assistant system has been completed.

4 Experimental Study

4.1 Communication Performance Test

Suppose that the communication channel of CAD drawing teaching assistant system experiences additive Gaussian white noise, so the average transmission rate of network is set between 8.5 and 12.5 Mbps, and the network simulation test environment is built by using the parameters in Table 1.

Table 1. Network environment simulation parameters

Parameter name	Value	Parameter name	Value
Path loss	4.55	Spreading factor	5–255
RTS	20 μs	CTS	15 μs
Distributed frame interval	50 μs	Short frame interval	10 μs
Discount factor	0.96	Learning parameters	0.1
Time to transmit ACK	10	–	–

According to the data in Table 1, build a simulation test environment, respectively use the designed system and traditional teaching auxiliary system to switch the content of the same civil architecture CAD drawing teaching. Table 2 shows the comparison results of MOS values to measure the communication quality of the system.

Table 2. Comparison of MOS values

Auxiliary users	System in text	Traditional system
10	4.88	3.57
20	4.64	2.33
30	4.89	3.31
40	4.63	2.21
50	4.72	2.54
60	4.85	3.45
70	4.66	3.22
80	4.77	3.11

According to the test results in Table 2, the MOS value of the auxiliary system studied has always been above 4.5 when processing multiple drawing tasks. However, due to the poor concurrency effect of the communication module in the traditional system, the MOS value is greatly reduced when a large number of drawing data are switched. It can be seen that the teaching assistant system designed based on digital technology has better communication function, and drawing teaching can provide better auxiliary effect.

4.2 Classification Performance Test

The integrated quality evaluation index is used as the basis for analyzing the system performance, and the system classification performance test is carried out to analyze the integration ability of different systems for information resources. The mean absolute error between the predicted value of the system score and the actual score is reflected by the precision measurement method, and the root mean square error of the precision of the predicted result is calculated. The calculation results of the two parameters can be obtained directly by the following formula:

$$\begin{cases} MAE(\kappa) = \frac{1}{|\delta|} \sum_{\tau_i \in R} \left| \tau_i - \tau_i' \right| \\ RMSE(\kappa) = \sqrt{\frac{1}{\delta} \sum_{\tau_i \in R} \left(\tau_i - \tau_i' \right)^2} \end{cases} \tag{11}$$

In the formula: $MAE(\kappa)$ represents the average absolute error of the error; $RMSE(\kappa)$ represents the root-mean-square error of the precision of the prediction result; δ represents the actual number of drawing teaching scoring items; τ_i represents the user's actual rating of the system; τ' represents the user's predicted rating of the system; R represents the score set. When the calculated $MAE(\mu)$ and $RMSE(\mu)$ values are smaller, the more it shows that the system's drawing data classification work is more compatible with the actual building frame. Based on the above calculations as the evaluation basis for the test results, select any 5 sets of data in the Movielens 100 k data set, and train and test the data set according to the ratio of 8:2. According to the above calculation formula, the performance evaluation results of different systems are obtained, as shown in Table 3 below.

Table 3. Comparison of classification performance of different systems

Test group	The system designed in the article		Traditional integration system	
	MAE	RMSE	MAE	RMSE
D1	0.6285	0.9007	0.9091	1.5542
D2	0.5947	0.8826	0.9184	1.7384
D3	0.5982	0.8849	0.9036	1.7109
D4	0.6035	0.8787	0.9155	1.7488
D5	0.6184	0.8912	0.8998	1.5666

According to the above calculation results, the MAE value and RMSE value of the designed system are lower, which indicates that the research system has more accurate division and matching effect for the classification of drawing data.

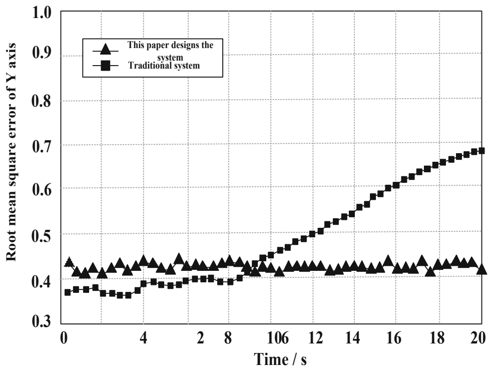
4.3 Tracking Effect Test

Use simulation testing software to simulate the basic structure of a building, let students draw a CAD image based on the structure, and then use the system designed in the article and the traditional system to track the data source of the image, and pay attention to adding noise in the process. The information fusion technology of different systems is compared, and the errors of the three test groups are estimated. Table 4 below shows the statistical results of the system's error sequence mean and variance.

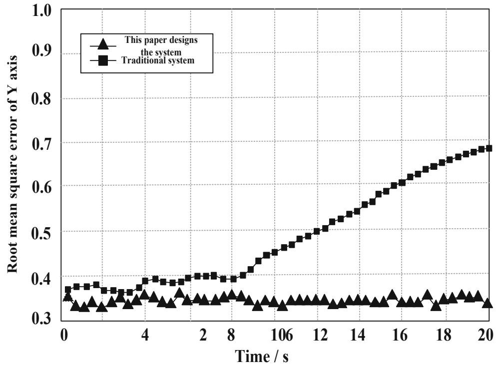
Table 4. The statistical results of the mean and variance of the error series

Test group	Mean value	Variance	Deviation
System in text	0.0036	0.0223	0.1492
Traditional system	0.0067	0.1538	0.3965

The deviation in the table is the degree of deviation between the result obtained and the actual drawing data after the system's quantitative calculation. According to the data in the table, it can be seen intuitively that after the system designed this time uses digital technology, its data accuracy is higher than that of the traditional system, and its mean, variance and deviation are respectively 0.0031 and 0.1315 smaller than the traditional system. And 0.2473. It can be seen that digital technology can more accurately process the drawing data obtained by the system. At the same time, the tracking effect of the two systems on the drawing data is shown in Fig. 3 below.



(a) Root mean square error of target X axis



(b) Root mean square error of target Y axis

Fig. 3. Comparison Test of system target tracking effect

From the two groups of test results in Fig. 3, it can be seen that with the increase of time, the tracking error of the designed system on two coordinate axes is far less than that of the traditional system. It can be seen that the design of the system, with the help of digital technology, enhances the anti-interference performance of noise information.

5 Concluding Remarks

Through three groups of experimental demonstrations, it is found that the drawing teaching aid system designed based on digital technology has better performance and provides a more complete teaching method for civil engineering CAD drawing teaching. However, the system designed this time still has shortcomings. In the future research work, PLC technology and clustering algorithm can be applied to the system to further improve the effectiveness of the system and provide more reliable teaching methods for civil engineering work and learning.

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