Design of intelligent invigilator system based on artificial vision

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Abstract. Aiming at the problems of high packet loss rate and low intelligent degree in the current video monitoring system for examination invigilation, an intelligent invigilator system design method based on artificial vision is proposed in this paper. The system design is divided into hardware and software parts, including A/D circuit, clock circuit, video frame cyclic error correction and coding circuit, program loading circuit and output interface circuit. The experimental results show that the system can effectively reduce the video packet loss in the process of invigilation, improve the visual coverage of the invigilator area, and the system is highly integrated and intelligent.

Keywords: Artificial vision; Feature recognition; Intelligent invigilator

1. Introduction
This paper introduces the research and development process of an automatic invigilation system. Through the comprehensive application of information collection module, evidence preservation module, remote control module and encryption transmission module, it can monitor the vast majority of students' violation behaviors and retain evidence under the premise of not strictly relying on the computer room environment, so as to facilitate invigilator teachers to monitor and retain evidence during or after the examination. At the same time, according to the actual application scenario, the system architecture which can handle high concurrency is designed and implemented, which performs well in the actual work [1].

2. Design of intelligent invigilator system

2.1 Hardware configuration of intelligent invigilation system
The data acquisition system of automatic invigilation system is the basis of the whole system. The data communication between PC and PCI bridge chip is carried out. The local bus design method of PCI9054 is adopted to collect the data features. The video information of the invigilator's site is stored on the PCI bus. The video information is transmitted and transmitted in the embedded RAM and encoded between the video frames. The video error correction is based on the video frame cyclic error correction coding method [2]. The hardware design mainly includes the following parts: DSP signal processor, analog signal preprocessor, logic control device of video information, external I / O device,
a / D device and power supply device. The A / D conversion flash register is controlled by DSP to store the video visual characteristic information of the invigilator site. At the same time, DSP communicates with PCI Receives the user information of PCI bus and output multi-channel video coding to power amplifier. Through serial E2PROM configuration verification, in C mode, through PCI bus to send sampling data or processing results to PC for monitoring information analysis. Combined with the selected peripheral devices, using the programmable DSP chip ADSP - bf537 as the core processing chip, the circuit design of automatic invigilation system for students' examination is carried out, which mainly includes a / D circuit, clock circuit, video frame cyclic error correction coding circuit, program loading circuit and output interface circuit.

**Fig. 1** Hardware structure of intelligent invigilator system

WF-209 WiFi image transmission module is used in the RF transceiver module of the overall system block diagram. WF-209 is a remote wireless monitoring terminal integrating image acquisition, compression, storage and transmission. After capturing the analog CVBS video signal, it uses advanced image compression technology to generate high compression ratio data stream, which is sent to any display terminal (Android, iPhone and other smart phones or tablet computers) through WiFi wireless way. The software of smart phone completes the post-processing of display, storage and other application functions. The RF transceiver module in the invigilator selects rfm75, which is a transceiver working in the frequency band of 2400 ~ 2483.5mhz. The data rate of burst mode transmission is as high as 2Mbps, which makes them suitable for applications requiring ultra-low power consumption. The embedded data packet processing engine can use a very simple single-chip microcomputer as a wireless system. The A / D circuit of the student examination invigilator system is to realize the digital to analog conversion of the input video acquisition information, and provide the original computer visual information that can be recognized by the computer and DSP chip, combined with the video frame cyclic error correction coding method for visual proofreading and video coding. The external I / O equipment includes two pieces of a / D converter AD7864. The resolution of a / D circuit is 12 bits, and the maximum sampling frequency is 25kHz. AD7864 (hereinafter referred to as 7864) is used as a / D chip. It is a high-performance ad chip with 4-channel input and 1.65 μ s conversion speed. The A / D input voltage of the automatic invigilator system meets the following requirements:

\[
\begin{align*}
AVSS - 0.3V &< VINA < AVDD + 0.3V \\
AVSS - 0.3V &< VINB < AVDD + 0.3V
\end{align*}
\]

The number of sampling channels is controlled by DSP data bus DSPD [3:0], A4 - A0 and iost rb decoding, and EOC signal is used as reading mark signal. Considering the time of processing video transmission information and reading matching, 7864 analog input / output corresponding code should be considered in a / D design. 5409a is used as the core control chip of the clock interrupt of the automatic invigilation system. 5409a has three multi-channel buffered serial ports mcbsps, which provides direct interface of serial A / D, D / a devices and other serial devices. The local bus supports...
multiplexing / non-multiplexing 32-bit address / data, including PCI bus operation and local bus operation. As the local bus and PCI bus of ci9054 in pc9054, the serial interface input and output of DMA data are realized through asynchronous operation [7].

The information obtained by the system camera is sent to the data processing unit after being processed by the video acquisition module. The data processing unit stores the information on the one hand, and displays it through the touch screen through the video browsing module. The RF transceiver module mainly receives the signal from another invigilator and reminds the invigilator through Bluetooth headset. In addition, the invigilator is also equipped with a keyboard and USB interface [8].

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The high-performance MPC850/86 of Motorola Company is selected as the core processing chip of visual verification visual analysis program loading circuit of automatic invigilator. In the program loading circuit, the programmable logic chip PLC is used to analyze the image information. In the program loading, the 16 bit packing mode is directly executed from the external 16 bit memory. The asynchronous memory space is configured by the boot ROM, and the SPI memory selection of the automatic invigilator system is determined by continuously reading the number of 0x00 bytes. The program loading circuit design is shown in the figure.
A 1 μf capacitor is paralleled between VCC and ground to meet the programmable hardware write protection function of program loading circuit and the accidental write protection function of on-chip. In the design of output interface circuit, the internal registers of CPU are accessed through JTAG interface, and the configuration is checked by serial E2PROM. JTAG simulator is used to implement 12 channel DMA asynchronous serial port design, and discrete components are used to constitute serial port reset circuit to reduce DSP energy consumption. The switching frequency can also be adjusted from 0 to 1 MHz, and the core voltage can be adjusted between 0.8 and 1.2 v. The core power supply is filtered by 10 μF and 0.1 μf capacitors to reduce power noise. The real-time clock power supply and I/O power supply adopt separate power supply strategy to ensure the operation effect of the system.

2.2 Software algorithm optimization of intelligent invigilator system

The system software design mainly includes the information transmission between the main control room monitoring system and the invigilator and camera in the examination room monitoring system, and the information transmission between the examination room invigilator and the camera and another invigilator. The input image is grayed to a single channel image. Gamma correction is applied to the image to normalize the color space to reduce the influence of uneven light and shadow on the experiment. The gradient of each pixel in the image is calculated, including the gradient amplitude and gradient direction. The gradient of the pixel at \((x,y)\) in the image is calculated as

\[
G_x(x, y) = H(x+1, y) - H(x-1, y) \quad (1)
\]

\[
G_y(x, y) = H(x, y+1) - H(x, y-1) \quad (2)
\]

Where \(H(x, y)\) is the pixel value of the image at the pixel point \((x,y)\). \(G_x(x,y)\) and \(G_y(x,y)\) represent the horizontal gradient value of \(X\) axis and the vertical gradient value of \(Y\) axis at the pixel \((x,y)\). Then the gradient amplitude \(G(x,y)\) and gradient direction of the pixel \(a(x,y)\) can be expressed as
Based on the above algorithm, the system is initialized, and then the camera is started to transmit the obtained information through the RF transceiver module. The server in the main control room will process and display the signal after receiving the signal. If everything is normal, it will continue. If there is a problem, the main control room will send a signal to the invigilator in the examination room, and the invigilator will deal with the information timely after receiving the information. The flow chart is as follows:

\[ G(x, y) = \sqrt{G_x(x,y)^2 + G_y(x,y)^2} \]  
\[ a(x,y) = \tan^{-1}\left(\frac{G_x(x,y)}{G_y(x,y)}\right) \]

![Flow chart diagram](image)

**Fig. 4 Information collection and transmission process of intelligent invigilator**

As shown in the figure, in the invigilator detection, the system should be initialized first, and then the camera will be started to transmit the obtained information to the invigilator through the RF transceiver module. After receiving the signal, the invigilator will process and display the signal. If the invigilator suspects that someone has cheated but can't see clearly, the invigilator will watch the invigilator. If everything is normal, continue. If someone is sure that someone has cheated, the invigilator captures or sends signals to another invigilator to remind another invigilator to process [11]. In this way, the problems existing in the general invigilation form are avoided, such as: the invigilator teacher can not see clearly the students at the back or more partial position; Or although the invigilator in front of the teacher saw the students cheating in the back of the classroom, when the teacher came near the student, the student had already hidden the entrainment or other cheating tools and could not get the evidence. Therefore, it is necessary to further optimize and improve the system.

### 2.3 Realization of intelligent invigilation

With the development of computer technology and artificial intelligence, artificial intelligence
technologies such as machine learning and deep learning will be more and more applied to the field of examination security \[12-13\]. In order to strengthen the security protection and prevent cheating in the examination, through the in-depth analysis of each link in the examination supervision stage, comprehensively adopt the new technical means with the theoretical technology of pattern recognition, deep learning and biological recognition as the core to process, classify and understand all kinds of examination information, improve the utilization efficiency of data information, and establish a unified information supervision. The examination system can monitor, trace and audit the examination information, and effectively crack down on discipline violations and fraud \[14\]. Considering the speed and detection rate of the algorithm, this paper proposes a two-layer classifier cascade method to detect candidates in the actual examination environment. As shown in the figure, the examinee monitoring framework based on multi-layer classifier is shown.

![Examinee monitoring framework based on multi-layer classifier](image)

The first layer of the graph is the primary classifier, which uses the low dimension hog feature detection, which makes the rate of missing detection low and the detection speed faster. The second layer is a secondary classifier, which uses the higher dimensional hog-ulbph features. On the basis of the detection results of the first layer, the hog-ulbph features of the waiting window samples are extracted to judge whether the window samples contain candidates \[15\]. This method can effectively reduce the false detection rate and improve the detection rate. Although the feature dimension of hog-ulbph is high and the calculation time is time-consuming, because it is detected in the limited number of waiting windows detected by the primary classifier, the time-consuming increase brought by this level is almost negligible. According to the sparse combination learning process, the trained model can be obtained, and then abnormal behavior detection can be started. The process of abnormal behavior detection is actually the process of signal reconstruction and threshold discrimination. If the reconstruction error is greater than the threshold value, the signal represents the sample without learning. In this paper, it is considered as abnormal behavior. After feature extraction and data processing, the test sample $x$ is obtained. Through the learned sparse combination $C = \{C_1, C_2, \cdots, C_K\}$, find the appropriate vector base combination $C_i$ for signal representation. By using a finite number of combinations, the corresponding reconstruction errors can be obtained respectively:

$$t_i = a(x, y) / \min_{\beta} \| x - C_i \beta \|_2^2 \quad \forall i = 1, \cdots, K$$  \hspace{1cm} (5)$$

Among them:

$$\hat{\beta}_i = (C_i^T C_i)^{-1} C_i^T x$$  \hspace{1cm} (6)$$

The reconstruction error corresponding to $C$ can be rewritten as follows:

$$t_n = \| C_i (C_i^T C_i)^{-1} C_i^T - I_p \|_2 x$$  \hspace{1cm} (7)$$

Where $I_P$ is an identity matrix of $P \times P$. Define an auxiliary matrix
The improved detection mechanism is further proposed. The abnormal behavior of examinees is detected by the combination of two channels. The video image is processed further. The reasonable process is constructed, as follows:

\[
R_i = C_i (C_i^T C_i)^{-1} C_i^T I_p (t_i - t_a)
\]

\(8\)

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Fig. 6 Operation process of intelligent invigilator system

The design of the information invigilation system based on the above process can assist the examination supervisor to inspect the examination room, obtain the invigilator data, and verify the identity of the invigilator and the examination staff, so as to prevent the occurrence of disciplinary anomalies. In channel one, the abnormal behavior detection method based on sparse reconstruction is used to detect the abnormal behavior of examinees, and the detected area is identified and warned. In channel 2, the traditional abnormal behavior detection method is used. Firstly, the MHI of the image is obtained, and the motion connected region is segmented. According to the result of segmentation, the area whose aspect ratio is greater than the experimental threshold is extracted according to its contour features. This area is marked as the abnormal behavior of examinees peeking or passing notes from left to right. The algorithm will be implemented in two ways respectively to give early warning to the detected abnormal behavior area, and upload the video segment containing the frame to the superior inspection center, so as to reduce the pressure on the transmission bandwidth and video storage. Based on this, the intelligent invigilation system carries out information processing. The information-based invigilation system not only has precise control of time nodes in the invigilation stage, but also has regular reminders Function, and can provide text, audio and video and other digital recording means. When the examinee enters the examination room, the identity information of the examinee is retained in the invigilator system, and the late examinee is automatically marked as "absent"; the text, image, audio and video records of emergencies in the examination room or examination room are used as evidence to ensure that the scene can be restored after the examination. After the examination, the invigilator records the candidates’ identity information and the submission time when collecting the examination papers etc. In addition, the information-based invigilator system can also assist the examination supervisors to inspect the examination room and obtain the invigilator data. The identity verification of the invigilator and the examination staff can prevent the occurrence of disciplinary anomalies. The information-based invigilator system can not only strengthen the ability of data analysis and behavior analysis in the examination process, but also realize the monitoring, traceability and traceability of the examination information Auditing can improve the utilization efficiency of data and information, ensure the seriousness, authority and fairness of the examination, and create a fair and just examination environment for the majority of candidates, so as to realize the reasonable design and improvement of intelligent invigilation system.
3. Analysis of experimental results

The software development and system debugging analysis of the intelligent invigilator system for students' examination are carried out. The software development is based on ccs2.20 development platform, with the help of LabWindows / CVI, C / C ++ to develop image and video information processing program under computer vision. According to the PCI card driver, the video information sampling and the original data acquisition of the invigilator system are carried out, and the video acquisition and analysis interface of automatic invigilation for students is obtained. The automatic invigilation system designed in this paper can effectively realize the invigilation video information transmission under the computer vision. The abnormal behavior of the students was monitored and evaluated. Based on pixel, video frame and event. Since the public video database has not been established for examinee's abnormal behavior detection, experiments are carried out on the video data sets, and the detection results are counted by event-based standards. In abnormal behavior detection, recall rate and accuracy rate are usually used to reflect the detection effect. Since there are only two kinds of samples, normal and abnormal, all the samples detected will be divided into four categories TP (true positive): Regular behavior samples predicted by the model as positive; TN (true negative): Abnormal behavior samples predicted by the model as negative; FP (false potential): The abnormal behavior sample predicted as positive by the model; FN (false negative): The normal behavior sample predicted by the model as negative.

\[
\text{Recall} = \frac{TP}{TP + FN} \times 100\% \quad (9)
\]

\[
\text{Precision} = \frac{TP}{TP + FP} \times 100\% \quad (10)
\]

According to the above formula, the test results can be obtained.

| Abnormal behaviors detected | Traditional system | The system of this paper | Precision |
|----------------------------|-------------------|-------------------------|-----------|
| Number of abnormal behaviors | detection result | Recal % | Number of abnormal behaviors | detection result | Recal % | Precision |
| Look around | 20 | 20 | 80 | 20 | 14 | 64 | 64 |
| Pry back and forth | 5 | 5 | 90 | 5 | 2 | 65 | 66 |
| Pass slip | 6 | 6 | 95 | 6 | 4 | 70 | 65 |
| Pick up a piece of paper | 5 | 5 | 97 | 5 | 3 | 67 | 67 |
| Late and leave early | 4 | 4 | 85 | 4 | 5 | 68 | 68 |
| total | 20 | 20 | - | 20 | 20 | - | 65 |
| Number of false checks | 0 | 0 | 0 | 6 | 6 | 67% | - |

Based on the detection results in the table above, compared with the traditional system, the intelligent examination system based on artificial vision proposed in this paper has lower monitoring error rate and higher recall rate in the actual operation process, which can realize the intelligent invigilation requirements more accurately. Further analysis shows that the intelligent invigilation system based on artificial vision proposed in this paper is different Compared with the traditional system, the performance area of the system lies in the higher coverage rate of video monitoring and the sharpness of video processing. Due to the long detection video in the invigilation process, the
packet loss rate and alarm time consumption in the running process of the invigilation system are further compared and the detection results are recorded, as shown in the following figure:

![Comparison detection results of system packet loss rate](image)

**Fig. 7** Comparison detection results of system packet loss rate

Based on the above detection results, the proposed intelligent invigilator system based on artificial vision in the actual application process, the packet loss rate is significantly reduced, which can better ensure the safety of data operation, and the operation accuracy of the invigilator system has been significantly improved, so as to improve the system integration and intelligence, and fully meet the current design requirements.

4. Conclusion

This paper presents a design method of intelligent invigilator system based on visual learning. The system design is divided into hardware and software parts. Firstly, the overall design framework and function index description of the automatic invigilation system are analyzed. Secondly, the hardware design of the invigilation system is carried out with ADSP - bf537 parallel microprocessor chip as the core, including a / D circuit, clock circuit, video frame cyclic error correction and coding circuit, program loading circuit and output interface circuit. Finally, in visual In ALDSP + + integrated development environment, the software development and design of the automatic invigilation system are carried out, and the program loading is combined with the cyclic error correction coding of video frame, so as to realize the automatic invigilation under the computer vision. The experimental results show that the system can effectively reduce the video packet loss in the process of invigilation, improve the visual coverage of the invigilator area, and has excellent performance.

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