Design of Autonomous Vibration Monitoring System

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Abstract. The design of the vibration monitoring system is based on the hardware of vibration sensor and signal conditioning circuit, virtual instrument as a diagnosis and alarm platform, auxiliary data acquisition card and alarm equipment. When the outside intrudes into the detection range, the vibration signal is generated and collected. The alarm is realized through the linkage of security monitoring system, so the video surveillance and video recording of the detection area are completed. In addition, the system opens the illumination equipment in the detection range to compensate for the environment of the video and deter the illegal intruders. The system includes acquisition of weak vibration signal by vibration sensor, amplification and adjustment of vibration signal by CCTV. This system has high feasibility and wide coverage. It is worth popularizing in security system in the future.

1. Introduction
Beginning with the initial mechanical vibrometer, various intelligent testing instruments, such as sensors, FFT analyzer and structural dynamics analysis software, which are made by applying the principles of physics, have been widely used in production and life. At the same time, in order to improve the testing efficiency, reduce the testing cost and meet the increasing testing requirements in speed, accuracy, data analysis and field practicability, virtual instrument technology is introduced into the traditional hardware testing field, and a vibration testing system based on virtual instrument is developed.

![Figure 1. Block diagram of vibration testing system](attachment:image.png)

2. Overall design of Autonomous Vibration Monitoring and Control System
The control platform mainly focuses on the innovative combination of vibration prevention system, video surveillance system and lighting control system. Vibration signal testing system records the mechanical vibration data in real time through vibration sensor, inserts the sensor directly into the USB data acquisition card, collects the vibration signal detected by the sensor, sends the processed vibration data to the upper computer, and then opens the linkage system of monitoring and lighting.
3. Design of System Control

3.1 Linkage of Vibration Sensor and Video Monitoring
If an illegal intruder triggers vibration sensor, the sensor immediately transmits the alarm signal to the host computer through an analog/digital converter. At the same time, the host computer monitors the trigger position through linkage control of camera.

3.2 Linkage with Lighting
If an illegal intruder triggers a vibration sensor, the sensor transmits the alarm signal to the illumination equipment in the area after five-second delay, and opens the illumination system. So that the intruder can stop the illegal intrusion after being frightened by the illumination. Meantime, after illumination compensation, the camera can record the intruder's behavior better.

Figure 3. System flowchart
4. Design of system’s hardware

4.1 Design of Signal Acquisition Module
Piezoelectric accelerometer is a typical active sensor, which belongs to inertial sensor and is also known as piezoelectric accelerometer. Its working principle is to use the piezoelectric effect and inverse piezoelectric effect produced by quartz crystal and artificial piezoelectric ceramics. When the accelerometer is subjected to external vibration, the pressure of the mass block attached to the piezoelectric element changes accordingly. Piezoelectric sensor is a force sensor. Under the action of external force, the surface of piezoelectric sensor generates electric charge, which realizes the purpose of non-electric measurement.

CA-YD-103 accelerometer is selected as vibration sensor. The static and dynamic characteristics of CA-YD-103 accelerometer meets the requirements of this study. It can communicate with signal regulator, amplifier, data acquisition system and analysis software, and has a wide range of applications.

4.2 Design of Data Acquisition Module
After collecting signals in vibration testing system, the signals collected by sensors need to be transmitted to the computer for further analysis and processing, and the data acquisition card is the bridge to undertake the front-end data acquisition and back-end data analysis and processing.

The design uses USB-6009 multi-function data acquisition card. USB-6009 multi-function data acquisition card is a multi-function data acquisition card developed by NI company. It has powerful acquisition function and provides hardware basis for theoretical courses of simulation, testing and automation.

5. Design of system’s software
System’s software design mainly meets the following two functions:
1) The camera's pre-fulcrum, cruise, trajectory and other settings enable the camera to record the video in accordance with the established route.
2) Lonwork establishes the address correspondence of lighting physical points, and realizes the adjustment and selection of illumination in force control software interface.

The design of software interface through Lonwork software is mainly to display the point position of light compensation and display the picture of response results. The background distributes the relevant physical points (DIO) through DDC field controller.

![Figure 4. Start flowchart](image)

6. Analysis and Verification
Autonomous security lighting control system improves and updates the accuracy, response time and processing method of the current security system, and realizes the linkage of three hardware. In
addition, the feasibility of the system is proved by experiments. The experimental results are shown in Table 1.

| Detection Area | Area Aimed by the Camera or Not | Screen at Operation or Not | Results of Light Sensor's Detection | Behavior of Fluorescent Lamp |
|----------------|---------------------------------|---------------------------|-----------------------------------|-----------------------------|
| Vibration Sensor Detects Vibration Signal | Turning and Auto-Focusing of the Platform | Video Start | 400lx | Detection Area Lamp Turn On |
| Turning and Auto-Focusing of the Platform | Video Start | 700lx | Detection Area Lamp Closure |

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References
[1] Huang J X. (2016) Discussion about the design of intelligent emergency lighting and evacuate indicating system. Building Electricity, 2016(10):35-40.
[2] Li H T, Zhang Z X. (2008) The application summary of the RFID technology in security system in residential communities. Journal of Shandong Institute of Light Industry(Natural Science Edition), 22(1):43-45.
[3] Zhou Y F, GUO J R. (2014) Summary of safety surveillance system. Journal of Hunan University of Arts and Science(Natural Science Edition), 2014(6):81-85.
[4] Wang X P. (2011) Design of campus security system based on Internet of things technology. Experimental Technology and Management, 28(8):103-106.
[5] Chandrabhanu Malla, Isham Panigrahi. (2019) Review of Condition Monitoring of Rolling Element Bearing Using Vibration Analysis and Other Techniques. Journal of Vibration Engineering & Technologies, Vol.7 (4):407-414.
[6] Liu Xiang, Cai Guoping. (2019) Nonlinear vibration control of a membrane antenna structure. Proceedings of the Institution of Mechanical Engineers:3273-3285.
[7] Filippatos Angelos, Wollmann Tino. (2018) Design and Testing of a Co-Rotating Vibration Excitation System. Sensors (Basel, Switzerland), 19(1):92.
[8] Zhu Cheng-hui, Zhang Si. (2018) The vibration signal recognition of optical fiber perimeter security system based on local mean decomposition. Manufacturing Automation, 40(7):107-111.