Study and selection of functional modules for intelligent boundary pillar systems

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Abstract. With the rapid development of society, the continuous expansion of cities and the speeding up of urbanisation, the rapid growth and destruction of all kinds of boundary pillars is a common occurrence. Up to now, there has been little product development and application of intelligent electronic boundary pillars in China, and the cost of managing open boundary areas is high because many special boundary pillars are located in harsh external environments that are difficult to inspect manually, thus leading to untimely discovery of problems and even greater losses. Therefore, a digital boundary pillar equipped with suitable software products and high-quality hardware that can adapt to a variety of environments has become a major need in the current boundary pillar market.

1. Background to the study
It is well known that pillars are national infrastructure, generally made of stone, wood, concrete and other materials and mostly rectangular in shape. In the current situation, the existing boundary pillars are static and isolated. The management function of boundary pillars relies on the traditional manual inspection mode, which cannot achieve real-time intelligent management and monitoring of the loss and displacement of boundary pillars. With the application of the Internet of Things technology has become more and more widespread, the technical development of all walks of life has been a radical change, the Internet of Everything has come into our lives. This has also made the application of intelligent electronic boundary posts possible. The intelligent electronic boundary pillars mentioned in this article can collect GNSS positioning information, can sense the surrounding state, with damage alarm, cross-border intrusion monitoring, capture and other functions, can effectively monitor the border and regional range, can be combined with the Internet of things technology, a good solution to the traditional boundary pillar is difficult to achieve self-test, complete real-time records and other issues, improve the current boundary pillar in the use of the process encountered in some difficult to solve! The following is an analysis of the selection of functional modules on the basis of this boundary pillar.

2. Overall programme

2.1. Architecture design
It is necessary to design and research a scientific and rational digital pillar management system with remote monitoring and management of boundary pillars for the existing management mode of boundary
pillars, which can be divided into system administrator, general operator and temporary operator permissions according to the work needs of the staff.

Uploading real-time data: Real-time data is uploaded at the boundary pillars based on the day's inspection.

Viewing real-time data: The current data status is displayed with data or curves as requested by the user.

View historical data: View previous data by date, month, year.

Modification of historical data: The administrator has the authority to record and modify error data when anomalous data has been found and determined to be an error record.

![Figure 1. Overall architecture design.](image)

2.2. Functional design

The interface for using the smart boundary pillar function as expected from this document broadly comprises the following sections.

2.2.1. Login window. Three types of permissions can be set for the system administrator, general operator and temporary operator to manage the system, perform general operations and browse respectively.

2.2.2. System Settings window. The settings can only be operated by the system administrator and include adding and changing the general operator's user name and password, changing the upper and lower alarm limits etc.

2.2.3. Data acquisition module. Collects data in real time, or according to a certain time period.

2.2.4. Data analysis module. It analyses the collected real-time data or other data, produces statistical reports and statistical curves, and carries out alarm operations if deviations are found.

2.2.5. Data query window. This allows the user to browse through the query data.

2.3. Its practical functions broadly comprise the following.

2.3.1. Alarm function: receive alarm information triggered by the boundary pillar terminal, such as vibration alarm, tilt alarm (violent movement), disconnection alarm (equipment damage), and battery undervoltage alarm. When an alarm is generated, real-time information about the boundary pillar will be displayed by means of sound, light, pictures and text, etc., and the information will be returned.

2.3.2. Data statistics: Mainly including system operation basic data and other data, the entire intelligent boundary pillar monitoring system, using data centralized storage mode, all data are centrally stored on the server, operation data query and statistics, mainly for the system operation of the basic data needed
to record and simple processing, to facilitate the operator in the follow-up maintenance is to carry out the corresponding management operations.

2.3.3. Data management: After the monitoring data is sent to the server data centre, the data is extracted and stored in a text file by the user terminal, so that the general user can easily query the data in the user terminal, the general operator can query data, statistical data, generate printed reports, while the system administrator, in addition to the first two permissions, can also delete error data, supplement data for a certain period of time, etc. Operation.

3. Module selection

3.1. Sensor modules

3.1.1. Self-test sensors. After a search of the literature, it was decided to protect the self-test sensors of the pillars themselves by using triaxial accelerometers for data measurement. The principle of the accelerometers is that they sense the acceleration of an object, produce a deformation and then convert it into an electrical output. The greater the deformation, the higher the voltage value and the smaller the deformation, the lower the voltage value. The output of an acceleration sensor is usually expressed in terms of an acceleration count (AC). According to the different materials, accelerometers can be divided into piezoresistive, piezoelectric, differential capacitive, etc. According to the number of sensing axes, they can be divided into uniaxial, biaxial and triaxial accelerometers. Uniaxial accelerometers can only measure acceleration in one direction, biaxial accelerometers can measure acceleration in two dimensions and triaxial accelerometers can measure acceleration in three dimensions and calculate the combined acceleration.

When the triaxial accelerometer is mounted perpendicular to the ground on the electron pile, its sensitive axis is shown in figure 2. When the accelerometer is in the zero position, i.e. horizontal, there is no input of acceleration due to gravity and the output is zero. When tilted at an angle in the sensitive direction of the accelerometer, the accelerometer senses a component of the acceleration due to gravity and outputs a signal related to the angle of tilt. The tilt angle is related to the output of the accelerometer in the following way:

$$\sin \theta = \frac{v_\theta}{\sqrt{\pi^2}}$$

As there is a sinusoidal function between the tilt angle and the output of the accelerometer, direct measurements can be made at small tilt angles, e.g. up to ±15°. When large tilt angles are to be measured, linearisation measures must be taken.

$$\theta = a r C \sin \frac{v_\theta}{\sqrt{\pi^2}}$$

Figure 2. Acceleration-sensitive axes when ADXL362 is perpendicular to the ground
The microcontroller can therefore recognise when the triaxial accelerometer measures an inclination greater than a certain number of degrees and alert the user.

3.1.2. Monitoring sensors. The photoelectric proximity sensor uses a photoelectric proximity switch, which is an ideal electronic switching sensor for monitoring environmental changes and biological movements in the vicinity of the boundary pillars. It has the advantages of high precision, fast response, non-contact, etc. The photoelectric sensors are simple in structure, easy to use, flexible in form and small in size. In recent years, the variety and output of photoelectric series sensors have been increasing, and are widely used in a variety of industrial automatic production, such as: yield statistics, position detection, material level control, etc. They are also widely used in textile machinery and tobacco machinery automatic production lines, such as: photoelectric strip run-off detection, packaging filler height detection, photoelectric colour quality detection, colour plastic packaging bag making, plastic film position control, etc. As shown in Figure 3, the photoelectric curtain type sensors are used in the production of plastic bags. As shown in Figure 3, light curtain proximity sensors have been widely used for safety protection and position detection in manufacturing workshops and installation sites, etc. Therefore, there are no technical difficulties in applying them to the boundary pillars designed in this paper.

![Figure 3. Proximity sensors in existing applications](image)

When the measured object is close to the sensor's sensing area, the switch can quickly issue electrical commands without contact, pressure or sparks, and accurately respond to the position and travel of the moving mechanism.

3.2. Power supply modules
Due to the special nature of the working environment of the boundary pillars, the selection of the power supply module requires an appropriate battery capacity, which is sufficient to ensure night-time street lighting, but also to prolong the life of the battery, which can achieve a certain degree of self-supply of electricity when paired with the solar panels, to achieve a longer standby time. On this basis, the system has been designed with a dormancy function for the power module.

The first thing to know is that the overall energy consumption of an intelligent boundary pillar includes output power consumption and no-load loss, of which the output power consumption is determined by the load current and cannot be reduced, and the no-load loss is caused by the normal power consumption without reaching the working state. This enables daily standby and emergency wake-up of the system's own power supply modules, while at the same time achieving maximum long-time standby.

3.3. Communication modules
ZigBee wireless communication technology is a network technology developed for Internet communication based on the way bees communicate with each other. Compared with traditional network
communication technology, ZigBee wireless communication technology shows more efficient and convenient characteristics.

As a short-range, low-cost, low-power wireless network technology, ZigBee wireless communications technology is based on the IEEE-approved 802.15.4 wireless standard for networking, security and application software. The technology is particularly suitable for services with low data traffic and can be easily installed in a range of fixed and portable mobile terminals, while ZigBee wireless communications technology also enables GPS functionality and adds a network and application layer based on IEEE 802.15.4. The application layer and the physical/MAC layer of IEEE 802.15.4; the network topology, routing, security and other functions are all implemented at this layer.

ZigBee networks are power saving, reliable, cheap, short delay and large network capacity. Considering the limited energy of wireless transmission nodes, WiFi networks with higher power consumption are not suitable for long time power-on operation. This is in line with the design of the power module, which can greatly improve the range of the pillar itself, improve the working efficiency of the pillar itself; reduce the workload of the pillar maintenance personnel and ensure the safety of the personnel.

4. Summary and outlook

The gradual improvement of IoT technology and BeiDou satellite system makes people have more choices on positioning technology and equipment, while the current sensor, high sensitivity, easy integration and other characteristics can be used for real-time monitoring of boundary pillar dynamics; sensor technology and BeiDou positioning technology with high-speed mobile network transmission technology, can really do real-time positioning, status monitoring, damage warning. After the design of the intelligent boundary pillar system is completed, the whole process of intelligent, digitalisation, visualisation and monitoring information security management will be realised, such as real-time return, analysis and analysis of boundary pillar status data. More importantly, the platform is able to carry out intelligent analysis based on the stored historical data, thus giving the development trend of the boundary pillar status in a certain period of time and greatly improving the management efficiency of the boundary pillars.

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