

THE RESEACH ON WIRELESS SENSOR NETWORK FOR LANDSLIDE MONITORING

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Abstract- ***The paper mainly discusses design and implementation of key functions such as transceiver unit, MCU control unit, Data acquisition module and Background monitoring unit. Furthermore, the corresponding software platform is implemented according to hardware architecture. Finally the solution is applied into Loess landslide at Luoshan County in China. The experimental results show that bit error rate remains between at 10^{-5}~ 10^{-6}. This range coincides with communication standards of wireless sensor network. Furthermore, collected data are proved to be consistent with natural phenomenon. Compared with traditional monitoring method, the new method has better advantages.***

Index terms: Wireless sensor network, landslide monitoring, landslide pre-warning, data acquisition, bit error rate.

I. INTRODUCTION

Real-time monitoring of landslide is a very complex technology and the product of multi-disciplinary combination. It spans many subjects such as the Electronics, Computer Science, Communication, Surveying [1]. So any new theories and techniques can make the landslide monitoring improve a lot. The improvement can not only improve accuracy of monitoring but also contribute to more precise generation process of landslide. Similarly, improvement on monitoring equipment also facilitates to lower cost and promotes application of monitoring system [2].

Deep inclinometer displacement monitoring and GPS table deformation monitoring based on borehole tilt meter are adopted popularly on current Real-time landslide monitoring system [3]. Signal from sensors and detection equipments are translated into central server by using cable or GPRS communication. Cable has obvious drawbacks such as difficulties on wiring and construction at the danger zone, man-made destroying and devastation from natural disasters. In addition, GPRS communication also has technical limitations. It can not be used in remote mountainous areas where signal is weak even hard to be received so that qualified GPRS network is hard to be established [4].

Wireless sensor network (WSN) technology which is utilized in reservoir area where geological hazards occurred easily is effective attempt. Because WSN itself has some better characteristics such as redundancy, wireless, the self-adaptive network and strong anti-destruction capability, WSN can still complete the limited communication even though all communications facilities are damaged totally [5].

Combination of Wireless sensor network and Landslide monitoring becomes the focus of research in the world. A number of research institutes and companies have taken a lot of hard work and gained some achievements in scientific research and corresponding products. For example Indian institute of technology designed a distributed monitoring system for landslides monitoring based on wireless sensor. The system includes two main parts:

(1) Fault tolerance capability, energy utilization efficiency and routing protocol;

(2) Distribution decision method. In order to verify monitoring capacity of the system, designers simulate pressure changes of the rock samples and track data changes. Finally some important information about monitoring capacities such as energy consumption of the system, routing

efficiency and decision-making effect, is validated. But system can only collect small-scale data and so far has no practical experience. Its reliability in harsh monitoring environment needs further be tested. The accuracy of the system for monitoring and forecasting of landslides needs also to be improved [6].

Ritsumeikan University developed ad hoc network and self-healing wireless sensor network for landslide monitoring system. The operation mode of system node is classified into: Initialization mode, measurement mode and emergency mode. According to environmental monitoring information, system node can choose operation mode automatically. So data can be transmitted timely and reliably. Pre-warning and forecasting of landslide are implemented. The system collects landslide data by acceleration sensor and the soil humidity sensor. Acceleration can be integrated into speed. Speed can be integrated into displacement again. Since there are larger errors at the process of gaining acceleration, the final result cannot meet the required displacement accuracy. Monitoring capacity of the system is impacted [7].

Johns Hopkins University proposed a three-step prediction algorithm for landslides monitoring based on wireless sensor:

(1) Surface displacement is monitored by wireless sensor. Thus static area and sliding area can be differentiated obviously.

(2) By trilateration mechanism, the sliding area's wireless sensor nodes can be positioned each other. Furthermore displacement between nodes can also be calculated.

(3) Direction and position of the node displacement can deduce position of the whole sliding surface. Then combined with the sliding surface information and the soil information (soil pore pressure), a finite element model is applied to predict whether the mountain landslide occur and occurrence time [8].

Although the simulation results show that the algorithm is very effective and can reach into centimeter-level accuracy, the positioning accuracy is difficult to be assured in the actual landslide monitoring environment. Therefore, the algorithm is difficult to gain accurate landslide displacement. Its reliability and stability needs to be proved.

Coimbatore University, in cooperation with European Commission and the Indian Space Research Organization, developed a wireless sensor network monitoring system for landslides monitoring. The project is part of WINSOC(wireless sensor network with self-organization capabilities for critical and emergency applications).The various parameters of soil such as

moisture, vibration and displacement are collected by the sensor nodes which are installed 15 meters off the ground. Data is transmitted to monitoring center of Coimbatore University through a wireless base station. Pre-warning and forecasting are implemented. Reliability of wireless communication between the nodes is impacted because sensors are placed at 15 meters below the surface. In order to communicate data between underground node and the ground node, the RF transmit power of nodes is set larger, thus the life cycle of the node is reduced. The overall system performance becomes weaken. Some other projects such as Germany's SLEWS program and the United States and India cooperation Senslide plan are under the way [9][10].

In China, only Wang Yanying and Yang Bin(Southwest Jiao Tong University Computer College) developed a real-time monitoring system based on wireless sensor network [11]. The system focuses on two parts: μC / OS-II operating system porting and sensor network topology. Routing algorithm of network topology has weaker control for routing. So accurate routing is hard to be carried out. Furthermore invalid transmission and energy loss of node are likely to occur. Since residual energy of the node is ignored at the process of routing, it is likely to cause node early death. The life cycle of the network is affected. Remote data transmission by GSM SMS can cause some obvious defects such as transmission delay and poor real-time. So the low-cost, real-time requirements cannot be satisfied. Overall performance of the system is reduced.

Currently, Landslide monitoring pre-warning system based on wireless sensor network can avoid the disadvantages of the traditional monitoring method, enhance advantages of traditional monitoring method and improve monitoring performance. But some key parameters such as accuracy, real-time and low power consumption, need to be further improved. In order to meet the landslide monitoring performance needs, wireless sensor with low-power consumption must be adopted. Flexible and effective routing protocol of wireless sensor network can guarantee reliability of data transmission while GPRS technology can implement remote real-time transmission. The combination of the two can achieve the real-time accurate monitoring and pre-warning for landslide.

II. THE SYSTEM STRUCTURE OF WIRELESS SENSOR NETWORK

In order to achieve pre-warning mechanism and wider-monitoring, WSN system mainly focuses on Data acquisition, effective transmission and the accuracy of processing. LAN is set as the

research platform. The structure of monitoring and pre-warning system is shown in Figure 1, which can be divided into two parts: the upper and lower control center monitoring station. Monitoring station and the monitoring center are connected by via Ethernet. In addition, the staff of management can also access to monitoring base station by customizing network. The combination between monitoring base stations and many wireless sensor nodes make up the wireless sensor network. Wireless sensor network has very good scalability. Random change for the node has no effect for the network topology and network model, so you can easily increase or decrease the number of monitoring nodes according to the actual condition.

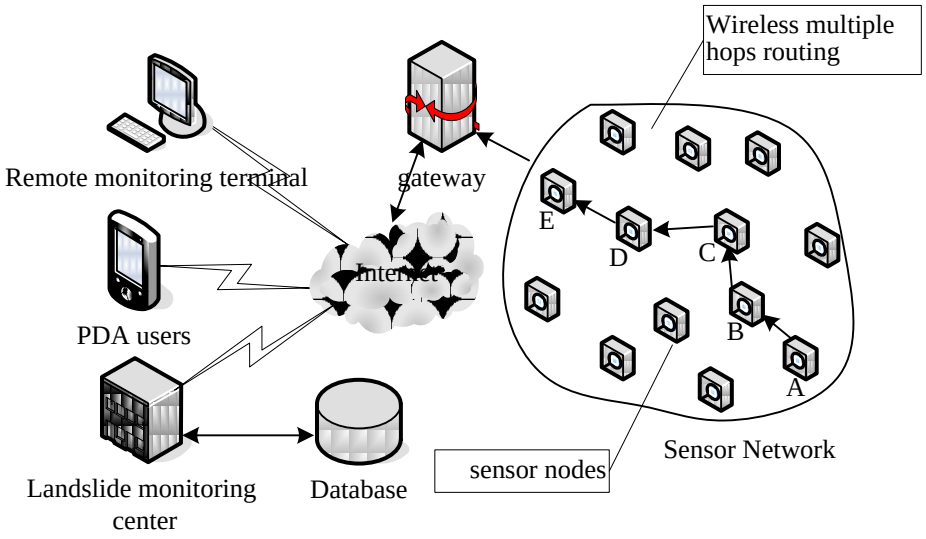


Figure 1. Landslide monitoring sensor network structure

The main function of each part in figure 1:

(1) Sensor node: sends air information which is collected from sensors periodically to the landslide monitoring and management center by multi-hop routing.

(2) Gateway: lies at the edge of the sensor network, make the interconnection between the sensor network and internet. So the conversion from sensors network protocol to internet protocol is achieved.

(3) Landslide Monitoring Center: is responsible for storage, processing, evaluation of sewage and other information and so on. Usually a management center can manage multiple monitoring areas. Remote monitoring and PDA terminal users can access the data of landslide monitoring server through the internet and can perform real-time inquiries from server.

III. THE DESIGN OF SYSTEM

As the real-time collection, transmission and processing of monitoring information are closely related with the node, so the paper focuses on the hardware and software design of the node.

a. The design of hardware system

(1) Wireless transceiver unit: adopting SRWF-501-50 micro-power wireless module, the wireless communication module has a strong anti-interference ability, and some functions, such as all transparent transmission, small size, long distance of transmission, low power consumption and dormancy.

(2) MCU control unit (AT89C52): data processing module is the core of the sensor network node, for one part, receiving measurement data from the sensors, processing and calculating dates as required, sent by a communication module. For another part, reading the data sent by communication module, controls the operation of other modules on the hardware platform.

(3) Data acquisition module: sensor adopts angle sensor and level sensor. Each hole will be deployed in liquid level sensors in the bottom and be deployed in a number of angle sensors in different depths. It can monitor the movement of the mountain by angle sensors, and collect the data of the depth of groundwater by level sensors .Figure 2 shows the block diagram of the wireless sensor node circuits.

(4) Background monitoring unit (embedded systems): the CPU of processor module uses Samsung S3C4480 ARM9-based microcontrollers, transplanted μ COS-II real-time multitasking operating system in the ARM for real-time multi-task management. For there will be many issues of resource competition owing to sharing the same kind of resource, the system used the way of the event flags and semaphores to achieve synchronization mechanism, making the atomic operations do not need to turn off all interrupts, which will not delay the system response.

b. Software module design

In accordance with the designs ideas of hardware circuit, the software adopts the way of Modular structured programming program. Software modules include: system initialization, the data

transmission module, receiving the interrupt service, sudden interruption acquisition, A/D acquisition module, UART serial port module.

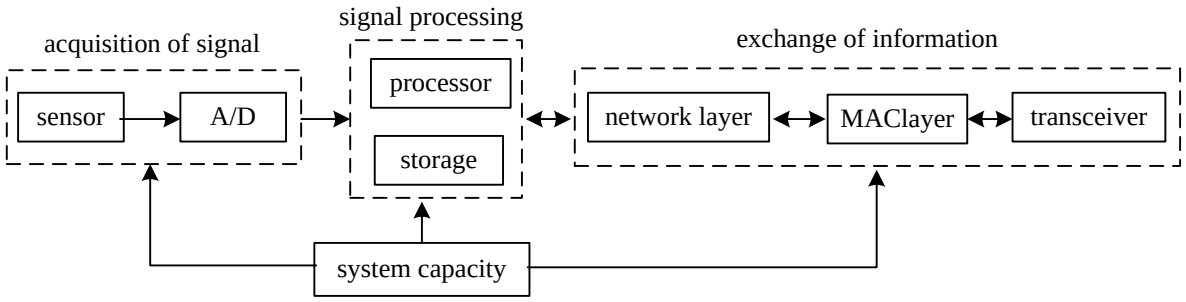


Figure 2. Wireless sensor node circuit structure diagram

Currently, the hardware of network node can only complete the functions of physical layer. The functions above physical layer have to be realized by software; therefore, the design of software has a great influence on the functions of the entire nodes and resource utilization. This paper, from two aspects of the design, provides protection for software performance, adopting multi-tasking operating system and object-oriented protocol design.

Firstly, the network nodes generally have functions of data collection, information processing, data forwarding and routing, which often occur simultaneously, therefore, in order to deal with these concurrent events in limited hardware resources, this paper adopts the multi-task Real-time operating system Tiny OS which has open source. The system, based on Component-based architecture, is mainly used in wireless sensor networks. When the external hardware, such as communications equipment, timers, sensors and other triggered hardware are interrupted, the system executes the corresponding interrupt handling. After the completion of all triggered events, the system goes to sleep to save energy. Secondly, taking the scalability of software into consideration, in order to make the node run a variety of communication protocols according to different applications, this paper uses object-oriented design of communication protocols, makes the MAC (media access control), network layer and every layer of protocols designed to be an object, defines the external interface of protocol as virtual functions. In the thesis, different communication protocols are implemented as instances of the object, It adopts the method of overriding virtual functions, Thus, developers can reuse the interface of development. Since the routing, MAC and other protocols are the objects achieved by their own. So when application

requirements change, you can change the concrete implementation methods rather than replace the interface.

The basic ideas of System initialization: set the serial port after power-on mode 3, open the timer interrupt and external interrupt, start receiving module, test communication, entering power saving mode. The main program flow chart is given here simply (as shown in figure 3); interrupt flow chart (as shown in figure 4.The interrupt in figure 4 belongs to receiving interrupt. The interrupt 1 belongs to the unexpected interrupt.

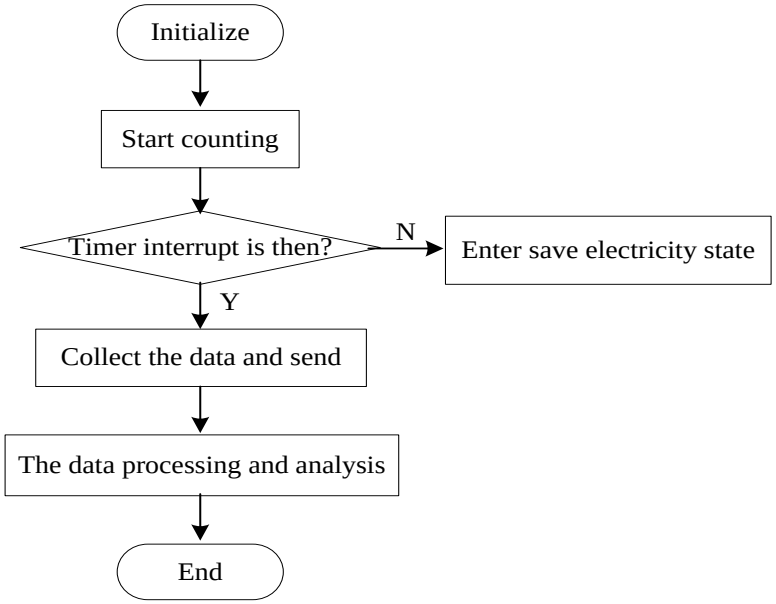


Figure 3. Main program flow chart

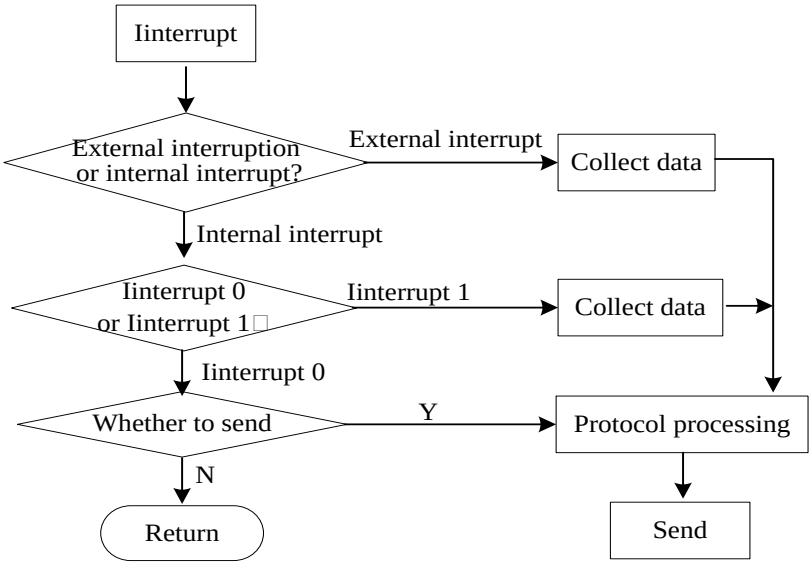


Figure 4. Interrupt flow chart

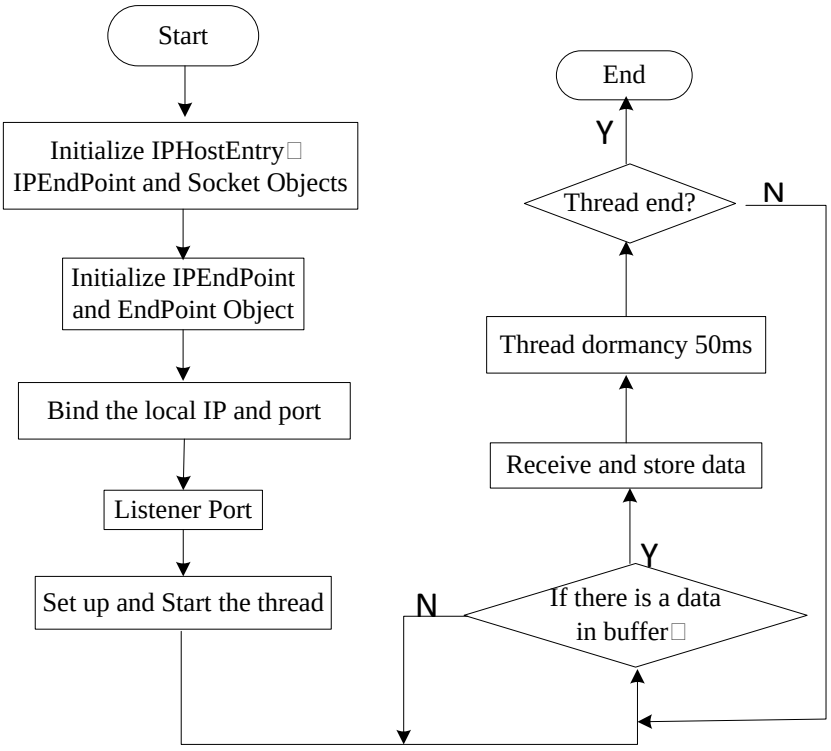


Figure 5. The packet reception procedure

A receiving data program:

Major steps of socket implementation are as follows:

(1) Create a Socket instance.

(2) IP address binds with machine's network port.

(3) Listen to local network's port.

(4) When connection request arrives, local machine begins to receive data.

A connection-oriented TCP service is applied to completing data transmission between GPRS module and remote monitoring center. Therefore, after IP binds with machine's port; the port needs to be assured whether the data is transferred. Since the data transmission is discontinuous, in order to be able to receive data, thread technique is utilized to check cyclically whether data is existed on data buffer. Once the data exists, the corresponding data is read instantly. Thus A receiving data program is achieved. The receiving data process is shown in figure 5.

IV. THE ANALYSIS OF TEST AND ITS RESULT

a. The background of application

Springs Road landslide is part of Kicking potential landslide Yuan Jia, which is located in the front of Kicking potential landslide Yuan Jia. The northern section of landslides lies in the left bank of the Yangtze River and the right bank of Daxigou, shown in Figure 6.



Figure 6. Luoshan country landslide of Shichuan

The northeast section of landslides lies in the left bank of the Yangtze River floodplain. Springs Road landslide is located in the two terraces of Yangtze River (the first level terrace, the second level terrace). Kicking potential landslide Yuan Jia (including springs Road landslide) is kidney-shaped, locating in the Yangtze River terraces of the first to the third level. The west side of the landslides is adjacent to long-Yam Tang landslide. As landslide is large loose debris landslide, after the normal operation of The Three Gorges Reservoir, the majority of the front of landslide will be flooded. 80% of springs Road landslides lie in the reservoir with the change of water level, and the partial and overall deformation are quite possible.. From deformation mechanism we can infer springs Road landslide is two sliding loose soil landslides, with two sliding surface. The determination of early landslide warning is the important content, and it also provides data analysis for managing landslide.

In June 2010, Luoshan County, Shichuan Province, located in the Three Gorges Reservoir Area Huangtupo volume of about 40,000 cubic meters of large landslide, bury 14 people and killed five people, the direct economic losses of more than 1000 million RMB, as shown in figure 6.

b. Data processing and analysis for result of landslide monitoring

By testing the bit error rate of the system through experiments in different environments, different distances of the communications test, we learn the channel bit error rate of the system is 10^{-2}, the transmission is at a distance of 500~1200m, the average bit error rate is between $10^{-5} \sim 10^{-6}$. On the actual test of Springs Road landslide, supposing sending data frame x, y frame is received, that is when sending $11\times x$, $11\times y$ is correctly received, then get the monitoring data of landslide, and according to the formula (1) to calculate the bit error rate, as shown in table 1.

$$BER = 11 * \left[\ x - y \ / x \right] \qquad (1)$$

Table 1: Test data for bit error rate

Send(x)	**Receive(y)**	$x - y$	**Bit Error Rate($BER = 11 * \left[\ x - y \ / x \right]$)**
200000	200000	0	0
500000	500000	0	0
1000000	999999	1	1.1×10^{-5}
1500000	1499999	1	0.73×10^{-5}
2000000	1999999	1	0.55×10^{-5}
2500000	2499998	2	0.88×10^{-5}
3000000	2999999	2	0.73×10^{-5}
4000000	3999998	2	0.55×10^{-5}
5000000	4999997	3	0.66×10^{-5}

The actual bit error rate of the system is obtained from the analysis, as shown in figure 7.As we can show from figure 7, When the data is small, the bit error rate is almost 0, As data increases, the bit error rate of the system remains at $10^{-5} \sim 10^{-6}$, which meets the communication requirements of wireless sensor networks, confirmed the system's effectiveness in landslide monitoring.

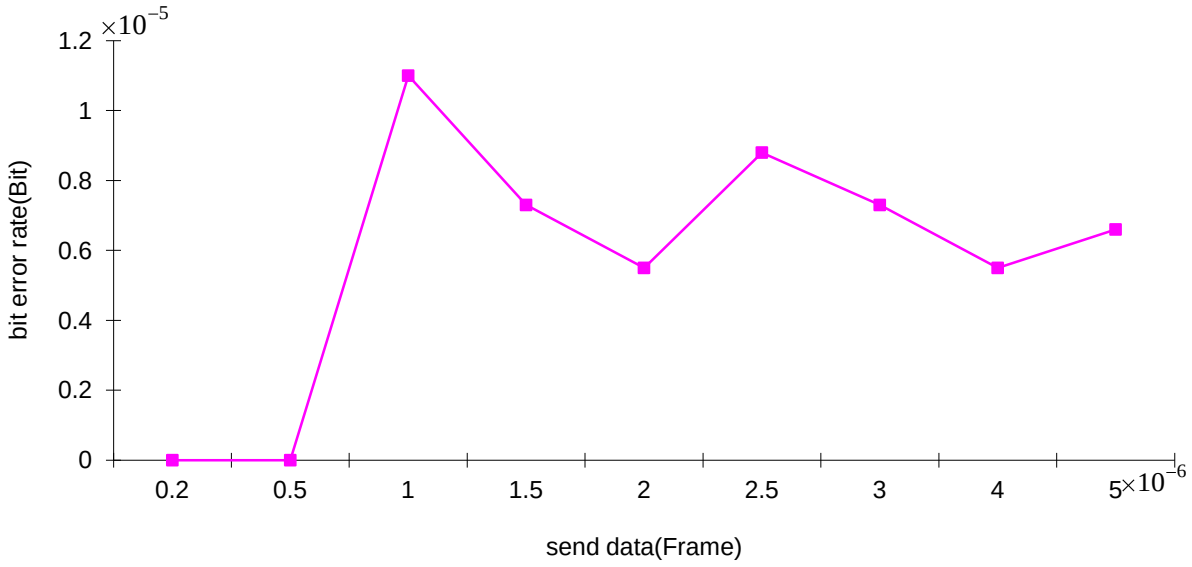


Figure 7. The test results of bit error rate

c. Analysis for result of landslide monitoring

c.i Network construction of landslide monitoring

In order to make an accurate forecast, a tiring working style becomes the only choice. In the mode, observers should collect continuously dynamic information of sliding force and revise results at any time. In theory, the process can not be interrupted even on the verge of landslide occurring. In the realty, for safety reasons observers must be away from the landslide area when dramatic landslide will occur. Record is suspended. So remote monitoring and forecasting system is imperative.

August 10, 2010, in Luoshan mines, the monitoring system was installed and debugged. After that, the system started working. The software was deployed in 53 different observing sites in order that the whole minor area can be covered. It indicated that network construction of remote monitoring system has set up successfully in Luoshan mine. Four landslide areas of Luoshan mine are gathered together and the whole area is about 179,600 m^2. So 53 observing sits can cover I and II, III and IV landslide area of Luoshan mine. After a four-month testing period, the results indicate that the system is not only stable and reliable, but also has some good specialty such as low power consumption and convenient operation. So the system can be adapted fully to

mountainous environment. Especially in -15 ℃ temperature, the system can keep durable, stable and reliable. So labor intensity of observer is greatly reduced.

c.ii Monitored data

Remote monitoring and early warning system are deployed in 53 different observing sites of Luoshan mine at August 10, 2010. In order to increase frequency of data collection and avoid losing some key data, a self-adaptive data collection program is applied. When sliding forces in landslide surface change smoothly, the collection frequency: f = 1/3 hours is set; when sliding forces in landslide surface change abnormally, acquisition module will automatically increase collection frequency: f = 2 / hours. Up to March 2010, by almost 20-month rigorous monitoring, massive useful data are collected. The data can provide important scientific facts for stability evaluation and development tendency of landslide.

Description:

(1) Statistics from August 6, 2010 to March 10, 2011.

(2) The peak-point of the pulse is ignored at Statistical process.

(3) Standard deviation of sample s:

$$s = \sqrt{\sum_{i=1}^{n} (xi - \bar{x})^2 / (n-1)} = \sqrt{\sum_{i=1}^{n} (x_i{}^2 - (\sum_{i}^{n} x_i)^2 / n) / (n-1)} \qquad (2)$$

According to the principles and standard of monitoring point's classification, history data on 53 monitoring sites are handled correspondingly. The range and standard deviation of sample are calculated and shown in Table 2. According to handled data, 53 landslide monitoring sites on Luoshan mine can be classified into normal sites and abnormal sites.

Table 2. Analysis and statistics table for monitored force change of sliding mass in Luoshan

Landslide mass	**Identifier**	**NO.1-01**	**NO.1-02**	**NO.1-03**	**NO.1-04**	**NO.1-05**	**NO.1-06**
I	ΔP(kN)	-30	20	88	20	18	18
	standard deviations	5.77	4.20	23.62	3.98	4.02	3.82
	Identifier	NO.1-07	NO.1-08	NO.1-09	NO.1-10	NO.1-11	—
	ΔP(kN)	71	-24	18	20	27	—
	standard deviations	20.04	5.51	3.85	4.13	3.87	—
II	Identifier	NO.2-01	NO.2-02	NO.2-03	NO.2-04	NO.2-05	NO.2-06
	ΔP(kN)	17	19	-22	25	20	12
	standard deviations	3.02	3.74	5.14	5.53	4.41	2.32
	Identifier	NO.2-07	NO.2-08	NO.2-09	NO.2-10	NO.2-11	NO.2-12
	ΔP(kN)	83	17	20	20	20	19
	standard deviations	25.10	3.65	4.90	4.69	5.06	4.02
III	Identifier	NO.3-01	NO.3-02	NO.3-03	NO.3-04	NO.3-05	NO.3-06
	ΔP(kN)	15	180	-29	-38	-32	39
	standard deviations	3.31	53.97	6.53	8.66	7.04	8.05
	Identifier	NO.3-07	NO.3-08	NO.3-09	NO.3-10	NO.3-11	NO.3-12
	ΔP(kN)	38	19	43	34	162	-27
	standard deviations	10.72	4.77	10.63	4.56	46.67	8.69
IV	Identifier	NO.4-01	NO.4-02	NO.4-03	NO.4-04	NO.4-05	NO.4-06
	ΔP(kN)	20	16	17	16	-20	19
	standard deviations	4.91	3.09	3.12	3.09	4.68	3.89

d. Analysis for N0.3-02 abnormal point

No.3-02 monitoring site is located in the root of the III landslide. Its elevation is about 734m.At July 8, 2010, Installation task was completed. At July 9, the system began working. Up to November 26, 2010, trend on the monitoring site shows a steady upward trend. This trend is shown in figure 8.

(1) Stable stage (2010-4-20 to 2010-05-19): Curve on the stage approximates to horizontal line. The average stress is about 380KN. Maximum stress is 400KN and range ability is about 20KN (2t);

(2) Slow rising stage (2010-05-20 to 2010-06-29): Curve on the stage shows upward trend but the change is smooth. Minimum stress and maximum stress is 404KN and 450KN respectively. Range ability is about 46KN (4.6t);

(3) Fast rising stage (2010-06-30 to 2010-08-14): Curve on the stage shows an upward trend and the rate of change is obvious. Minimum stress and maximum stress is 442KN and 542KN respectively. Range ability is about 100KN (10t);

(4) Steady stage (2010-08-15 2010-10-07): This change on the stage is relatively stable. The monitored curve was straight line.

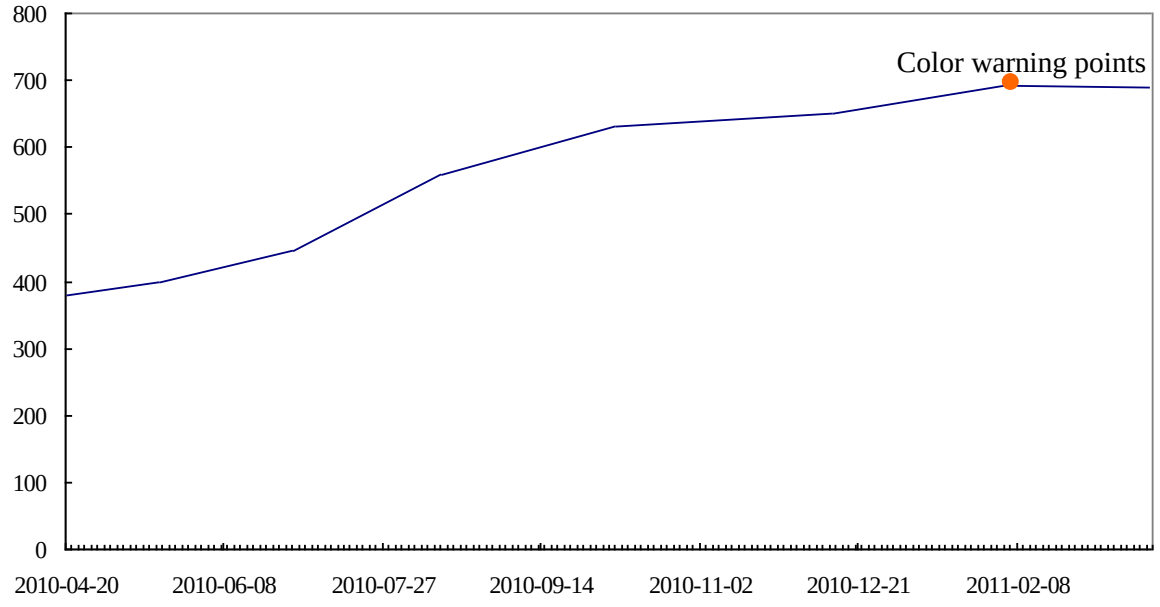


Figure8.Monitoring points screen shots of No.3-02 from engineering disaster monitoring network

In summary, the trend of sharp rise or sharp decline does not occur on 1-IV stage of No.3-02 monitoring site. The rate of change is also relative smooth. Through many practical observations on the monitoring site, no abnormality on the surface is found. This result agrees with monitored curve. The scene on monitoring site is photo and recorded. In addition, data on adjacent #12 observation station have not significantly changed. However, because the increase of stress exceeds more than 30t, yellow warning is issued. So this trend need be concerned carefully.

d.i Analysis the results

After the scene reconnaissance of Inoue and underground, main factors of curve rising on No.3-02 monitoring site are terrain ground anchor, nature and structure of soil-rock, underground mining.

(1) Topography: Vegetation coverage is low near No.3-02 monitoring site. A width of 3m gully is located at the north of the monitoring point one meter. Layout of the gully is in parallel with III-III' monitoring line. During the rainy season, rainwater from the peak is drained to this gully. So obtained results are affected.

(2) Properties and structure of rock-soil: Colluvial soil and slag heaps are main substances on slope of No.3-01 monitoring site while fragmentation of granite appears largely at the slope of No.3-02 monitoring site. The fragmentation has some important features such as fracture development, high degree of weathering and intricate structural surface. Those rock blocks which are formed by structural surface cutting are good medium for transmitting internal stress because of its small size, high density and effect of finite element. Owing to roadway excavation engineering and mining activities under No.3-02 monitoring site, transmit of internal stress of soil-rock in this area is changed. So the monitoring site is easy to receive this influence, thus affect monitoring curve.

d.ii Conclusion

Generally speaking, abnormal changes at monitoring sites are at the early stage. Since all mining activities and experiment tunnel projects are terminated, surveillance data from remote monitoring sites will maintain a steady state. In order to analyze steady state of landslide III

comprehensively, the multi-faceted methods need to be implemented. For example the frequency of monitoring for surface and underground needs to be strengthened, abnormal changes of piles and underground are analyzed with combination of data from geodetic theodolite and data from remote monitoring sites .All works are to forecast accurately occurrence of accidents and provide some protective measures timely. Finally mining activities are to ensure that it is safety.

d.iii Alert classification

According to standard of alert classification, danger rating of the slope near the monitoring site is defined as orange, which is also called just before sliding. According to monitoring data, sliding force at this point is greater than 600KN and meets range of orange standard.

e. Analysis for NO.1-07 abnormal point

e.i Phenomenon

This monitoring site is located at the top of landslide I. The elevation of the site is about 897m.monitoring equipments was installed on July 10, 2010.it started work from July 11, 2010. For the period finishing with February 21, 2011, data at this site shows that there is a steady

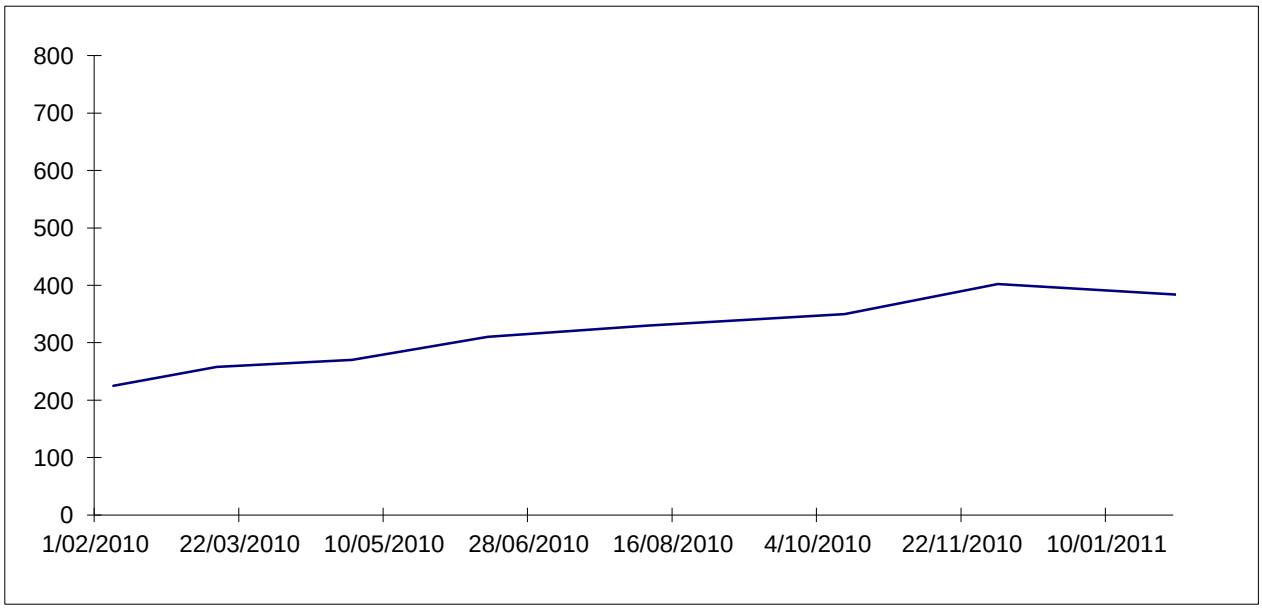


Figure 9. Monitoring points screenshots of NO.1-7 from engineering disaster monitoring network

Between 2010-7-11 and 2011-2-7 monitoring curve at this site presents steady trend. The curve approximates to inclined line. Maximum stress value is 345KN and minimum stress value is 231KN.Between 2011-2-8 and 2011-2-16, monitoring curve presents an obvious down-trend. The stress value decreases from 345KN to 305KN.Rate of decline reaches to about 40KN (4t).between 2011-2-26 and 2011-2-28 the curve drops drastically again. The stress value decreases from 305KN to 384KN.Rate of decline reaches to about 21KN (2t).

e.ii Analysis

This monitoring site is located at the top of landslide I, and prosperous vegetation covers on this area. In 2009 geological disaster around the monitoring site such as subsidence area, ground fissures and dangerous rock mass was managed intensively. The main measures include artificial landfill, tamping, blasting and land reclamation.

(1) Artificial soil constructs the main body of surface soil-rock mass at the monitoring site. The soil is the Quaternary clay, color of which presents yellow, dark yellow and brown. Because of the consolidation effect of under consolidated soil, stress redistribution of rock mass of slope has been affected.
(2) The old mine or goaf exists at deep part of monitoring site. The growth of rock fissures at the roof of tunnel leads to infiltration of surface rainwater. So strength of rock is reduced. There is certain threat for stability of the landslide.

e.iii Conclusion

The two above situations demonstrates that there is potential trend at this monitoring site. So the trend of internal stress of rock and soil needs to be monitored closely. In order to make a rational, scientific judgment, the corresponding trends of surrounding monitoring sites also need to be monitored closely.

According to standard of alert classification, danger rating of the slope is yellow. It belongs to incomplete stability. According to monitoring data, sliding force at this point is greater than 400KN and meets range of yellow standard.

V. CONCLUSIONS

Wireless sensor networks are considered to be one of important technologies that affect the future life. This new technology provides a new way to obtain and process information. The normal working of landslide monitoring system based on wireless sensor technology and ground monitoring network in special areas proves the feasibility of the whole system. Low-cost online monitoring can be implemented by excellent characteristics of wireless sensor network such as low power-consumption of node, long working hours, low cost, self-adaptive communications and convenient installation at danger zones or broad areas. So compared with tradition monitoring system, new system obtains better performance and practicality. The system can be modified slightly in order to be applied in other fields such as in water pollution, forest fires and other natural disasters. Indoor security, intelligent transportation, industrial control is also included in the range of the system application.

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