Research on application of GIS and GPS in inspection and management of city gas pipeline network

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Abstract. To solve the problems existing in the current Gas Company patrol management, such as inaccurate attendance, whether or not the patrol personnel exceed the scope of patrol inspection. This paper proposed that we apply the SuperMap iDeskTop 8C plug-in desktop GIS application and development platform, the positioning function of GPS and the data transmission function of 3G/4G/GPRS/Ethernet to develop a gas pipeline inspection management system. We build association between real-time data, pipe network information, patrol data, map information, spatial data and so on to realize the bottom data fusion, use the mobile location system and patrol management client to achieve real-time interaction between the client and the mobile terminal. Practical application shows that the system has completed the standardized management of patrol tasks, the reasonable evaluation of patrol work and the maximum utilization of patrol resources.

1. Introduction
Urban gas pipeline network is widely distributed. Road construction, harsh environment and human factors will affect the normal transportation of gas. Therefore, the high quality inspection of gas pipeline network is essential to its normal operation. There are two main types according to the current domestic gas pipeline inspection methods: manual inspection and PDA (palmtop computer) inspection; manual inspection mostly adopts the composite cross inspection method, the main problems are that there is no objective and accurate inspection, the attendance of the patrol personnel is not in place, and the patrol record has no electronic records, which leads to irregular records, inaccurate and easy to lose. The cost of PDA inspection is higher and communication can not be realized, GPS positioning, and user experience is poor. Direct observation methods are used abroad, such as the use of ground vehicle patrols, air drones and so on [1], which are costly and unreliable. Smith and Gregg put forward the combination of satellite and image analysis to monitor the operation of gas pipeline, Almazyad proposed to strengthen the monitoring of gas pipeline through the deployment of wireless sensor networks[2]. These methods are of high cost and do not conform to the current situation of urban gas pipelines in China. Aiming at the problem of the efficiency of domestic gas pipeline inspection, statistical work is not accurate, personnel management is not in place, this paper introduces how to use GPS and GIS technology to construct the inspection management platform and the development of inspection system, inspection to realize intelligent management, equity management, so as to ensure the normal transportation of gas.
2. Design and development of gas pipeline

2.1. System architecture

The system uses GIS, GPS, data transmission and other technologies, and uses C# language to develop patrol management platform, and uses JAVA language to develop mobile patrol positioning system in two parts, the real-time location of mobile patrol positioning system using GPS and mobile phone base station positioning to obtain the inspector [3], and the location of data sent to the computer through the network in the network system. The inspection management platform and database server can obtain location information from the computer network, the location data stored in the database can be used to make reasonable evaluation on the inspection staff attendance, inspection management platform based on GIS by the technology to build a gas pipeline map and inspection management functions of two parts, the use of location data and GIS map function ation the function of the best path for the inspector to the fault analysis, traffic guide, cross-border alarm etc.. The administrator can set up patrol tasks through the management platform, manage the basic information of the patrol, register the Patrol Records uploaded by the inspector, and check the location information of the inspector uploaded to the database. The inspector performs the corresponding patrol tasks according to the task of the administrator. The overall architecture of the system is shown in figure 1.

![Figure 1. Framework of gas pipeline inspection management system](image)

3. Design of patrol positioning terminal system

Patrol positioning system is mainly divided into two parts: patrol and location. Electronic filing inspection mainly realizes the operation conditions and operation parameters of pipelines and ancillary facilities, improve the inspection efficiency; easy to quickly grasp the positioning inspection personnel in place, effectively prevent the off-site inspection personnel, to ensure that they are required to complete the inspection work according to plan.

There are three kinds of mobile phone location technology, which are GPS positioning, mobile base station location and network location [4]. The network location is suitable for indoor and is not suitable for outdoor inspection. GPS is more accurate in the first position but take a few minutes to locate and
can only receive satellite signals[9]; the base station positioning is realized through the base station network of mobile operators, as long as there are mobile operators base station can achieve fast positioning. In order to ensure the reliability and sensitivity of localization and shorten the initialization time of localization, we select GPS and location of base station to realize the location of patrol personnel.

Start the mobile inspection positioning terminal software, as shown in Figure 2 the function interface, first ensure that the inspector GPS open, and then enter the job number and password login to the system login interface as shown in Figure 2, after entering the system in the inspection process inspection records can be uploaded to the server, but also coordinate inspector every 1 minutes will be automatically uploaded to the server. The patrol record registration interface is shown in figure 3.

![Figure 2. Login interface diagram](image-url)
Inspector in the inspection process system in minutes, precision of recording position information of the inspection staff, using Baidu maps API function of the position of inspector in a period of time to connect, display in the corresponding position on the Baidu map. Track playback is mainly based on the GIS map, record the running track inspector, patrol the area to reflect the inspector, to facilitate scientific planning work arrangements, one way is to measure the quality of work and the inspector. The workflow of track playback is shown in Figure 4, and the patrol path is shown in figure 5.

![Figure 3. Patrol record registration interface diagram](image)

![Figure 4. Patrol flow chart](image)
4. Function design of patrol management platform
The main interface of the management platform is shown in figure 6. According to the actual operation requirements of patrol management, the system is divided into four functional modules: Patrol task formulation, patrol record registration, nearby patrol personnel search and cross boundary alarm. In order to facilitate the use of users, the toolbar has to enlarge, shrink, Translation, map, basic view, operation tools.
4.1. The main function modules are introduced

4.1.1. Patrol operation. Patrol line of work is mainly on the process of inspection process management, the first administrator needs to advance the development of inspection according to the inspection, inspection staff into the inspection management platform interface in the inspection before the day to check their inspection tasks for [5], and then to conduct inspection according to inspection tasks, and will be recorded in the mobile inspection and positioning system problems upload to the server, the administrator through the management platform to see the inspector to upload inspection records, and the corresponding inspection record registration module issues recorded, and has yet to solve the problem, the existence of hidden records, and according to the task of formulating and inspector upload tasks completed registration form to complete the work of inspection staff for quantitative analysis, convenient face work performance inspection staff assessment.

4.1.2. Fault alarm. When the emergency operation occurs during the operation of the gas pipeline network, the administrator needs to contact the patrolling staff near the accident point to deal with the emergency in a timely manner. Through the GIS network topology and path comparison algorithm, inspector position information in a given radius range according to GPS positioning can upload near accurate search to the accident spot inspection personnel, then the administrator can give the inspector send instructions through the system, an inspector put current inspection work immediately to solve the accident unexpected problems, administrators received instructions issued by the mobile inspection and positioning system will pop up a message, until the inspector click on the confirmation after receiving the information, the information tone disappears, while the inspector received this information feedback to the system administrator. The nearby inspector looks for the interface, as shown in figure 7.
4.1.3. Cross boundary alarm. The use of cross-border alarm function management platform to start work, the system will first search according to the location of the inspection personnel positioning information sent to the smart mobile phone system server, whether the search in the inspection area inspection personnel inspection system within the set, in order to obtain accurate information real time, we are positioning through the classical method to determine the relationship between point and polygon to inspector for range searching, taking into account the search positioning system and network problems because of the occasional failure to locate the situation, we will advance to the system setting and positioning cycle times, when the failure of patrol personnel positioning search, according to location and cycle set the number of positioning, in the inspection area again on the inspector by searching positioning. If the inspector is in the range of inspection, the location information of the inspector is recorded, and when not in the system, the frame prompt the administrator that the inspector is beyond the scope of inspection. The automatic positioning search flow chart is shown in figure 8.
4.1.4. Property settings. The module mainly maintains the information of the patrol personnel and equipment, and can increase or decrease the patrol personnel, update the original equipment and patrol personnel information.

4.2. General framework of platform module function
The four functional modules of the management platform also contain many small auxiliary modules, as shown in figure 9.

Figure 8. Automatic positioning search flow chart
5. Conclusion
GIS map management function and GPS high-precision positioning technology have been successfully applied to gas pipeline inspection management. Location information of inspector is obtained by GPS. GIS technology is used to monitor the patrol's movement and provide the best route for patrol and we use 2G/3G/4G/ Ethernet to realize the communication between client and patrol location system. We have realized the visual control of gas pipeline inspection, Flexible deployment of tasks, Fair examination of patrol work, and solve the problem that inspection is missed, the inspector is not on time, the inspection record is inaccurate. Application of technology of GIS and GPS will greatly promote the development of China's gas pipeline inspection.

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