

# Study on LBS-based Positioning Technique of Pipeline Robot

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**Abstract**—To manage the wireless positioning of pipeline robot, STM32 mobile positioning module is adopted to build a mobile positioning system to solve the quick troubleshooting and positioning of robot in the complicated pipeline. In this paper, it analyzes the influences of the node number variation and positioning range referring to the pipeline robot at obstacle and turning on the accuracy of positioning system. According to the experiment: with the specific pipeline, the more the number of the reference data, the higher the positioning accuracy; however, at a certain turning or obstacle when the number of data increases to a certain number, the positioning accuracy will be improved to a limited extent. For the 400~650mm pipeline diameter, 100m with 3 turning positioning regions, the positioning accuracy of 4 failure nodes is about 1M. The experiment result can provide references for the application of LDS positioning system in the pipeline robot positioning.

**Keywords**—pipeline robot; LBS positioning; failure node

## I. INTRODUCTION

In addition to the advantages i.e. not being bound up to wires and rapid & flexible networking, the radiocommunications technology has become the most active communication technology field for it can provide the mobile communications. As a radiocommunications technology with low cost, low power consumption and long distance, LBS is being widely applied to the communication between the fixed equipment and mobile equipment. LBS data transmission speed can be 114KBS, it adopts the frequency hopping and time-division multiplexing for the one-to-one and one-to-many communication mode. Therefore, the research of a wireless pipeline robot positioning technology based on LBS is proposed in this paper.

Pipeline robot <sup>[2]</sup> is an intelligent device integrating mechanical and electrical integration, test technology, intelligent mobile carrier technology and working in the specific space of pipeline. In operation, motion performances of the pipeline robot, i.e. the running speed, stability, turning ability and obstacle crossing ability are directly related to the operation result. The failure performances of robot are influenced by the in-pipeline obstacles, output errors of robot actuator and changes in load of robot itself etc.; accordingly, failure<sup>[3]</sup> <sup>[4]</sup>positioning of pipeline robot becomes one of the problems to be solved.

In this paper, the author adopts the popular STM32-SIM868-based GPRS LBS positioning module to build a positioning platform based on mobile LBS. The experiment is carried out in two cases: one, the positioning range is confirmed and the number of reference nodes varies;

two, the number of reference nodes is fixed and the positioning range varies. The LBS positioning accuracies in the two different cases are tested respectively to provide the experimental basis for the application of pipeline robot positioning.

## II. LBS POSITIONING SYSTEM COMPOSITION

### A. Hardware Platform

LBS positioning system platform is mainly composed of computer, network, STM32-SIM868 development board, test pipeline and test pipeline robot. It is established with the star network [5] as shown in Fig.1. As the data receiving and processing platform, computer can be used for parameter alternation etc.; network is used to receive the positioning information of LBS base station; STM32-SIM868 development board can be used as the LBS data sending; pipeline can be the test environment; pipeline robot can be the test carrier; the base stations participate in the positioning and data receiving of the pipeline robot.

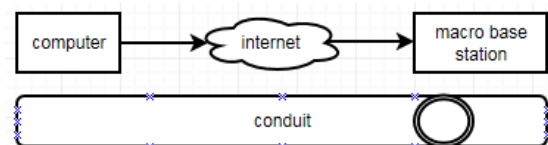


FIGURE I. NETWORK DIAGRAM

Computer and network are connected through RJ45. Fig. 2 is the material matter of the STM32-SIM868 development board, in which the power input is supplied by the pipeline robot.



FIGURE II. MATERIAL MATTER OF DEVELOPMENT BOARD

### B. Software Platform

Base station positioning [6] service is also known as location-based service. It obtains the location information (geological coordinates or geodetic coordinates [9]) of the mobile terminal users through the radiocommunication

network (i.e. GSM network, CDMA network) of the mobile telecom operators or the external positioning mode (i.e. GPS). Its principle is: to measure the downlink pilot signals of different base stations to get the TOA (Time of Arrival) or TDOA (Time Difference of Arrival) of the downlink pilot signals of different base stations. According to the measurement result in combination with the coordinates of base stations, the trigonometric formula estimation algorithm is generally adopted to calculate the signal locations. The larger the number of base stations measured by mobile stations, the higher the measurement accuracy, the more obvious the improvement of the positioning performance.

The positioning software compiled by VB is adopted as the test software of the system [10]. The development kit of STM-SIM868 development board is adopted to obtain the LBS positioning information through the network as shown in Fig.3. The Sd card shall be inserted into the development board and connected to the data packet through the compiled software.

The software operation during the test is as shown below:

(1) To confirm the test boundaries.

To lay the reference failure nodes on the pipeline.

(3) To power on the computer and run the programs, check whether the development board of pipeline robot is normally connected.

The robot moves according to the pipeline.

To record the coordinates of all failure nodes.

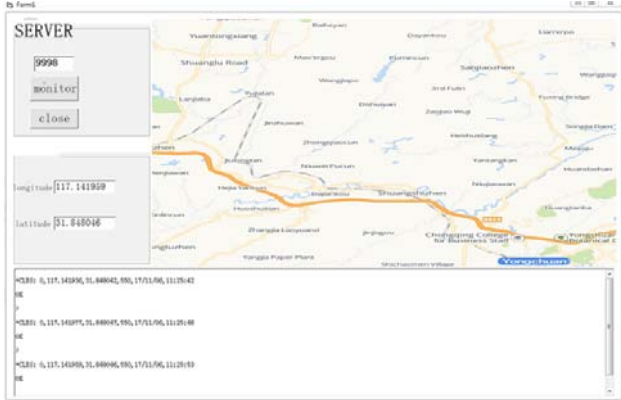


FIGURE III. LBS POSITIONING DISPLAY

### III. RESEARCH AND ANALYSIS OF LBS POSITIONING EXPERIMENT

As shown in Fig. 4(a) and Fig. 4(b), a larger place outside shall be selected as the test location to test the LBS positioning region. The pipeline of 400mm~650mm diameter with 3 bends and 8 obstacle points shall be installed. The experiment has two purposes: one is to analyze the influences of number of reference nodes on the positioning accuracy in the certain space range; the other is to analyze the positioning accuracies that can be reached with the same number of nodes in different space ranges.



FIGURE IV. (A) MACRO BASE STATION OF EXPERIMENT LBS ; (B) TEST PIPELINE

#### A. Fixing of Testing Range, Variation of Number of Test Nodes

Firstly, in the above range test environment, 100-m pipeline will be selected for test. Take the positioning experiment of 4 failure nodes in the experiment as an example, the 4 failure nodes are distributed evenly in the 100-m pipeline to obtain the longitude and latitude of the 4 failure nodes through the position indicator. To get the more accurate error of LBS positioning system under the 4 failure nodes, the coordinates of mobile nodes positioned by the software on the left and right of the failure nodes are respectively measured for comparative analysis. 8 nodes are measured in this experiment, each node is measured repeatedly for 10 times to take the mean value of several errors. The final error obtained is as shown in Table 1.

TABLE I. DATA OBTAINED FROM 8 POSITIONING UNDER FOUR FAILURE NODES

Positioning node (X, Y)	X error (absolute value)	Y error (absolute value)	$\sqrt{(X-X)^2+(Y-Y)^2}$
105.893234,29.39743	0.2649	0.2485	0.85
105.893241,29.39739	0.3258	0.2451	0.84
105.893254,29.39729	0.2486	0.7415	0.64
105.893264,29.39736	0.4525	0.8261	0.93
105.893234,29.39744	0.4216	0.5216	0.41
105.893244,29.39747	0.7845	0.9652	0.26
105.893237,29.39728	0.2154	0.2684	0.87
105.893239,29.39740	0.7845	0.8216	0.64
Mean value	0.437225	0.57975	0.68

It can be seen from the table that when the LBS positioning module has fixed and approximate site, the error is

relatively stable. According to the experiment, with 4 failure nodes, the mean error of the LBS site positioning is 0.68M. Taking the same approach with the condition of even pipeline nodes, when the failure nodes are increased to 6 and 8, the mean errors can be 0.6 and 0.54. Accordingly, in the invariable situation, the more the failure nodes, the smaller the mean value; when the failure nodes increased from 6 to 7, the error will be even smaller. Within a certain range, the accuracy will be improved to a limited extent when the nodes are increased to a certain number.

#### B. Fixing of Testing Failure Node, Test Range Variation

With the same number of nodes, to research the influences of positioning range variation on the positioning accuracy, another test experiment will be built. It means that there remains 4 failure nodes to collect 8 data nodes for the mean value; however, the range is the same as 50M, 100M and 150, the bends and the failure nodes are also the same. Fitting the experimental process with 2.1 to obtain the data of 8 data nodes and get the mean value. The result is as shown in Table 2.

TABLE II. ERROR DATA OF CHANGING POSITIONING RANGE

Positioning range	Mean value of positioning error
0.68	0.68
0.87	0.87
1.69	1.69

According to Table 2, with the same failure node, when the positioning range is enlarged, the positioning effect will be decreased. For the 8 failure nodes in this experiment, according to the layout of 3 bends, when the positioning range is 50M, the mean positioning error is about 0.68M; influenced by the macro base station, when the positioning range is 100M, the error is increased to 0.87M; when the range is increased to 150M, the mean error is even increased to 1.69M.

#### IV. CONCLUSION

Experiment and research on the simulation and positioning accuracy of the LBS positioning pipeline robot are carried out. According to the experiment, the positioning range and number of failure nodes will influence the positioning accuracy of the macro base station. With the same number of bend and macro base station, the increased number of failure nodes can improve the positioning accuracy; however, as the number of failure nodes increases, the magnitude of increased accuracy will be reduced. With the same number of failure nodes, the increased positioning range will reduce the positioning accuracy. Once the LBS positioning system is officially applied to the pipeline robot, it will fix the position fast, find out and solve the failure nodes in case of failures during the operation of the pipeline robot, so as to improve the working efficiency and save the cost. LBS positioning is influenced by factors i.e. site and network delay; accordingly, the following research can focus on simulating the positioning of macro base station to further verify the conclusion in this paper. What's more, positioning accuracy of LBS macro base station is influenced by the number of surrounding macro base

stations. For instance, there will be delay in case of excessive surrounding macro base stations etc., this will be discussed and analyzed in the future research.

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