Analysis and Application of Indoor Fire Fighting Positioning Technology Based on Inertial Navigation

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Abstract. In recent years, all kinds of complex buildings have increased rapidly, and the difficulty of fire rescue has increased significantly. Therefore, it is of great significance to improve the level of fire rescue to study the precise positioning technology that can be applied to the firefighter's room in all kinds of complex scenes. In this paper, several common indoor positioning technologies are summarized and introduced, and their positioning principles, positioning accuracy, use scenarios and other parameters are analyzed by analogy. The application of inertial navigation positioning technology in the positioning of firefighters in complex indoor environment is discussed and verified by experiments. According to the analysis results, the key technologies for the indoor positioning of firefighters are optimized. The analysis and research in this paper can provide theoretical support for improving the positioning of firefighters in the room.

1. Introduction
With the fast development of industries, a cluster of tall buildings, all kinds of new equipment materials increased, which brought great pressure to fire control work, but because of people to fire protection consciousness is not strong, easy to fire, as the major workplace fire accident site construction characteristic space is large, complex, monomer and a building area of use function is various, complex electrical equipment and circuits, such as large fire load characteristics, firefighters after entering the fire scene of the accident, the firefighters real-time positioning harder, firefighters can not timely and outdoor command center for effective communication, In addition, the high temperature, smoke and toxic gas in the fire scene often cause burns, oxygen deprivation and dehydration of firefighters, which requires accurate real-time positioning of firefighters entering the fire scene to ensure the safety of firefighters.

Currently, the widely used mainstream positioning technology is still GPS positioning technology. However, due to the complex structure of the building and the barrier of concrete and steel bars, the indoor GPS signal is weak, and the GPS positioning system cannot be effectively used for indoor positioning [1, 2]. With the rapid development of Internet technology, some new location technology, such as inertial navigation and positioning technology [3-6], WIFI positioning, uwb positioning technology [7-9], ultrasonic positioning, monocular vision positioning technology [10], bluetooth indoor positioning technology [11, 12] Zigbee positioning technology, infrared personnel positioning...
technology [13], RFID positioning technology, such as [14], these new positioning technology has been gradually applied in the industrial field.

There is no accurate positioning technology for indoor accurate positioning of complex buildings such as super high-rise buildings, large underground buildings and large commercial complexes. Therefore, this paper is devoted to studying the principles and advantages and disadvantages of various positioning technologies. Through summary and analysis, key technologies that can be used to accurately locate firefighters in complex buildings are explored to effectively improve the real-time location information of firefighters in the process of fire rescue, which is of great significance for improving the level of fire rescue in complex scenes.

2. Common indoor positioning technology

In nowadays, common indoor positioning technology are: such as inertial navigation and positioning technology, in the large commercial complex of heavy and very large fires, the site environment information is very complex, the personnel flow is much, the fire spread way is much, easy to form a three-dimensional fire, easy to cause the casualties of firefighters, the application of a variety of indoor positioning technology is analyzed, summed up the technology suitable for firefighters indoor positioning.

Table 1. Comparison of indoor personnel positioning technology.

| Positioning technology | precision | The advantages and disadvantages | Main application scenarios |
|------------------------|-----------|----------------------------------|---------------------------|
| WIFI                   | general   | Limited to indoor environment, positioning accuracy is general, need to arrange base station, advantages of low cost | Applied to medical institutions and factories |
| ultra-wideband         | high      | The cost is high, but the accuracy is very high, and anti-interference, need to arrange the base station | Applied to personnel positioning in factory hospitals and tunnels. |
| ultrasonic             | higher    | Due to the sharp sound attenuation, the indoor positioning range is too small, and the cost is high, the anti-interference ability is poor, the stability is poor need to arrange the base station | It is applied to the automobile driving test |
| Monocular vision       | higher    | More algorithms, great potential, need future development | It is applied to the field of driverless cars and so on |
| bluetooth              | higher    | More base stations need to be arranged, the real time is complex, easy to be disturbed by noise, transmission distance is limited | Application to factory |
| Zigbee                 | higher    | Easy network, strong anti-interference, short acting distance, signal vulnerable to interference, need to arrange base station | Applied to plant personnel location |
| infrared               | higher    | The indoor environment is complex, which hinders the infrared ray transmission | It is applied to security field |
| RFID                   | higher    | The transmission distance is short, the range is small, need to arrange the base station | Personnel positioning under the mine |
| Inertial navigation    | high      | No need to arrange base station, easy to carry, suitable for indoor positioning, high precision | It is used for indoor positioning and aerial positioning of firefighters |

To sum up, the above positioning technology can be summarized and analyzed. Among the many indoor positioning technologies.
The positioning technology that has been used in the field of fire protection includes inertial navigation and the positioning technology that integrates inertial navigation with other positioning technologies. However, a single positioning technology, such as bluetooth, WiFi, ultrasound, ultra-wideband and so on, needs to be deployed in advance. Firemen in the fire occurs, impossible to predict in advance when a fire, impossible to have the opportunity to advance to decorate base station, the positioning technology of several single cannot be effectively used in indoor positioning under complex conditions, inertial navigation technology does not need to decorate a base station, and the accuracy is high, so the principle of inertial navigation positioning technology, fireman is very suitable for indoor positioning.

3. Application of inertial navigation technology in fireman positioning

The inertial navigation devices are used in the experiment to analyze whether they are suitable for the indoor positioning of firefighters. On this basis, the accuracy of the inertial navigation positioning system is studied, so as to play a guiding role in the future implementation of firefighters' rescue. Inertial navigation USES the gyroscope, accelerometer, electronic compass (magnetometer) and other MEMS sensors in the positioning module to achieve the goal of accurate positioning and navigation.

(1) Firstly, experiment is conducted to explore which part is suitable for assembling the inertial navigation system module. The experiment was carried out from the actual simulation situation, and the 100-meter straight line experimental data was verified. The sensor data of different positions were collected, and the value of each position was recorded for comparison with the actual position value. Three groups of experiments were conducted and the average value was calculated.

Table 2. Experimental data of different installation locations of sensors.

| location          | arm | The neck | A foot | The elbow | Big leg | The head | The waist |
|-------------------|-----|----------|--------|-----------|---------|----------|----------|
| The first experimental error (m) | 1.2 | 0.8      | 0.5    | 1.2       | 0.8     | 1        | 0.9      |
| Second experiment error (m)      | 1.5 | 1        | 0.45   | 1.4       | 0.5     | 1.2      | 0.48     |
| Third experiment error (m)       | 1.6 | 1.1      | 0.4    | 1.4       | 0.7     | 1        | 0.9      |
| The average error               | 1.43 | 0.97    | 0.45   | 1.3       | 0.67    | 1        | 0.76     |

Table 2. Experimental data of different installation locations of sensors.

![Figure 1. Error histogram of different parts.](image)

It can be seen from the table that the positioning accuracy is relatively best when the sole of the foot. (2) Then we carried out accuracy verification, carried out horizontal accuracy test of 100 meters straight line, and placed the navigation module on the foot for experiment. The measured data were as follows:
According to the four experiments, the maximum horizontal error within 100 meters is 0.7m, the minimum error is 0.2m, and the average horizontal error is 0.425m.

In order to judge the error size more intuitively, the following formula is used: error = \(\frac{0.425}{100} = 0.425\%\), and the overall horizontal error of the system is 0.425%, that is, the error is about 0.425 meters after walking 100 meters.

(3) Then we carried out accuracy verification and carried out accuracy test for 25 floors straight, about 95 meters. The navigation module was placed on the sole of the foot for experiment. The measured data were as follows:

According to the four experiments, the maximum vertical error within 95 meters is 0.5m, the minimum error is 0.2m, and the average vertical error is 0.325m.

In order to judge the size of the error more intuitively, the following formula is used: error = \(\frac{0.325}{95} = 0.342\%\), and the overall vertical error of the system is 0.342%, that is, the error is about 0.342 meters if the system walks 100 meters vertically.
Through the analysis of experiment (2) and experiment (3), it can be seen that the vertical precision is slightly higher than the horizontal precision.

4. Summary and prospect

(1) This paper firstly introduces the firefighters indoor positioning method of the research background, explains the indoor locating technique research value, and then the specific lists various indoor positioning technique, introduces the principle of its each positioning method, through the comparative analysis on the advantages and disadvantages of the various positioning method, for the study of the indoor positioning system deployment support reference to a wide range of application.

(2) The indoor positioning of firefighters based on inertial navigation is discussed and analyzed, and the accuracy of the inertial navigation system is verified by experiments, which provides an alternative method for indoor positioning of firefighters in the future. This positioning method has high precision and is simple to deploy.

(3) In a word, there are a lot of indoor positioning technology, now the new positioning technology is also in development, all kinds of positioning technology on the market have advantages and disadvantages, in the future equipment, personnel location indoor positioning, should fully consider the cost of precision two major factors, determine the appropriate positioning technology. The follow-up research can go deep into these technical points one by one, and seek a balance between various positioning needs, integrate various positioning technologies to correct each other, make up for the shortcomings of a certain technology, and ultimately improve the positioning accuracy.

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