Application of Multi-sensor Data Fusion Technology in Internet of Things

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Abstract

With the development of sensor technology and Internet of Things technology, the trend of miniaturization of sensors has prompted more sensors in the Internet of Things. Data fusion and data conversion between these sensors has become more important, thus promoting the development of multi-sensor data fusion technology. This paper first introduces the development of IoT and its research status, and then discusses the implementation methods of several multi-sensor data fusion technologies and their value in use. Finally, the practical application scenarios and application value of multi-sensor data fusion technology are discussed.

Keywords

Internet of Things, Sensor Technology, Multi-sensor data fusion.

1. Introduction

Under the call of the national science and technology powers, China's research in the fields of sensor technology, computer technology, and computer control technology has advanced by leaps and bounds, making many smart devices that integrate many high-tech technologies into the homes of ordinary people. Throughout the society, the popularity of smart phones has increased year by year, and the equipment rate of intelligent robot equipment in factories has increased year by year. For example, mobile phones can scan codes, have gravity sensors, and fingerprint recognition. These technologies use sensors to collect and process information, and finally display it in front of people in a visual form.

There are many problems in the application of Internet of Things technology. In particular, the multi-sensor data fusion problem involved in sensor networks; the connectivity problems of various equipment items and the communication problems between these devices are all technical problems that require considerable research efforts in the Internet of Things[1].

This paper first discussed the current research status of the Internet of Things sensor technology. Secondly, it discusses the problems existing in the current IoT sensor technology. Then, we discussed the principle, fusion method and application value of multi-sensor data fusion. Finally, it discussed the multi-sensor information fusion technology in the Internet of Things Applications.

2. The development history and new problems of Internet of Things

2.1 The development of Internet of Things technology

In Western Europe, the United States and Japan, where science and technology are relatively developed, and Germany, where control technology is quite developed, sensor technologies in these countries are quite developed. The development of Internet of Things technology started earlier. In the traditional sense, sensor technology can be divided[2]. For three generations:

The first generation was a structural sensor, which is designed and used to acquire signals by the use of certain materials that are subject to natural signals or that can sense changes in structural parameters that affect the natural environment. For example, a resistance sensor developed by using certain metal

materials to undergo a shape distortion and changing the characteristics of an electrical signal when subjected to a force.

The second generation is solid state sensor. A sensor designed and manufactured using its own characteristics such as a semiconductor or an electrolyte. For example, a sensor fabricated using the principle of electrothermal effect. The second generation of sensors can sense the external environment and collect the natural signals from the outside world, thus gradually developing into solid sensors. This generation of sensors generally has the characteristics of low cost, good reusability of interfaces, and high reliability.

The third generation is of smart sensors. With the development of microprocessors, the microprocessor is the core, and the sensors and micro-processing are integrated to collect natural information. The same genus has certain analysis, self-diagnosis and data processing capabilities. It is computer technology and sensor technology. A product that combines with integrated circuit technology.

2.2 Research on problems brought about by the development of the Internet of Things

Every country in the world has made its own definition of the Internet of Things. Since the launch of the IoT development strategy in various countries or organizations, in the early 21st century, the country launched a national strategy of “perceive China” through comprehensive research and introduced many preferential policies, followed by major companies in China, such as China Unicom's "one card" business, China Telecom's "wing payment" business. And there are also a lot of startups that focus on the Internet of Things, like mushrooming, and the problems that exist in the Internet of Things[3].

1) Sensor data redundancy and accuracy

The redundancy of sensor data is divided into the redundancy of single sensor data and the redundancy between data when multiple sensors cooperate. It refers to the multiple backup of data or the inconsistency of information volume and volume. With the development of technology, people need more accurate acquisition data to support the development of applications. It is impossible to meet people's needs through a single sensor. It is necessary to use multi-sensor data fusion technology to improve data accuracy.

2) IoT construction issues

The Internet of Things requires all physical devices to be interconnected. To achieve this goal, each object must be "eyes" and "skins" so that they can collect and process data, which requires the support of sensor technology[4]. The construction and development of the Internet of Things is inseparable from the data support of the IoT perception layer. It is inseparable from the accurate digitization of some natural phenomena in the sensing layer. The IoT sensing layer is mainly the application range of sensors, so the development of sensor technology is certain. The extent determines the development of the Internet of Things. The development of sensors will eventually move toward the visual direction that people want to see. The fusion and unification of multi-sensor information mainly realizes processing various analog signals or natural signals into related information that people understand daily.

3. Multi-sensor data fusion technology

3.1 Related concepts and principles

Multi-sensor data fusion is also called information fusion. It is difficult for most researchers to give a consistent and comprehensive definition for information fusion. However, with the research of data fusion technology and the gradual development of computer technology, most researchers agree that the definition of multi-sensor data fusion can be summarized as: for the same test volume, we use multiple sensors to measure the raw data at different times and spaces, and then use computer technology to time or process the raw data.Under certain principles, the processing, analysis, and synthesis the processed data to obtain a unified and true interpretation of the observed quantity,

thereby supporting the decision-making process.The resulting data from this multiple sensor is made more dense than the amount of information it has in its various components.

3.2 Multi-sensor data fusion principle

For the understanding of the basic principles of multi-sensor data fusion technology, we will illustrate the example of human brain comprehensive processing information, in which the human eye, skin, and nose are combined as sensors, and the human brain comprehensively processes the data signals from the eyes, skin, and nose. The process of obtaining a unified concept or conclusion. Therefore, the basic principle of data fusion is to make full use of multiple sensors to collect data. These data may be heterogeneous or may be from different platforms for detecting different physical quantities[5]. By observing the data of these sensors, these observation data are in a certain criterion. Time or space combination use time series and strategy, and finally obtain a unified interpretation of the observation. The principle of multi-sensor data fusion is as follows:

(1) n different types of sensors collect data of observation targets Nn;

(2) performing feature extraction on the sensor output data Nn, extracting a feature vector Yi representing the observed data;

(3) performing pattern recognition processing on the feature vector Yi to complete the description of each sensor with respect to the target;

(4) Associate each target data processing;

(5) Using the fusion algorithm to synthesize each sensor data of each target to obtain a unified interpretation of the target.

3.3 Multi-sensor data fusion method

The research on multi-sensor data fusion method is an important part, which is related to the quality and efficiency of information fusion. In general, nonlinear mathematical methods with fault tolerance, adaptability, memory, and parallel processing capabilities are all fused algorithms. Research on fusion algorithms is very popular nowadays, and many researchers are conducting research in various fields, although a complete theoretical system of data fusion algorithms has not yet been formed. However, according to different application fields, many efficient fusion algorithms are proposed. Among them, the common ones are divided into two categories: random classification and artificial intelligence.

1)Random classification method

The stochastic classification methods include weighted average method, Bayesian method, D-S evidence reasoning method, and production rule. Among them, the weighted average method is a relatively simple method, which can perform weighted averaging on a set of sensor data preprocessed in time series, and use the obtained result as a fusion value. The weighted average method is faster, but it has a general effect.

With the development of statistics and probability theory, Bayesian provides an effective method for multi-sensor data technology. This method of using Bayesian estimation has a multi-sensor advanced information fusion field and is of great application value. It works by using each sensor as a Bayesian estimate and then combining the sensor information according to a probability function. It finds the post-join probability function by the associated probability of each sensor. The likelihood function is minimal and the resulting fusion value is finally obtained. This method improves the fusion precision to a certain extent, but this method has certain defects.

The DS evidence reasoning method is a method that is further extended on the basis of Bayesian. This method mainly uses the properties of the likelihood function and the trust function, etc., to derive the amount of information contained in the original data. The DS evidence reasoning method is generally divided into three steps, namely the first step of synthesis, the purpose of which is to synthesize the data sent by each sensor into an output result according to the probability distribution function; the second step is to infer the stage and synthesize according to the trust function. The results are combined into a credibility-based reporting form; in the third update phase, the raw data

is updated and a complete inference result is generated based on existing rules. Generating rules, according to the confidence factor and the technique of generating a series of rules, in the multi-sensor information fusion system, the mis-setting factor is the uncertainty of the corresponding information between the target feature and the sensor, and the symbol indicates the relationship between them.

2) Artificial intelligence method

Artificial intelligence methods mainly include fuzzy logic inference and artificial neural networks. Fuzzy logic reasoning is a kind of information fusion multi-valued logic method generated by operation. It will clear the meaning of "0" and "1" respectively and will be between (0, 1) as well under normal circumstances. The real number is expressed as realism, so that the uncertain reasoning process of fuzzy logic reasoning can be introduced into the process of data fusion. The advantage of fuzzy logic reasoning is that it has no problems in probabilistic reasoning, and it is closer to people's cognition, but fuzzy logic reasoning is still developing, not systematic and mature, and its existence is too dependent on subjective factors. The advantage of fuzzy logic reasoning is that it has no problems in probabilistic reasoning, and it is closer to people's cognition, but fuzzy logic reasoning is still developing, not systematic and mature, and its existence is too dependent on subjective factors. Artificial neural network is an artificial intelligence algorithm, which is an algorithm that simulates the principle of human neuron work. Artificial neural network itself has certain fault tolerance and self-adaptive ability, which makes it very good at nonlinear computing. This data-driven research method makes it possible to achieve multi-information fusion and unified requirements, and has good data fault tolerance and self-learning adaptive ability. The neural network maps the potential high-dimensional data feature expressions in the original data to the weights of its own network nodes through step-by-step training of its own network. After iterative training, the network model gradually conforms to the original data features, thus achieving the purpose of data fusion for the original data.

3.4 The significance of multi-sensor information fusion

Data fusion technology offers us the possibility to use data with higher precision, larger scale, and higher dimensions. The difficulties of data formats are diverse, data volume is large, and data dimensions are high have also been solved in the case of multi-sensor data fusion. Multi-sensor information fusion technology has the application values as follow:

1) Extends the range of system time and space.

2) Increased fault tolerance.

3) Utilization of system content increased.

4) The number of sensors used can be greatly reduced by increasing of system content utilization, which greatly saves the cost of the system.

To a certain extent, the multi-sensor fusion algorithm makes the system avoid the influence of noise, and has important significance for data accuracy and data precision improvement.

4. Multi-sensor data fusion technology

This paper introduces the application of multi-sensor information fusion and unified in the Internet of Things, and illustrates the practical application of multi-sensor information fusion in the Internet of Things with a high-rise escape planning route device.

4.1 Device composition

1)Hardware composition. Acceleration sensor: Wall or beam collapse caused by high temperature will cause the route to be blocked, and the device uses the acceleration sensor to sense whether the channel collapses. Carbon monoxide sensor: Monitor whether the concentration of carbon monoxide in the channel is suitable for escape. Temperature sensor: Monitor whether the channel temperature exceeds the human body's tolerance.

2)Software composition, using open source hardware platform combined with various sensors to complete the construction of the demo system and the preparation of the software.

Using computer data processing and fitting under simulated conditions to obtain the connection between each sensor data and each objective situation, such as the relationship between temperature and the reliability of the simulated structure.

The connection between the direction sensor and the structural integrity, comprehensively reviewing the data and data, verifying the application of different sensor data to the implementation of the system function and the improvement of the specific data processing method. After obtaining the research and verification experiments of multiple independent sensors, the programming of the perfect MCU and the PC will complete the initial setup of the system, and after completion, you can use the office tools such as mobile phones to view.

4.2 Implementation

The sensor part will be placed in each escape route of the escape place. Different sensor data will be used for different fire environment factors. After the data is transmitted to the MCU, it is calculated according to the preset formula whether the escape route is feasible and sent to the Bluetooth module. The escape personnel client can also be transmitted to the host through wired or wireless means. The host integrates multiple sensor data to design an optimal route or enables the dispatcher to monitor the fire environment data in real time. If necessary, the dispatcher can also send the app manually. Intervene route planning and send the final results to the escaper client. The specific working principle is shown in Figure 1.

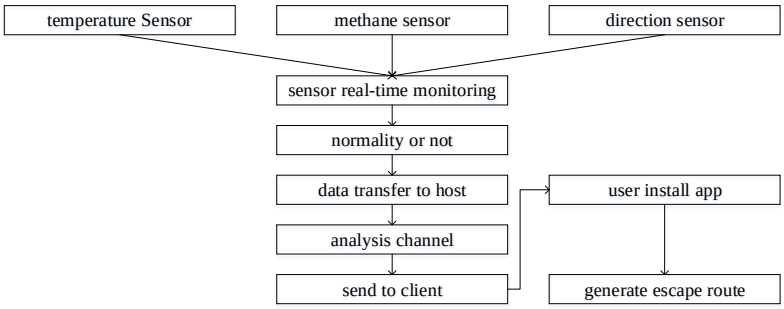

Fig. 1 Multi-sensor fusion working principle

5. Conclusion

Multi-sensor data fusion technology in sensor technology is booming, it can be simply understood as a process of data processing and purification, which can include today's mainstream information processing methods. This paper mainly discusses the development course of IoT sensor technology, discusses the bottleneck of sensor technology today, discusses the characteristics and importance of sensor information fusion technology, and discusses in detail the main technical means of sensor information fusion at present.And finally, combined with the escape planning route device of a certain building, this paper discusses the concrete application examples of IoT sensor information fusion technology.

With the development of data processing technology, especially the progress of artificial intelligence technology, such as neural network, genetic algorithm and other advanced algorithms, new and more effective information fusion methods will continue to be discovered, multi-sensor data fusion technology is bound to become the future of industrial data processing and data fusion of the key technology its application areas will continue to expand.

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