Research on the Application of Multi-scale & Multi-sensor Fusion Algorithm in MEMS Gyroscope Data Processing

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Abstract. The application of multi-scale and multi-sensor data fusion algorithm in sensor data processing, especially the data fusion of MEMS gyroscope, can greatly improve the accuracy after fusion. Based on this, this paper first analyzes the concept of multi-scale multi-sensor data fusion, then studies the application status of multi-scale multi-sensor data fusion, and finally gives the application of multi-scale multi-sensor data fusion algorithm in MEMS gyroscope data processing.

Keywords: Multi-scale, Multi-sensor, MEMS Gyroscope, Fusion Algorithm

1. Introduction

With the iterative progress and maturity of intelligent info tech represented by computer, it has been widely and deeply studied and popularized in many fields, especially in the field of data processing, which greatly promotes the development of multi-scale and multi-sensor fusion. At present, multi-sensor data fusion tech has been widely and deeply studied and applied in both military and civil fields, and the progress of data fusion is relatively slow. In recent years, with the iterative progress of computer algorithms, data fusion has gradually made great progress. Multi scale estimation theory is mainly applied to several aspects as shown in Figure 1, so as to achieve repeatable measurement.

![Figure 1. Application fields of multi-scale estimation theory.](image)

The improvement of measurement accuracy needs to minimize the adverse effects of random factors in the measurement process. Multiple measurements can be used to ensure the accuracy. Due to the influence of multiple interference factors in the real measurement environment and process, it is necessary to adopt multiple measurement methods to meet the actual measurement requirements. For example, multi-sensor is used to measure a single physical quantity, and multi-scale sensor data is
organically fused, so as to achieve efficient and accurate data processing. In addition, with the deepening of the research and application of MEMS represented by navigation, the performance of MEMS gyroscope is required to be improved.

The precision and reliability control of MEMS gyroscope is always the difficulty and key point of tech implementation, and the fusion algorithm of multi-scale and multi-sensor can better meet the needs of data processing [1]. The application of multi-scale and multi-sensor fusion algorithm in data processing of MEMS gyroscope is to obtain the true value of the measured physical quantity by using multiple sensors to measure the same physical quantity at the same time. The configuration scheme of multi-sensor fusion is helpful to improve the reliability, accuracy, fault detection and isolation requirements of MEMS gyroscope data processing. Multi scale and multi-sensor data fusion algorithm is widely used in sensor data processing. The data fusion of MEMS gyroscope can greatly improve the accuracy of the fusion. At present, by improving the statistical characteristics of multi-scale sensor fusion algorithm in smooth signal and detail signal, data measurement and processing with intuitive analysis and flexible structure can be realized.

In a word, the application of multi-sensor fusion algorithm in multi-scale frame analysis structure can achieve better performance in obtaining instantaneous data such as position and velocity for the equipment represented by MEMS gyroscope, and also has better application in the identification of physical phenomena on different scales. At present, multi-scale and multi-sensor fusion algorithm has been widely studied in many basic scientific research and engineering applications, and has shown a wide range of practicability. Therefore, it is of great practical value to study the application of multi-scale & multi-sensor fusion algorithm in MEMS gyroscope data processing.

2. The concept of multi-scale & multi-sensor data fusion

2.1. Connotation of multi-scale & multi-sensor data fusion
Multi scale and multi-sensor data fusion is mainly to automatically analyze, optimize and synthesize the observation info of several sensors obtained according to the time sequence under specific criteria with the help of computer tech, so as to realize the info processing for the required decision-making and estimation tasks [2]. Among them, multi-sensor is the foundation, multi info is the processing object, and the core of coordination optimization and comprehensive processing data fusion. Secondly, multi-scale and multi-sensor data fusion is to make multi-level, aspect and level judgment on the data from multi-sensor, so as to realize the comprehensive processing of info and draw more accurate and reliable conclusions.

2.2. The necessity of multi-scale & multi-sensor data fusion
At present, the performance and function of various sensors are constantly improving, and their types and info forms are becoming more and more diversified, specifically showing the multi-source of info, the significant increase in the number of info, the complexity of heterogeneous info relations and the strengthening of real-time requirements. In this context, the comprehensive processing ability of info becomes an important characterization of sensor performance. In addition, many complex application scenarios also require the application of multi-sensor system to provide comprehensive observation data and optimize its synthesis. The iterative progress of emerging technologies represented by Internet, wireless sensor network and Internet of things makes the diversity and complexity of data further improved [3]. Therefore, data fusion inevitably becomes a necessary way to carry out comprehensive analysis of a large number of unstructured and semi-structured data.

2.3. Targets and advantages of multi-scale & multi-sensor data fusion
The form of multi-sensor info processed by data fusion is more complex and appears in different info layers, including data, feature and decision-making layer [4]. The goal of multi-scale and multi-sensor data fusion is to separate observation info by means of each sensor, and to derive more effective info by optimizing the combination of info. Using the advantages of multi-sensor joint operation can
improve the effectiveness of the whole sensor system. On the one hand, the multi-scale multysensor data fusion system enhances the reliability of the system and expands the performance of a single sensor; on the other hand, it improves the reliability and robustness of the system, expands the observation range of time or space, and enhances the credibility and resolution of the system.

3. Application status of multi-scale & multi-sensor data fusion

3.1. Research status of multi-scale and multi-sensor data fusion
Multi-scale and multi-sensor data fusion is one of the core technologies of IoT. In addition to the classical theories represented by Kalman filtering, Bayes reasoning and evidence theory, multi-sensor data fusion methods also include AI algorithms represented by computers [5]. There is still a lack of a mature and complete theoretical system and method for multi-scale and multi-sensor data fusion. Secondly, there is no general architecture and terminology for multi-scale and multi-sensor data fusion. In addition, the data fusion algorithm of multi-scale and multi-hypothesis testing and its mathematical basis are discussed.

3.2. Application status of multi-scale multi-sensor data fusion
Multi-scale and multi-sensor data fusion applications include military, civil and industrial process monitoring, remote sensing image fusion processing and many other fields [6]. Among them, the application in the military field is mainly in the related fields represented by navigation, such as using inertial components to sense the motion data of the vehicle, so as to determine the position of the vehicle. In the civil field, the application is mainly in the intelligent field represented by robots, such as using cameras, sonar, gyroscopes, laser rangefinders, and other sensors to realize autonomous control and decision-making of related equipment and systems. In addition, the application in the field of industrial process monitoring mainly uses various sensors to identify the fault conditions that cause the system condition to exceed the normal operation range, and then trigger the alarm.

In the level of remote sensing image fusion processing, the application is mainly to monitor, identify and locate the ground targets or entities. When multi-source images are fused, pixel-level registration is used to fuse multi-band and multi-period remote sensing images to improve the accuracy of classification [7]. In the fields of public safety, intelligent materials, environmental pollution monitoring, intelligent transportation, agriculture and IOT, multi-scale and multi-sensor data fusion has also achieved remarkable results.

3.3. The problem of multi-scale & multi-sensor data fusion
The key of multi-scale and multi-sensor data fusion is to model the error and uncertainty. Due to the difference of multiple detection of the same sensor under the same conditions, there will be some problems such as the error of fusion process, the error of sensor info and the error of system operation [8]. The error of the fusion process mainly comes from the propagation of the error, and the error of the sensing info is due to the existence of the wrong info in the sensing process. The error of the system is mainly due to the coupling between multiple sensors, so it is necessary to calibrate the sensor in the known and unknown environment, so that the system can automatically recover in the case of sensor failure.

4. Application of multi-scale & multi-sensor data fusion algorithm in MEMS gyroscope data processing

4.1. Multi-scale & multi-sensor data fusion structure model
The structure model of multi-scale and multi-sensor data fusion mainly includes function model, structure model and mathematical model [9]. The architecture of the functional model is shown in Figure 2 below. The info sources include sensors and related data sources, data preprocessing, data pre-screening, and data allocation, so as to reduce the computing burden of the fusion center and
provide the most important data for the fusion center. Secondly, in the level of data target evaluation of MEMS gyroscope, by fusing the position, speed, identity and other parameters of the target, the accurate expression of these parameters is achieved, including data registration, tracking, data association and identification. In addition, at the level of situation assessment, it detects the current environment, infers the relationship between the detection target and the event, and judges the intention of the detection target.

Figure 2. The architecture of the functional model

4.2. Multi sensor fusion hierarchy in MEMS gyroscope data processing
The data processing capability of MEMS gyroscope is affected by many factors, such as sensor type, distribution form, and communication capability, computing capability, design objective and topology of MEMS [10]. Among them, multi-sensor fusion level mainly includes data level, special level and decision-making level. In the data layer, sensors are required to be homogeneous. In the case of heterogeneity, fusion can only be carried out in the feature layer and decision layer. Secondly, the application of multi-scale and multi-sensor data fusion system in MEMS gyroscope data processing needs further comprehensive consideration of sensor performance, system computing power, communication bandwidth, expected accuracy, and capital to determine which level is the best. In addition, the demand of multi-source heterogeneous info fusion needs to combine the characteristics and requirements of intelligent, networked, distributed and scalable sensors with the reality of MEMS gyroscope data processing, as shown in figure 3 below.

Figure 3. Gyro data fusion architecture
4.3. Realization and application of multi sensor fusion algorithm in MEMS gyroscope data processing

At the level of determining the adaptive weights, the adaptive weighted data fusion algorithm is selected. Firstly, multiple groups of data are decomposed by wavelet transform. Secondly, the adaptive weight method is used to determine the data fusion weight of different groups of data. In addition, different data are fused adaptively at each decomposition scale, and the fused wavelet coefficients are denoised by threshold. The threshold of each scale of wavelet is determined and the wavelet coefficients of each scale are estimated. After data fusion algorithm, the data error of gyroscope is greatly reduced, and the accuracy of data is effectively improved.

5. Conclusion

In summary, the configuration scheme of multi-sensor fusion is helpful to improve the reliability, accuracy, fault detection and isolation requirements of MEMS gyroscope data processing. This paper analyzes the concept of multi-scale multi-sensor data fusion, and studies the necessity and advantages of multi-scale multi-sensor data fusion. Through the research on the application status of multi-scale and multi-sensor data fusion, the structure model of multi-scale and multi-sensor data fusion is analyzed. Based on the analysis of the application of multi-scale & multi-sensor data fusion algorithm in MEMS gyroscope data processing, the application level and the realization of fusion algorithm are studied.

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