Combined Navigation System program under different flight conditions

Chunguang Wang, Xiaoxu Chen, Qi Wang, Ming Ming, Yu Jin, Xin Wang

Aviation University of Air Force,Changchun, 130022,China

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Abstract. Combined Navigation is now widely used means of navigation, aircraft at different speed, altitude and other conditions should be targeted integrated navigation system solutions. This paper mainly studies outline plan for the integrated navigation system under subsonic, hypersonic, high-altitude and long endurance conditions.

Introduction

Integrated navigation system is the integrated navigation system using satellite navigation, radio navigation, astronomy, navigation and other systems of one or several combined with an inertial navigation system formed by Kalman filtering data processing technology, the characteristics of each system to play each other, be improved navigation accuracy, reliability and automation to optimize navigation performance.

Currently the most widely used integrated navigation system program is mainly GNSS / SINS Integrated Navigation.

Global Navigation Satellite System (GNSS) to provide users with all-weather land, sea and space, full-time, continuous two-dimensional position, velocity and time information is two-dimensional, dynamic performance disadvantage is poor, vulnerable to electromagnetic interference, the satellite signal is easily occlusion.

Strap down Inertial Navigation System(SINS) is a not dependent on external information, without transmitting information autonomous navigation system, has a hidden, anti-interference ability and other advantages, disadvantages navigation error over time accumulate.

The combined GNSS and SINS, can take advantage of short-term SINS high precision, high free from outside interference and the advantages of long-term accuracy of satellite navigation, navigation accuracy is low for a long time to overcome the SINS and satellite navigation system dynamic performance is poor, vulnerable to interference shortcomings, Further, in terms of accuracy and reliability than can be obtained using any of the navigation apparatus alone have excellent performance. Various combinations of the navigation system has its own advantages and disadvantages program. Aircraft altitude and speed performance for different conditions require, integrated navigation system solutions used should also be different.

Performance comparison of several commonly used navigation

The following is a brief comparison of the performance of several commonly used navigation. As can be seen from the comparison, the different ways to navigate each have different performance characteristics.

Way navigation	Inertial navigation	Satellite navigation	Celestial Navigation
Output parameters	Position / speed / heading / attitude	Position / speed	Posture or position / speed

Accuracy	High (Short time)	High	High
Autonomy	Completely independent	Controlled by sovereign states	Completely independent
Immunity	Strong	Weak	Strong
Concealment	Strong	Strong	Strong
Environmental conditions	Essentially no limitation	No shelter, No larger motorized flight	Good altitude,weather conditions

Combined Navigation Information Fusion Technology Overview

Application Combined Navigation System rely heavily on information fusion technology. In the multi-sensor integrated navigation system, information fusion technology to ensure full and effective use of multiple sources of information, it is crucial to get the best effect navigation technology. Kalman filter is one of the multi-sensor data fusion technology is mainly technical means, usually adopt a standards-based centralized Kalman filter algorithm to measure the fusion of information from multiple sensors.

As shown in Figure 1:Centralized filter outputs the combination of multiple sensors to a measurement equation, and then use the Kalman filter to obtain the best estimate of the system state. Simple centralized filter structure, thus the system state of high dimensionality, computing capacity, poor real-time performance, poor fault tolerance, fault diagnosis is not conducive to the existence of deficiencies.

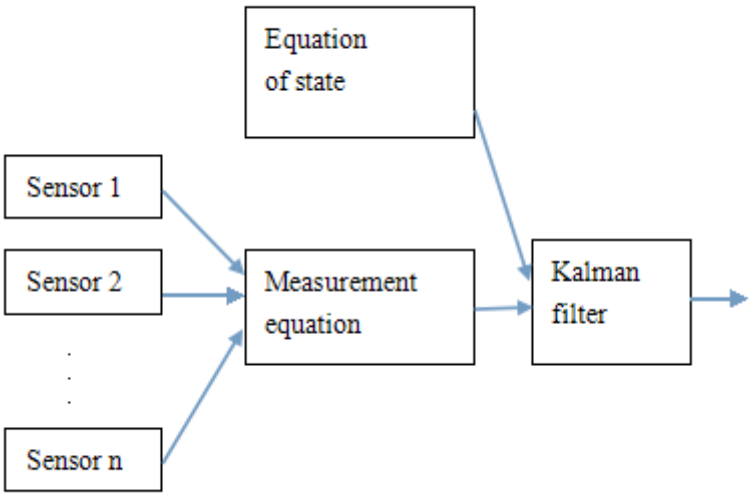

Fig.1: Schematic diagram of a centralized filter

Due to the existence of a centralized filter these shortcomings, research and design staff to seek a decentralized processing filter structures, thus dispersing filter assigned to widespread concern.

As shown in Figure 2:The filter large distributed system is decomposed into several sub-systems, establish measurement equation for each sensor, and design their own Kalman filter to obtain the best estimate of the local individual sensors, final estimates for each local optimal information

integration, global optimal estimation. Dispersion filter first distributed processing for each subsystem, and then conducting a global integration, making it possible for data parallel processing, the amount of computation and real-time performance compared with centralized filter have been greatly improved and enhanced.

In decentralized filtering trial is the most widely Carlson proposed 1988 federal filter, which uses technology to eliminate the upper bound of the variance correlation between the sub-filter for fault-tolerant multi-sensor integrated navigation system is designed to provide a theoretical basis . Because federal filter design flexibility, a small amount of computation, and has good fault tolerance, it is determined to be the US Air Force as a universal filter next-generation navigation system.

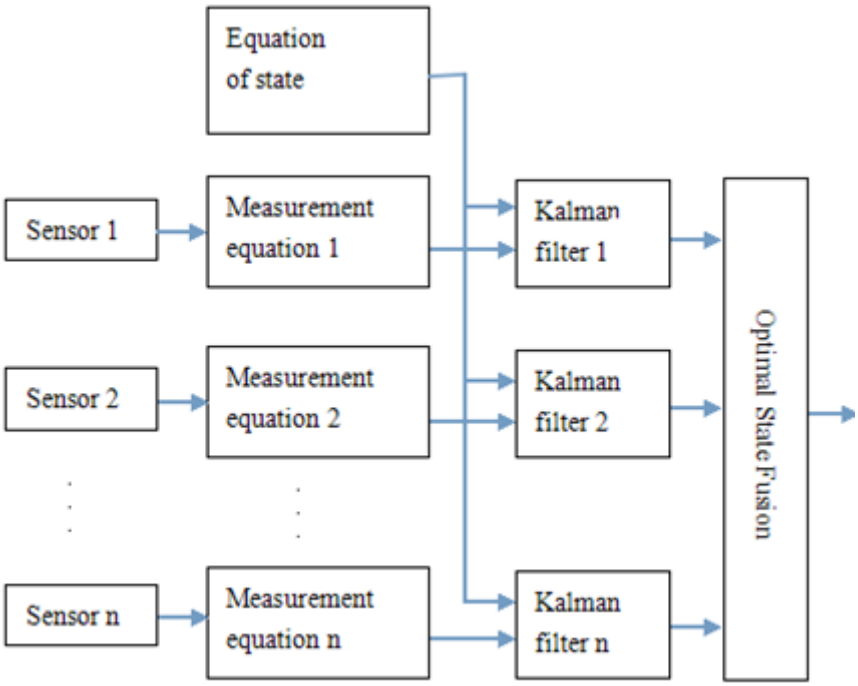

Fig.2: Schematic distributed filters

Subsonic Aircraft Navigation System Scheme

Subsonic aircraft with low flight speed, flight time is long, low dynamic characteristics. At present such aircraft navigation often Inertial Navigation Systems (INS) mainly in the use of terrain matching guidance. The biggest drawback is that the accuracy inertial navigation decreased with time increases. Terrain matching mission planning for a long time, low precision navigation and flight in the desert, the ocean, extreme lack of landmarks. Therefore, it is necessary to subsonic aircraft navigation program improvements. Radio navigation program has been the first choice for subsonic aircraft navigation.

Our existing radio navigation resources are two: one is the "Changhe 2" remote radio navigation system, covering China's coastal regions, mainly for ships to provide navigation, the system transmits power, wide coverage, receiver technology is simple, its the disadvantage is the low precision navigation, combining the two sets of chain department will be blind; the other is the "Beidou" satellite navigation system, a group of geostationary satellites and ground control system. The advantage of this system is that a wide range of navigation, can cover our local and neighboring regions, the drawback is the use of "response" mode, easy to expose.The global satellite navigation systems, such as the GPS and GLONASS systems, because of the autonomy of the problem, only the navigation system can be used as a reference, and not as a means to rely on. Navigation system solutions for subsonic aircraft, can be the basis of inertial navigation, inertial navigation and use of

our ownership of the "Beidou" satellite navigation system based, celestial navigation, supplemented with GPS / GLONASS reference navigation means of information, the use of information fusion technology, navigation and improve the stability and accuracy of the navigation system. At present, our country can make the necessary improvements radio navigation receiver: First, "Changhe 2" receiver with dual sets of chain coordination system, complemented by ground conductivity database technology; the second is the "Beidou" satellite navigation receiver uses independent time systems, change the "Beidou" navigation system "response" mode.

Hypersonic Vehicle Navigation System Scheme

Hypersonic aircraft inertial navigation system can be / satellite / Star Navigation System program. In hypersonic aircraft inertial / satellite / Star integrated navigation system, SINS system with navigation parameters comprehensive, strong mobility tracking, output timely, continuous, subtle, strong anti-jamming ability, etc., and thus as a combination of navigation The basic system. Satellite navigation system to "Beidou" system-based, compatible with multiple systems CPS, GLONASS, etc., between them with each other as a backup, to improve system fault tolerance and anti-jamming capability. Star Navigation System can be anti-radiation and strong, large dynamic range COMS APS star tracker, real-time output precision attitude information carrier.

Parameter is focus position and velocity information. Because of the offset angle of precise observation platform CNS system, but not directly to the filter input position and velocity information, can be soft as amended, the establishment of the system of equations SINS system platform drift angle and position and velocity error between the use of federated filter global output is estimated with CNS observable platform drift information, position and velocity estimates obtained through non-Keplerian orbit error equation system, due to the observation platform CNS output value of the true value of real-time observations, the estimated global output has the highest accuracy of the system, therefore, the error information about the position and speed can be obtained with a very high precision.

Combination of conditions under long-endurance Navigation System Scheme

Long flight navigation system can be SINS / star sensor / Beidou Navigation System program under the conditions. A brief analysis of the most commonly used navigation program is easy to see:

INS / GPS navigation, there is a heading accuracy is not high, and poor long-term anti-jamming capability outstanding problems, satellite navigation signals especially under conditions of extremely long-range, long-endurance outside interference or shielded so that INS / satellite navigation can not be qualified in the field of aircraft high-precision navigation and guidance during the long voyage; use SINS Star Sensor combined constitute SINS / Celestial navigation System, autonomy and immunity is good, but the long-term accuracy is not high and navigation error divergence; SINS / Star / satellite navigation, the use of poor attitude matrix as one integrated navigation measurements, resulting in a filter calculation is more complicated, and does not consider the Star sensor installation error, which will seriously affect the starlight navigation accuracy.

Star sensor as an instrument attitude determination, with high accuracy, strong anti-interference ability of long-term, good for hiding other significant advantages, has been widely precision spacecraft attitude determination. Because of the performance characteristics of the star sensor and inertial / satellite navigation can form complementary advantages, therefore, under INS / satellite navigation exists in order to overcome the problem of long-endurance, using SINS, star sensor receiver and Compass formed SINS / star sensor / Beidou navigation System program to solve the problem of aircraft navigation precision at long-endurance conditions.

Scheme of the navigation system combinations when conditions HALE

Integrated navigation system can be SINS / SAR / CNS Integrated Navigation altitude long-endurance under program conditions. SINS (SINS) and synthetic aperture radar (SAR) can output horizontal position independent carrier, and position error SAR is convergent, and thus make use of SAR assist correction SINS SINS / SAR integrated navigation, can effectively overcome SINS error defect divergence over time. But the SAR imaging is likely to expose themselves, in order to conceal the need can not be continuous imaging, and imaging due after the match fails and can not locate the problem, it will seriously affect the SINS / SAR integrated navigation accuracy. Celestial navigation as an autonomous navigation tools, can provide accurate, drift over time attitude information, and strong anti-interference. The celestial navigation system (CNS) is introduced into the SINS / SAR integrated navigation system, when the SAR imaging or unable to match fails, you can use to assist correction CNS SINS, in order to slow down the rate of divergence SINS error.

CNS can also significantly enhance the overall SINS / SAR / CNS Integrated Navigation System's interference. In SINS / SAR / CNS Integrated Navigation System, SINS as a navigation master, SAR, CNS and barometric altimeter as a navigation aid equipment, the use of SAR to determine the carrier through the radar image matching locate the horizontal position, the use of CNS by capturing the stars and star identification get the attitude angle vector.

INS / CNS / GNSS navigation research techniques

Information fusion INS / CNS / GNSS Integrated Navigation System with advanced filtering method study

INS / CNS / GNSS Integrated Navigation System is a multi-sensor data fusion system, integrated navigation system to achieve high accuracy, high reliability navigation, the need to address multi-sensor data fusion technology in many practical problems, such as: integrated navigation system navigation computing power sensor type, distributed in the form of systematic and effective integration algorithm. Development and improvement of the basic theory of information fusion, improved fusion algorithm to improve system performance, is an important development direction of information fusion technology integrated navigation system.

INS / CNS / GNSS Integrated Navigation System is a non-linear, non-Gaussian noise system for filtering method is relatively high. EKF or UKF use particle filtering method to produce significant density function can effectively solve the system of nonlinear and non-Gaussian noise problems. But the particle filter computationally intensive shortcomings exist, how to improve the real-time algorithm is a serious problem of these methods. Continue to explore new ways filtering INS / CNS / GNSS integrated navigation system suitable for the development of integrated navigation technology is significant.

Real-time study of INS / CNS / GNSS Integrated Navigation Method

In engineering applications INS / CNS / GNSS navigation system, real-time is an important measure of its performance. To improve the accuracy of navigation systems, usually using a variety of means of observation, thus increasing the system's state dimension and measurement dimension, thus increasing the amount of computation; in addition, because of the navigation subsystem observation information is not synchronized and output frequency is inconsistent, also increases the difficulty of calculating navigation data. These are the real-time focus of the study INS / CNS / GNSS navigation methods.

Integration of technology integrated INS / CNS / GNSS Integrated Navigation System

INS / CNS / GNSS navigation system, while having high navigation accuracy and reliability advantages, but because the system contains more than one navigation source and makes the complexity of the system is high. Under high-tech conditions, navigation equipment miniaturization and cost increasingly demanding. For reducing the size and weight of the device, application and popularization of the equipment is of great significance, especially in the integration and integrated aerospace, equipment.

Conclusions

Combined Navigation As the most widely used and effective means of navigation, especially navigation technology inertial navigation system / celestial navigation system / satellite navigation systems, high-precision sea, land-based, air-based and space-based platforms, high reliability of navigation applications play an important role. INS / CNS / GNSS navigation technology has increasingly gained national attention, and achieved a lot in terms of navigation technology research portfolio.Each system is a combination of programs, each address different navigation accuracy, reliability, performance requirements, highly targeted. In the design of integrated navigation system program, should be fully analyze aircraft performance and flight characteristics of the environment, navigation requirements, select or create a targeted integrated navigation solutions. Pay close attention to international navigation on the new technology, new ideas, understand trends, learn from the successful experience of the best design.

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