Research on Localization Vehicle Based on Multiple Sensors Fusion System

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***Abstract*—In the implementation and verification of multi sensor fusion of vehicle positioning, we built a verification platform positioning algorithm combined simulation of Car Sim-Simulink to Car Sim, the vehicle model and the sensor output as the data source, and the noise, then in the simulink environment to build the fusion localization algorithm, and the real vehicle experiment using inertial laboratory navigation equipment, to the actual sensor data validation algorithm. Simulation and experimental verification results show that the effectiveness of the fusion location algorithm, the GPS is invalid; the error is effectively reduced to rely solely on dead reckoning positioning inertial navigation system, to achieve effective positioning all the time.**

Keywords-Multiple sensors; Vehicle positioning; Style; Autonomous vehicle; Fusion System

I. INTRODUCTION

Real time and accurate positioning of moving vehicles for vehicle navigation systems, vehicle networking, unmanned vehicles and other intelligent vehicles. Technology is very important. Various independent positioning schemes using single location sources exist different types of faults: GPS cannot output high frequency and is seriously disturbed by obstacles. The positioning error of INS is at any time [1]. There is a great deviation between the location results after a long time and the reliability of the vehicle location method using a single location source cannot guarantee.

In recent years, researchers have paid more and more attention to the method of vehicle location using multi-sensor fusion, especially GPS and INS fusion method, in the GPS low-frequency output interval, using INS In short time, integral output high-frequency positioning information, both make up for the GPS[2] . The output frequency is not enough, and the long time integral of INS is avoided to produce greater accumulation Error, GPS and INS. The complementary characteristics make this combined positioning method a very wide range of applications. When the GPS signal is not occluded for a long time, GPS-INS Combined positioning can achieve high frequency and high precision output, however, when GPS When the signal is blocked, the output of INS cannot be corrected, which will lead to greater error accumulation[3].

Aiming at the problems of the GPS-INS integrated positioning system, this paper introduces the dead reckoning method, the wheel speed sensing to obtain accurate distance of vehicle information, using the method of dead reckoning to compensate GPS drift of INS system when invalid A GPS-INS-DR is designed. The combined vehicle positioning method is used for accurate positioning of moving vehicles in real time[4]. When GPS is invalid for a long time, the positioning output is guaranteed to be accurate, and the output of the positioning system is high frequency at all times. The system can provide the vehicle location information with certain precision through the tunnel and the dense city condition[5].

In the strange or field environment, unmanned vehicles need to rely entirely on the perception system of the equipment, the modeling of the surrounding environment, the construction of the map to explore a feasible path, path planning and motion control, to achieve mission objectives[6]. An unmanned vehicle traveling on a structured road can reduce its reliance on a high precision perception system by using a traffic environment map. This paper explores the application of electronic map and related technologies in unmanned vehicles, and studies the navigation of unmanned vehicles[7].

II. VEHICLE COMBINATION POSITIONING SYSTEM ARCHITECTURE

According to the characteristics of different positioning methods and the characteristics of various sensing fusion methods, GPS is selected, INS and ABS dead reckoning based on wheel speed sensor fusion as a data source, fusion method based on Calman filter as the multi-sensor fusion

algorithm of vehicle positioning design. This section first introduces the overall architecture of the fusion algorithm, and then introduces several key coordinate systems involved in the algorithm. Ease of Use[8].

A. *System Overall Architecture*

The algorithm is based on inertial measurement unit, ABS wheel speed and GPS receiver. As the input source, the Calman filter is used to fuse the vehicle position and velocity information. Multi sensor fusion vehicle location system uses INS positioning results as the main reference value of high frequency data output. When GPS is valid, i.e; when the GPS signal is not occluded, the INS is used to locate the low-frequency location information of the GPS The output deviation estimation; when GPS is invalid, the GPS signal is occlusion for a long time, the wheel speed and yaw information for dead reckoning, the results of calculation. The deviation of the INS output is estimated. The final output of the algorithm is determined by the INS positioning result and the estimated deviation. Therefore, the combined positioning algorithm is composed of INS kinematics, DR kinematics, GPS coordinate transformation and Calman filter, and the INS positioning error is estimated by Calman filter.

The local level coordinate system for space coordinate system, the coordinate origin selected as the surface point, X axis pointing east direction, Y axis pointing north direction, the Z axis by the X axis and Y axis by coordinate criterion, coordinate system is called coordinates[9].

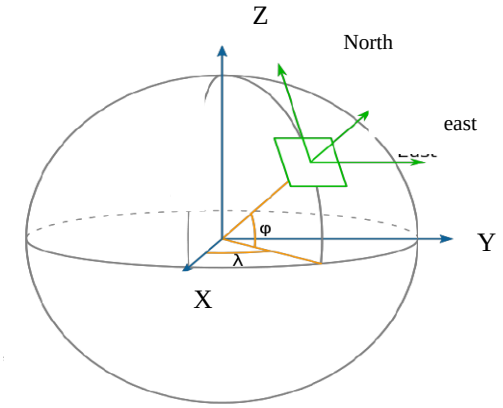

Figure 1. The local horizontal coordinate system and the geocentric coordinate system

In the multi-sensor ,as shown in Fig .1,fusion localization algorithm introduced in this paper, the local horizontal coordinate system is selected as the navigation coordinate system. The data fusion of each sensor source and the output of the algorithm are expressed in the navigation coordinate system.

B. *Vehicle Coordinate System*

The vehicle coordinate system is fixed on the vehicle sprung mass coordinate system, the coordinate origin chosen vehicle centroid, X horizontal axis pointing to the front of the vehicle is stationary, and parallel to the vehicle longitudinal symmetry plane, Y axis perpendicular to the vehicle longitudinal symmetry plane, the left is the Z axis directions.

Strictly speaking, the vehicle inertial sensor data measured in the said sensor coordinates, the installation position of sensor in vehicle body coordinate system to transform, not the algorithm of this paper introduced by conversion of each sensor coordinate system and body coordinate system, the sensor data in the car under the system said as the input to the algorithm.

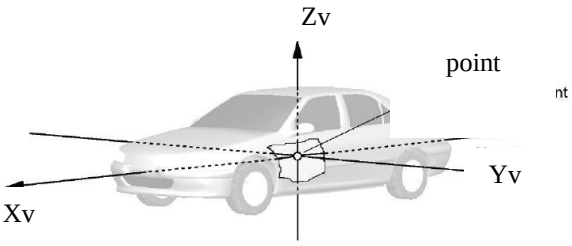

Figure 2. Car body coordinate system

III. INDEPENDENT LOCATION ALGORITHM

As shown in Fig .2,integrated positioning algorithm to output the inertial navigation system used as reference data to inertial positioning system as the filter state equation, the output of each independent positioning algorithm as the difference of the input filter. Then, introduces the dead reckoning algorithm, the inertial navigation system independent positioning algorithm and calculating the position independent GPS coordinates conversion algorithm[10].

A. *Inertial Navigation System Algorithm*

Inertial navigation system positioning relies on the inertial measurement unit. The inertial measurement unit consists of an acceleration accelerometer that measures three directional lines and an angular rate gyroscope measuring the rotational speed of the three axes. All the measurement data in this algorithm are derived from inertial measurement unit.

From the inertial measurement unit test vehicle line acceleration and angular velocity, according to the relationship between the line of the vehicle motion and angular motion, can calculate the derivative in vehicle body coordinate system along the three direction of the line speed, speed is the derivative of the vehicle speed in the body coordinate system. The body coordinate system conversion speed to navigation coordinate system, get the speed of the vehicle motion in the navigation coordinate system, the integral of the navigation coordinates are speed, navigation coordinate position, the final output is the inertial navigation algorithm for vehicle positioning. The first part of this part introduces the transformation from the body coordinate system to the navigation coordinate system, then introduces the calculation in the vehicle body coordinate system and the navigation coordinate system..

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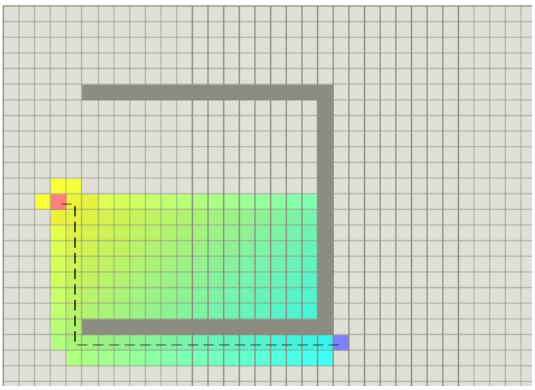

Figure 3. A* algorithm example

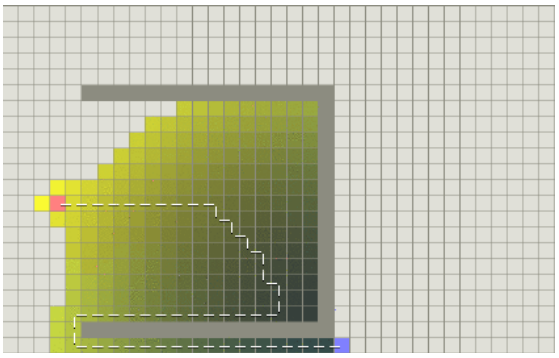

Figure 4. Best first search algorithm

B. *Dead Reckoning Algorithm*

Wheel speed estimation method of vehicle position is not affected by obstacle occlusion signal, and it is less than INS drift error, especially when the vehicle is stationary, avoid excessive drift. But the wheel speed is used to estimate the position of the vehicle under the influence of the tire radius calibration. In this paper, the effective radius of the wheel is estimated by using the accurate velocity information of GPS and the wheel speed, and the influence on the vehicle position is reduced.

The wheel speed calculation of vehicle mileage, assuming the vehicle trajectory arc, as shown in Figure 3,can calculate the longitudinal and lateral position changes in the car under the system in the running process of the vehicle, the vehicle navigation system to coordinate transform matrix to vehicle navigation coordinate position change.

As shown in Figure 4, assume that the vehicle travels from O to A, and the trajectory is r, with B as the center of the circle and radius as the radius. In a small step, the position change of the vehicle traveling to the X and the y. According to the vehicle speed and yaw rate can be calculated from the vehicle trajectory radius, then get tired wheel speed mileage, vehicle trajectory can be obtained corresponding arc central angle, the vehicle position change solution.

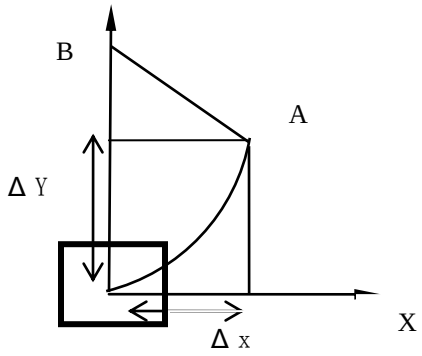

Figure 5. Vehicle position estimation

$$\begin{bmatrix}\Delta x\\ \Delta y\end{bmatrix}=\begin{bmatrix}r\sin\alpha\\ sign(\omega_r)r(1-\cos\alpha)\end{bmatrix} \quad (1)$$

The position obtained is converted to the representation of the vehicle system, and the position of the vehicle in the navigation coordinate system can be accumulated by the matrix CNV transformation to the navigation coordinate system.

C. *GPS Coordinate Transformation*

The transformation process consists of two parts, according to the WGS-84 earth model, the vehicle position will transform the longitude and latitude and elevation information description for earth fixed coordinates to rectangular space coordinate representation; the space coordinate system coordinates to local level coordinate system.

By transforming the coordinates of the coordinate system in the geocentric coordinate system to the local horizontal coordinate system, the coordinate data between the longitude and latitude data acquired by GPS and the geocentric coordinate system are converted to the navigation coordinate system.

$$C_{NE} = \begin{bmatrix} -\sin\varphi\cos\lambda & -\sin\lambda & -\cos\varphi\cos\lambda \\ -\sin\varphi\cos\lambda & \cos\lambda & -\cos\varphi\cos\lambda \\ \cos\varphi & 0 & -\sin\varphi \end{bmatrix} \quad (2)$$

D. Multi sensor fusion localization algorithm based on Calman filter

Calman filter is a set of mathematical equations, using recursive method to minimize the variance of the state estimation, can be used to estimate the past, present and future, can still better estimate the precise system model is unknown. In the application of inertial navigation system to estimate vehicle position, the error of position estimation is often taken as the system state, and the accurate position is calculated by estimation error. By using this method, the amplitude of the variable can be reduced to reduce the numerical error, and the nonlinear positioning problem is close to the linear hypothesis.

Therefore, this paper uses the system state error and not the system state as Calman filter state estimation, inertial navigation output and GPS wheel speed and position estimation deviation, deviation filter to compensate the output of the inertial navigation system, as the system output.

The error model of the dynamic system is usually represented by a set of differential equations and error state, which is a set of linear differential equations by linear to nonlinear differential equations corresponding to the location according to the established differential equation of inertial positioning system, obtained the error equation of linear filtering, as Calman equation of state.

IV. CONCLUSION

This paper studies the method for estimating the position of the vehicle wheel speed signal of global positioning system and inertial measurement unit and the ABS car, the vehicle position and attitude of full time estimation, especially in the GPS signal is invalid, the wheel speed signal by car ABS, solve INS alone positioning error with time increases rapidly the problem. Calculate the vehicle position in the use of inertial sensors, the position of the vehicle body vehicle dynamics estimation and calculation method, achieved high accuracy.

1) The kinematic equations based on the output of the inertial measurement unit and the kinematic equations based on wheel wheel speed are established, and the positioning error is estimated according to the Calman filter theory, and the positioning output of the inertial navigation system is compensated.

2) Multi sensor fusion for vehicle positioning, GPS-INS positioning is not valid in GPS long time, relying solely on inertial navigation system positioning error accumulated big problems, put forward GPS-INS fusion calculation algorithm of wheel speed based on GPS in the dead, invalid, by dead reckoning to reduce the cumulative error of inertial navigation system..

3) In the use of wheel speed information dead reckoning method, the vehicle trajectory is assumed to be circular, according to the mileage and vehicle yaw angle change to estimate the position change, at the same time, according to the GPS speed information dynamic estimation of wheel radius, in order to reduce the different driving conditions, wheel radius change of position calculation.

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