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Using BP Neural Network and Kalman Filter to Signal Processing of MEMS Inertial Sensors

[1] Wenxian XIAO, [2] Hao ZHANG, [1] Xiaoqin MA
[1] Henan Institute of Science and Technology,
Henan Xinxiang, 453003, China
[2] Dept. of Computer Science and Technology, Henan Mechanical and Electrical Engineering College,
Henan Xinxiang 453003, China
Tel.: 13849382972
E-mail: wenxianxiaoedu@163.com

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Abstract: The paper put forward using BP neural network and Kalman filter to signal processing of MEMS inertial sensors. This paper uses Kalman filter value for information fusion of gyroscope and accelerometer, and the attitude angle is accurate. The state and observation equation of attitude angle measuring system with characteristic of BP neural network, and the design of the Kalman filter is simple and gyroscope measurement information data fusion, the preparation of the corresponding MATLAB program Kalman filter is designed. Through the simulation results of the image, this method can compensate the zero drift of gyroscope, improves the measurement precision of the attitude angle. *Copyright © 2013 IFSA.*

Keywords: BP neural network, Kalman filter, Inertial sensors, MTALAB.

1. Introduction

With the development of inertial sensor technology, inertial navigation system (INS) is independent, not susceptible to interference, real-time output and other excellent characteristics so that it is widely applied in military, commercial and related fields. INS depends on the accuracy of inertial sensor, gyroscope and accelerometer accuracy. There is a large amount of random noise and inertial sensor of the measurement data, to measure the carrier through the gyro attitude angle, its stability and short-term advantages of high precision, is suitable for the measurement of fast changing information, but the carrier attitude gyro measuring angle error will be rapid accumulation (drift), when the long time work when the drift infinite increase, cause the system to not work [1]. The accelerometer and magnetometer can also be used for measuring the attitude, and the measuring error is not accumulated with time, its static performance is good, suitable for measuring the slow changes in the information, but when the acceleration is larger this method cannot be used.

Inertial sensors including accelerometers (or acceleration sensors) and angular velocity sensor (gyroscope) and their single, double, three axis combined IMU (inertial measurement unit), AHRS (attitude reference system includes a magnetic sensor). MEMS accelerometer sensor is measured using inertial force sensing quality, generally by the standard mass (sensor) and detection circuit. According to the sensing principle is different, mainly piezoresistive, capacitive, piezoelectric, tunnel current, resonant, thermoelectric coupling and electromagnetic.

MEMS (Micro Electro Mechanical System) inertial sensor chip using inertial sensor manufacturing microelectronic processing technology, system integration is the micro devices composed of micro sensor, micro actuators, signal processing and control circuit, communication interface and power supply and other components of the system. The goal is to capture, processing and implementation of integrated information, composed of multifunctional micro system integration system, so as to greatly improve the system automation, intelligence and reliability level.

Although MEMS devices precision has not yet reached the limit, by improving the hardware design and manufacturing method can improve the accuracy, but by hardware manufacturing high precision gyroscope is not nearly technology difficult, and its cost is high. Method for collecting and handling the signal of the inertial sensor output signal to improve the precision of gyroscope, can reduce the needs of inertial sensor precision of hardware, and then achieve the goal of reducing the cost, this is the inertial circles has been an important research direction. According to the characteristics of these two kinds of sensors need to be fused the measurement information, improve the signal precision inertial sensors, to obtain more reliable information of attitude. Kalman filter has the ability to suppress the interference of strong, and can make the control method has good dynamic performance, has been very good application in nonlinear optimal estimation. The paper put forward using BP neural network and Kalman filter to signal processing of MEMS inertial sensors.

2. Application of MEMS Inertial Sensors Analysis by BP Neural Network

The low accuracy of MEMS inertial sensors for consumer electronic products mainly used in mobile phone, portable game machine, music player, wireless mouse, digital camera, PD, hard disk protection device, intelligent toys, pedometer, anti-theft system, GPS navigation. Because of the acceleration measurement, inclination measurement, vibration measurement and measurement of rotation and other basic measuring function, to consumer electronics application of mining will continue to occur [2]. Intermediate of MEMS inertial sensors for industrial and automotive products, mainly used in automotive electronic stability program (ESP or ESC) GPS aided navigation system, automobile airbags, vehicle attitude measurement, precision agriculture, industrial automation, medical equipment, robotics, instrumentation, engineering machinery and so on.

Problems of BP neural network prediction ability and training ability: prediction generalization ability also known or generalization ability, training ability also known approximation ability or learning ability. Under normal circumstances, training ability, predictive ability is poor, and to a certain extent, with the ability to improve the predictive ability of the training, will be improved. But the trend is not fixed; it has a limit, when reaching the limit, as the training ability, predictive ability will decline, also is the so-called "fitting" phenomenon. Reasons for this phenomenon is the network learning too much detail in the sample, the learning model cannot reflect the sample contains the rules, so how to grasp the important research content of learning, problem solving contradiction prediction ability network and training ability and BP neural network.

The development trend of MEMS inertial sensors are mainly in the following aspects: Technology: precision will continue to improve, with the top as an example, there are alternative low precision of fiber optic gyro trend. For consumer applications, more seek to further simplify the manufacturing process, reduce the cost of the trend. At the same time, the integration is the future trend of development, not only the module manufacturers go software, hardware integration approach, more and more upstream chip manufacturers also walk route technology integrated block. Thus constantly biaxial, three axis accelerometer, and gyroscope chip is published.

Using the inertia element can be on the moving body attitude measurement, inertial MEMS (Micro-Electro-Mechanical System) is the inertial component appears in recent years, it has low cost, high reliability, low power consumption, small size and other advantages, but the precision is relatively low, the gyroscope in the motion body attitude angle measurement, with increasing the measurement time will drift, so that the measured attitude angle is not accurate. In the vertical take-off and landing aircraft, aircraft can be regarded as a fixed base device, which can electrically equivalent angle measurement of aircraft with an accelerometer, and because the accelerometer drift angle is small, the long time measured are accurate. Therefore, the compensation and correction is in order to inclination measurement of gyroscope, as is shown by equation 1.

$$E_{jB}^{\xi}(m,n) = \sum_{m'\in J, n'\in K} w_B^{\xi}(m',n')[D_{jB}^{\xi}(m+m',n+n')]^2 \quad (1)$$

Due to the single on continuous improvement of instrument design and processing, to improve the method of debugging accuracy of inertial instrument accuracy, in practice, due to the cost, complexity and other issues encountered more and more difficulties, which makes the inertial sensor and components of the signal processing technology more attention in error compensation and the application, from the original one-sided pursuit of lower instrument absolute error, to focus on ensuring the instrument performance stability, random error compensation using signal processing technology as much as possible to reduce the instrument [3]. Gyro signal processing research mainly concentrated in the static error model, the dynamic error model and error compensation of these three aspects. Gyro static model and dynamic model because of its error trends are identified, so the error modeling has formed a fixed mode.

Modern inertial sensors are using tuning fork and piezoelectric vibratory silicon micromachining. Their sensitivity to small rotation of moving objects by reciprocating vibrating tuning fork based on Coriolis acceleration. Modern inertial sensors are widely used in such as a digital camera anti-shake, vehicle rollover airbag.

$$\frac{\partial^2 f}{\partial y^2}(i,j) \approx \frac{1}{h_2^{\ 2}}\left[f(i,j+1)-2f(i,j)+f(i,j-1)\right] \quad (2)$$

The gyro can measure positive, reverse direction angle speed ratings range. The rated range, gyro scale factor nonlinearity satisfies the requirements. (1). the scale factor (mV / deg / S) Scale Factor (Sensitivity) also known as the scale factor, scale factor, gradient, sensitivity. Refers is to the ratio of output and input angular rate gyro. The ratio is based on the input; output data of the whole input angular rate was measured over the range, slope straight line by least square method to fit the calculated. (2). the scale factor nonlinearity (%) Scale Factor Nonlinearity refers to the input angular rate gyro output range, relative to the least squares fitting linear maximum deviation and the maximum output ratio. (3) At zero bias and zero bias stability (V; V, deg / h or deg / S) Bias and Bias Stability bias refers to the output of gyroscopes in zero input condition. The output set time measured mean to represent. The bias stability is a measure of the gyroscope output around its mean zero input state (bias) discrete degree of ups and downs, get used to the RMS value representation, and the equivalent input corresponding angular rate. The industry is also known as the bias stability of zero drift, as is shown by equation 3 [4].

$$\hat{f}_n = f(u_n) = f[\sum_{k=1}^{K} w_k \sum_{m=1}^{M} x_m \psi(\frac{x_m - b_k}{a_k})] \quad (3)$$

Analysis of variance has been recognized as the practical method of fiber optic gyro random error standard analysis. This is because the output of fiber optic gyro random drift data with statistical characteristics and frequency fluctuation is very similar, the noise of the Allan variance and power spectrum density has the quantitative relationship between, can be directly from the output data of fiber optic gyro type and amplitude of each error source in fiber optic gyroscope in the time domain. Allan variance analysis with standard identification method for white noise, bias instability in high frequency, angle random walk and quantization noise not only results in low frequency band, to identify the rate ramp is not the only. So the improvement of Allan variance also emerged.

BP neural network in training can through the study of automatic extraction of output, output data between “rule of reason”, and adaptive learning content on the network weights in memory. BP neural network with a high degree of self-learning and adaptive ability. Generalization ability: generalization ability refers to the design of a pattern classifier, namely to consider the network in the guarantee of the required classification on the correct classification, but also concerned about the network after training, can not seen mode or noise pollution model, were correctly classified. The BP neural network has the ability of learning achievements are applied to the new knowledge.

The training process of BP network are as follows: (1) network initialization, assignment of the network parameters and the weight coefficient, the coefficient should take random number; (2) the input training samples, each layer of the value prediction, and compared with the true value, the network output error (3); on the basis of error back propagation rules, weight coefficient between hidden layer between input layer and hidden layer and is shown by equation 4.

$$C(t) = \frac{E[B(t), B(-t)]}{E[B(t)^2]} = 2^{2H-1} \quad (4)$$

In the gyro signal demising, wavelet transform has been widely applied because of its excellent characteristics of multiresolution. The fog signal was decomposed into multi-scale, signal reconstruction on each scale is after, multiscale gyros drift data. Time series modeling on scales of the drift data reconstruction, can get the multi-scale time series model of gyro random drift [5]. Then the model based on, on scales of the gyro random noise are filtered using the Kalman filter, which can effectively improve the signal-to-noise ratio of fiber optic gyro. Some domestic researchers’ wavelet neural network technology is applied to the gyro random drift model.

THELMA is a non – integrated MEMS manufacturing process, than the polysilicon surface micromachining process is complex, but has unique advantages, to achieve a thicker structure, this is extremely useful for capacitive inertial sensors. Although the THELMA process for the realization of capacitive inertial sensors, but the technology is very flexible, but also can be used for manufacturing the accelerometer, gyroscope and other MEMS devices.

$$I = -\sum_{t=0}^{T} q(t)\log q(t) - (-\sum_{t=0}^{T} p(t)\log p(t)) \quad (5)$$

Micro mechanical acceleration score for drape / displacement type or resonant using closed loop capacitive sensing and static electricity. The restoring force of micro machined accelerometer is a kind of typical structure, the accelerometer as silicon structure of a single, consisting of one can read the capacitance of the torsion pendulum and electrostatic torque device, device size was about

300 μm × 600 μm. Supported by a pair of crankshaft torsional pendulum, below inclined plate as output and torque electrode, while the integrated output angle sensor, used to drive torque to maintain the initial position of the modified inclined plate. Output balance required torque and acceleration in a certain proportion. Performance index (Revised) of the error is about 100 μg, at the same time scale factor error is 100 * 6, silicon accelerometer has a wide application prospect in the commercial domain, can also be used in military field and independent of traffic industry market. It can be applied to the measurement of acceleration extreme, such as the projectile velocity measurement in gun.

While the gyro random drift due to the random noise sources, compensation error is more complex difficulties. The gyro drift test and modeling has done a lot of work [6]. The mathematical and physical model is established from the physical structure of the fiber optic gyroscope fog layer, and then to compensate for gyro mechanical structure and other physical compensation. But the traditional IIR filtering, smoothing filtering and other classical digital filtering technology has been used as auxiliary analysis method used in gyro signal processing.

$$\binom{\delta}{k} \equiv \frac{\delta!}{k!(\delta-k)!} = \frac{\Gamma(\delta+1)}{\Gamma(k+1)\Gamma(\delta-k-1)} \qquad (6)$$

The attitude angle based on MTi inertial sensors to measure the angular velocity gyroscope, which is used to measure the angular velocity vector, the integral processing to obtain the attitude angle vector angle, but accumulated error, when the long time work accumulated error will be increased indefinitely, the relevant control system leads to the measured attitude information is not trusted which causes the carrier will not work properly. Attitude angle measurement vector with the accelerometer, its static performance is good, suitable for measuring the slow changes in the information, not suitable for tracking dynamic angle movement.

In BP network, transfer function derivation is very important, Tansig, logsig and purelin have guiding function dtansig, dlogsig and dpurelin correspondence. In order to get more transfer derivative function, transfer function, you can take the character “derive”: Tansig (‘deriv’) the first step of ANS = dtansig network construction and initialization of training a feed forward network is to establish a network object. The function newff is to set up a training feed forward neural network. 4 input parameters that need to be. The first parameter is an Rx2 matrix to define R input vector of the minimum and maximum values. The second parameter is an array of weakly each layer neuron number. The third parameter is an array containing the cells in each layer transfer function name. The last parameter is the name of the training function used in the.

Micro mechanical gyroscope MTi system in this paper refers to the vibrating gyroscope (vibratory gyroscope, VG). Micro mechanical gyroscope working principle: the use of mass of the high frequency vibration produced by Coriolis acceleration in the base is driven to rotate, which uses the vibration mass made of monocrystalline silicon or polysilicon, rotation will cause the energy conversion between the two vibration modes. Vibration vibration gyroscope is driven to work in the first vibration mode (drive mode), when the direction of vibration modal and the first vertical rotating angular rate input, the vibration parts due to brother’s effect produced second vibration modes of a vertical to the first vibration mode (also called sensitive mode), this mode is directly proportional to and the angular velocity of rotation. To detect the sensitive mode, you can detect the angular velocity.

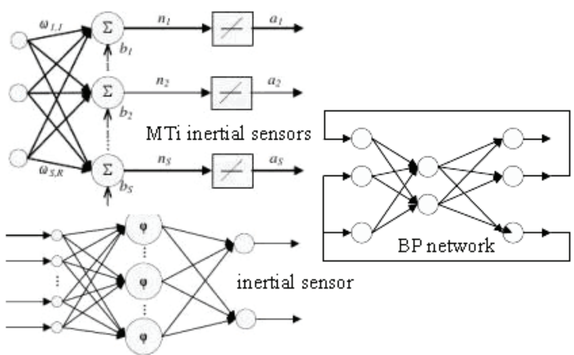

Fig. 1. The information processing of MEMS Inertial Sensors Analysis by BP Neural Network.

The basic principle of the information processing model of BP network is: input signal Xi through intermediate nodes (hidden layer) effect on the output node, through non – linear transformation, generates the output signal Yk, each sample for training the network comprises an input vector X and expected output T, the output value of the network Y and the expected output value deviation between T by adjusting the input nodes, and the nodes in the hidden layer connection strength value of Wij and the hidden layer nodes and the output nodes of the connection strength Tjk and threshold, the error decreases along the gradient direction, after repeated training, determine the network parameters corresponding to the minimum error phase (weights and thresholds), training is stopped [7]. The trained neural network can input information of similar samples, dispose of output error is minimized by non – linear transformation information.

The accelerometer is in accordance with the principle of inertia relative to inertial space work. Acceleration itself is difficult to directly measure, the actual existing accelerometer are the sensitive quality into force of indirect measurement, accelerometer measurement principle of Newton based on the second law: the force which acts on an object is equal to the object’s mass times acceleration. In other words, the acceleration effect in the sensitive quality formation of inertial force gauge can not distinguish between the forces of inertia and gravity, so the output of accelerometer is reflected by the quality unit force detection of inertial space, namely the inertial force and gravitational force and it.

MTi has two kinds of data output mode: raw data output mode and the corrected data output mode; the corrected data are effectively compensate the original data of non-orthogonal error, installation error, temperature transform on silicon micro machined devices, the effect of scale factor error based on the acquired data. The corrected data for decimal data, corrected data is not after the filtering and other real-time processing and only the physical calibration model is applied to the data obtained from the A/D converter. Data output format corrected as shown in equation 7. Inertial sensor experimental data used in this paper are corrected data.

$$u'(x_1,x_2)=\sum_{s=-n}^{n}\sum_{t=-n}^{n}w(s,t)u(x_1+s,x_2+t) \quad (7)$$

In summary, the neural network has four kinds of structure, hierarchical network layer hierarchical network, connecting the feedback hierarchical network, interconnection network connection, the neural network model of a sensor network, linear neural network, BP neural network, radial basis function network, feedback neural network, BP neural network is mainly studied in this paper to study, BP neural network and the approximate inertial sensor function and the estimation of sample size of two examples of application.

3. Inertial Sensor Signal Processing Based on Kalman Filter

Due to the random drift in inertial navigation system using the method cannot simply be compensation, so it becomes the most important measure of the gyroscope precision index. Our research on MEMS gyro noise reduction system is for MEMS Gyroscope Random Drift. In addition, the long-term stability of the gyro drift and characterization of a random drift rate, called drift uncertainty or successive drift rate. Drift uncertainty reflected in successive start in the random variations in drift rate of the system, it will affect the precision of inertial navigation system of compensation for gyro drift.

The main error sources of accelerometer in the following aspects: (1) fixed deviation: under the condition of constant acceleration, constant value deviates from the standard acceleration voltage nominal value. (2) Scale factor error: the change in output voltage and the input acceleration change ratio. Can a simple table show a proportional form, also can be expressed as a percentage of the full-scale measurements [8]. (3) Cross coupling error: error in the accelerometer output value is due to the accelerometer to orthogonal to the input shaft of the acceleration is extremely sensitive to the cause.

In the inertial navigation system, gyro is the key of its sensitive element. So the error of the MEMS gyroscope has become the main source of error in inertial navigation system. Precision gyro azimuth reference mainly depends on the size of the gyro drift error. In general, the gyro drift rate refers to the time variation of gyroscope output relative deviation from the ideal output rate, and the corresponding input relative to inertial space with unit time angular displacement [9]. Gyroscope drift will in open-loop state caused by range of deviation over time, even if the main factors in closed loop work shift are caused by the measurement error. Gyro drift error of the size of the drift angular velocity value, usually called the drift rate.

According to the characteristics of these two kinds of sensors need to be fused to the acquisition of information, to get the attitude information reliable. Kalman filter has the ability to suppress the interference of strong, and can make the control method has good dynamic performance, in the field has been well applied to estimate the nonlinear optimal. Fig. 2 is the research content of this article briefly structure diagram, which uses Kalman filter value for information fusion of gyroscope and accelerometer to get by, the attitude angle is accurate.

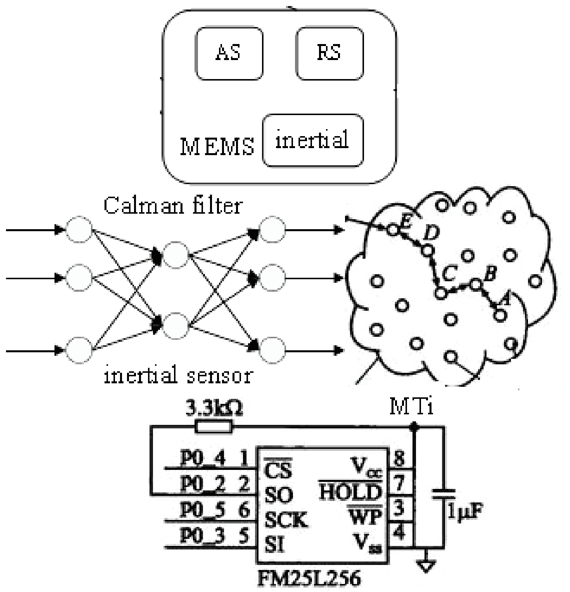

Fig. 2. The Inertial Sensor Signal Processing based on Kalman Filter.

For a specific application, Kalman filter state equation and measurement equation design problem. We must consider the actual process and the operation is simple and easy to use, so that the design of the filter is feasible. In the design process, to the amount of selected affect the entire state equation of the structure is a key part of Kalman filter design. Taking into account the existence of derivative relations angle and angular acceleration, angle can be used to make a state vector, and the angular acceleration is not suitable as a state vector, because its derivative is not given, a feasible choice is not directly estimate the angular acceleration of the true value, and estimate the gyroscope zero offset B, and this deviation as the state vector established as the system of equations.

$$MEAN = \sum_{i=0}^{M-1}\sum_{j=0}^{N-1} F(i,j)/(M \times N) \tag{8}$$

Using the gravity magnetic field between the geographic coordinate system and body coordinate direction cosine transform is absolute angle solution, get the attitude angle. Drawback is the slow dynamic response of the accelerometer, and it is not suitable for tracking dynamic angle movement, interference and is very interested, so it cannot be used for dynamic measurement of vehicle attitude.

Method using gyros and accelerometers integrated attitude determination method, is one of the above two and method together, acceleration information method of the attitude determination to output accelerometer use in computing the attitude of the MTi is used as the measurement value to compensate the gyro drift, this algorithm can guarantee the alignment of the MTi inertial sensor precision, and can guarantee by the gyro dynamic and stability of system has higher [10]. In this manner, the gyroscope, accelerometer integrated attitude determination fixed integrating gyro angle after drifting through the Kalman filter, improve the precision of inertial sensors.

Kalman filter is used to estimate a time, coupled with the real-time measurement of real-time estimation. Kalman filter is a recursive linear minimum variance estimation, because the estimation of time is measured using a moment before and the quantity, so the real-time estimation of the recursion is measured data obtained by all volume; secondly, Kalman filter to estimate the state of the system is used, with the system state equations to describe the transfer process, state thus, state correlation function between each time, can according to the transfer characteristic equation of state to describe the non-stationary random process, solve the difficulty in estimating. Kalman filter optimal criterion and linear minimum variance estimation, estimation of every moment to estimate the minimum mean square error. The state equation of the system is used, must be linear Kalman filtering.

Kalman filtering algorithm with two loops: gain loop and filter loop. The calculation of loop gain is calculated independently, filter loop depends on the gain calculation circuit. On 8 basic equations for linear discrete is stochastic system of Kalman filter. As long as the given initial value based on the observed K values of Z (k), can be recursive calculation of K moment state estimation. In a filter cycle, from the Kalman filter in the use of information and information of observation sequence, Kalman filter has two obvious information renewal processes: time update process and the observation update process. Type (9) shows that with the k-1 time state estimation and prediction K.

$$\frac{\partial u}{\partial x_1} = u(x_1+1, x_2) - u(x_1, x_2) \tag{9}$$

By using the statistical characteristics of the system noise and observation noise, the measured values as the input filter system, the estimation (system state or parameter) as the output of the filter, between the input and output filter is composed of time updating and the observation update algorithm together, according to estimate all need treatment the signal system and observation equations. It with conventional filter completely different meaning and method is actually an estimation method for the optimal [11]. The Kalman filter is applied to the error of inertial sensor attitude angle compensation, first needs to determine the measurement and state transition matrix.

The output signal data of the inertial sensor in stationary and motion is obtained by experiment, data analysis in Matlab 7.0 software platform, in the stationary state was observed in drift of gyroscope, and through the Kalman filter in gyroscope and accelerometer data fusion, effectively inhibit the accumulated drift of gyroscope, and improve the measurement accuracy of inertial sensor. In the state of motion as the accelerometer slow dynamic response is not suitable for tracking dynamic angle movement, and measure the attitude gyroscope angular and cumulative error, by Kalman filtering fusion of accelerometer and gyroscope signals, through the simulation of the image can be seen, this method compensates the zero drift of gyroscope, improve the measurement precision measuring the attitude angle, to achieve the desired effect research.

4. Using BP Neural Network and Kalman Filter to Signal Processing of MEMS Inertial Sensors

Inertial measurement unit composed of inertial sensor axis of this study, can find the pitch angle and roll angle of the vector of the output signal of the sensor, but the attitude angle of the random drift error, this paper proposed a Kalman filter to achieve fusion and gyroscope information on the acceleration, the filtering algorithm is simple and practical, to compensate the error of inertial sensors to obtain optimal estimation of attitude angle, so as to obtain more precise attitude information.

BP neural network is a kind of supervised learning, one-way communication, and multilayer feedforward neural network. Between the upper and lower BP network neuron implement the right connection, namely each unit of each unit and the upper layer are implemented in connection, no connection between the same layer neurons. Because of the network, the weight adjustment using back propagation (Back Propagation) learning algorithm, so called BP network. BP neural network is the core part of front network, embodies the essence of artificial network [12]. BP neural network through iterative gradient algorithm for solving network between the actual output and the expected output of the minimum mean square value, and can reverse transfer and modify the error.

In this paper, the design data of the inertial sensor output signal in stationary and moving down through the experiment, by using Kalman filtering in the MATLAB program, the simulation obtained gyro and accelerometer data fusion of the pitch angle and roll angle of the image signal and eliminate the simulation image of gyro's drift by Kalman filter using MATLAB software.

$$\widetilde{W}_{j,k} = \sum_{l=0}^{L_j-1} \widetilde{h}_{j,l} X_{k-l \bmod N} \tag{10}$$

In this paper, the use of MTi is the MEMS structure, composed of micro inertial measurement unit system and the three axis magnetometer. Micro inertial measurement unit 3 silicon micro accelerometer sensitive to X, Y, Z three directions of the linear acceleration; angle of rotation speed of 3 silicon micro machined gyroscope sensitive around the X, Y, Z three direction; the 3 axis magnetometer measurements of the earth's magnetic field strength. Gyro, accelerometer and magnetometer fixedly connected on the bracket of micro inertial measurement unit of the device, in mutually perpendicular position to install [13].

The design of the BP network, the hidden layer number, hidden layer nodes (neurons) determination is a very important question. People usually think, the simulation accuracy and complexity of the topological structure of network is proportional to, the network topology structure is more complex, more number of hidden layer nodes, the simulation precision is high, the smaller the possibility of getting into local minimum. But a large number of experimental results show that: the simulation accuracy does not vary with the complexity of network topology structure increased. Simulation for the same problem and it is network topology of the large difference.

The actual rate gyro drift is generally consists of two part system drift and random drift rate: (1) systematic drift rate: is defined with the specified operating conditions related to the drift rate component, it has nothing to do with acceleration by drift and drift and acceleration of the rate of group, represented by the angle displacement per unit of time. The system reflects the gyro drift rate under actual conditions of use and the working precision. Generally speaking, this kind of drift is systemic or regularly, it can be used to describe the relationship between the deterministic function, can use a certain method of compensation, and is a very mature approach of systematic drift compensation. (2) random drift rate: refers to the specified operating conditions drift rate in non systematic time-varying component, this kind of drift is random, such as disturbance torque electronic circuit noise, friction, temperature gradient caused by the nature of it.

The MTI inertial sensor data acquisition device is tied to the human leg, with the normal walking and acquisition of the signal data series, about 852 steps, the sampling frequency is 130 Hz, the data will be stored in the TXT file. The scene experiment as shown in Fig. 3. Will preparation good Kalman filtering program kalman11.m open in matlab7.0, signal output data and open the inertial sensor in the stationary state, simulation experiment is carried out and the corresponding movement in the state of TXT file into the Kalman filter program.

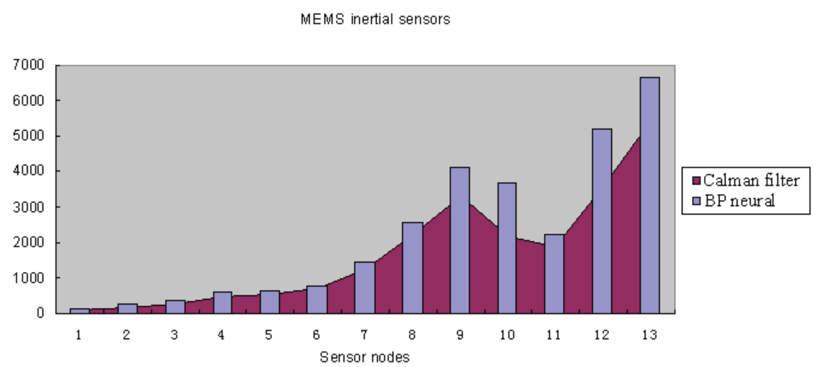

Fig. 3. Comparison signal processing of MEMS inertial sensors based on Kalman filter with BP neural network.

In the carrier in motion when the inertial sensor accelerometer and gyroscope signals sampled data, through the MATLAB maps, X axis and Y axis of gyroscope measured angular velocity gyroscope, obtained by integral point of view, the green line to the X axis, Y axis blue dotted line. Can be seen from the chart, the existence of relatively large drift by the gyroscope points obtained angle, which rely on untreated gyroscope output signal can not get a long time accurate carrier attitude angle.

BP neural network algorithm, the core idea is to reverse the spread of forward propagation and error signal information signal. The input signal from the input layer to the hidden layer, transmission, the final output layer obtained by converting output signal output, this is the forward propagating signal. The network output signal, obtained between the output signal and the expected output of the difference value of the error signal. The error signal from the output layer to reverse propagation, and according to the error signal correction output layer, and it is hidden layer and the threshold value matrix of input layer, in order to improve the output of the network effect. In every training session, positive signal propagation in the process of the network, the weights and thresholds are invariant.

5. Conclusions

Highlight the shortcomings of inertial navigation is the navigation accuracy decreases with the time increasing. Because of the existence of the core components of the gyro drift error of inertial navigation instrument, the carrier working time increasing, deviation from the reference position angle increases, the calculation error measurement and real-time location and speed increasing, the navigation accuracy decreases. In order to improve the precision of inertial navigation, the need to improve the measurement precision of gyroscope and accelerometer, but due to the manufacturing process, to improve the precision of the already difficult or increase micro inertial instrument accuracy, have to pay expensive cost. Therefore, the research of inertial sensor signal processing, mainly to complete the following several aspects: analysis of the gyroscope and accelerometer structure and working principle, and analyzes the source of error, the error model is suitable for it. The paper put forward using BP neural network and Kalman filter to signal processing of MEMS inertial sensors.

This paper uses BP neural network data forecast, we should first establish the BP neural network. The BP neural network construction, generally from the network level, the number of neuron and learning rate and other aspects of each layer are considered. For the BP neural network, there is a very important theorem. In addition, this paper also studies the implementation of Kalman filter, and based on the MATLAB7.0 environment prepared by the accelerometer and gyroscope won the attitude angle program.

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