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Algorithm of Multi Sensor Data Fusion Based on BP Neural Network and Multi-scale Model Predictive Control

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Abstract

Multi sensor data fusion is the data from multiple sensors and information from the relevant database are combined, which obtained judgment and description that can not achieve the goal, more accurate and complete by any single sensor. BP neural network is a kind of artificial neural network based on error back-propagation algorithm. It adopts adding hidden layer, to estimate the error directly leading layer of output layer by the error output. The paper presents Algorithm of multi sensor data fusion based on BP neural network and multi-scale model predictive control. The multi-scale model predictive control can not only obtain the previous information, and increase the flexibility in modeling and optimal phase.

Keywords: *BP neural network, multi sensor, data fusion, multi-scale model predictive control*

1. Introduction

Equation of state, the transfer function of this kind of traditional model can be used as a predictive model. For linear stable object, even the step response, impulse response of this kind of non parameter model, also can be directly used as prediction model. In addition, nonlinear system, a distributed parameter system model, as long as have the function, also can be in of the predictive control for this class of system as a model, therefore, the predictive control to break the strict requirements on the model structure of conventional control, and more focus on the basis of the information according to the functional requirements according to the most convenient way of the model was established.

BP neural network is a kind of two or more than two layers BP neural network has, inter layer neurons to achieve fully connected, i.e. each neuron in each neuron and the upper layer is connected to the right, and neuron layer without connection. A typical BP network is three layered feed forward hierarchical network, that is: input layer, hidden layer and output layer.

Obtained from the sensor data to discriminate analysis, the purpose is to better classify the data, and the ultimate purpose of this research is to better sensor management [1]. Multi sensor data fusion refers to data from multiple sensors are multi level, multi aspect and multi levels of processing, resulting in significant new information, and this information is any single sensor can not get. In order to get the accurate and reliable conclusion and it is reducing the potential in the information processing errors, often used to determine the object from different angles using multiple sensors.

Open loop system is stable and can not guarantee the stability of the closed-loop system, but it requires closed-loop stability. Open loop stability is determined by the characteristics of process and controller of potential. So the multi-scale model predictive control is the use of the expression of the same state space and standard model predictive control of input and output constraints, in addition to all of the feasibility of the control stability characteristics of time domain can be used multi-scale model predictive control.

Multi sensor data fusion is a combination and a process of multi-source information. Through coordination, combination, complement each other to improve the effectiveness of the system to obtain information from a variety of sensors, performance than a single sensor has more good. But sensors with limited resources, and how much sensor management has

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become the key data fusion system performance. The paper presents Algorithm of multi sensor data fusion based on BP neural network and multi-scale model predictive control.

2. Using Multi-scale Model Predictive Control to Multi Sensor Data Fusion Methods

Multi sensor information fusion is mainly refers to multiple information source or sensor information acquisition, processing, integrated process, it can better understand the observed object. In recent years, with the rapid development of computer technology and manufacturing, multi-sensor system for the complex application background of the emergence of a large number of. The complexity of the military and civilian fields growing, urgent need to use new technology for comprehensive treatment of too much information, interpretation and evaluation, which makes the multisensor data fusion theory to obtain the considerable development, the technology has been widely used in many fields.

Two linear quadratic optimal regulator problems in optimal control theory occupies an important position, it belongs to the open loop optimal controller. The so-called regulator problem, is when the system of the controlled output deviates from the equilibrium point, how to design a proper control input signal is applied to the system, so that the output tends towards equilibrium. If the control signal to make a performance index function is maximum, said the regulator for the optimal regulator.

Therefore, in predictive control, optimization is not an off-line, but repeatedly online; this is the meaning of the rolling optimization. Suboptimal limitations of this finite time optimization goal to make it in the ideal case can only get the global optimization solution, but the rolling implementation can be estimated due to the model mismatch, time varying, interference and other uncertainties, timely remedy. Always put the new optimization based on practical basis, to maintain optimal control in fact. For the complex industrial process, the model mismatch, time varying, the interference caused by uncertainty is inevitable, so the establishment of the rolling optimization strategy in finite period but more effective.

Four threat sensor different systems adopts distributed, network detection method can effectively deal with the modern war [2]. In the distributed network detection system, usually take the following manner: firstly by each detector to form local tracks; and then the track data report to superior intelligence center; finally Information Center on the local tracks is a fusion suboptimal trajectory tracking by data fusion. Multi sensor target association method mainly has two kind of scheme, one is measurement scheme of a track association; another is to track a track association scheme.

In the multi rate signal processing, often require multiple sensors simultaneously on different scales of the phenomenon or process observation. How will the sensors of different types, different scales of information obtained by the effective comprehensive is the common concern at work, the multi-scale analysis and multi-scale modeling is an important research problem.

Feedback forms are diverse, can guarantee a predictive model based on invariant, for the future to predict and compensate the error; it can also modify the prediction model according to the principle of on-line identification. Whatever the correction form, predictive control based optimization is established in the actual system, and tries to make more accurate predictions on the future system dynamics in the optimization, as is shown by Equation (1).

$$L(\theta) = L(x_1, x_2, \cdots, x_n; \theta) = \prod_{i=1}^{n} f(x_i; \theta) \tag{1}$$

Where $L(x_1,x_2)$ is correction form function, $f(x_i)$ is Multi sensor data which provides a powerful multi-source data fusion processing tools, it is the data from multiple sensors and information from the relevant database are combined, which obtained using any single sensor which can not be achieved, the target is more accurate and complete descriptions of judgment and.

Using non parametric model of the object (the impulse response and step response model) for prediction, and the introduction of management in areas such as the long-standing rolling optimization idea, the modeling errors and uncertainties are timely feedback correction using the tree cluster error current, forming a non - parametric model predictive control, which

laid the foundation for the development of predictive control. Because the parameters are redundant, non parametric model robust control, but the online computation; according to the current output error on future output feedback correction while the calculation is simple, but the correction action co.

Multiscale data fusion of multi-sensor case was significantly different from the single sensor, the latter is mainly according to the order of time by measuring the block in the value of the state block update; while the former state block estimation in general can be carried out at two levels: the first level is estimated at different times according to the time sequence of the system is updated, the second level is at the same time according to the sensor measurements coming order state blocks for the time update, as is shown by Figure1.

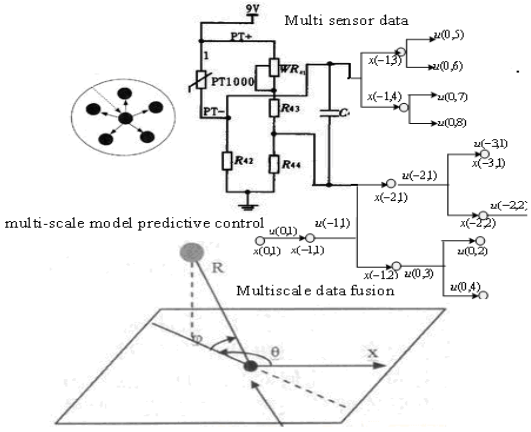

Figure 1. Using Multi-scale Model Predictive Control to Multi Sensor Data Fusion Methods

Aiming at the constrained multivariable DMC controller proposed an online parameter tuning strategy: according to the predictive output and the parameters of controller objects (such as weight coefficient, the closed-loop error control coefficient) approximate linear relationship, at each sampling time according to the deviation of adjusting the controller parameters online reference trace output and the expected object, and then use the weight coefficient the new rolling optimization a new round of, so that the response tracking reference trajectory the desired controller.

Constraint conditions are imposed; predictive control amount of calculation will be greatly increased [3]. Early methods of two planning are as an online optimization strategy. After the shift limit algorithm, can effectively solve some special control problem, the basic idea is to predict the time after several steps to limit the output, which is equal to the set sequence values, to improve the performance of the system. For this kind of problem, only equality constraints, though the performance index is the two type, the Lagrange multiplier method to the unconstrained optimization problem is obtained by analytical method, control strategy.

These three models will survey three types and three kinds of geometric objects up. If the minimum geometric distance definition for each of the two geometric objects and asked for a geometric object of any point to another geometric object took the minimum one point of the segment length, the minimum geometric distance can be used as measurement of association measure a measurement of the. Measure the similarity degree is to determine the two measurement or two measurement sets are from the same target.

This is a real-time algorithm provides the possibility of. While the other algorithms only a piece of measurement and block the relationship between the states, thus real-time estimation of the difficulty of system. In this chapter, we use MSBKF algorithm to deal with multi rate multi sensor data fusion, in order to ease in writing, without confusing situation, we use and represents the estimate and the estimation error covariance, and don't use and to represent.

To study and said from the aspects of function, structure and mathematical model to information fusion model [4]. Function model from the fusion process of information fusion which, describes the main function, database, as well as the interaction information fusion

system between the various components of the process; structure model from information fusion, information fusion system soft, hardware, data flow, system and external environment interface; mathematics model is the information fusion and integrated logic.

For a stable process, the choice of an appropriate control and prediction horizon, making the assumption that the 1 and 2 set up. An unstable process, people need to prove to the current state value possible stability. This is a transform and makes the control variables to achieve the desired target value, so that the uncontrolled mode becomes stable.

Because of the complexity of the degrees of freedom and the optimal problem is the number of input variables, if the control time constraints in a finite time as short as possible, which reduces the amount of computation in the very great degree. We can also to express the control vector by a number of parameters, so in the face of certain variables is limited when the control time is infinite. People can degenerate to predict these restrictions will cause the performance or even make the system unstable. To control the time length choice to a large extent by the design decisions, once it's fixed is maintained as a constant. In recent years, researchers have proposed changes of MPC in the time domain, the main is to ensure that the adjustment time length so as to ensure the stability of the system.

Performance measurement system in MPC or performance index cannot be fixed in advance. Instead of the compensation, it is in order to ensure the maximizing or minimizing the performance index. Before the optimization process is completed, the performance index value is unknown. In the unconstrained MPC due to this solution can be expressed as a closed form, then we can according to the system parameters and weighting in the objective function to represent these properties. Thus the performance theory also can be adjusted well. You can change the distribution of arbitrary properties to change the weighting value.

In the model predictive control stability in the literature only people in a time domain is given, the state and the output from a given initial value to a predetermined target value near. When this time becomes larger and approximate infinite, then the deviation of the state and output to the target value is approximate to zero.

The multi-scale model predictive control of closed-loop stability is very similar to the traditional model predictive control [5]. We can use Lyapunov theory to prove the approximate stability. The multi-scale model predictive control does not need to limit any to ensure the stability, so the algorithm only needs the final time point to reference line can be. This view can be considered a compression method. The reference path is a filter, which defines the true optimal open-loop state will be close to this range of values, so that the loop is approximate stability (time domain at the end point of N, but people know there exists on the input of the solution, the approximate the true target value, and the solution to the equation, as is shown by Equation (2).

$$L = \sum_{i=1}^{c} \sum_{k=1}^{n} \mu_{ik} \; d_{ik}^{2} \tag{2}$$

Where L is data fusion occurs from the existing research in the detection and estimation, u_{ik} is position estimation and d_{ik} is attribute estimates that the three part. In fact, all kinds of fusion can be realized together in a unified fusion system, it is very natural. There are three main types of structure model of multi sensor data fusion: centralized, distributed, hybrid. Centralized structure is a fusion of original observation data, the sensor data transmitted to the fusion center, in the fusion data calibration, data association, track / trace fusion, prediction and tracking center executive.

When the detection and multiple sensors simultaneously for multiple target tracking and identification, resource scheduling problem must be solved between sensor and target detection, and tracking and recognition, which is how under certain conditions, make full use of the sensor resources to meet the optimal system performance requirements, because of the objective environmental restrictions make some sensors can not fully its function, for some purposes on specific constraints, sensor using the proposed in addition, sensor resources are limited.

The multi-scale model predictive control (MSMPC) and classical model predictive control (MPC) sharing a lot of theoretical characteristics. Therefore MSMPC can be directly

derived directly from the MPC, it and the time domain MPC. This makes the system theory; all of the MPC can be adopted.

3. Research of Multi Sensor Data Fusion Based on BP Neural Network

BP neural network algorithm: the network is composed of neurons and neuron weights, namely: input nodes and output nodes of hidden layer nodes, three parts; each neuron weights are mutually connected strength. The neural network through training, learning knowledge from the sample, and the knowledge stored in the connecting weights value in. The classification process neural network is divided into two parts, first learning network weights, weights to obtain the data model using the data for training the network are known; then the unknown sample categories on the basis of the existing network structure and weight parameters [6].

Neural network predictive control is used as the neural network identification model to produce predictive signal, and then using the control vector optimization technique, so as to realize the control, prediction of nonlinear system further, get the optimal control trajectory, can also be trained to another as the neural network controller, so as to approach the time control function, after the end of the training, to directly control the controlled object. Artificial neural network is applied in the following three aspects: signal processing and pattern recognition, knowledge engineering and expert system and process control, as is shown by Equation (3).

$$\begin{cases} p_{i,j}^{mid} = p_{i,j}^{4} + \frac{1}{4} \times (\Delta p_{i,j}^{t} - \vec{g}_{\Omega + \partial\Omega}) \\ p_{i,j}^{t+1} = (1-r)\, p_{i,j}^{t} + sp_{i,j}^{mid} \end{cases} \quad (3)$$

Where $P_{i,j}$ is the BP model of the I/O problem for a set of samples into a nonlinear optimization problem, r is the most common optimization gradient descent method. If the neural network as the input to output mapping, this mapping is a highly nonlinear mapping. The design of a neural network expert system focuses on the structure and learning algorithm of model selection. Generally speaking, the structure is determined according to the research field and the problems to be solved. Through the analysis of a large amount of historical data and the data of the anterior neural network theory development level, the establishment of a suitable model, and the corresponding learning algorithm based on the model, the network learning process, constantly adjust the network parameters, until the output results meet the requirements.

Based on the comprehensive treatment of all sensor data, to obtain the final data is more accurate. According to the different research questions and it is data fusion for different purposes. Generally speaking, data fusion can be broadly divided into two types. A class of problems is to study characteristics of data through data fusion; a feature of the object of study was repeated determination. In this kind of observation, each sensor can be considered similar; to solve this kind of problems can often be data fusion by means of mutual support between the sensors.

In the control used in more BP network and RBF network, BP network and RBF network are very shallow biological background and close to the person with ability of nonlinear function. A nonlinear relationship between output and network connection of the former, which makes the learning algorithm must use the nonlinear method, thus inevitably exist the problem of local minimum. For the RBF network, although has a unique optimal approximation points, connecting the network power and the output characteristic of linear relationship so that it can use linear optimization algorithm can guarantee the global convergence, but its center point set selection is not easy, as is shown by Equation (4).

$$Z_i = \frac{\left(Z_B + n^2 Z_L\right)^2}{2(Z_B + n^2 Z_L)} = \frac{Z_B + n^2 Z_L}{2} \quad (4)$$

Where Z_i is nonlinear function, n is the distributed structure nodes first in the local sensor local processing of the observation information, L is the local processing results which

are transmitted to the data fusion center, forming the final global estimate in the fusion center. In the distributed structure, as in the data fusion center is the vector data, so the computation load of the fusion center is greatly reduced. Ability of distributed structure not only has the local tracking, and the system overhead is not expensive and good stability, so the structure is widely used in engineering [7], as is shown by Equation (5).

$$E = -\sum_{i=0}^{L-1} p_i \log_2 p_i \tag{5}$$

Where E is the neural network model, p_i is neural network nonlinear object to select different neural network models and structure determination problems; and from the nonlinear identification aspect, there is sufficient incentive, parameter identification, with the noise of system identification, identification algorithm is fast and the convergence problem. For these two problems, and it is to the application of nonlinear theory and optimization method for the existing and development. The modeling algorithm and the control system and neural network convergence and stability, as the controlled object and neural network are nonlinear, it is difficult to solve.

The BP algorithm not only has the input layer, output layer nodes, also can have 1 or more nodes of the hidden layer. For the input signal, the first forward propagated to the nodes of the hidden layer, the function, the hidden node output signal to propagate to the output node, finally, the output results [8]. The role of incentive function nodes usually selected S type functions, such as 1 f (x) = Sigmoid + e - x /Q parameters of the 1 type of Q to adjust the excitation function form. The learning process of the algorithm is by forward and reverse transmission component. In the forward propagation process input information from the input layer, the hidden layer by layer processing, and transmitted to the output layer. Each layer of neurons in the next layer state affects only the states of the neurons.

In the training process of BP neural network, the need for some training parameter is set, in order to speed up the process of network training, improve the stability of network training, try to achieve the best effect of training. To complete the training parameters, which can be called the training function is used to train the BP neural network.

Through data fusion and it is to determine the characteristics of object ownership. In such problems, the sensor is often different, different characteristics of each sensor is respectively studied were determined. This kind of problem due to the characteristics of each sensor was not the same, so the use of the mutual support and unsatisfactory, but also may be due to the neglect of a sensor is the degree of support is relatively low, thus losing some unique properties of the sensor by the determination of the object.

4. Algorithm of Multi Sensor Data Fusion Based on BP Neural Network and Multi-scale Model Predictive Control

The data fusion task is the value of the state, determination, research object ownership. Each sensor on the determined respectively different characteristics of the study, in order to determine the characteristic of the research object through the sensor, in practical applications often choose independent characterization research object characteristics indexes were observed, from the viewpoint of probability theory is regarded as independent of each other, at least relative degree is very low.

The standard model predictive time length control is used as the parameters, because the output constraint limits the time choice, if the inappropriate choice of words will not produce the feasibility problem (input constraint is always feasible). Control in each link is the choice of time domain algorithm infinite simulation makes the output constraint was almost meet the predictive multiscale model. On the changes of time and the reference path tracking MSMPC set it in time domain for the infinite horizon case.

The standard deviation as the percentage of each number, it can not only variation between units of comparison values of different variables, but also can compare the difference between the mean variation between variable values. Need to point out, the first point: variability index variation values or dispersion, often with position index average method, the variable value centralized location and dispersion degree [9]. The second point: Although the variability

indicator species, but any variation index, its value is greater, that variation is greater, the more serious the numerical stagger; said the smaller variation is small, Equation (6) is shown concentrated.

$$F(a,b) = \sum_{i=0}^{n} \varepsilon_i^{\ 2} = \sum_{i=0}^{n} (y_i - ax_i - b)^2 \tag{6}$$

Where F(a, b) is the model of BP neural network parameters on the network, E_i need to initialize, y_i is variability indicator. Since the system is nonlinear, the initial value for learning can achieve the local minimum and can convergence results great relationship. An important requirement is: the initial weights so that each neuron state values close to zero in the input accumulation, weight is in (-1, 1) random number between, to relatively small. Also hope that input sample was normalized, so that relatively large input can still fall in the transfer function gradient.

The performance of network training and the training samples are closely linked. The design of a good training set should note that the sample size, but also should pay attention to the quality of the sample. Because the road information acquisition may be inconsistent in the unit, higher value and so on, therefore before BP neural network prediction, we must take some data processing methods of normalization pretreatment on road traffic flow data, making the processed data can fall on the (0, 1), to accelerate the convergence of training network, which facilitates the BP neural network model.

The robust stability of MSMPC, or is the system modeling error or the ability to handle the change of parameters in other words, we use the MPC method to deal with. The object at different scales of model mismatch, using a different calculation structure can only improve the robustness, so the open-loop optimal link is to get more information about the system through different scales or frequency bandwidth. The experiment can select parameters adjustment of MSMPC, makes it possible to accurately obtain similar to MPC as results, so that it can have the same performance.

This is a dynamic system; we assume that all States are completely observable. No modeling and measurement error and external disturbance in here, the reference path followed by the dynamic model is from a starting point to the target point process. In order to verify the proposed algorithm and it is show that the proposed algorithm is effective and practical. Example is according to the 4 sensor data to determine an object of study, and finally determine the research object.

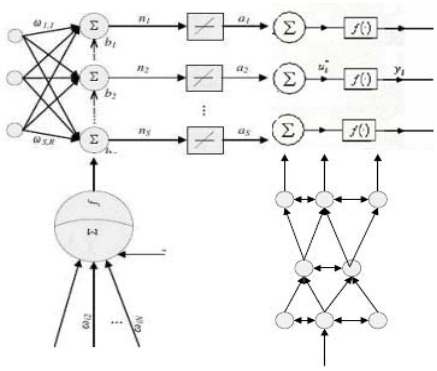

Figure 2. Design of Multi Sensor Data Fusion Based on BP Neural Network and Multi-scale Model

Design of Multi Sensor Data Fusion based on BP Neural Network and Multi-scale Model is shown by Figure 2. In the construction process of BP neural network, for any continuous function in closed interval can be approximated by BP network with one hidden layer, and a three layer BP neural network is to form decision regions of arbitrary complexity, arbitrary n-

dimensional mapped to m dimension. Therefore, this paper uses only a single hidden layer of three layers BP neural network structure to construct BP neural network prediction model based on time series modeling.

The paper presents Algorithm of multi sensor data fusion based on BP neural network and multi-scale model predictive control. In this paper, multi-scale domain model predictive control; and then gives a new representation method and its characteristics; the problems of traditional methods, gives the calculation method of parallel. Finally, it is the algorithm and simulation.

5. Conclusion

In the multi sensor data fusion system, especially in the large multi sensor data fusion system, the existence of a large number of homogeneous and heterogeneous sensor, which can reflect the characteristics of the external world space from different sides. How much sensor management has become the key data fusion system performance? That is how the sensor resources allocation, in order to make the system achieve the best overall performance.

BP neural network (Back Propagation Neural Network) is a kind of artificial neural network based on error back-propagation algorithm. It adopts adding hidden layer, to estimate the error directly leading layer of output layer using the error output, and then the error estimation error of a layer, so a layer back propagation under go to, will obtain the error estimates for all other layers. The multi-scale model predictive control can not only obtain the previous information, and increase the flexibility in modeling and optimal phase.

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