Novel Methods of Nodes Management in Wireless Sensor Networks by Predictive Control Model

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Keywords: Nodes management; Wireless sensor network; Predictive control model; Control strategy; Parametric model

Abstract. This paper analyzes the main model contents of predictive control. Wireless sensor networks consist of large number of sensor nodes through the network. Predictive control is the three basic characteristics introduced above: predictive model, receding horizon optimization and feedback correction. These methods are belonging to the non parametric model predictive control. The paper puts forward novel methods of nodes management in wireless sensor networks by predictive control model. Experimental results show the effectiveness of the proposed method.

Introduction

With the development of intelligent control technology, control strategy of combination prediction control results have been achieved with fuzzy control, neural network and genetic algorithm, the expert control system, and is moving towards intelligent predictive control direction, so as to further enhance the predictive control processing capacity in the face of complex environment, complex objects and complex tasks, expand the prediction research and application of control theory field, but also fully shows that the intelligent predictive control of great practical value.

Optimal predictive control is not using constant global optimization objectives, optimization strategy instead of using the finite time rolling. At each sampling time, the optimization performance index involves only from the moment to future time limited, but to the next sampling time, the optimization time also goes forward. Therefore, the predictive control in every moment there is a relative to the performance index of time optimization. Relative form different time performance is the same, but the absolute form, namely the time zone contains, is different.

For the unconstrained MPC, define the weighted method, is to enable the controller frequency corresponding to meet certain requirements. If there are no hard constraints, we can use the frequency to characterize this objective function. If they are variable, and they can not be localized in the time domain, you will not be able to use the frequency domain method, which makes the hardware limit the event is to produce at a certain point in time. Similar characterizations in constraint in MPC ring, these restrictions prevent the use of frequency domain method.

Predictive control is in the adaptive control of a predictive control algorithm is developed in the study, which is inspired by the receiving DMC, modified online prediction model, in order to give more accurate forecasts [1]. GPC is from the self correcting control developed, so keep the self-tuning method principle, namely in the control process, the input and output information online estimation of model parameters, and corrects the control rate, realize the online identification and correction. This is a generalized feedback correction. The optimization of the predictive control theory and DMC similar, this is no longer a detailed description. Recently, it is also appeared in the continuous generalized predictive control (CGPC). In the generalized predictive control (GPC), the minimum variance control in the controlled auto regressive integrated moving average model to describe the object subject to random interference. The paper puts forward novel methods of nodes management in wireless sensor networks by predictive control model.

The Main Model Contents of Predictive Control

Predictive controller parameter is adjustment method of the system. The original process model with a first order plus dead time model approximation, based on the analytical expression obtained control coefficient. Because the control coefficient in multi variable control has two kinds of effect, inhibitory control effect of severe hand, another role is to improve the condition number of the system matrix and make it more definite [2]. The main idea of the algorithm is that, using the analytical expression of condition number of system matrix and the control system is derived, through coefficient control given a fixed system matrix to offline solution.

Stability is a basic structural property of the system. Stability is an important task for system control theory. In most cases, stability is a prerequisite for the normal operation of the control system can. Dynamic stability of system can be classified as exterior stability based on the input output and internal stability based on the state space description. Under certain conditions, internal and external stability are equivalence relations. Mainly discussed here is the stability of MPC sense, as is shown by equation (1).

$$MSE = \frac{1}{MN}\sum_{x=1}^{M}\sum_{y=1}^{N}(\tilde{P}_{xy} - P_{xy})^2 \tag{1}$$

The predictive control of output deviation accumulation point, used to overcome some adverse effects caused by the reverse characteristics of process, because this kind of system in the control of initial output deviation in the control effect increased, resulting in the illusion of control is too weak, the control effect to enhance future produce large overshoot, is not conducive to the stability of the system. After the shift error accumulation beginning, adverse effects on human get rid of the reverse characteristic in the objective function, can prevent the large overshoot.

Predictive control is the three basic characteristics is introduced above: predictive model, receding horizon optimization, feedback correction, makes it popular in the complex industrial environment. First of all, for the complicated industrial object, because the minimization model identification of great cost, often to the control algorithm based on transfer function or state equation is difficult. The predictive control not only of the model structure, so it can according to the characteristics of the object and control requirements, the forecast model to gather information the simplest way to establish. The formula used in the method is as follows [3].

$$\psi_{a,b}(t) = \frac{1}{\sqrt{|a|}}\psi\left(\frac{t-a}{b}\right) \tag{2}$$

Based on the above situation, in the industrial process control field, the control effect of the controller design using the modern control theory, often than by classical theory to the design of PID (or PID) regulator [4]. Therefore, so far, in the industrial process control, the dominant is the classical PID regulator. In order to overcome the above theory and application of disharmony, from 70 time since, in addition to the people to strengthen the research process modeling, system identification, adaptive control, robust control outside, also began to break the traditional ideas, trying to characteristics for industrial process, looking for a variety of low model, online calculation convenient, comprehensive control effect good algorithm.

Predictive control for SISO out of the situation, the world, based on the principle of the prediction control can be easily extended to the MIMO case. In the industry control process, the successful application of predictive control, mostly in the multi variable and constrained optimization case is implemented, which is a reflection of the advance in the theoretical research on the application of predictive control of reality.

In order to solve the problems of complex industrial process and the uncertainty of the multi-objective optimization, prediction on the crossover study methods in control theory, a predictive control is becoming the focus of research of intelligent fuzzy control, neural network control

technology and intelligent control mechanism combining forecasts, especially widely used with PID control technology. Attach importance to the application of predictive control theory, a scene from the industrial practice constantly looking for predictive control to solve or emerging issues and the future direction of development, as is shown by equation(3).

$$\begin{cases} w^{\xi}_{j,\min}(m,n) = \frac{1}{2} - \frac{1}{2}\left[\frac{1 - M^{\xi}_{j,AB}(m,n)}{1-T}\right] \\ w^{\xi}_{j,\max}(m,n) = 1 - w^{\xi}_{j,\min}(m,n) \end{cases} \tag{3}$$

The main contents of optimal control problem is: how to choose the control law can make the control system performance and quality is optimal in some sense, method for solving optimal control problems, at present mainly is the two kind of method, also will use some numerical solution, as is shown by figure1 [5]. These methods have been successfully solved many dynamic control problems, such as the minimum time control, minimum fuel control and optimal regulator. Optimal control has been in aerospace, navigation, missile, power system, control device, production equipment and production process has been applied successfully, but also obtained the widespread application in the economic system and social system.

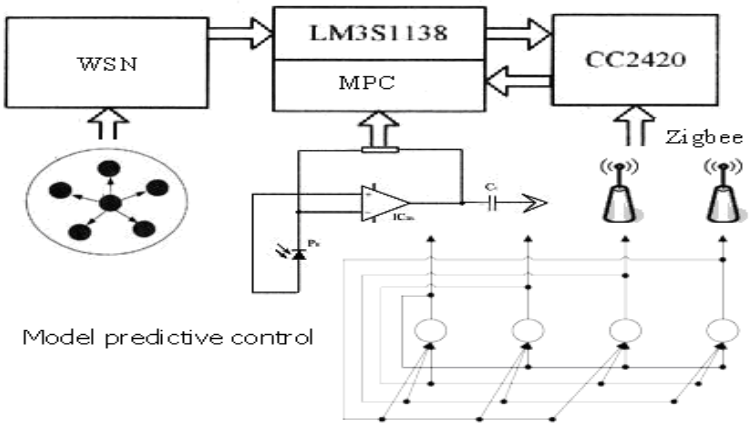

Figure 1. The main model contents of Predictive control

Forecast model with the dynamic behavior of the function display system in the future [6]. In this way, you can use predictive model to forecast the future time controlled output change of deviation and the controlled variable with a given value, as determined on the basis of control function, so as to adapt to the dynamic system with storage and causal features, get better control effect of the conventional control is shown by equation4.

$$C_c(\tau,t) = X(t - \frac{\tau}{2})X^*(t + \frac{\tau}{2}) \tag{4}$$

Prediction model is based on DMC sampling data object step response. For the asymptotic stability of the system, its step response in one sampling period will tend to a steady value, i.e.. The dynamic characteristics of the step response of a finite set can be sampled data to describe the system unit order, known as N modeling in time domain [7].

The Basic Elements of the Sensor Node Network

That low-power wireless communication technology for short distance is most suitable for sensor networks, so called wireless sensor networks. The basic elements of the sensor node sensor network is composed of a power part, embedded processor, memory, perception, communication part and the software part. The power supply is to the normal work of the energy. Perception parts perception,

access to outside information, and convert them into digital signals. Treating all parts coordinator node, such as access to the perception component information preservation processing, necessary, control sensing components and power supply mode. Communication components are responsible for its sensor or the observer [8]. The software for the sensor to provide the necessary support, such as embedded operating system, embedded database system.

The location information of the nodes or deployment information can be pre estimated and used for key management, Liu in static WSN in the establishment of geographic information of the closest to the pairwise keys scheme based on (simply called CPKS (closet pairwise keys scheme) scheme). Before deployment, and it is node randomly and closest to the self expectations C nodes location to establish pairwise keys. For example, for the V neighbor node u, the deployment server generated random pairwise keys Ku, V, then (V, Ku, V) and (U, Ku, V) were assigned to u and V, deployment, neighboring nodes by determining whether both sides are paired key node ID exchange. The advantages of the CPKS scheme, each node to establish pairwise keys with finite adjacent nodes, the network scale is not restricted; paired binding key and location information, damaged not any node other node security, as is shown by equation5 [9].

$$f(t)=\sum_{s=-\infty}^{+\infty}\sum_{n=-\infty}^{+\infty}\delta\tilde{f}(s,n)\psi(s,2^{s}t-n) \tag{5}$$

Sensor nodes need to keep the length of time synchronization, wireless sensor network time synchronization in various time length need, from instant to permanent synchronous network synchronization with the existing. Synchronous range: time synchronization scheme can give network all nodes provide time, part of the node can also give the local area of the time. Because of the reason of scalability, full time synchronization is difficult, for sensor networks in large areas, taking into account the use of energy and bandwidth, but also very expensive. On the other hand, a large number of nodes to common time needs to be collected from remote nodes to synchronize the data, for large-scale wireless sensor networks is very difficult to achieve, but also directly affect the synchronization accuracy.

Experiments and Analysis

This paper presents the predictive functional control, mainly used in industrial robot control etc.. These algorithms are belonging to the non parametric model predictive control [10]. The characteristics of this kind of control strategy is: the model is easy to obtain in the industrial field, does not require the system identification and modeling of complex feedback correction; the rolling optimization based on replacing the traditional optimal control, so it can overcome the influence of various uncertainty, enhance the robustness of system, and the on-line computation is relatively simple. But its limitations, only applies to open loop self stable object, and when the time constant is larger, more is bound to the parameters of the model, control algorithm.

Because of the multi step prediction mode, expanded the amount of information reflecting the change trend in the future, so it can overcome the influence of various uncertainty and complex changes, the predictive control can obtain good application effect in control nodes of wireless sensor network, as is shown by equation(6).

$$W = \begin{bmatrix} \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} \\ \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{1}{\sqrt{8}} & \frac{-1}{\sqrt{8}} & \frac{-1}{\sqrt{8}} & \frac{-1}{\sqrt{8}} & \frac{-1}{\sqrt{8}} \\ \frac{1}{2} & \frac{1}{2} & \frac{-1}{2} & \frac{-1}{2} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{2} & \frac{1}{2} & \frac{-1}{2} & \frac{-1}{2} \\ \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \frac{1}{\sqrt{2}} & \frac{-1}{\sqrt{2}} \end{bmatrix} \tag{6}$$

Classification of nodes in wireless sensor networks can greatly reduce the routing control information, improve the utilization rate of network bandwidth, and greatly influenced by the scale of the number of nodes in the network with less restriction of equation(7). However, there are some disadvantages into structure: (1) selection algorithm for cluster head need extra cost, joined with the old node clustering is completed due to sensor nodes have weak mobility or a new node's death, the need for timely maintenance of the cluster structure and update, which also increases the load of network nodes; (2) the cluster head node "extra" compulsory capabilities make it relatively heavy task, the cluster head will often become the bottleneck of the network; (3) the inter cluster routing is often not necessarily optimal routing.

In sensor network used in the process, some sensor nodes due to energy depletion or environmental factor is the cause of failure, there are also some nodes in order to make up for the failure node, increase the monitoring accuracy and added to the network, so that the number of nodes in sensor network can dynamically increase or decrease, so that the network topology is dynamically changing. Sensor network self-organization can adapt to the dynamic changes in the network topology.

Conclusions

Each virtual beacon nodes based on the received average hop distance according to the weight of the correction, and according to the number of hops recorded calculated to each virtual beacon distances, pick out the virtual beacon node distance information optimization, according to the three edge measurement method to calculate their position. The paper puts forward novel methods of nodes management in wireless sensor networks by predictive control model, so it should have larger weights.

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