Chapter 38
A Parallel Levenberg–Marquardt Algorithm for Recursive Neural Network in a Robot Control System

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ABSTRACT

This article has the purpose of overcoming the shortcomings of the recursive neural network learning algorithm and the inherent delay problem on the manipulator master control system. This is by analyzing the shortcomings of LM learning algorithms based on DRNN network, an improved parallel LM algorithm is proposed. The parallel search of the damping coefficient β is found in order to reduce the number of iterations of the loop, and the algorithm is used to decompose the parameter operation and the matrix operation into the processor (core), thereby improve the learning convergence speed, and control the scale of the delay. The simulation results show that the pro-posed algorithm is feasible.

1. INTRODUCTION

In recent years, with the rapid development of robot technology, multi-joint and multi-degree of freedom robot (referred to as manipulator) has become one of the hotspots in the field of robot research. Due to the increase in the degree of freedom and the diversity of the way, the robot master control system becomes extremely complicated. The robot system is not only a multi-input and multi-output nonlinear system,

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but also a complex system with strong coupling, time varying and many uncertainties, and it is difficult to model it by mathematical method, so its control is relatively difficult (H Yazarel,2002). Therefore, Document (Noore, 2003) points out that the main criterion for measuring the advanced degree of the robot system is to see what control technology it uses.

The neural network has a wide range of applications in the identification of nonlinear systems because of its ability to approximate any nonlinear function in theory. In particular, the recursive neural network is often used in the robot control system because of its internal feedback mechanism, and can automatically store the dynamic information and realize the dynamic mapping. It does not need to know the detailed object knowledge when the system is identified. However, the system also has shortcomings, due to its complex feedback loop structure and hardware circuit mechanism, prone to delay. And the scale of the delay, whether too large or too small, will affect the stability of the neural network, and ultimately affect the control of the quality. Therefore, the delay problem should be the main flaw of the control system.

Solving the problem of delay control alone does not help to improve the performance of the system, and the solution to the problem should be solved from the essence of delay. Document (Oscar, 2002) shows that, due to the use of feedback loop structure, recursive neural network in the training phase of the LM learning algorithm convergence speed is slow, it should be the main reason that the network speed cannot improve, and the algorithm contains multiple iterations and a large number of matrix calculations, which makes the computation of the system too large and too concentration, thereby leads to increase the scale of the delay.

Therefore, this paper proposes an improved parallel LM (Levenberg-Marquardt) algorithm based on multi-core environment to realize the parallel search of the damping coefficient β in order to reduce the number of iterations of the loop and decompose the computation to each processor, thereby improve the convergence rate, the delay scale is fundamentally controlled within the criterion, this not only can guarantee the stability of the system, but also enable the system performance to be improved.

2. RELATED WORK

The main task of manipulator control is to solve the robot in the work space in the movement of the location, trajectory and attitude, operation sequence and time control and other issues. The most important and most basic is the Invesrekinematics and Invesredynamcis problems and the corresponding control strategies (Oscar, 2002). If we achieve effective control, we need to solve two problems, one is how to achieve the stability of the closed-loop error system, making the trajectory tracking error as soon as possible close to 0; the other is how to suppress interference, as far as possible to reduce the interference signal on the tracking accuracy. For the above problems, the general method is modeled by mathematical methods, and through the linear servo control theory to design the controller, you can get a solution. However, due to the particularity of the robot (uncertainty factors and excessive interference signal), it is difficult to obtain accurate mathematical model, there is no precise mathematical model, it cannot guarantee the quality of control. Until recently, with the increasingly sophisticated neural network control technology, the control problem of the robot seems to have a new opportunity.

Neural networks are similar to robotic systems, and they can all be seen as a nonlinear dynamical system with multiple inputs and outputs. The neural network is trained by modifying the connection strength, thereby adjusting the input and output relationships of the entire neural network. If it is used as a controller, it does not need accurate mathematical model of the controlled object, and it also exhibits