International Journal of Smart Sensor and Adhoc Network

Volume 3 | Issue 1 Article 14

October 2012

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INTELLIGENT CONTROLLER: AN ALTERNATIVE APPROACH FOR NONLINEAR SYSTEM CONTROL

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ABSTRACT:

Control of non liner systems is difficult in the absence of a systematic procedure as available for linear systems. Mathematical model that we use for nonlinear system control needs very expensive and sophisticated instrument. Intelligent system which is suppose to posses humanlike expertise within a specific domain, adopts itself and learn to do better in any condition. Soft computing an approach for constructing computationally intelligent system consist of several computing techniques, including neural network, fuzzy set theory and derivate free optimization method such as genetic algorithms and simulated annealing. As it incorporate human knowledge effectively, to deal with imprecision and uncertainty, and to learn to adopt itself to unknown or changing environment for better performance.

Key Word: Soft Computing, Fuzzy Set, Neural Network, Nonlinear System, Adaptive Control.

INTRODUCTION

In modern control area, there are many systems with strong interference, nonlinear, time-varying characteristics, and the traditional PID control is not satisfactory. In addition, the control quality of its parameters will decline when the object or operating condition changes. Currently, intelligent control has become a central issue in control field, especially neural network control and fuzzy control. Artificial neural networks (ANNs) have been used as computational tools for data quality identification because of the belief that they have greater predictive power than signal analysis techniques. Neural network can be trained to learn and are in reality a form of mathematical function approximation. They have been used to design control systems and astonishingly accurate performance has resulted in many cases.

CONTROL OF NONLINEAR SYSTEMS

A nonlinear system can be controlled in many ways to make it act like a linear system in its overall performance. Making a nonlinear system act like a line system has many advantages, since linear systems are much easier to work with and are better understood. However, even if a model of the nonlinear system is available, no systematic and generally applicable control theory is available for the design of controllers for nonlinear systems. The best-known controllers used in industrial control processes are proportional-integral-derivative (PID) controllers, because of their simple structure and robust performance in a wide range of operating conditions. Attempts have been made to use feed forward and recurrent neural networks for the control of nonlinear plants. The work reported makes use of two neural networks, one for representing the requirements on the controller and the other representing the system from the input output data if the plant model is not known in a mathematical form.

INTELLIGENT CONTROL

The use of artificial intelligence (AI) methods to design and implement automatic control systems has been broadly described as 'intelligent control'. According to an IEEE task force report an intelligent system has been described as follows:

An intelligent system has the ability to act appropriately in an uncertain environment, where an appropriate action is that which increases the probability of success, and success is the achievement of behavioral sub goals that supports the systems ultimate goal. Intelligence is a property of the system that emerges when the procedures of focusing attention, combinational search, and generalization are applied to the input information in order to produce the output. Machine intelligence is the process of analyzing, organizing and converting data into knowledge, where (machine) knowledge is defined to be the structured information acquired and applied to remove ignorance in uncertainty about a specific task pertaining to the intelligent machine. A useful definition of intelligence must span a wide range of capabilities and at a minimum include the ability to make decisions, to control action and to sense the environment. Such decision-making ought to be autonomous and should result in improved overall performance over time.

Today several AI methods are well established and some of them have been used to design control systems, expert systems, fuzzy logic, genetic algorithms and neural networks are the most prominent ones. On occasion researchers have suggested that hybrid AI controllers be used, i.e. combinations of two or more of these techniques. In this work we shall limit our discussions of intelligent control to those system that use neural networks.

NEUROCONTROL

Neural network or 'connectionist' methods have emerged as very powerful tools for designing intelligent control system owing to the fact that they are designed to emulate, on a much simpler scale, the human learning process. The term 'neurocontrol' is now in use to control system literature and refers to control methods that employ neural networks.

It has been demonstrated that neural networks can be used effectively for the identification and control of complex dynamical systems. While linear-time-invarient plants with unknown parameters can be controlled quite effectively with conventional methods that are based on linear systems theory, the identification and control of nonlinear dynamic (time-varying) plants pose a far more difficult problem to the designer. In real life most industrial process plants are in the latter catogory and hence the need of intelligent methods to control such systems. Out of the many different 'intelligent' approaches, neurocontrol appears to be growing in popularity. As these methods are based upon what is commonly termed 'training' and 'learning' it is worthwhile attempting to design more efficient training methods and improved learning algorithms in order to build more intelligent control systems.

The procedure to adaptively control a nonlinear plant depends largely upon prior information available regarding the unknown plant. This includes knowledge of the bounds Adaptive Neurocontrol.

ADAPTIVE NEUROCONTROL

Design of a control system concerns two basic aspects : plant identification (or modelling) and controller design. In both these areas neural network techniques have been applied successfully and the feasibility of implementing the concept of MRAC with neural networks is at present being examined.

THE IDENTIFICATION ISSUE

It is commonly accepted that an accurate model of the plant to be controlled has to be made available before attempting to design a controller for the plant . A model is basically a set of mathematical equations that describe the input-output and internal state level relationships within the plant. Such a model is often difficult to identify accurately especially if the plant is highly non-linear. and there are parameters which vary over time due to external and environmental factors. Neural networks can be a highly efficacious tool for such identification.

Plant identification techniques with the use of neural networks (fig. 1) have been found to be far more accurate than conventional methods especially in nonlinear systems with varying parameters. Hence a neural network model would be preferable if a method of adaptive control such as MRAC was used.

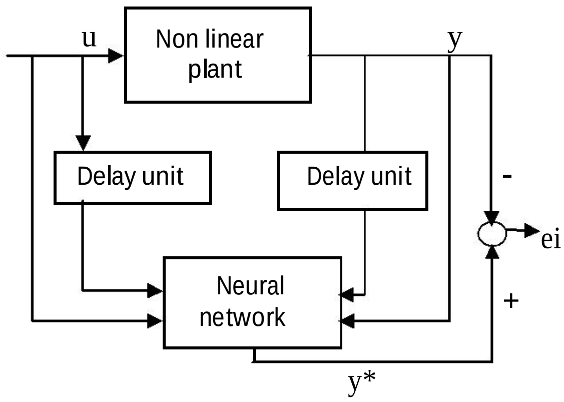

Fig 1: identification of a nonlinear plant with a neural network

MODEL REFERENCE ADAPTIVE CONTROL WITH NEURAL NETWORK

The procedure to adaptively control a nonlinear plant depends largely upon prior information available regarding the unknown plant. This includes knowledge of the bounds of the input and output signals u and y respectively. Control action must be initiated so that the plant output closely follows the output of a stable reference model.

Application of neural networks to the adaptive problem would mean that the weights of a network would be considered as elements of the controller parameter vector θ and the learning process involves determination of the vector θ^* this optimizes a performance index J based on the control error. Instead of using a standard feed forward neural net architecture that employs static back propagation for training, recurrent networks are preferred both in identification and adaptive control of dynamic nonlinear systems. Dynamic back propagation through a system consisting of recurrent neural networks and linear dynamic elements can be used to determine the gradient of J in parameter space. Based on the values of this gradient at every step, adjustment of θ would then take place. The identification model which is obtained using a neural network and delay lines (fig.1) can therefore be used to compute the partial derivatives of a performance index used for adjustment of the controller.

The application of neural networks to model reference adaptive control systems is a relatively new area of application as yet and scope for much work remains . Much of the current research today is upon the selection and use of appropriate learning algorithms for the adaptive adjustment of the controller on.

FUTURE DIRECTION

Control system growth and development is presented. Much work yet remains to be done in the development of adaptive neuro controllers: however researchers are already considering the design of systems that are a step ahead in terms of intelligence, namely controllers that can learn to improve their performance over time. It is still an open question as to which AI technology will gain precedence in the design of intelligent controllers of the future. Neuro control appears to be gaining ground and one of the areas where its application has achieved much success is the control of static and mobile robots. There are currently limitations in the generalization abilities of neural networks and work is being carried out to develop more efficient learning methods. Some researchers are looking at ensembles of neural networks in order to achieve better generalization. A fair prediction regarding intelligent controllers of the next century would be that they will be able to autonomously improve their performance co-line and to plan while they learn in order to achieve a desired goal.

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