A Survey on Control Techniques to Stabilize and Control the Non Linear System

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Abstract
For the past decades, neural network plays a main research highlights and it achieved many successful results from different aspects. It is significant to consolidate the latest knowledge and information to keep up with the research needs with this growing research trends. Stability and control of a nonlinear system represent an important system configuration that often arises in engineering practice. In this paper, the results of different learning algorithms of neural network to attain stability and to control the control parameters of the system are summarized.

Keywords: Neural Network, Propotional-Integral-Dervative Controller (PID), Fractional order Neural Network,

INTRODUCTION
Most systems encountered in practice are nonlinear to some extent due to inherent distortion introduced by the components of the system such as saturation or because they include intentionally introduced nonlinear effects. To develop a mathematical models for non-linear systems is a most important topic in many disciplines of engineering. Models can be used for analysis of the system’s behavior, better understanding of the underlying mechanisms in the system, design of new processes, design of controllers and simulations. In a control system the plant displaying nonlinearities has to be described accurately in order to design an effective controller. System Using Soft Computing Techniques 250 identification and is preferred in the cases where the plant or process involves extremely complex physical phenomena or exhibits strong nonlinearities. Artificial Neural Networks have been increasingly in use in many engineering fields. ANNs have proven superior learning and generalizing capabilities even on completely unknown systems that can only be described by its input-output characteristics. This paper surveys the recent theoretical results on the stabilization of nonlinear systems with unstable modes.

LITERATURE REVIEW
Jian Hana b et al, develops RBFNN for NN-based TILC(terminal iterative learning control) problem for nonlinear discrete-time system. RBFNN(Radial basis function Neural Network) is introduced to approximate the nonlinear controller directly instead of approximating the system itself. A quadratic index is used to generate the recursive estimation of the weights of RBFNN. In this paper both time-invariant input and time-varying inputs are considered. The proposed NN-based method is more suitable for nonlinear systems when it is compared with traditional ILC(Iterative learning control) method. The traditional ILC usually uses a P-type learning update law, while the learning gain is hard to tune without knowing prior knowledge. Whereas the proposed NN-based method provides robust compensation for the unknown nonlinearity and thus could ensure a bounded convergence of tracking error[7].

Guo-Qiang Zeng et al., says that the connection weight parameters plays an important roles in adjusting the performance of PID neural network (PIDNN) for complex control systems. This paper formulates this problem as a typical constrained optimization problem by minimizing the cumulative sum of the product of exponential time and the system errors, and a real-time penalty function for overshoots of the system outputs, and then proposes an adaptive population extremal optimization based (multivariable PID Neural Network) MPIDNN method for the optimal control issue of multivariable nonlinear control systems. From the perception of algorithm design, PEO-MPIDNN is simpler than other optimization algorithms-based MPIDNN such as RCGA-MPIDNN and PSO-MPIDNN due to its fewer adjustable parameters. Owing to difficulty of search for an optimal set of initial connection weights parameters in standard BP-MPIDNN, the proposed PEO-MPIDNN is considered as a promising evolutionary algorithm-based MPIDNN method for complex multivariable nonlinear control systems[6].

Shu Li et al., suggests that an adaptive predictive control algorithm is employed to control a class of continuous stirred tank reactor (CSTR) system. CSTR system are in discrete-time form and none-symmetric dead-zone inputs are considered. The unknown functions, dead zone are estimated and the mean value theorem is utilized in the algorithm design process by considering the Radial basis function neural networks (RBFNN). An adaptive fuzzy temperature controller is proposed for a class of CSTRs based on input-output feedback linearization, concentration dependent terms and to estimate other unknown system parameters. The stability of CSTR system is proved based on conventional Luenberger
observer. Based on the Lyapunov analysis method, the closed-loop system is proved to be SGUUB (semi-global uniformly ultimately bounded) and the tracking error is converged to a small compact set[13].

Moulay Rachid Douiri et al., proposed an Artificial Neural Network (ANN) based Direct Power Control (DPC) strategy for controlling power flow, and synchronizing Double Fed Induction Generator (DFIG) with grid and Voltage Oriented Control (VOC). The ANN system employs the individual training strategy with fixed-weight and supervised models in order to deal with the complex calculations in DPC. The proposed ANN-based scheme sustains much shorter execution times hence the errors caused by control time delays are minimized. The proposed ANN has to be trained as a part of the vector control system to estimate the grid-side and rotor-side converters reference voltages. The positive and advantageous aspects with the ANN-based controllers: transient regimes present small peaks, or absence of them in some cases; faster system responses, reaching the steady state condition in shorter time. ANN-based controllers are strong when it is compared to alternative linear controllers[8].

Rajesh Kumar et al. proposed an adaptive control of nonlinear dynamical systems using diagonal recurrent neural network (DRNN) in this paper. The structure of DRNN is a modification of fully connected recurrent neural network (FCRNN). DRNN gives an ability to capture the dynamic behavior of the nonlinear plant under consideration due to the presence of self-recurrent neurons in the hidden layer. Update rules are developed using lyapunov stability criterion to ensure stability of the system. These rules are used for adjusting the various parameters of DRNN. The responses of system obtained with DRNN are compared with the response of system obtained with multi-layer feed forward neural network (MLFFNN). Robustness of the proposed control scheme is also tested against parameter variations and disturbance signals[10].

Ying Yang et al., examines the stability of fractional-order neural networks (FNNs) without and with delay by the fractional Lyapunov direct method and the fractional Razumikhin-theorem. To handle the nonlinear constraints and to obtain a wider parameter selection of the systems, S-procedure is applied. For FNNs without delay, the improved less conservative conditions of the existence and uniqueness of the equilibrium point and the global Mittag-Leffler stability are all derived in the form of linear matrix inequalities (LMIs)[15].

Xinjun Wang et al, proposed an adaptive neural control method combined with backstepping technique and the radial basis function neural networks (RBFNNs) for a certain class of strict-feedback nonlinear systems subject to unmodeled dynamics, system uncertainties, completely unknown external disturbance and input dead zone. In recursive backstepping design, a dynamic signal is introduced to cope with the unmodeled dynamics and a disturbance observer is employed to approximate the unknown disturbance and also dead zone equalled to the sum of the simple linear system and the partial bounded disturbance. By using Lyapunov methods, the developed control scheme can ensure semi-globally uniformly ultimately bounded (SGUUB) of all signals within the closed-loop systems[14].

Alireza Abbaspour et al., developed a robust neural network adaptive control for polymer electrolyte membrane (PEM) fuel cells (FCs). Deviations between the partial pressure of hydrogen and oxygen in PEMFCs lead to serious membrane damage so it is required to design a robust and adaptive control to stabilize the partial pressure, which can significantly lengthen the lifetime of PEMFCs. A linear control with fixed gains cannot control the PEMFC system due to high nonlineairities in system parameters. In order to overcome the above said problem, a neural network adaptive control with feedback linearization is developed. With a feedback linearization control the performance is deviated in the presence of unknown dynamics and disturbances. Therefore, a robust adaptive neural network control is added to the feedback linearization control to reduce the deviation. The proposed control can significantly enhance the output performance as well as reject the disturbances [1].

Gabriel Villarrubia et al., states that the optimization problems often require the use of optimization methods that permit the minimization or maximization of certain objective functions. Problems that must be optimized are not linear so they cannot be precisely resolved, and they must be approximated. This work proposes, artificial neural networks (ANN) to approximate the objective function in optimization. The objective function is approximated by a non-linear regression that can be used to resolve an optimization problem. To resolve optimization problems in the cases where the use of linear programming or Lagrange multipliers is not feasible when neural network such as heuristics is used. To overcome this problems a multilayer perceptron is applied to approximate the objective functions[5].

Shoeb Hussain et al., developed a new neural network observer design for a three phase Induction Motor drive. Neural Network observers do not require the exact mathematical knowledge of the system. Therefore NN observer design is easy, parameters are independent and accurate. It reduces the computational problems associated with other observers as is the case with Extended Kalman filter, unscented Kalman filter etc. The speed control is attained by Fuzzy Logic controller. Simulation is carried out in MATLAB/Simulink for a three phase Induction Motor drive in order to verify the physical behavior of the system when subject to disturbances, change in load and speed[12].

Didi Susilo Budi Utomo et al, describes that Brushless DC (BLDC) motor control system is comprises of a multi-variable, non-linear, strong-coupling system, which is used to represent robust and adaptive abilities. Neural Control is an ANN (Artificial Neural Network) based control method, where the available data is the result of parameters measured from the dynamic behavior of the system. This capability is to be applied to adaptive control systems where the controller requires adaptation due to changes in system behavior. ANN is used to build the inverse model of BLDC motor speed. This model is used as a controller. In order to obtain good dynamic response, MRAC(Model Reference Adaptive Controller) is applied in this work[3].
BimalKantaSethi et al., defines that a Superheater temperature control for a circulating fluidized bed combustion (CFBC) is a challenging work due to factors affecting the temperature such as main steam flow, drum pressure, spray water flow, flue gas flow and temperature during plant operation. This paper, focuses on single input single output (SISO) system, where spray water flow is the manipulated variable &superheater temperature is the process variable. To control the temperature of a system through PID controller is not satisfactory due to large process lag and process non-linearities and presence of external disturbances. To overcome this problem, an Internal Model Control (IMC) using artificial neural network (ANN) is designed. ANN is obtained by training available plant input-output data of boiler. Parameters for ANN are optimized by Particle swarm optimization (PSO) algorithm[2].

Seema Agrawal et al., established an artificial neural network (ANN) based control algorithm to compensate harmonics and to improve power quality in three phase three wire shunt active power filter (SAPF) an is developed in this paper. System consists of three phase insulated gate bipolar transistors IGBT based current controlled voltage source inverter (CC-VSI), series coupling inductor and self-supported DC bus. Non-linear loads causes power quality problem. In order to overcome this problem, SAPF is used to improve power quality. A new ANN based fundamental extraction based on Lavenberg Marquardt back propagation algorithm is proposed to improve power quality. Feed forward MNN and ADALINE are most commonly used ANN structures for self-learning[11].

R J Rajesh et al., states that the nonlinear process control is a challenging and difficult task in process industries due to its non-linear behavior, delays and time variation between inputs and outputs of system.level control in conical tank is a complex task due to its constantly changing cross section area. So, Artificial Neural network (ANN) based controller is designed, since it has ability to model nonlinear systems and its inverses. The Direct Inverse Control (DIC) designed using ANN is mainly dependent on the inverse response of the system. In this paper, ANN based DIC is trained by Levenberg Marquardt Back propagation algorithm and it helps to obtain optimized performance of the system[9].

E. Anderlini et al, developed a model-free algorithm for reactive control of a wave energy converter. Artificial neural network is used to map the significant wave height, wave energy period, and the power take-off damping and stiffness coefficients to the mean absorbed power and maximum displacement. A Multistart optimization is employed, which uses the neural networks within the cost function. The aim of the optimization is to maximise energy absorption, whilst limiting the displacement to prevent failures. Once training has occurred, the algorithm presents a similar power absorption to state-of-the-art reactive control. It also does dispensing with the model of the point-absorber dynamics to remove its associated inaccuracies and it enables the controller to adapt to variations in the machine response caused by ageing[4].

CONCLUSION

Neural network systems can be used to solve difficult real-world problems. To control dynamical systems using neural network is a very abundant area of research, because of the excellent results that can be achieved without using complex mathematical models.Experimental work has to be done to test different combinations of soft computing techniques to decide which will be the best for a particular problem. The stability analysis of neural network based non-linear controllers is discussed in this work. This review presents an overall summary on the various learning techniques of neural network and its challenges to stabilize and control the nonlinear systems.

REFERENCES


IEEE International Conference on Computer, Communication and Control.


