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Tuning of PID Controller Parameters with Neurofuzzy Technology

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Abstract- In the area of process control engineering, PID controller plays a very vital role, which can be used as a process controller for the general industrial processes like liquid level, temperature, pressure, flow, and etc. Most of the research papers in the area of process control deals with setting up of these PID controller gains. There were many tuning algorithms evolved starting from the famous Ziegler - Nichols in 1942. But, still it is a major challenge for setting of PID controller gains. Also, since PID controller is an off-line controller, the gains are set in offline and then the controller is put in to the process loop. Hence this conventional off-line PID controller cannot cope up with the online process variations due to the non-linear disturbances/ noises. Hence PID controller is associated with poor disturbance rejection. Based on these typical challenges from the conventional tuning methods, the paper proposes an original philosophy of providing ± 10% disturbance rejection feature to the PID controller. The novelty used in the design is automatic tuning of PID controller gains by the use of intelligent predictors like Artificial Neural Networks (ANN)[5].This provides the facility of online automatic tuning of PID controller gains and so, good disturbance rejection for the system. The whole system is modelled and simulated by using MATLAB/Simulink software. The results show that the system has good disturbance rejection up to ± 10% with the proposed control strategy.

Keywords- *PID Controller, Neurofuzzy Technology, Fuzzyfication.*

1. Introduction

Background

With reference to a real industrial application of process control, some considerations are discussed concerning the accuracy of methods for auto-tuning of proportional, integral and derivative factor (PID) [3]. In particular, a theoretical–experimental approach is described, that allows to evaluate the adequateness of new methods for auto-tuning of PID, able to significantly reduce the time duration for auto-tuning with respect to traditional ones. This result has been achieved by using suitable techniques of experimental data processing, based on neural-networks algorithms, set for this specific application. The effect on described methodology of environmental and operating disturbances is also described.

2. Technological Background

Tuning of PID controllers has always been an area of active interest in the process control industry. Ziegler Nichols Method (ZN) is one of the best conventional methods of tuning available now. Though ZN tunes systems very optimally, a better performance is needed for very fine response and this is obtained by using Fuzzy Logic (FL) methodology which is highly effective. The FL methodology used in this paper is applied in the form of Fuzzy Set Point Weighting Controller (FSPWC) [2] The idea of multiplying the set-point value for the proportional action by a constant parameter less than one is effective in reducing the overshoot but has the drawback of increasing the rise time. To achieve both the aims of reducing the overshoot and decreasing the rise time, a fuzzy module can be used to modify the weight depending on the current output error and its time derivative. Thus by using FSPWC, which was suggested by Antonio Visioli and modifying it in accordance to our desired performance criteria, simulation of the FSPWC is performed in MATLAB to obtain desired results.

3. Objective of Project

In this paper, A combination of neural networks and fuzzy logic offers the possibility of solving tuning problems and design difficulties of fuzzy logic [10]. The resulting network will be more transparent and can be easily recognized in the form of fuzzy logic control rules or sem In this paper, a neuro-fuzzy controller architecture is proposed, which is an improvement over the existing neuro fuzzy controllers. It overcomes the major drawbacks of the existing neuro-fuzzy approaches; of either keeping neural networks and fuzzy logic as separate entities (co-operative models) working towards a common goal or in most of the existing neurofuzzy [5] approaches, the trained controller no longer can be interpreted as fuzzy logic controller. The novelty of this scheme is that the fuzzy controller itself is interpreted as a neural network. So,an error in the resulting control value can be distributed back among the control rules, instead of the integrating neural networks in certain parts of the controller, acting as black boxes to optimize the weights. One of the objective of this paper is to understand adaptation of the membership functions as a reverse mechanism deduced from the forwarding inference machinery of the fuzzy logic controller. The architecture and the learning algorithm of a proportional fuzzy controller (PFLC) is presented.

4. Neuro-Fuzzy Controller

We consider a multi-input, single-output dynamic system whose states at any instant can be defined by "n" variables X1, X2,...,Xn. The control action that derives the system to a desired state can be described by a well known concept of "if-then" rules, where input variables are first transformed into their respective linguistic variables, also called fuzzification. Then, conjunction of these rules, called inferencing process, determines the linguistic value for the output. This linguistic value of the output also called fuzzified output is then converted to a crisp value by using defuzzification scheme. All rules in this architecture are evaluated in parallel to generate the final output fuzzy set, which is then defuzzified to get the crisp output value [9] The conjunction of fuzzified inputs is usually done by either min or product operation (we use product operation) and for generating the output max or sum operation is generally used. For defuzzification, we have used simplified reasoning method, also known as modified center of area method. For simplicity, triangular fuzzy sets will be used for both input and output. The whole working and analysis of fuzzy controller is dependent on the following constraints on fuzzification, defuzzification and the knowledge base of an FLC, which give a linear approximation of most FLC implementations.

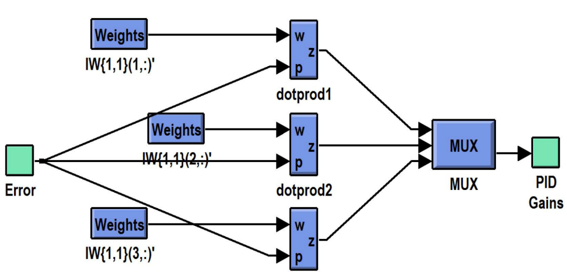

Fig. 1

CONSTRAINT 1: The fuzzification [4] process uses the triangular membership function.

CONSTRAINT 2: The width of a fuzzy set extends to the peak value of each adjacent fuzzy set and vice versa. The sum of the membership values over the interval between two adjacent sets will be one. Therefore, the sum of all membership values over the universe of discourse at any instant for a control variable will alwaysbe equal to one. This constraint is commonly referred to as fuzz fuzzy [11] partitioning.

CONSTRAINT 3: The defuzzification method used is the modified center of area method. This method is similar to obtaining a weighted average of all possible output values.

An example of a very simple neuro fuzzy controller [12] with just four rules is depicted in Figure This architecture can be readily understood as a "neural-like" architecture. At the same time, it can be easily interpreted as a fuzzy logic controller. The modules X1 and X2 represent the input 4 variables that describe the state of the system to be controlled. These modules deliver crisp input values to the respective membership modules (modules) which contain definitions of membership functions and basically fuzzify the input. Now, both the inputs are in the form of linguistic variables and membership associated with the respective linguistic variables. The -modules are further connected to R-modules which represent the rule base of the controller, also known as the knowledge base. Each -module gives to its connected R-modules, the membership value (xi) ofthe input variable Xi associated with that particular linguistic variable or the input fuzzy set.

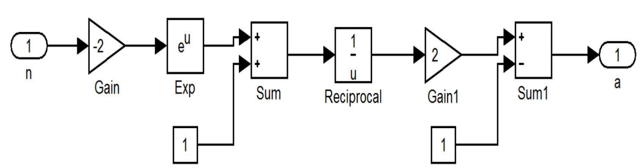

Fig.2

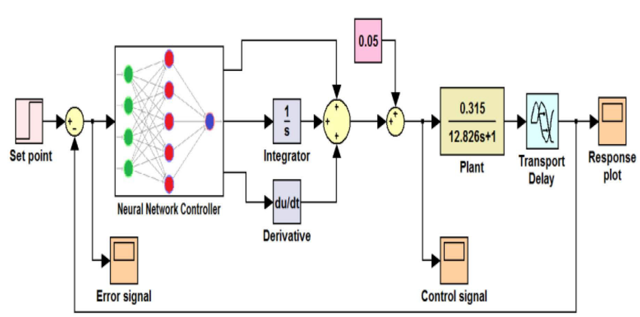

Fig.3

3. Conclusion

In this paper the major drawback of conventional PID controller is addressed. That is PID controller is an offline controller, tuned one time and put in the control loop, need to correct different variations of errors. A single tuned PID controller can't control the nonlinear variations in the error caused with respects to various disturbances/noises. So, we need a facility that can tune the PID gains online to overcome the effect of disturbances on the system. Hence, the proposed ANN based PID controller can tune the PID parameters online with respect to the error variations and so, effectively provide disturbance rejection. Hence, theproposal increases the system stability.

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