# Design and Analysis of Type-2 Fuzzy PID Controller Using Genetic Algorithm

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***Abstract*** **:** Type-2 fuzzy logic systems have recently been utilized in many control processes due to their ability to model uncertainty. This research article proposes the temperature control . The proposed algorithm of this article lies in the application of a genetic algorithm interval type-2 fuzzy logic controller (GAIT2FLC) in the design of fuzzy controller for temperature control . The entire system has been modeled using MATLAB R2013b. The performance of the proposed GAIT2FLC is compared with corresponding conventional type-2 FLC in terms of several performance measures such as , settling time, integral absolute error (IAE) and in each case, the proposed scheme shows improved performance over its conventional counterpart. Extensive simulation studies are conducted to compare the response of the given system with the conventional type-2 fuzzy controller to the response given with the proposed GAIT2FLC scheme.

***Keywords***- *Genetic Algorithm(GA), Type-2 fuzzy PID , GA Interval type-2 (GAIT2FLC).*

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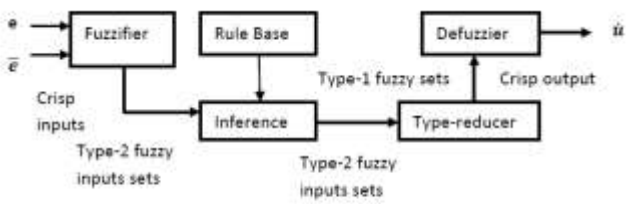
## INTRODUCTION:

### 1. Interval Type-2 Fuzzy Logic Systems (IT2FLS)

In recent years, fuzzy logic has emerged as a powerful tool and is starting to be used in various power system applications. Fuzzy logic can be an alternative to classical control. It allows one to design a controller using linguistic rules without knowing the mathematical model of the plant. This makes fuzzy-logic controller very attractive systems with uncertain parameters. The linguistic rule necessary for designing a fuzzy-logic controller may be obtained directly from the operator who has enough knowledge of the response of the system under various operating conditions. The inference mechanism of the fuzzy-logic controller is represented by a decision table, which is consists of linguistic IF-THEN rule. The fuzzy logic approach makes the design of a controller possible, without knowing the mathematical (exact) model of the plant. Interval Type-2 fuzzy sets, characterized by membership grades that are themselves fuzzy, were introduced by Zadeh in 1975 to better handle uncertainties. Fuzzy logic systems constructed using rule bases that utilize at least one interval type-2 fuzzy sets are called interval type-2 FLSs. Since the FOU of a type-2 fuzzy set provides an extra mathematical dimension, type-2 FLSs can better handle system uncertainties and have the potential to outperform their type-1 counterparts. A type-1 fuzzy system consists of four major parts: fuzzifier, rule base, inference engine and defuzzifier. A type-2 fuzzy system has a similar structure, but one of the major differences can be seen in the rule base part, where a type-2 rule basehas antecedents and consequents using Type-2 Fuzzy Sets (T2FS). In a T2FS, we consider a Gaussian function with a known standard deviation, while the mean (m) varies between m1 and m2.Because of using such a uniform weighting, we name the T2FS as an Interval Type-2 Fuzzy Set (IT2FS). Utilizing a rule base which consists of IT2FSs, the output of the inference engine will also be a T2FS and hence we need a type-reducer to convert it to a type-1 fuzzy set before defuzzification can be carried out. Fig.3 shows the main structure of type-2 FLS




FIG(1): Interval Type-2 Fuzzy Logic Systems (IT2FLS)

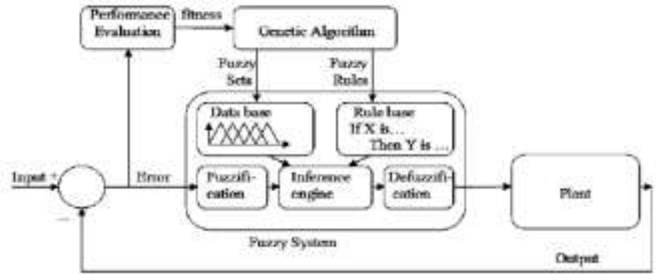
## 2. Genetic Algorithm-based parameter

Learning GAs is optimization technique for the natural selection, which consists of three operations, namely, reproduction, crossover, and mutation [Fleming et al (2002)]. The most general considerations about GA can be stated as follows:

1. The searching procedure of the GA starts from multiple initial states simultaneously and proceeds in all of the parameter subspaces simultaneously.
2. GA requires almost no prior knowledge of the concerned system, which enables it to deal with the completely unknown systems that other optimization methods may fail.
3. GA cannot evaluate the performance of a system properly at one step. For this reason, it can generally not be used as an on-line optimization strategy and is more suitable for fuzzy modeling.

## 3. Genetic Fuzzy Systems

The genetic fuzzy systems are primarily used to automate the knowledge acquisition step in fuzzy system designThe optimization criterion is the problem to be solved at hand and the search space is the set of parameters that code the membership functions, fuzzy rules and fuzzy rule-weights. The Fig.1 represents a genetic fuzzy system




FIG(2): Genetic Fuzzy Systems

## RELATED WORK :

Ahmet Sakalli, Tufan Kumbasar, M.Furkan Dodurka, Engin Yesil discussed with a simple interval Type-2 Fuzzy PID controller . In this paper analysis the structure of simplest IT2-FPID by using KM algorithm . The structure of ST1T2-FPID is compared with IT2-FPID , T1-FPID and hybrid fuzzy pid on the basis of stimulation result . The outcome of the study shows that, the advantage of the proposed STIT2-FPID structure is related to hybrid nature of the self-tuning structure because it benefits the advantages of the T1-FPID and IT2-FPID controllers by changing the size of the FOU in an online manner .This paper also the work on the tuning the fuzzy PID for enhance the transient state and disturbance rejection performance . This indicate tuning mechanism will improve the result . [1]

Jouda Arfaoui , ElyesFeki , Abdelkader Mami have Discussed the Genetic algorithm which is generally used in the various best possible problems . This paper propose an another method for designing fuzzy logic controller for temperature control inside the cavity of refrigeration. This paper compare the result of GA FLC with Conventional PID and GA PID with respect to stability ,settling time and energy consumption . The result of this paper shows GA-FLC has good response compare with the other. GA_FLC reduced the consumption energy of about 1.3401kWh.[2]

Ahmet Taskin and Tufan Kumbasar has discuss an open source Matlab / Simulink Toolbox foThe main goal of this paper is to introduce the research community with a free open source Matlab/Simulink toolbox for the development of IT2-FLSs for a wider accessibility to users beyond the fuzzy logic community. We have reviewed the main features of the current toolkit, including the support for a GUI for an easy design, various IT2-FS constructionsr interval Type-2 Fuzzy Logic Systems .[3]

## CONTRIBUTION OF THIS PAPER:

In this paper we are design type-2 fuzzy PID and Genetic algorithm base type-2 fuzzy pid , for design of fuzzy pid we are design membership function for temperature control application and analyzed the result , the result is analyses by stimulation base.

## RESULT ANALSIS:

### (A)TYPE-2FPID

First we analyze the result of TYPE-2 FPID without GA , with the input temperature 30 and Reference temperature 20, we observe that output will be set at 32.6 and time required is 5sec in fig 3(a). So the error obtain is 12.6 that will be observed in fig 3(b)

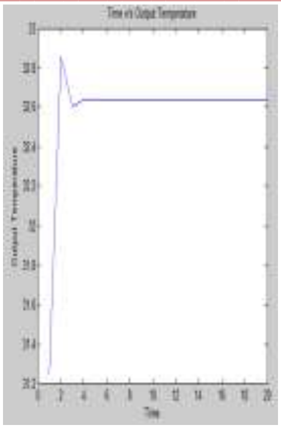


Fig: 3(a)

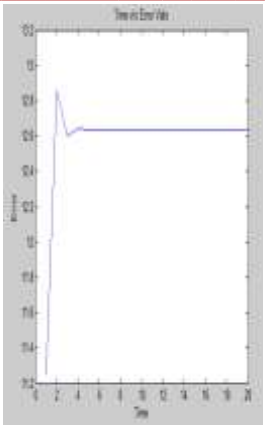


Fig: 3(b)

Fig 3(a) Time v/s output temp.

3(b) Time v/s Error.

**(B) GATYPE-2FPID**

Now we observed the result of Genetic Algorithm base TYPE-2 FUZZY PID (GA-TYPE-2), with the same input and reference temperature; that is input temperature 30 and Reference temperature 20. We observe that output temperature is set at 20.3 within 9sec shown in fig 4(a), so the error obtain is 0.3 shown in fig 4(b).

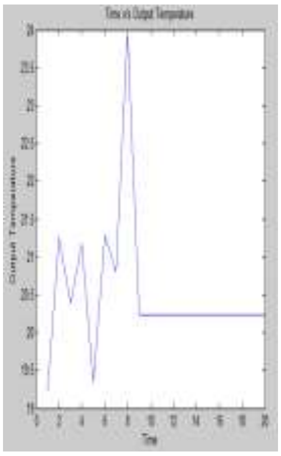
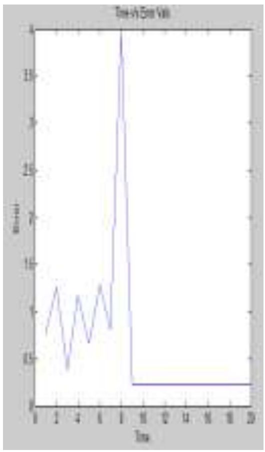


Fig. 4(a)



4(b)

Fig 3(a) Time v/s output temp.

3(b) Time v/s Error

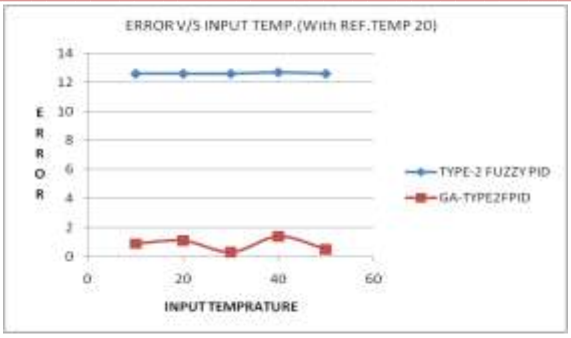
**Table No.1:** Comparison with input and reference temperature

| ANALYSIS OF TYPE-2 FUZZY PID AND GA BASE TYPE-2 FUZZY PID | | |
|---|---|---|
| INPUT TEMP.=30 REFFERENCE TEMP= | | |
| | TYPE-2 | GATYPE-2 |
| ERROR | 12.6 | 0.5 |
| TIME | 6sec | 9sec |
| INPUT TEMP.= 30 REFFERENCE TEMP = 20 | | |
| | TYPE-2 | GATYPE-2 |
| ERROR | 12.6 | 0.3 |
| TIME | 5sec | 9sec |
| INPUT TEMP.=30 REFFERENCE TEMP= 20 | | |
| | TYPE-2 | GATYPE-2 |
| ERROR | 8.2 | 0.4 |
| TIME | 5sec | 9sec |
| INPUT TEMP.=30 REFFERENCE TEMP= 20 | | |
| | TYPE-2 | GATYPE-2 |
| ERROR | 8.2 | 1.4 |
| TIME | 3sec | 9sec |

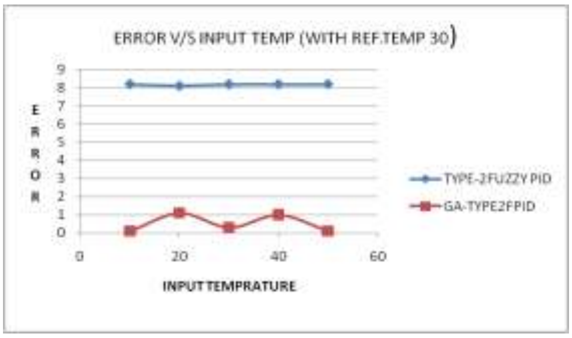
Table 1 shows the Analysis of TYPE-2FPID With GATYPE-2 , by taking different input and Reference temperature we are observe that error is minimize ,more than 95% error can be minimize but comparatively some settling time will be increase.

The complete analysis is observed with different input temperature , Fig(5) & Fig(6)

Shows the graph of error verses input temperature with reference temperature 20 and 30 , in both the graph we clearly observe that error in TYPE-2FPID is more than the GATYPE-2 ,error in TYPE-2FPID is in range 12 to 13, that can be minimize in GA-TYPE-2 FPID with error in range 0.5 to 1.5.




**Fig(5):** Error v/s input temperature with Reference temperature -20




**Fig(6):** Error v/s input temperature with Reference temperature -30

**CONCLUSION**:

In this paper a Genetically tuned interval type-2 fuzzy PID (GT-IT2FPIDC) type controller is proposed for increase the accuracy of the controller .In order to reduce design effort and find better fuzzy system control, a GA with a strong ability to find the most optimistic results algorithm has been used to fuzzy controller rule bases. The aim is to reduce fuzzy system effort, find a better fuzzy system control and take large parametric uncertainties into account. The effectiveness of the proposed method is analyzed my taking different input and reference temperature . The simulation results show that with the use of GT-IT2FPIDC improved the result than conventional. More than 90% error is minimized my Genetic algorithm but comparatively some settling time will be increase .

In a system if you want more accuracy and time is not important then Genetic algorithm is best.

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