Moth-Flame Optimizer Algorithm For Optimal Of Fuzzy Logic Controller for nonlinear system

AHMED BENNAOUI 1,*, AISSA AMEUR 2, AND SLAMI SAADI 3
Laboratoire des semi-coducteurs et des matériaux fonctionnels , University of Amar Telidji, Laghouat, Algeria.

Abstract

The Moth-Flame Optimizer Algorithm (MFO) is one of the modern meta-heuristic optlmlzation techniques . In this paper, The Moth-Flame Optimizer algorithm has been utilized to find the optimal parameters of membership functions of fuzzy logic controller for nonlinear systems .The results demonstrated that producing optimum membership functions by Moth-flame optimization algorithm gives better performances.

Introduction

The control of nonlinear systems is a difficult and complex task and generally requires an adequate model to describe the totality of the behaviors of the system. In the absence of this type of model, it is necessary to use either control strategies insensitive to the uncertainties of the model, or non-parametric techniques that do not require the availability of a mathematical model of the process. The fuzzy command is part of the last class and can be an alternative. In 1974, M. Mamdani made the first application in the regulation of industrial processes, then other applications are made by Sugneo (1985). Then fuzzy controllers are adopted using the analogy with the classical PID [1,2] and combinations with other types of control such as sliding mode [3,4]. Fuzzy logic is widely used in dc-dc con-verter controls [5,6, 7,8], and presents effective and rigorous results. There are many studies use optimization algorithms of tuning the membership function parameters of Fuzzy logic controller such as[9][10] .. one of the most new algorithms that developed by Seyedali Mirjalili[12] is Moth-Flame Optimization technique. The Moth Flame Optimization (MFO) Introduced by (Mir-jalili, 2015) [11][12][13], MFO is a new nature-inspired algo-rithm is proposed to compete with current optimization algo-rithms. The main inspiration of this proposed algorithm is the mechanism of navigation of moths in nature called transverse orientation, where butterflies fly at a constant angle to a dis-tant light source, As shown in Figure 6,. However, if the light is extremely close (Flames) to the butterflies, we observe that the butterflies are spiraling around it in a search space and the flames are the best position of the butterflies obtained, shown in Figure7 [11)][12][13], . Butterflies and flames are seen as a solution, while they differ in their analysis and update.

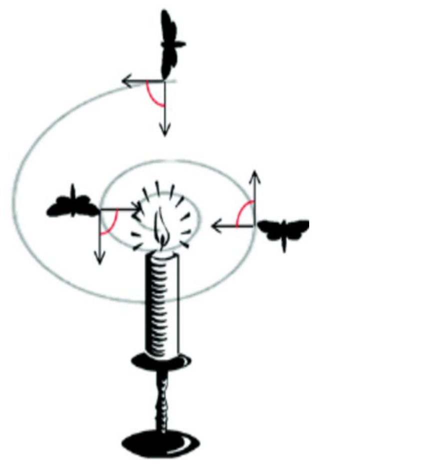

Fig 2.Spiral flying path around close light sources

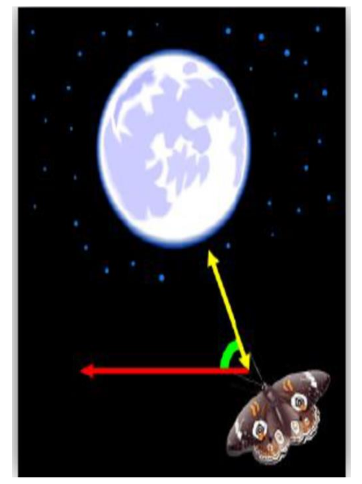

Fig 1.Transverse orientation

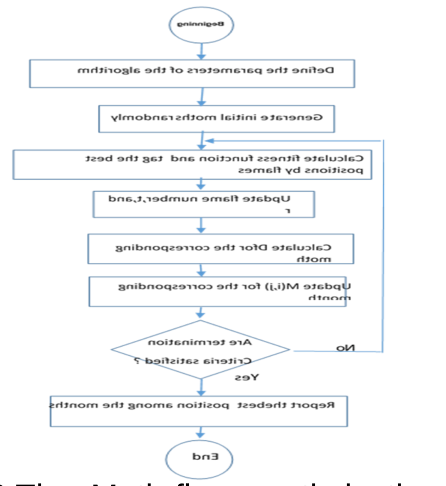

Fig 3.The Moth-flame optimization (MFO) Algorithm flowchart

Fuzzy Logic Controller for nonlinear system

The fuzzy logic control theory was first introduced by Zadeh [13] in 1965. fuzzy logic control is not based on a mathematical model and is widely used to solve problems under uncertain and pvague environments with high nonlinearities fuzzy logic control has been successfully appliedin many areas[14], [15], [16],[17],[18] [19, 20]. etc. fuzzy logic control has three main components such as: fuzzification, fuzzy inference engine (decision logic), and defuzzification stages A Fuzzy Controller is characterised by inputs and outputs are correlated by Membership Functions (MF). In this case there are The two input fuzzy sets The error (e) and the change of error (de) are composed of three membership functions : Negative(N), Nule(Z) and Positive(P). The output fuzzy set is composedof fivemembership functions :Negative High(GN),Negative(N), Nule(Z) and Positive(P),Positive High (GP)[21]

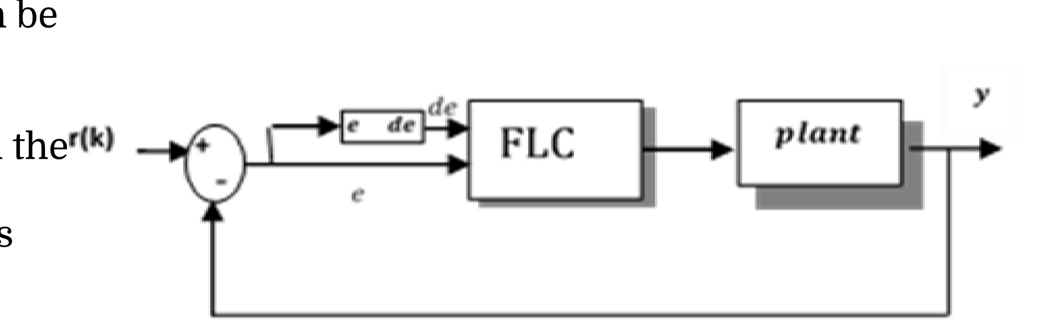

Fig 4.Fuzzy Logic Controller for nonlinear system

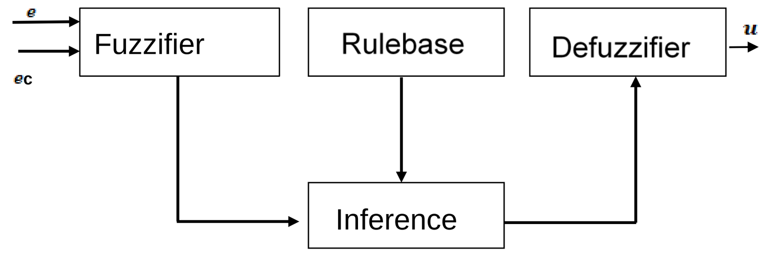

Fig 5.The fuzzy logic controller(FLC)

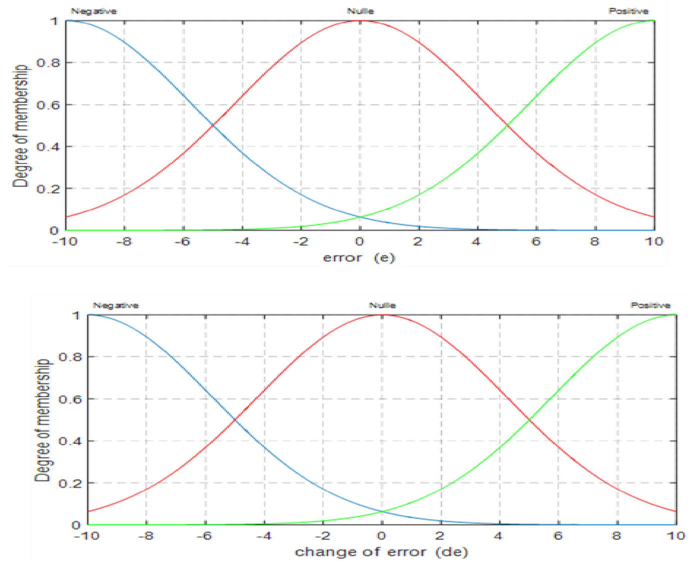

Fig 6.The inputs fuzzy sets (e and de) [21]

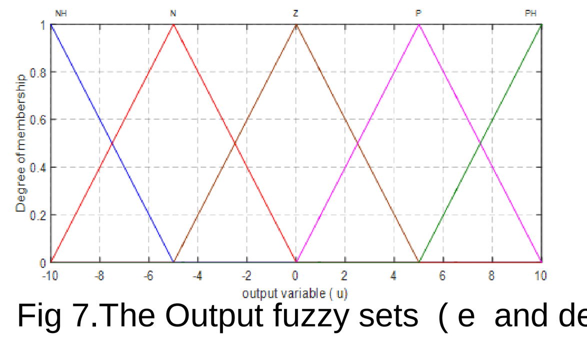

Fig 7.The Output fuzzy sets (e and de) [21]

Table 1 Rules and Output Membership Functions[21]

e ↓ de →	Negative	Nule	Positive
Negative	PH	P	Z
Nule	P	Z	N
Positive	Z	N	NH

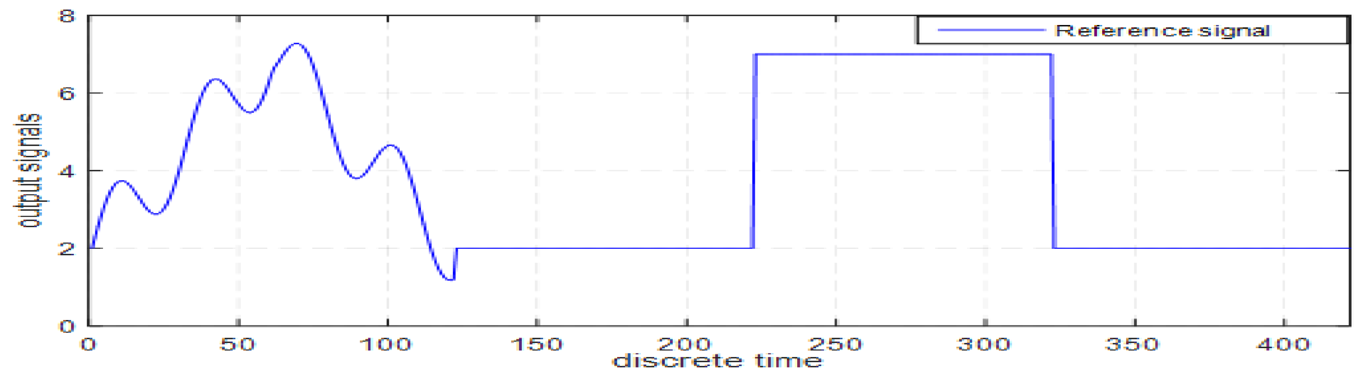

Fig 8.Reference signal [21]

Results

we proposed using MFO optimization algorithms for tuning the choice of The inputs and The Outputs Membership Funcions of FLC weare taken as The fitness function following:

Cost Function $= \mathrm{ISE} = \int_0^{+\infty} [e(t)]^2 \, dt$,Where :ISE is Integral Square Error

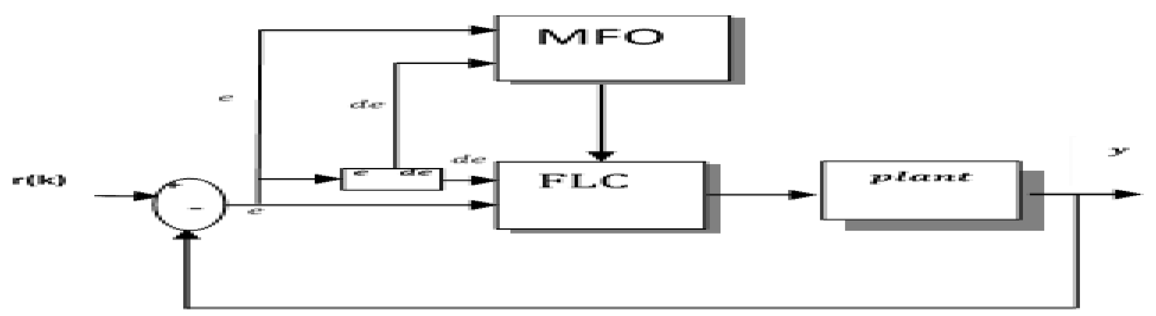

Fig 9.Fuzzy Logic Controller with MFO for nonlinear system

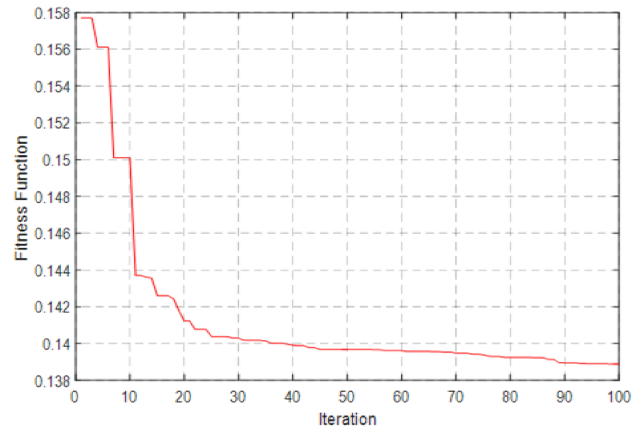

Fig 10.Iterative convergence curve (MFO)

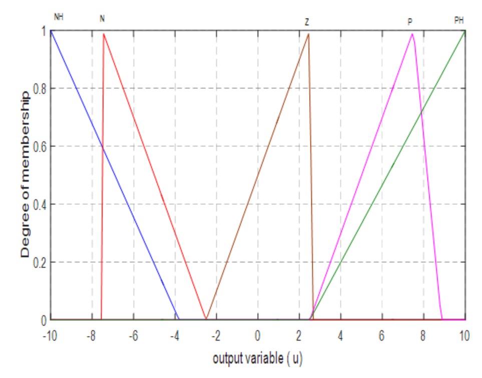

Fig 12.The optimal Output fuzzy sets with MFO

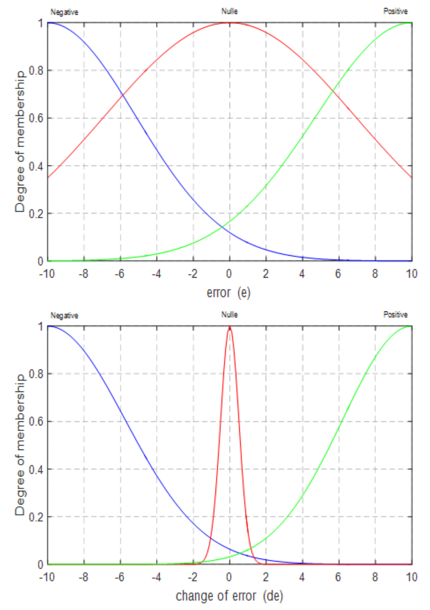

Fig 11.The optimal inputs fuzzy sets (e and de) with MFO

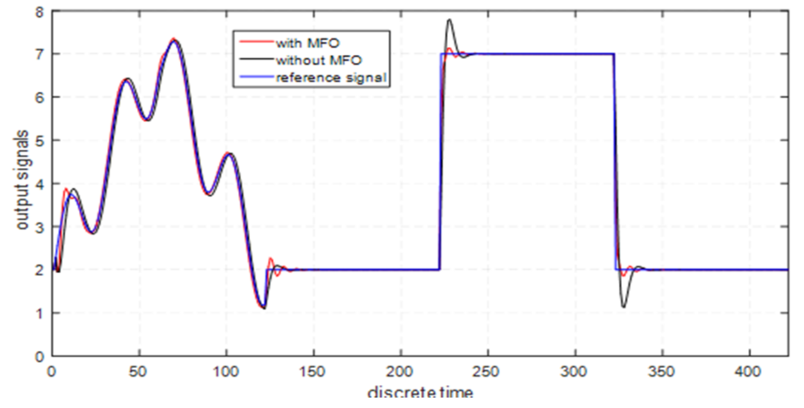

Fig 13.The output signals

Table 2.Performance comparison between FLC with MFO,and FLC without MFO

	ISE
FLC With MFO	0.1389
FLC Without MFO	0.2362

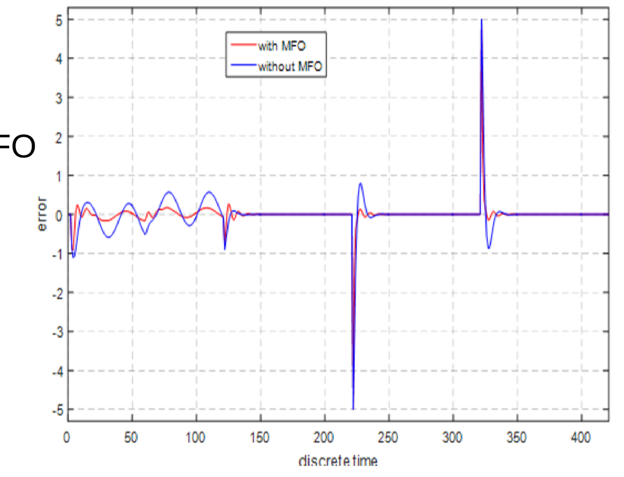

Fig 14.The error

Conclusion

In this work,, we propose using The Moth-Flame Optimizer (MFO) algorithm for Optimal the parameters of fuzzy logic con-troller for nonlinear system . simulation results show the fuzzy logic controller with MFO has excellent performance on: achieve lower the integral of square of errors (ISE) comparing with FLC without MFO

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