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Implementation enhancement of AVR control system within optimization techniques

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Abstract

In this research, Jaya optimization algorithm has been introduced to develop and enhance the performance of the Automatic Voltage Regular system that known as (AVR) system with proposed techniques equilibrium optimizer and rider optimization algorithm which is contributed as additional algorithms to assist PID controller to find the optimum values for the controller in order to improve the performance of the AVR control system to achieve high stability and best for both rising times and settling time and these the best coefficients that made the proposed system work in the greatest performance in addition to that the step response on AVR control system also has been presented in this research and all these techniques implemented on MATLAB Simulink with optimized techniques.

Keywords: PID Controller, Jaya Optimization Algorithm, Automatic Voltage Regulator System, Rider Optimization Algorithm, MATLAB.

1. Introduction

The AVR control system is one of proposed system that can solve many problems like voltage stability which is the main issue that the researchers previously tried to solve it by using many techniques, in general background on the proposed system [1, 2, 3, 4, 5, 6, 7, 8, 9], that consists of four types that based on the main equipment like amplifier which is increase the voltage signal more than one times in order to give the optimum voltage for the overall circuit and exciter that work as alarm which the voltage arrive to the high bad performance and the generator that give the optimum

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voltage when make initialization and finally sensor when the proposed system arrive to high or low voltage to send feedback [10, 20]. According to this research that combines of four main important equipment, amplifier that make increase the voltage many times, exciter which is make alarm sound when arrive to bad performance in order to give notification to the generator, generator when get the suitable stability from exciter to generate the required voltage to the system, sensor which is responsible for performance to send feedback again to the amplifier to repeat the process.
high unstable of voltage, maximum overshooting and rising time these the main the issues lead to motivation system efficiency and may reduce the performance unless solve these problems.

The main objective of this current proposed research was to develop and improve an automatic voltage regulator system using equilibrium optimizer, rider optimization algorithm, jaya optimization algorithm which is belong to the swarm intelligent family of artificial intelligent algorithms. The following were implemented on proposed article:

1. Analysis of the required performance for enhance an electro hydraulic position servo control system and high stability on both hydraulic valve and amplifier servos.
2. Modelling and improvement of an electro hydraulic position servo control system and achieve high step response of change for the current project.
3. Implementation of the enhanced system based on MATLAB Simulink platform version R2021a.

2. Related Work

In this literature, the following researchers had been made enhancement on the AVR control system are shown below respectively. In(2017) [8] discussed the evaluation of Automatic Voltage Regulator(AVR) control system, in use DE-optimization algorithm compared with the conventional proportional integral derivative controller (PID) with the overshooting 32.8537%, Ts(sec) 2.6495, Tr(sec) 0.1516 using MATLAB-SIMULINK.
In(2017) [8] evaluated the Automatic Voltage Regulator(AVR) system. Use the Particle Swarm Optimization (PSO) technique to get the optimum solution for the proportional derivative controller (PID) with tuning with the overshooting 18.8183%, Ts(sec) 3.3994, Tr(sec) 0.1493 using MATLAB-SIMULINK.
In(2017) [8] illustrated the tuning behavior of the Automatic Voltage Regulator(AVR) system in Use ABC technique that tuned with the PID controller and improved as the best technique that used in this study that other and also improved in the comparison with the overshooting 25.0071%, Ts(sec) 3.0939, Tr(sec) 0.1557 using MATLAB-SIMULINK.
In(2018) [9] Studied the Automatic Voltage Regulator control system in using the GOA with the conventional proportional integral derivative controller that enhanced in use GOA optimization technique with the overshooting 20.5306%, Ts(sec) 0.9706, Tr(sec) 0.13 using MATLAB-SIMULINK.
In(2019) [11] Enhanced the Automatic Voltage Regulator control system in using the BBO with the conventional proportional integral derivative controller that improved in the use of the BBO optimization technique with the overshooting 15.5187%, Ts(sec) 1.4457, Tr(sec) 0.1485 using MATLAB-SIMULINK.

3. The Mathematical Model of the AVR Control System

The automatic voltage regulator system can be express its mathematical equations as separated equations can deals as a non-linear system so should make partitions for it as the following. The first of them is amplifier so the sin wave enlargement it as the amplifier system and transfer function

in SIMULINK for the amplifier, exciter, generator [12, 14, 15, 16], the sensor can be shown below respectively:
The transfer function for the amplifier

$$G^A = \frac{K_A}{1 + ST_A} \tag{3.1}$$

The transfer function for the exciter

$$G^E = \frac{K_E}{1 + ST_E} \tag{3.2}$$

The transfer function for the generator

$$G^G = \frac{K_G}{1 + ST_G} \tag{3.3}$$

The transfer function for the sensor

$$G^S = \frac{K_S}{1 + ST_S} \tag{3.4}$$

The completed AVR control system in MATLAB SIMULINK that built as the figure below:

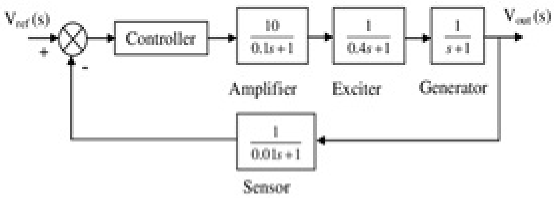

Figure 1: AVR Control System with PID Controller[8]

4. The Optimized Technique

The methodology of the Rider Optimization Algorithm had inspired from four persons for Racing Car when they looking's for the best one among them to win the race all of Riders they looking for the best position depend on their fitness function so the lower weight (Best One) between them it will be win for find the best position(the first one that won the race) and then it will compare between this best position and the global best position(among Riders) and which one between them it the best so it will be take it and after that the best among Riders can take its parameters to use in Proposed system and can win to go in the target and the mechanism of the technique can shown in the Figure 2 [21, 26].

The following general equation could used to update the rider optimization positions to be appropriate to the values that entry to the controller and to make it give the optimum three coefficients for the P-I-D controller, the modification can shown below in the followin

$$pos\_dir = i * 360/indiv \tag{4.1}$$

Figure 2: The Mechanism of the ROA Method.

Table 1: ROA parameters for the AVR control system with PID controller.

The Parameters for The ROA algorithm	*The values*
Number of iterations	*1000*
indiv	*2*
dim	*2*
num_gear	*5*

The best position will replace to the Maximum of individuals for riders, which recommends the rigid outcome restricted by the full scale circle for the riders, which approximates 360 a more noteworthy number of than four quartiles. The best one rushes to execute the most fitting reaction for the proposed Implemented design.

5. Results and Analysis

The P-I-D controller has been utilized in the A-V-R system as the ideal answer for utilize the essential components kp and ki and kd relying upon past investigations that present a correlation between past calculations with another Novel proposed three optimized algorithms these boundaries of PID Controller, transient reaction and generally examination that displayed beneath individually. The experiments implemented with MATLAB Simulink platform and the tests prove that automatic voltage regulator system can be developed much better with three optimized algorithms with the utilize of proportional integral derivative controller. Figure 3 that describe the step response of change for equilibrium optimizer implemented on an automatic voltage regulator system with P-I-D parameters 1.2697,0.8338,0.3429 respectively. And step response of change for maximum overshooting, rising time, settling time 18.6755%,0.9556,0.1229 which is based on proposed methods and previous algorithms parameters selection as in Table 2

Figure 4 that describe the step response of change for rider optimization algorithm implemented on an automatic voltage regulator system with P-I-D parameters 0.7823,0.5631,0.1991 respectively and step response of change for maximum overshooting, rising time, settling time 10.3161%,0.9324,0.1065 that shown below:

Figure 5 that describe the step response of change for jaya optimization algorithm implemented on an automatic voltage regulator system with P-I-D parameters 0.2832,0.1919,0.0681 respectively and step response of change for maximum overshooting, rising time, settling time 0%,0.9235,0.0967 that shown below:

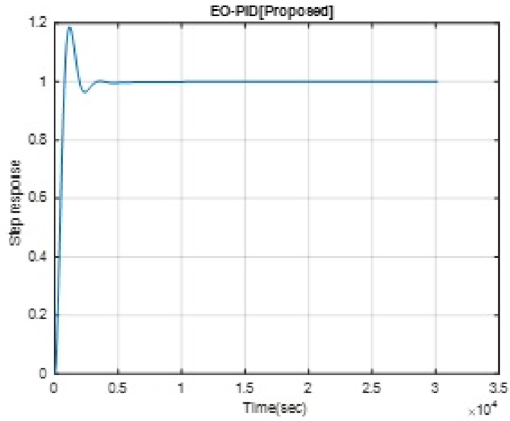

Figure 3: The step response of the equilibrium optimizer with PID controller on AVR control system.

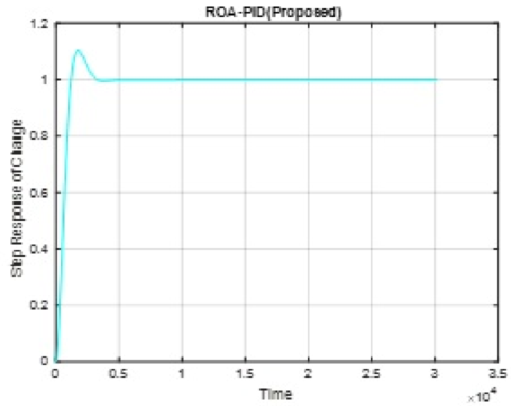

Figure 4: The step response of the rider optimization algorithm with PID controller on AVR control system.

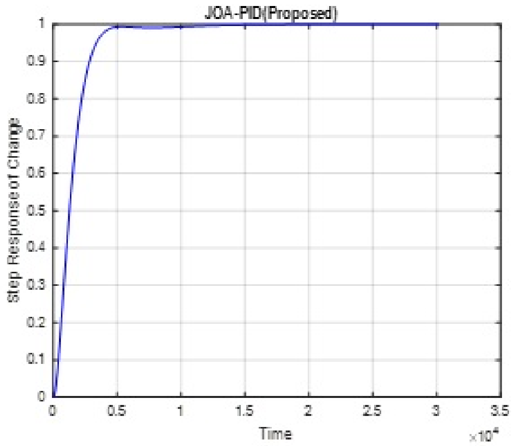

Figure 5: The step response of the jaya optimization algorithm with PID controller on AVR control system.

Table 2: The P-I-D coefficients for the proposed system

Coefficients	DE-PID[8]	PSO-PID[8]	ABC-PID[8]	GOA-PID[9]	BBO-PID[11]	EO-PID (Proposed)	ROA-PID (Proposed)	JOA-PID (Proposed)
Kp	1.9499	1.7774	1.6524	1.3825	1.2464	1.2697	0.7823	0.2832
Ki	0.4430	0.3827	0.4083	1.4608	0.5893	0.8338	0.5631	0.1919
Kd	0.3427	0.3184	0.3654	0.5462	0.4596	0.3429	0.1991	0.0681

Table 3: The completed comparison in step response of change.

PID tuning method	DE-PID [8]	PSO-PID [8]	ABC-PID [8]	GOA-PID [9]	BBO-PID [11]	EO-PID (Proposed)	ROA-PID (Proposed)	JOA-PID (Proposed)
Mp%	32.8537	18.8183	25.0071	20.5306	15.5187	18.6755	10.3161	0
Ts(sec)	2.6495	3.3994	3.0939	0.9706	1.4457	0.9556	0.9324	0.9235
Tr(sec)	0.1516	0.1493	0.1557	0.1300	0.1485	0.1229	0.1065	0.0967

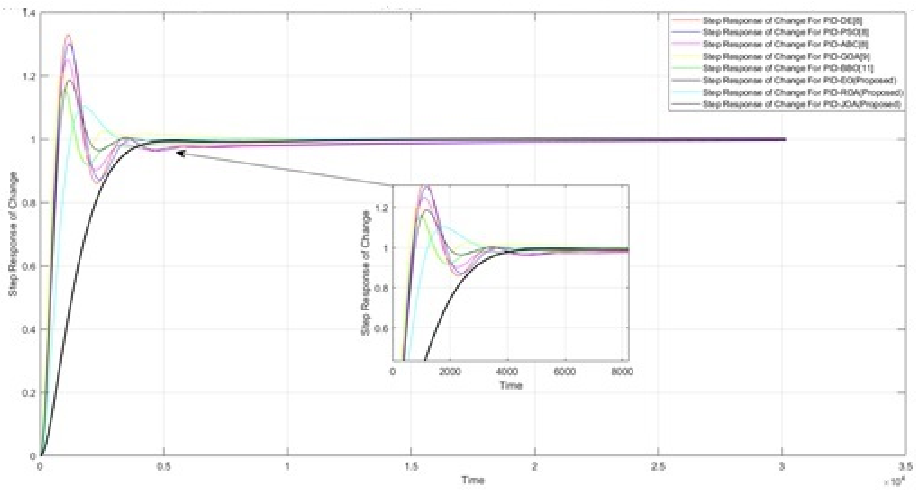

Figure 6: The completed comparison in step response between techniques algorithms.

6. Conclusion

In this work, three optimized techniques has been introduced to the AVR control system in using intelligent algorithms which is actually belong to the intelligent techniques are equilibrium optimizer, rider optimization algorithm and Jaya optimized algorithm which are made a self tuning for the PID controller that based on function type that connected with the controller to make high stability on voltage and on both rising and settling times and the three suggested optimized techniques gave the solution for the controller to use these parameters that mentioned in results and analysis section and solved the working stability for the AVR control system that consists of amplifier, exciter, generator, sensor all of them has been modelled and implemented using MATLAB platform.

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