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Enhancement of Electro Hydraulic Position Servo Control System Utilising Ant Lion Optimiser

Hamzah M. Marhoon[a,*], Ahmed R. Ibrahim[a], Noorulden Basil[a]

[a]*Department of Computer Techniques Engineering, Al-esraa University College, Baghdad, Iraq.*

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Abstract

In this article, ant lion optimiser algorithm is proposed for resolve the working of the electro-hydraulic position servo control scheme on controlling in the general position when compared with local position like the mechanism of work that inspired from particle swarm optimization algorithm in additional to that servo valve contributed by ant lion optimizer algorithm that enhanced and improved the hydraulic cylinder working by using the conventional proportional integral derivative (PID) controller in utilize the optimized algorithm that works as attractive solution added as artificial intelligent algorithm to enhanced the proposed system to achieve best performance for the PID controller and the results analysis achieved for maximum overshooting, rising time, settling time 0 %, 0.020 (sec), 0.0115 (sec) respectively and this work is implemented using MATLAB Simulink.

Keywords: PID Controller, Ant Lion Optimizer, Electro Hydraulic Position Servo Control System, Optimization Algorithm, MATLAB.

1. Introduction

The Electro Hydraulic Position Servo Control System was utilised in the businesses because their benefits for the rapid responsiveness and high force [3]. Due to the improvement of the cut edge enhancement, electronic advances, the proposed structure has the most popular topics whether in intelligent achievement or mechanical tasks [1, 18]. The proposed structure that present the position servo control system could expression as regular circle power control system. In additional to that are used in the operating systems belong to the marine also industrial systems [5]. Can presented

*Corresponding author
Email addresses: hamza@esraa.edu.iq (Hamzah M. Marhoon), ahmedrashid@esraa.edu.iq (Ahmed R. Ibrahim), nooralden@esraa.edu.iq (Noorulden Basil)

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as a fundamentals for the control enhancement because of use the multi layers and can be back useful to the world in this point. Because that, the PID controller should be used with it in order to get high accuracy and high stability of work, the conventional PID controller has widely used in industrial and mechanical tasks [20, 17, 4]. According to this topic that consists of three main important equipment, servo amplifier that make high voltage that increase voltage many times, servo valve which is make control on asymmetric hydraulic cylinder to arrive to the best performance which achieve high stability on cylinder.

Low stability of voltage and asymmetric hydraulic cylinder these main the problems lead to motivate system efficiency and may reduce the performance unless solve it. The main objective of this current research was to enhance and improve an electro hydraulic position servo control system utilising ant lion optimizer which is belong to the swarm intelligent family of artificial intelligent algorithms. The following were implemented on research:

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

2. Related Work

ALO is extraordinarily inconceivable at keeping an eye out for a wide degree of streamlining issues, and it has been satisfactorily applied in various reasonable and explicit fields using both the primary ALO and its assortments.

[20] has been suggested the merging between neural networks in feature back propagation and merging it with optimised algorithm called beetle antennae search and created a new model. The model can present more regression whether in multi or logistic. In next literature, the support vector machine merged with beetle antennae search to introduce the new model.

[7] has been illustrated the proposed algorithm called beetle it's belong to swarm intelligent family in order to make merge between two optimized algorithms neural network with back propagation and a new optimization called particle and it's also belong to swarm intelligent.

[8] has been developed the working of the neural network especially in back propagation with vector machine in using the support model.

[9] has been proposed an enhancement to develop the working of the model in using vector machine merge with neural network with back propagation. The upgrading and enhancing on back propagation that is already belong to the neural network has been enhanced and developed by using beetle antennae with swarm intelligent algorithm.

[10] has been suggested to be make the points cutted off to be split it to multiple targets.

[11] Made an empowering to avoid the optimized beetle antennae with swarm intelligent algorithm, and it's actually utilized in plan of a course for the unmanned aerial vehicle.

[12] empower the optimized CPSO with neural networks in use back propagation and according to the final.

[13] utilized the practical procedure for merging between particle swarm optimization and beetle antennae with swarm intelligent to made a fit for the loads to be related to each other in proposed systems.

3. The Proposed Method with System

Electro Hydraulic Position Servo Control System has been proposed in this article that consists of three major equipment's firstly the concept of the system split into two main parts electrical and mechanical and the circuit rely up on servo amplifier and the signal that entry to the proposed system amplify more than one time to make distribution for all equipment's especially for servo mechanism and according to the servo valve that control on the hydraulic cylinder with asymmetric feature. A schematic depiction of the system with various previous implemented algorithms is shown respectively.

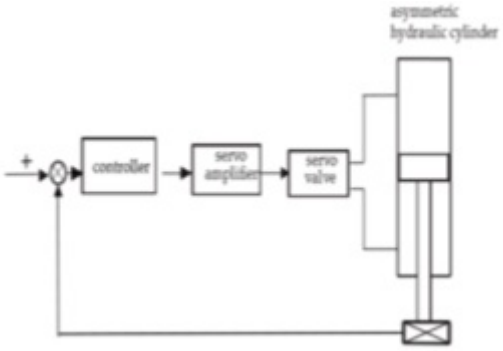

Figure 1: The overall block diagram of the electro-hydraulic position servo control system.

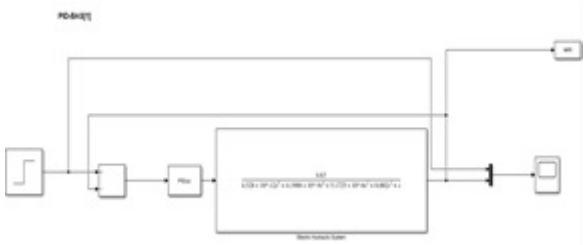

Figure 2: The overall block diagram of the electro-hydraulic position servo control system with BAS optimized algorithm.

Figure 3: The overall block diagram of the electro-hydraulic position servo control system with FA optimized algorithm.

The mechanism of work for the position servo control system is made underneath in order to make conversion from voltage signal to be electrical signal in use servo amplifier and the signal entry into valve of servo which is responsible for moving the valve of sliding that rely up on the valve of central based on the signal that comes from the valve of servo. According to the rate that related with streaming in the chamber of water is effected by the valve of slide.

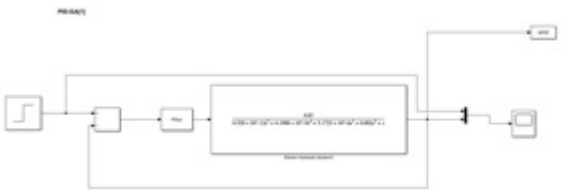

Figure 4: The overall block diagram of the electro-hydraulic position servo control system with GA optimized algorithm.

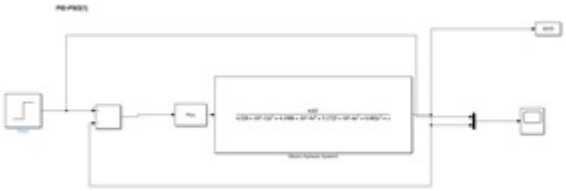

Figure 5: The overall block diagram of the electro-hydraulic position servo control system with PSO optimized algorithm.

Figure 6: The overall block diagram of the electro-hydraulic position servo control system with ALO proposed algorithm.

The bar of chamber is connected with sensor in position. At the last, the signal will be modified and converted to electronic and also return to the controller. The mistake among the real signal and the suggested signal can be diminished by using the position servo control system.

It can be expression as hard issue to the whole connection of work by made the completed mathematical model for plan because of complexity of the enhancement also delay of broad, the basic place of this testing is to made the controlled electro hydraulic servo control system as imaginable although there are no description for the mathematical model [14, 15, 16], the overall transfer function for the proposed system that shown in the following equation.

$$\frac{4.63}{4.528 * 10^{-12}s^5 + 4.1988 * 10^{-9}s^4 + 5.1725 * 10^{-6}s^3 + 0.002s^2 + s} \tag{3.1}$$

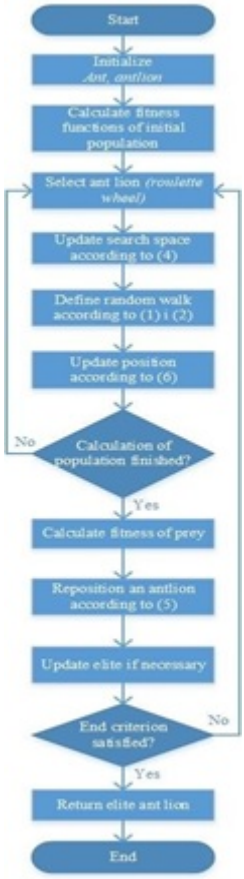

Figure 7: Ant Lion Optimizer Flowchart.

Table 1: Ant lion optimizer parameters.

Parameters Name	***Values***
Number of search agents	*40*
Maximum number of iterations	*200*
Optimized variables number	*3*
Lower bound of variable	*0*
Upper bound of variable	*15*

```
% You can simply define your cost in a seperate file and load its handle to fobj
% The initial parameters that you need are:
%_____________________________________
fobj = @cost_func_Noor
dim = 3
Max_iteration = 200
SearchAgents_no = 40
lb=0
ub=15
```

Figure 8: Ant Lion Parameters on MATLAB Code.

4. Results

The PID controller has been improved the proposed controlled system in utilizing ant lion optimizer algorithm that depend up on 3 essential boundaries and the PID boundaries for the proposed technique ,previous techniques and step response for the proposed algorithm , previous techniques , the general comparison in step response of change between ALO technique and previous techniques algorithms is displayed underneath individually in the current tables II ,III and figure 4.

Table 2: The PID parameters for the proposed system.

PID Parameters	***BAS[1]***	***FA[1]***	***GA [1]***	***PSO [1]***	***ALO [Proposed]***
Kp	*7.99*	*9.57*	*8.015*	*8.2923*	*12.93247*
Ki	*0.14*	*6.94*	*0*	*0.0225*	*0.00005*
Kd	*0.05*	*0.07*	*0.097*	*0*	*0.0000007*

Table 3: The PID parameters for the proposed system.

Step Response	***BAS[1]***	***FA[1]***	***GA [1]***	***PSO [1]***	***ALO [Proposed]***
Mp%	*0.0067*	*0.1439*	*0.101*	*0.15*	*0*
Tr	*0.022*	*0.051*	*0.056*	*0.05*	*0.020*
Ts	*0.023*	*0.026*	*0.029*	*0.03*	*0.0115*

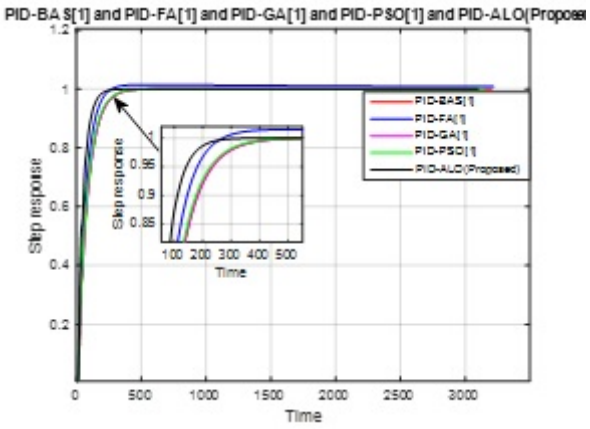

Figure 9: The overall comparison in step response between techniques.

5. Discussion

The experiments executed with MATLAB Simulink and the tests prove that electro hydraulic position servo control system can be enhanced much better with ant lion optimizer algorithm with the use of proportional integral derivative controller. Figure 5 that describe the step response of change for ant lion optimizer implemented on an electro hydraulic position servo control system with P-I-D parameters 12.93247, 0.00005, 0.0000007 respectively. And step response of change for maximum overshooting, rising time, settling time 0%, 0.020, 0.0115 which is based on ALO and previous algorithms parameters selection as mentioned below:

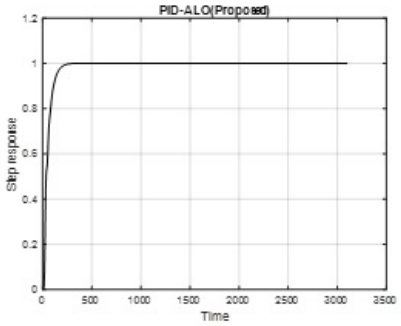

Figure 10: The transient response for ant lion optimizer with P-I-D controller on an electro hydraulic position servo control system.

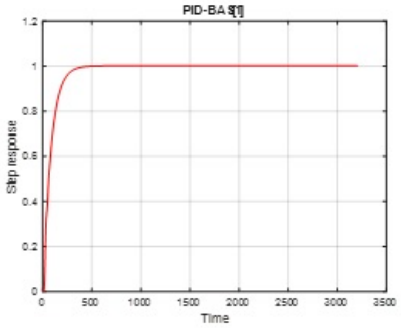

Figure 11: The transient response for BAS with P-I-D controller on an electro hydraulic position servo control system..

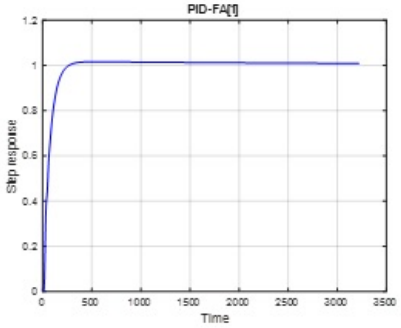

Figure 12: The transient response for FA with P-I-D controller on an electro hydraulic position servo control system.

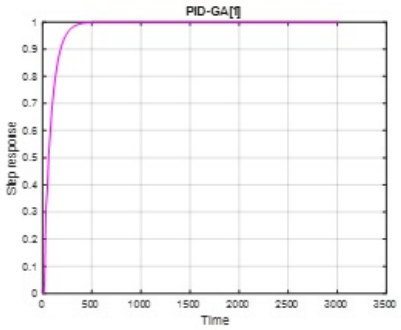

Figure 13: The transient response for GA with P-I-D controller on an electro hydraulic position servo control system..

Limitations

The enhancement of the an implemented electro hydraulic position control system with ant lion optimizer algorithm is limited to the following:

(i) The voltage for valve that comes from an amplifier initialization.
(ii) The P-I-D parameters in use ant lion optimizer in electro hydraulic position servo control system.
(iii) Tracked performance for proposed system with ant lion optimizer algorithm using Simulink model execution.

6. Conclusion and future work

The goal of the evaluation was to find three parameters of the PID controller confines that might be used to revive the control precision and breaking point of the electro hydraulic control of position servo system. The proportional integral derivative controller limit tuning theory subject to the underground startling little animal lion enhancer estimation was used for electro hydraulic control of position servo system. A trade work model was made using structure limit ID. The advancement of a chief mathematical modelling of the electro-water driven position servo control system relied on hypothetical appraisal. The fundamental of PID tuning was rethought as a three-dimensional advancement issue. The introduction of the ALO tuning structure was isolated from the advancement response execution of the PSO, GA, FA, and BAS evaluations. According to an evaluation of the introduction of the ALO with Conventional proportional integral derivative controller with electro hydraulic control of position servo system, the ALO estimation may electively change three limitations of the proportional integral derivative controller. The ALO with proportional integral derivative controller offers a variety of benefits, including restricting system check and fulfilling the requirement for control structure adaptability when particular external signs are free, enthralling the electro-pressure driven position servo control configuration to significantly more quickly stay aware of its control essentials. The following is the future work for the next researcher recommended to use:

- Utilise fractional order proportional integral derivative controller and connected directly with an electro hydraulic position servo control system.
- Implement another optimized algorithm and compare it with ant lion optimizer or merge between new algorithms with ant lion optimizer.
- Add stabilizer transfer function and connect it with electro hydraulic system with fuzzy type-1 or 2.

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