Optimization and Enhancement of Charging Control System of Electric Vehicle Using MATLAB SIMULINK

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Abstract. Several algorithms and approaches have been adopted for wide range of controlled systems. One of the most interesting algorithms was the Rider Optimization Algorithm (ROA), which has been widely used in many applications for the control system. In this paper, the ROA algorithm has been utilized in the Controlled System (Charging Control System associated and decrease the steady-state error, high overshoot, decreasing for rising time and settling time these issues that we are looking for disentangling it in the controlled System to get furthest reaches of depending capacity that makes Controller work in a best case. of Electric Vehicle) to enhance and optimize the charging procedure. Results obtained shows significant enhancement where the parameter values achieved for the Maximum overshooting, raising time, peak time and the settling time were zero%, 0.0341, 0.7, 0.1188 second respectively, which could be considered as more realistic results as compared with latest work in the same field. Such results have showed a significant enhancement as compared to the related results achieved in the same manner.

1. Introduction
The charging control system of electric vehicle is a system that is demonstrated to make controlling on the Charging for the Electric Vehicle that employees to make stability on this controlled system to avoid instability whether by losses of the received voltage or another, this system that faces more errors in usage because of controlling usage on the Charging and many problems like settling time and rising time were calculated as the proof for the performance, the usage of the Rider Optimization Algorithm (ROA) as the extra algorithm that called in MATLAB code to make tuning with conventional Proportional Integral Derivative (PID) Controller by built the overall transfer function of the Controlled System, its specific for the electric vehicle, After that the transfer function was employed to design a PID controller system to use the PID by adding library browser it contains 3 general parameters that called in sequencing, P, I, D. An electric vehicle is a vehicle that utilizes at least one electric engines or footing engines for drive. An electric vehicle might be controlled through an authority framework by power from off-vehicle sources or might act naturally contained with a battery, sun based boards, or an electric generator to change over fuel to electricity. Electric vehicles incorporate, however, are not constrained to, street and rail vehicles, surface and submerged vessels, electric airplanes, and electric shuttle and the three scale factors when it connected with the proposed system it can optimize the performance by using these coefficients depend on the implemented ROA.
algorithm that the four racers will racing depend on the first racer whose win the race depends on the weights of the algorithm and the angles and other ROA Parameters. Many authors have investigated and proposed methods for evaluating the charging control system. For example, in [3] the researchers evaluated the use of the charging control system by MATLAB Simulink by using Conventional PID Optimizer. In addition to that, in 2018 the researchers in [7] developed the use of the charging control system by MATLAB Simulink by using the Conventional PID Optimizer by using the PSO Algorithm to Optimize the Performance of the proposed system. However, the general performance of PSO would depend on the total number of iteration. Meanwhile, recently the researchers in [1] discussed the use of the charging control system to design the mathematical model of the electric vehicle by MATLAB Simulink by using a PID Optimizer within the Genetic Algorithm that used as Tuned Algorithm for the proposed system. However, using genetic algorithm has been reported to be required high complexities procedure and computational process. In this work, it has been proposed and evaluated the performance of the charging control system of the electric vehicle by MATLAB Simulink by using PID Optimizer within Rider Optimization Algorithm that used as Extra Algorithm for the implemented system. The rest of our work is classified as follows: the background of PID and its related application is discussed in section 2, while in section 3 the proposed mathematical model is clarified for charging control system for electrical vehicle. The proposed methodology and the ROA are withdrawn in section 4. Finally, the result and the conclusion are discussed in section 5 and 6 respectively.

2. Background of Proportional Integral Derivative Controller and its application

proportional integral derivative controller (PID controller) is a control circle component utilizing input that is generally utilized in modern control frameworks and an assortment of different applications requiring ceaselessly tweaked control. In viable terms, it naturally applies precise and responsive rectification to control work. A regular model is the voyage control on a vehicle, where climbing a slope would bring down the speed if just consistent motor force were applied. The controller's PID calculation reestablishes the deliberate speed to the ideal speed with negligible deferral and overshoot by expanding the force yield of the motor. The main hypothetical examination and the reasonable application was in the field of programmed guiding frameworks for ships, created from the mid-1920s onwards. It was then utilized for programmed process control in the assembling business, where it was broadly executed in pneumatic, and afterward electronic, controllers. Today the PID idea is utilized all around in applications requiring precise and advanced programmed control.

3. A mathematical model for Charging Control System of Electric Vehicle

The design of the charging control framework for an electric vehicle can be executed by utilizing MATLAB Simulink being used the transfer function (Laplace Transform) rely upon the standard model of charging control framework for an electric vehicle that taken from the previous researcher as in [1]. Furthermore, the design of the completed transfer function overall can be written as the equation below:

\[
\frac{1000s}{0.1s^2+15s+1}
\]  

The completed charging control system for electric vehicle as block diagram that shown in Figure 1.
**Figure 1.** The completed charging control system with general equipment concept [14]

### 4. Methodologies

In this work, the design of proposed charging system in MATLAB that done by using Simulink library browser is based on transfer function overall as the equation that referenced above to make tuning on the proposed system that ought to use of PID controller is one of the Controllers that deals with Proportional (P), Integral (I), Derivative (D) as three scale factors to make tuning on it to demonstrate that utilization of PID with proposed framework more proficient than use without controller. The design of the proposed framework can be seen in Figure 2.

![Diagram of the completed charging control system](image)

### 4.1 Rider Optimization Algorithm

The ROA concept about two or three-rider social affairs, who travel to a common target region for transforming into the champ of the race, to characterize its thought. “The amount of social affairs considered is four, where the amount of riders in each get-together is picked also from without a doubt the number of riders. The four social occasions of riders are avoided rider, fan, overtakes, and attacker. Every social occasion follows different frameworks to show up at the target [5, 6]. Indeed, even anyway the riders follow a predefined philosophy, the central segments to show up at the goal are the right riding of the vehicle by genuine treatment of the coordinating, fixing, animating operator, and brake [7]. For each time second, the riders change their circumstances toward the goal by modifying these boundaries and follow the predefined strategy subject to the current accomplishment rate, which is alternately comparing to the partition between the circumstance of the riders and the objective”[8, 9]. The primary rider is described as reliant on the accomplishment rate at the current second. This system is continued, until the riders go into off time [10], which is the best time given for the riders to show up at the goal. After the off time, the rider, who is the fundamental rider, is named as the victor of the ridden race [11]. The overall ROA parameters for our charging control system with PID have been listed in Table 1, where the number of iterations has been set to 1000, indiv is the individual total number of riders, num_gear is the number of gear level and dim represent the dimensions of x and y for the ROA algorithm.

**Table 1.** The Overall ROA Parameters for the Charging Control system with PID

| The Parameters for the rider optimization algorithm | The values |
|----------------------------------------------------|------------|
| set how many iterations                            | iter_max = 1000 |
| indiv                                              | 42         |
| dim                                                | 2          |
| num_gear                                           | 7          |
Depending on the general parameters in the rider optimization algorithm it should update to be suitable for the controller and the proposed system to arrive at the best three values for the PID controller, by the way, can utilities the following general equation as its mentioned in equation 2

$$\text{pos}_{\text{dir}} = \frac{i \times 360}{\text{Indiv}}$$

(2)

Where pos_dir represent the position direction and i is the speed counter. Meanwhile, by updating on the above equation the best position will change depending on the Maximum of (Indiv) that means the total result over dividing by that the total loop for the riders that approximate to 360 over four quartiles, where each quartile represented by 90 degree[12,13]. As a result, the best one is the first one take the appropriate path to execute the best solution for the proposed implemented system. The technique of ROA consists of 4 groups, which are the basic terms of the algorithm, and as seen in Figure 3. These groups are [15, 16, 17]

a) Bypass rider: represented by the riders who bypassing the leading path and reach the target. Hence, the bypass rider does not follow the leading rider, who is the rider in the leading position.

b) Follower: in most of the axis, the followers depend on or follow the leading rider.

c) Overtaker: this rider would follow his own position to arrive to the target, in accordance with the nearby location of the leading rider.

d) Attacker: such player would looking for the position of the rider to reach the target point by using the maximum speed. Furthermore, to these 4 groups, there is a winner who wins the race. [18,19,20]

![Figure 3. The Mechanism of the ROA Technique](image)

### 5. Results and discussion

The experiments have been tested for the charging control system to test the efficiency of the PID on the proposed charging control for the electric vehicle system. Thus, the results obtained would be compared with the most relevant work achieved by other researchers [1] to prove the efficiency of the results. The comparison would be based on PID-Optimizer with Genetic Algorithm and PID with the proposed ROA on the same proposed system. For the convergence quality, it can be seen that our proposed method has achieved higher quality for minimized value of FF as compared to the latest work in the same manner and as listed in Table 2.

| Parameters                  | GA-PID [1]   | ROA-PID [our work] |
|-----------------------------|--------------|---------------------|
| Minimized value of FF       | $3.157 \times 10^3$ | $6.283 \times 10^4$ |
In addition to that, the parameters $K_p$, $K_i$, $K_D$ for the PID which have been utilized with charging control system of our work have been listed in Table 3. Furthermore, it has been compared with the parameters that have been utilized in a previous related work. Using our parameter could achieve overall performance.

Table 3. The Overall Comparison in PID Parameters with charging Control system for 100 Filter Coefficient

| Parameters | GA-PID [1] | ROA-PID [our work] |
|------------|------------|---------------------|
| $K_p$      | 0.0012     | 0.0060              |
| $K_i$      | 0.8500     | 0.9720              |
| $K_D$      | 0.00002    | 0.00001             |

Additionally, the results of transient response for charging control system, which have been obtained from our proposed method based on ROA has been listed in Table 3. It can be notices, that by comparing our result with the related previous work, our method has achieved a maximum overshooting ($%Mp$) of zero percentage; hence, the efficiency of the proposed system has increased. While, the raising time ($Tr$) has been reduced by 0.0013 second as compared to the value of GA-PID method. The peak time ($Tp$) has been reduced by 0.11 second, which increase the reliability of our system performance. Finally, settling time ($Ts$) achieved by our work were 0.1188 sec, which is faster and better than the time achieved by the GA-PID method. It is worth to mention, that a comparison in charging step response have been carryout in this work and as seen in Figure 4. It can be seen that in first case the system was not stable when handling the charging control system without any optimization method. For GA method with blue curve, there was a higher overshooting. Meanwhile, our proposed method has achieved better step response with lower angular speed value. Indicating the efficiency of our system.

Table 4. Comparison of transient response with charging Control system

| Parameters | GA-PID [1] | ROA-PID [our work] |
|------------|------------|---------------------|
| $%Mp$      | 0.9411     | 0                   |
| $Tr$       | 0.0354     | 0.0341              |
| $Tp$       | 0.81       | 0.7                 |
| $Ts$       | 0.1751     | 0.1188              |
Figure 4. The overall comparison in step response of charging control system of electric vehicle

6. Conclusions
In this work, it has been utilized the Rider Optimization Algorithm (ROA) for enhancing the control of the SCS-EGC System. In addition, the conventional PID controller has been utilized, where the parameter estimations of PID has been depend on the values that obtained from ROA. Results obtained in this work showed an inhanecmment in the transient response with charging control system, where the parameter values achieved for the Maximum overshooting, raising time, peak time and the settling time were zero\%, 0.0341, 0.7, 0.1188 second respectively. Such results have showed a significant enhancement as compared to the related results achieved in the same manner. In future work, the other numerous ROA could be performed, tested for getting more reliable results and higher system efficiency.

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