1.6 Outline of the Thesis

The other chapters in this thesis are as follows:

Chapter 2: Background Theory which describes and discusses the main background theory that is used in a research as well as the main tools, methods, and approaches of PID tuning a dc motor, as well as some fundamentals.

Chapter 3: Design and Implementation of the Proposed System which describes and discusses the whole approach of the proposed system and discuss each implanted step as well. Also, we described some algorithms, pseudocode and flowcharts that are used in the proposed system.

Chapter 4: Experimental Results which lists and discusses the main results they are achieved in the proposed system using different criteria's such as figures, tables, and graphs.

Chapter 5: Conclusion and Suggestions for Future work. Finally, we list some conclusion points that are achieved through our research as well as some suggestions for the future work.

the proposed algorithm is thought to be superior to that of existing methods [22].

Table (1.1): Previous Works Technique.

No	Author(s)	Ref. No.	Year	Technique Used
1	Meng Joo Er and Ya Lei Sun	[5]	2001	evolutionary algorithms
2	Wei Li.	[6]	2003	fuzzy P+ID
3	Ya Lei Sun and Meng Joo Er	[7]	2004	fuzzy PID controller
4	Bassi, S., et al.	[8]	2011	PSO algorithm
5	Solihin, M. et al	[25]	2011	PSO algorithm
6	Shiha , I., et al	[10]	2012	Ant-Colony algorithm
7	S. Ghosal et al.	[11]	2012	Swarm intelligence (SI)
8	El-Telbany, M.	[12]	2013	bee colony optimization algorithm (ABC)
9	Kesarkar, A., et al	[13]	2015	bee colony algorithm(ABC)
10	Shamseldin, M. et al.	[14]	2015	DC motors
11	Marie, M. et al	[15]	2015	algorithm (PSO)
12	Sahib, M., et al.	[16]	2016	PSO method
13	Myrtellari, A. et al	[17]	2016	the LQR and PSO algorithms
14	Pandey et al.	[18]	2017	DC motor with the PSO_PID method
15	Berair, A.	[19]	2017	Particle swarm optimization (PSO) algorithm
16	S. Awad	[20]	2018	Ant colony algorithm and fuzzy logic-based
17	Amaral, J., et al.	[21]	2018	genetic algorithms
18	Bhullar, A, et al	[22]	2020	metaheuristic algorithms

In 2018, to regulate the DC motor's output frequency, S. Awad proposed an ant colony optimization technique. The most popular PID control is offered for artificial usage due to its high efficiency, easy implementation, and broad applicability, as well as its composition utilizing AI. They contrasted the outcomes of utilizing an ant colony algorithm and fuzzy logic-based automated tuning for a PID controller to fine-tune a DC motor. The latter group has access to the findings of the aforementioned study. Using MATLAB computer program [20].

In 2018, Genetic algorithms were proposed by Amaral, J., et al. for use in PID controllers. Previously, step response was available in a closed loop through genetic algorithms. Results from a number of different tests indicate that genetic algorithms' potential benefits may provide superior results to those obtained using the tried-and-true Ziegler-Nichols technique. Another advantage of genetic algorithms is that they may make systems money even when conventional methods no longer work [21].

In 2020. Bhullar, A, et al. a crow search method for AVR improvement was proposed as a possible solution to several practical engineering problems. CSA's results are compared to those of other metaheuristic algorithms; CSA borrows the standard functions of these algorithms to increase the performance of its own; and CSA has been applied to the improvement of the proportional-integral-derivative (PID) controller to demonstrate the efficacy of the proposed method. Analysis of CSA-performance PID's in comparison to that of the classic Ziegler-Nichols (ZN), ACO, multi-objective ACO, multi-objective GA, and challenging and space gravitational enhancement method" revealed the proposed algorithm's resilience across a variety of settings. Verification of the effectiveness of the proposed technique is provided by the results of both the standard and AVR systems and their modifications. The efficiency of performance benchmark is included in this article's extensive scope. The PSO technique was used to examine the proposed goal function in PID control design for an automated voltage regulation system (AVR) [16].

In 2016, in order to compare and contrast the efficacy of various controls for regulating the speed of DC motors, Myrtellari, A. et al. advised looking at the efficacy of linear square regulators and PSO algorithms. The Ziegler-Nichols based PID controller, particle swarm optimization, the PID controller tuning technique, and the linear quadratic controller are compared and contrasted with one another. Drive system for DC motors was tweaked in MATLAB/SIMULINK. MATLAB is used to run the LQR and PSO algorithms [17].

In 2017, Pandey et al. proposed comparing the evolutionary algorithm used to control a DC motor with the PSO-PID method. The genetic algorithm-based DC motor controller was enhanced using a particle swarm application to fine-tune the PID controller's gain settings, and the controller was further adjusted with PID to achieve optimal performance. To some extent, the DC motor model may be employed for second-order system speed control. There were three primary genetic operators available for use with the genetic algorithm. The recommended method improves the features, particularly the efficiency of execution and calculations [18].

In 2017, Berair, A. Particle swarm optimization (PSO) algorithm as an AI technique for setting optimal PID controller parameters of speed control of DC motor system to achieve the mean target. Which is the correlation between output and the standard rate? Using this strategy has significant features such as low complexity and constant convergence superiority in characteristics and processing power over more conventional approaches [19].

suggest that an industrial bee colony algorithm may provide a heuristic solution (ABC). The stochastic approach has just emerged, and it was designed in accordance with the eating habits of a hive of intelligent bees. As one of many examples, they evaluate how well ABC performs in comparison to the deterministic Nelder-Mead-Simplex algorithm [13].

In 2015, Shamseldin, M. et al., A. propose a GA-based PID controller for DC motors that may be put into practice. Their research aims to evaluate how well the proposed GA-based PID controller can achieve The BLDC motor's rotor speed is very consistent in its ability to follow an already established speed profile. The value function's primary goal is to minimize the quadratic error, while other goals include minimizing the onset delay, the stationary error, and the steady-state value. As well as the significant overrun that depends on the designer's mainstream. The It's the third value function's job to evaluate whether or not minimizing the maximum timing errors that overshoot or undershoot, or that climb too quickly or fall too slowly. Evidence from simulation and experiment supports the idea that genetic PID controller According to the third value function, whose performance is superior [14].

In 2015 Marie, M. et al. to handle the adjustment of the "PID controller parameters and to govern the MIMO system attitude", a PSO was devised for the MIMO (Twin Rotor Multi-Input-Multioutput) double rotor system. There is a clear delineation between the primary and tertiary parts of the system. In order to get a robust control system, the controller's parameters are optimized using an algorithm (PSO)[15].

In 2016, Future developments in PID optimization algorithms may benefit from the recommendations of Sahib, M., et al., who proposed a contemporary multi-aim performance criterion. A contemporary

In 2012, Shiha , I., et al. presented a PID tuner that improved upon previous designs using a multi-lens ant colony algorithm. The researchers wanted to see how well the Ant-Colony algorithm did at picking the optimal values for the PID controller's Kp, Ki, and Kd, against the more conventional Ziegler-Nichols method. The current method, which employs multipurpose ant colonies, has been shown to increase control system performance suitably in comparison to the conventional method and genetic algorithms through the application of imitation [10].

In 2012, the article's authors, S. Ghosal et al., propose using swarm intelligence approaches to tune PID controllers with varying structures and the ingenious PID controller architecture introduced in the outset. Swarm intelligence (SI) methods such as Ant colony optimization (ACO), swarm optimization (PSO), and the algorithm improvement for bacterial food (BFOA) search functions are put to the test and analyzed in detail to find the optimal PID tuning parameters [11].

In 2013, M. El-Telbany, suggested a DC motor PID controller: an artificial bee development technique. This article discusses the commercial application of the bee colony optimization algorithm (ABC) in the tuning of PID controllers for DC motors. The recommended strategy aims to develop DC motor tracking abilities [12].

In 2015 increasing the efficiency was proposed by Kesarkar, A., et al. industrial bee colony algorithm as a fractional-order PID controller .The particular performance parameters of absolute mistake, total quadratic error, and absolute total time error were taken into account during the construction of the fractional-order PID controller. The complexity, scale, and multimodality of the enhancement issue that results from the design structure render it intractable from an analytical perspective. Their findings

In 2003, Approaches to the incremental design of a hybrid fuzzy logic proportional plus conventional integral derivative (fuzzy P+ID) controller were given by Wei Li. This controller is built by substituting a normal PID controller's proportional term with an incremental fuzzy logic controller[6].

In 2004, Ya Lei Sun and Meng Joo Er demonstrated a novel strategy for arriving at the optimal design of a hybrid fuzzy controller for robotics systems. In order to address the nonlinear control problem, their suggested system integrates the "fuzzy gain" scheduling technique with a "fuzzy PID controller", nevertheless, when compared to other controllers, it fails to meet the required minimum values for overshoot and steady-state error [7].

In 2011,Bassi, S., et al. proposed employing particle swarm optimization (PSO) techniques to automate PID tuning. In their research, they introduced a PSO algorithm based AI technique for optimal tuning of PID controller settings in industrial operations. This approach is more efficient computationally than the Ziegler-Nichols tuning scheme and has important topographies such as its simplicity of implementation, its constant convergence characteristic, and its ease of execution. Excellent step response properties, such as reduced final-state inaccuracy, faster rising times, and less overshoot from the DC motor speed regulator, were developed using the proposed approach [8].

In 2011, Particle swarm optimization (PSO), as proposed by Solihin, M. et al., may be used to fine-tune the PID controller's sensitivity and gain. A comparison of the PSO-PID implementation and the ZN-PID strategy was presented. The findings obtained show that the PID tuning feature's use of the PSO algorithm yielded the best results [9].

will provide the desired control performance for a given system. The challenge lies in finding the right balance between these three gains to achieve stable and responsive control without overshooting or oscillating. Additionally, the tuning process must take into account the characteristics of the system being controlled, such as its dynamics, non-linearity's, and disturbances. The ultimate goal is to achieve a well-tuned PID controller that can maintain set point tracking and disturbance rejection while minimizing error and maintaining stability.

1.3 Research Objectives

The goal of tuning a PID controller by optimization algorithms is to find the optimal values of the proportional, integral, and derivative gains that will result in the best performance of the system. Optimization algorithms use mathematical models and algorithms to search for the best set of parameters that will minimize a specific performance criterion, such as overshoot, settling time, or steady-state error.

1.4 Contribution

The contribution we made is to employ the algorithm artificial gorilla troops optimizer (GTO) for the first time in tuning the optimal parameters of the PID controllers system.

1.5 Related work

In 2001, Meng Joo Er and Ya Lei Sun introduced a new strategy for the optimal construction of a "hybrid PID controller" using evolutionary algorithms. This strategy may be used to the control of both linear and nonlinear systems. This technique is mathematically challenging, and it is possible to observe distinct ripples in the step response and detect the overshoot [5].

Stability, the intended rising time, peak time, and overshoot time will be essential characteristics of the output that must be met. The needs for these parameters vary from one process to another, and satisfying those requirements requires performing significant tweaking of the PID parameters [3]. The tuning approach entails doing a study of the step input response of the system in order to acquire a variety of PID parameters. This is only possible if the system can be brought offline. However, the majority of industrial applications require the system to be online, and tuning must be done manually. This calls for employees with a great deal of knowledge, and there is still an element of uncertainty because of the possibility of human mistake [4] .

There are two types of approaches: classical and computational or optimization techniques. In classical techniques assumptions concerning model assumptions and controller settings are commonly made in conventional methodologies. Step response data is used to determine the dynamics of these systems. Different traditional techniques have relied on various equations to specify this reaction. On the other hand, optimization techniques are additional mathematical programming approaches that differ conceptually from the tar-based optimization methods that have been developed in the last several years. Methods like this are considered contemporary or unconventional. Numerous techniques have been developed by studying biological, molecular, swarm-insect, and neural systems [3].

1.2 Problem Statement

Tuning a PID controller can be difficult and time –consuming , requiring trial – and – error adjustments of gain values until optimal performance is achieved. The problem statement of tuning a PID controller is to determine the optimal values of the proportional, integral, and derivative gains that

Chapter One

Introduction

1.1 Introduction

As a general control loop feedback mechanism, the PID controller may be found in a variety of industrial control systems, and an adaptive control system automatically adjusts controlled settings to account for changes in system dynamics without any human intervention. The proportional-integral-derivative (PID) controller is the type of controller that is utilized in industrial applications the most frequently. It have a straightforward construction and consistently reliable performance over a diverse array of operational parameters. These kinds of controllers are the most time- and resource-effective alternatives to consider when there is little information about the process. Proportional (P), Integral (I), and Derivative (D) are the three most important characteristics that are at work here. The mathematics that underpins PID control is complicated, and in order to achieve maximum performance, it is necessary to pick process-specific values for a number of different interacting parameters. They offer a decent reaction to process control, but depending on the conditions, they could not give an ideal performance. In the event that there is a process offset or the dynamics of the process change or alter, it is necessary to reset the PID parameters, which include the proportional gain, the integral time, and the derivative time. Tuning refers to the process of making adjustments to the PID settings, which may either be done manually or automatically [1].

In the process industry, almost all feedback loops are controlled using a P, PI or PID controller [2] . The term tuning is used to describe the process of adjusting the different parameters (P, I, and D) of a PID controller in order to attain an optimal value of the intended response.

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List of Abbreviations

Abbreviation	Meaning
PID	Proportional-Integral-Derivative
GTO	Gorilla Troops Optimization
ZN	Ziegler-Nichols method
PSO	Particle Swarm Optimization
ISE	Integral Squared Error
IAE	Integral Absolute Error
ITSE	Integral Time Squared Error
ITAE	Integral Time Absolute Error
DC	Direct Current
GA	Genetic Algorithm
ABC	Artificial Bee Colony
GWO	Grey Wolf Optimizer

Contents

Abstract

Tuning a PID controller is a crucial task in control engineering to achieve optimal performance of the system. However, manual tuning of PID parameters can be inaccurate and difficult without extensive experience.

One approach to tuning the PID controller is by utilizing met heuristic algorithms. These algorithms are based on natural phenomena and can efficiently search for the optimal set of PID parameters. Therefore, utilizing met heuristic algorithms for tuning PID controllers can significantly improve the system's performance and reduce costs associated with manual tuning.

In this thesis, proposed a new methods for tuning parameters of the PID controller of DC motors using a hybrid adaptive PID_GTO predictive model based on the artificial gorilla troops optimizer algorithm(GTO) .The empirical results are compared based on four type of error indicator functions ,Integral Time Squared Error (ITSE) , Integral Time Absolute Error (ITAE), Integral Absolute Error (IAE) , and Integral Squared Error (ISE) and with other previously techniques in literatures, such as the Ziegler-Nichols and PSO Optimizer algorithm. The empirical results show that this method outperforms other techniques in improving steady-state error, stability, overshoot, rising time, and settling time of the DC motor .

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Automatic Tuning of PID Controller Based on Gorilla Troops Optimizer

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