ISSN 2347-4289

Optimal Cruise Control Using Genetic Algorithm And Simulated Annealing Tuned PID Controller.

Upasana, Dr. Anu Mehra

M.Tech Student, Associate Professor, Department of ECE, ASET, Amity University, Noida, India.
Email: upasanaarora004@gmail.com

ABSTRACT: This paper shows the execution correlation between the different delicate figuring methods utilized for advancement of the PID controllers, executed for velocity control system for the cruise control system. PID controllers are widely utilized as a part of mechanical control in view of their straight forwardness and heartiness, however when mechanical control is risked by outer glitches, prompts the shakiness of the system. PID controller streamlining utilizing delicate registering calculations lays accentuations on acquiring the best conceivable PID parameters for enhancing the solidness of the system. The PID controller has been actualized for pace control of a system and the outcomes got from improvement utilizing delicate registering are contrasted and the ones got from the Ziegler-Nichols strategy, and relatively better results are gotten in Genetic algorithm case.

Keywords: PID Controller, Controller Optimization, Genetic Algorithm, Stimulated Annealing, Cruise Control.

1 INTRODUCTION

Since there is an enormous improvement in the force electronic frameworks, yet the direct current machines are the prime hotspot for the era of the electric footing. Presently a days, discovering more helpful applications in auto industry if there should arise an occurrence of electric vehicles. Since, in cruise system, by conforming the terminal voltage we can work it over an extensive variety of paces, consequently making them good with most mechanical loads by excellence of their torque/speed qualities, along these lines conveying superior and simple controllability [1]. Yet, progressively applications, there are sure variables like outer clamor, variable and questionable inputs, obscure parameters, changes in the motion of the heap, and so on.; prompting the flimsiness in their control. PID controllers reason for their straightforwardness and vigor discovers applications in 90% of the control frameworks being used today. In this way, the streamlining of the PID controller parameters is a standout amongst the most essential fields in execution and outlining of PID controllers [2]. The traditional and broadly acknowledged technique for tuning the PID parameters is calculation by Ziegler-Nichols system. Then again, registering the additions doesn't generally gives the best parameters in light of the fact that tuning measure presumes one-fourth diminishment in the initial two crests. Be that as it may continuously applications, due to the commotion, the tuned parameters does not generally give the best results, so need is there to try and tweak them, so they can undoubtedly adjust with these changing framework elements. For better versatile reaction of the framework, in vicinity of outer glitches, the utilization of different delicate registering procedures like Fuzzy-Logic, Artificial Neural Networks, Genetic Algorithms, Particle Swarm Intelligence, Neuro Fuzzy, Neuro-Genetic, and so on have ceded better results. In this paper, the optimization of the PID controller additions has been completed utilizing by Genetic Algorithms (GA), Multi- Objective Genetic Algorithms (Mobj-GA) and Stimulated Annealing, while utilizing the Ziegler-Nichols parameters for the determination of the lower and upper headed points of confinement for the introduction of PID parameter. At that point, the improvement of the PID controllers for the estimation of the best PID parameters has been finished concerning the goal capacity, expressed as, "Aggregate of the fundamental of the squared slip and the squared controller yield veered off from its enduring state" As per the outcomes got in this paper, impressively better results have been acquired on account of the genetic algorithm, when contrasted with alternate systems in admiration of the step reaction of the system. Automatic cruise control is an excellent example of a feedback control system found in many modern vehicles. The purpose of the cruise control system is to maintain a constant vehicle speed despite external disturbances, such as changes in wind or road grade. This is accomplished by measuring the vehicle speed, comparing it to the desired or reference speed, and automatically adjusting the throttle according to a control law.

2 PID CONTROLLERS

Proportional Integral and Derivative – PID controllers because of their simplicity and acceptability ,are playing an imperative role in control systems, and for regulating the closed loop response in industrial controls, PID controllers alone contribute 90% of all the PID's used today [3]. A PID controller based system is represented in simple block level diagram as in figure 1.

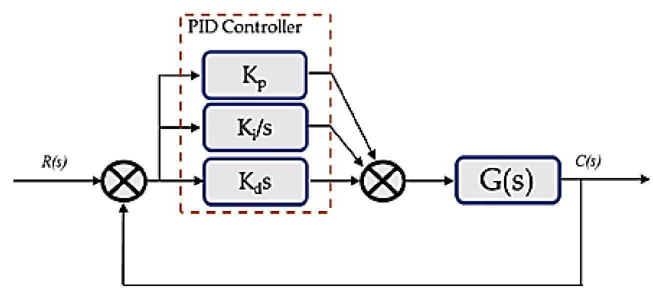

Figure 1. *Schematic representation of unityfeedback PID controller system architecture.*

The general equation for a PID controller for the above figure can be given as [4]:

$$C(s)= K_p.R(s)+K_i\int R(s)dt + K_d\, dR(s)/dt$$

Where K_p , K_i and K_d are the controller gains, C(s) is output signal, R(s) is the difference between the desired output and output obtained. A percentage of the prime routines for tuning are : Mathematical criteria,cohen-Coon strategy, Trail and Error Method, Ziegler-Nichols Method and now a days the Soft-Computing methods, being lesser inclined to slip when contrasted with routine metods; like fluffy logic,Gnetic Algorithm,

ISSN 2347-4289

Praticle Swarm Optimization, Neuro-Fuzzy, Simulated Annealing and Artifical Neural Network, are additionally getting to be predominant in examination Methodologies.

3 Mathematical Modelling of Cruise Control

The simple mathematical model of cruise control is shown in Figure 2. The calculation of transfer function of the cruise control has been done using various parameters listed below as [1]:

- Vehicle mass (m) 1000kg
- Damping coefficient (b) 50 N.s/m
- A = -b/m;
- B = 1/m ;
- C = 1 ;
- D = 0 ;

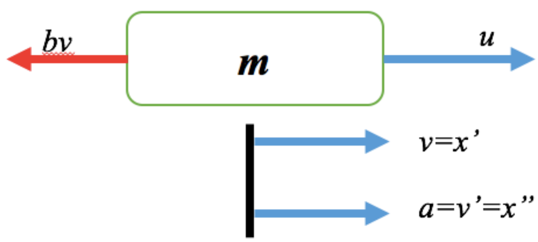

Figure 2: *Physical setup of cruise control.*

We consider here a simple model of the vehicle dynamics, shown in the free-body diagram (FBD) above. The vehicle, of mass m, is acted on by a control force, u. The force u represents the force generated at the road/tire interface. For this simplified model we will assume that we can control this force directly and will neglect the dynamics of the powertrain, tires, etc., that go into generating the force. The resistive forces, bv, due to rolling resistance and wind drag, are assumed to vary linearly with the vehicle velocity, v, and act in the direction opposite the vehicle's motion. Taking the Laplace transform of the governing differential equation and assuming zero initial conditions, we find the transfer function of the cruise control system to be:

$$P(s)=\frac{V(s)}{U(s)}=\frac{1}{m\,s+b}=\frac{1}{1000\,s+50}$$

4 Designing and Tuning of PID Controllers

4.1 PID Tuning using Ziegler-Nichols

The simulink model of the closed loop system is represented as under:

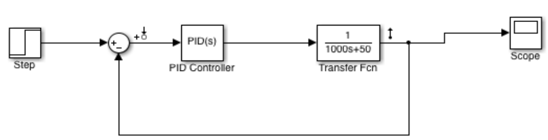

Figure 3: *Closed Loop Unity Feedback system implementation with ZN PID Controller*

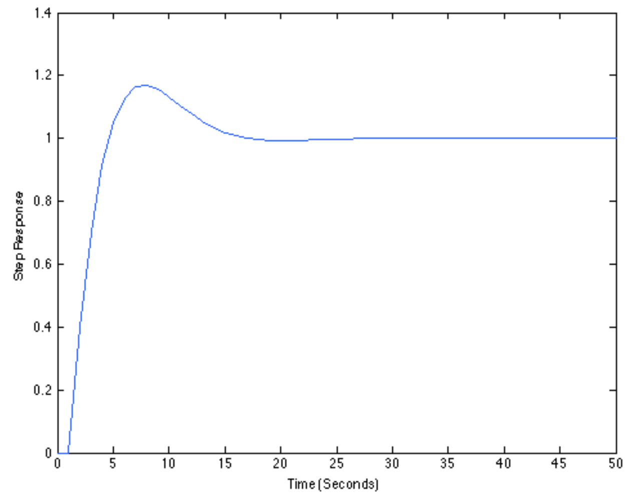

Figure 4: *Closed loop step response of the system with ZN-PID Controller*

Table 1. *Parameters of PID Controller Calculated by Ziegler-Nichols.*

.

PID Parameter	Value
Kp	450.0567
Ki	126.302
Kd	0

4.2 PID Optimization Using Genetic Algorithm

Since the Ziegler-Nichols based PID controllers gives an oscillatory reaction, so the PID parameters are not ideal for direct execution for the plant. So their sorted out improvement is must, so that better parameters can be assessed and when connected to the framework, conveys best execution and power. Genetic Algorithm gives an answer for the improvement of the PID controllers, by minimizing the goal capacity. The parameters got by Ziegler-Nichols strategy are utilized for the introductory revelation for the parameter populace, with a specific end goal to accomplish speedier union. The different steps included in enhancement utilizing Genetic Algorithms [6, 9] are as:

1. Generation of starting irregular populace of settled number of people for the beginning extents if Kp, Ki and Kd.
2. Evaluation of wellness necessary, it minimizes the basic square blunder, trailed by the choice of the fittest people.
3. Reproduction among the individuals from the populace.
4. Crossover of the replicated chromosome, trailed by transformation operation, and the determination of the best people i.e. Survival of the Fittest.
5. Looping the step 2 till the predefined joining.

The enhancement of the framework has been composed and recreated in Matlab and Simulink environment and the streamlining has been completed utilizing genetic algorithm. The different, parameters, utilized as a part of Genetic Algorithm are, 50 populace sizes, scattered hybrid, movement in both bearings, and tournament based determination capacity. Figure 5 and 7 shows the step response of the closed system and Fig-

ISSN 2347-4289

ure 6 & 8 shows the minimization of the objective function.

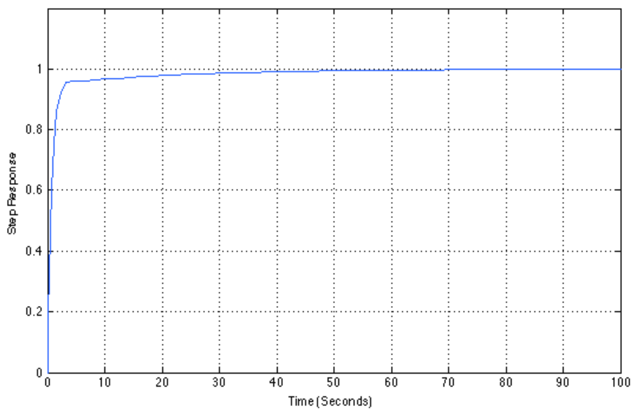

Figure 5: *Closed loop response of the system using GA optimized PID Controllers my minimizing ISE.*

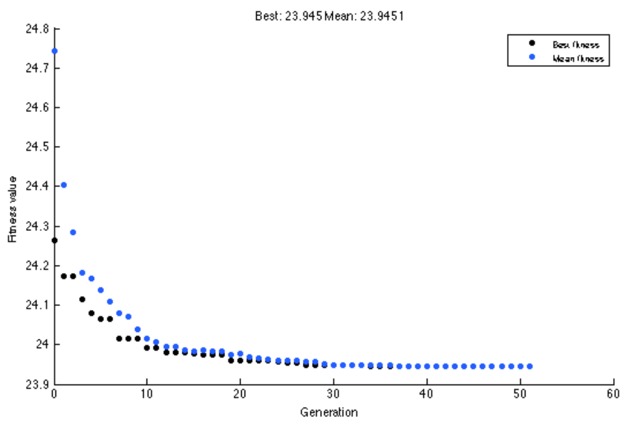

Figure 6: *Plot of best and average fitness value of the genetic algorithm optimization for ISE fitness fucntion.*

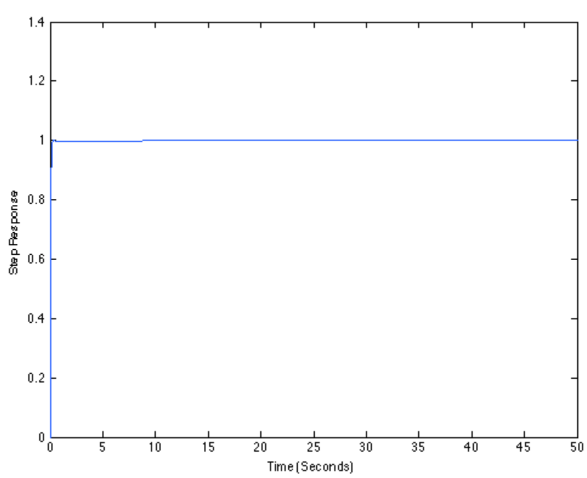

Figure 7: *Closed loop response of the system using GA optimized PID Controllers my minimizing ITSE.*

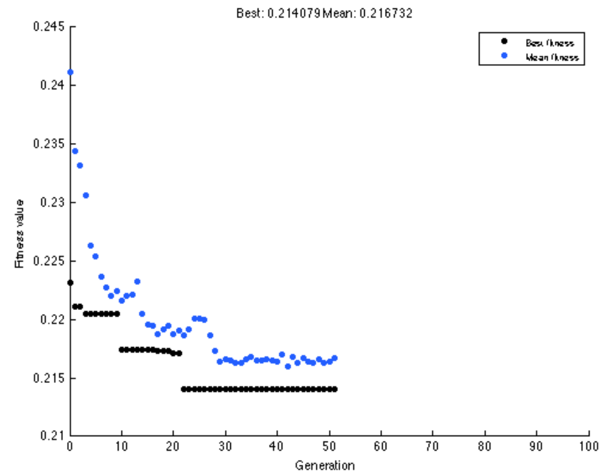

Figure 8: *Plot of best and average fitness value of the genetic algorithm optimization for ITSE fitness fucntion.*

Table 2. *Parameters used in optimization by genetic algorithm.*

PID Parameter	Value (ISE)	Value (ITSE)
Kp	594.994	8936.549
Ki	27	639.654
Kd	-499.99	-516.435

Table 3. *Shows GA Parameters estimated for optimization.*

GA Parameters	
Population Size	50
Selection Function	Tournament
Tournament Size	4
Crossover Fraction	0.8
Crossover Function	Scattered

4.3 STIMULATED ANNEALING

Simulated Annealing is a worldwide improvement calculation, as the name proposes, the muse originates from metallurgic tempering, which includes connection between the connection between the statical mechanics and multivariate enhancement [7]. It takes after the strategy including warming the material took after by controlled cooling, bringing expanded precious stone size and lessened deformations. In Simulated Annealing(SA), at every emphasis, another point is arbitrarily produced and its separation from the current point is the capacity of likelihood dispersion with a scale corresponding to temperature. The arbitrarily produced focuses are acknowledged in the event that they bring down the goal however so as to help the calculation to look for worldwide arrangement and to exclude the catching of the calculation in neighborhood minima, a few focuses are chosen to the point that they raise the target [8, 10]. With the approach of calculation, the temperature is diminished driving in lessening of the degree of hunt to merge the minima. Figure 9 and 11 shows the step response of the closed system and Figure 10 & 12 shows the minimization of the objective function.

ISSN 2347-4289

***Table 4.** PID Parameters obtained by SA*

PID Gains	Value (ISE)	Value (ITSE)
Kp	2058.112	2005.249
Ki	281.686	665.048
Kd	-894.408	-790.01

***Table 5:** Parameters used in Optimization by SA*

Simulated Annealing Parameters	
Population Size	50
Annealing Function	Fast Annealing
Reannealing Interval	100
Initial Temperature	100

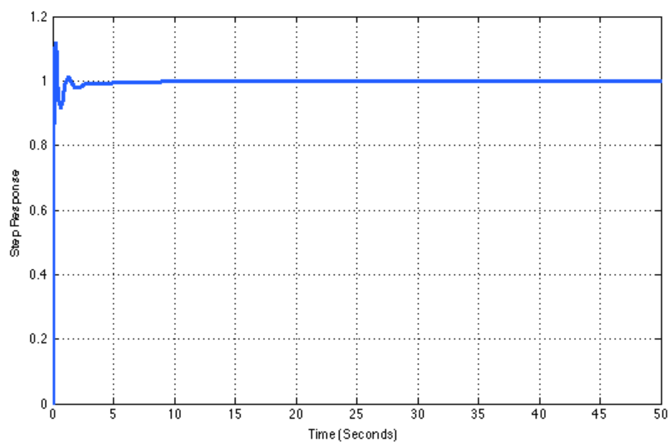

***Figure 9:** Closed loop response of the system using SA optimized PID Controllers my minimizing ISE.*

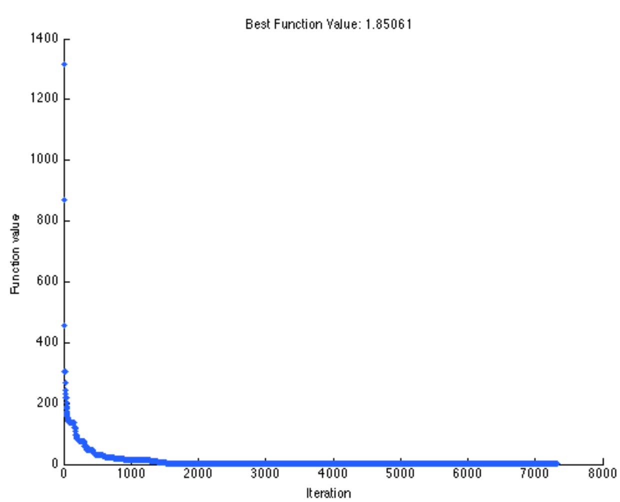

***Figure 10:** Plot of best fitness value of the simulated annealing optimization for ISE fitness fucntion.*

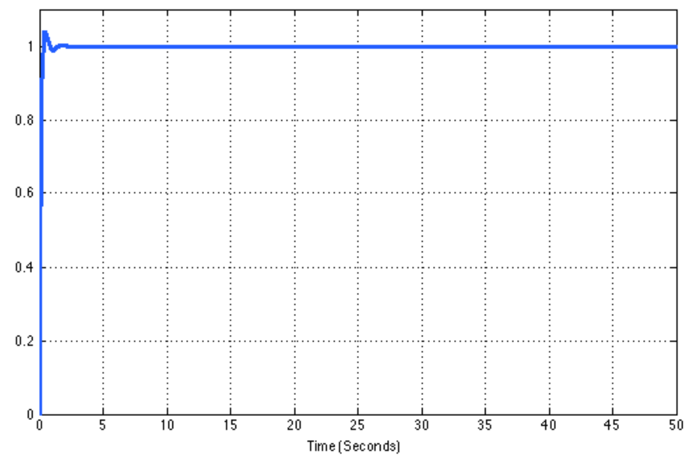

***Figure 11:** Closed loop response of the system using SA optimized PID Controllers my minimizing ITSE.*

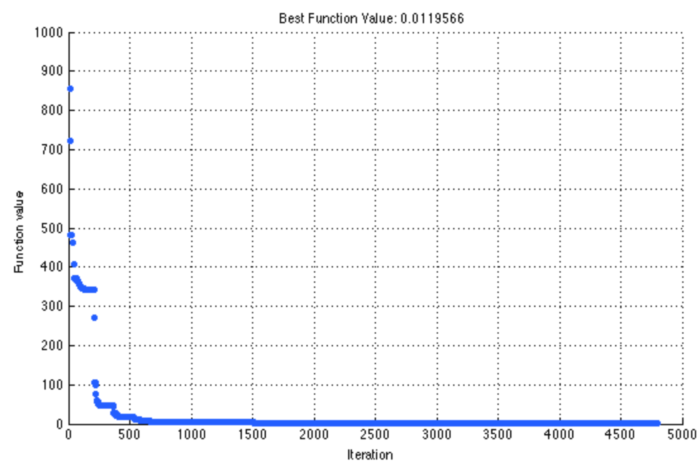

***Figure 12:** Plot of best fitness value of the simulated annealing optimization for ITSE fitness fucntion.*

5 Results and Discussion

In this paper, the transfer function of the cruise control system has been obtained. Classical Zigler-Nichols based PID controller tuning has been used to tune the controller initially. Since an oscillatory response has been obtained, so the parameters are not optimum for the implementation in the real plant. So, genetic algorithm and simulated annealing has been used to optimize the controller while taking the time domain performance criteria of ISE and ITSE as fitness function in optimizing the controller. Table 6 shows the comparative response of the PID controllers.

Table 6: *Comparison of Results.*

Method of Design	Rise Time(Sec)	Settling Time (Sec)	Overshoot (%age)
Ziegler Nichols	2.6925	13.9031	16.9854
Genetic Algorithm (ISE)	1.8143	3.4797	0
Genetic Algorithm (ITSE)	0.1181	0.2084	0.0175
Simulated Annealing (ISE)	0.2091	0.1879	2.8836
Simulated Anneal-ing(ITSE)	0.1090	2.8836	11.1710

6 Conclusion

The use of Genetic Algorithm (ITSE) for optimizing the PID controller parameters as presented in this paper offers advantages of tremendously decreased overshoot percentage, rise and settling times for the designed cruise control. Simulation results when compared with the other tuning methodologies as presented in this paper, Genetic Algorithm has proved effective in achieving the steady-state response.

References

[1] Cruise Control: System Modeling. Control Tutorials for Matlab and Simulink

[2] Ziegler, J.G and Nichols, N. B. (1942). “Optimum settings for automatic controllers.” Transactions of the ASME. 64. pp. 759–768.

[3] Goodwin, G. C., Graebe, S. F. and Salgado, M.E. 2001. Control System Design, Prentice Hall Inc., New Jersey.

[4] Norman S. Nise, 2003 , Control System Engineering, 4th Edition,

[5] Katal, N., and Singh, S. K. Singh. (2012) Optimal Tuning of PID Controller for DC Motor using Bio-Inspired Algorithms. *International Journal of Computer Applications* 56(2):1-5. DOI: 10.5120/8860-2822

[6] Deb, Kalyanmoy. “Multi-Objective Optimization Using Evolutionary Algorithms.” John Wiley & Sons, 2001.

[7] Kickpatrik S., Gelatt C.D., Vecchi M.P. (1983), “Optimization by Stimulated Annealing”, Science (220) 4508, p-671-680,

[8] Granville, V.; Krivanek, M.; Rasson, J.-P. (1994). "Simulated annealing: A proof of convergence". IEEE Transactions on Pattern Analysis and Machine Intelligence 16

[9] Abdullah Konak, David W. Coit, Alice E. Smith ,“Multi-objective optimization using genetic algorithm”, Reliability Engineering and Safety System, 91 (2006) 992-1007, Elsevier Ltd.

[10] Berrsimas D., Tsitsiklis, “ Stimulated Annealing” (1993), Statistical Science, Vol. 8, No. 1, 10-15

[11] MATLAB and SIMULINK Documentation