An Optimized Tuning of Pid Controller for Photonics and Optics Using Bio-Inspired Algorithm for Controlling Voltage and Current for Enhancement of Robustness

Swaminathan S (Swaminatans@outlook.com)
SASTRA Deemed University: Shanmugha Arts Science Technology and Research Academy
Raajan N.R
SASTRA Deemed University: Shanmugha Arts Science Technology and Research Academy

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Abstract

Optics and photonics are applied in vast range of application for information transmission between the Internet. In automated control system optics and photonics characteristics is important for automated processing. Automatic control demand for a vast range of applications such as food processing, aerospace and chemical industries. The issue with the automated control is the design of optimal controllers for off-line and on-line applications with reduced cost as the optics function. Renewable energy system gains the attention of the recent research for electricity generation especially in photovoltaic model robustness is major constraints. To mke use of the automated model for the photovoltaic system it needs to provide robustness. To achieve the desire robustness with minimized disturbance elimination physical and operating constraints need to be considered as multi-optics function. In this paper, developed a Multi-Optics Particle Swarm Optimization (MoPSO) algorithm for reduced complexity and improved ease of use. The proposed MoPSO provides the artificial intelligence-based metaheuristics approach for desire robustness in the PID controller. The designed MoPSO computation technique validated with the Phase Locked Loop system (PLL) and Magnetic Levitation System (MLS) for improved robustness in PID controller. The performance of proposed MoPSO is evaluated for the designed parameters to evaluate the output response. The measured output response of proposed MoPSO exhibits desire performance parameter for the RGA algorithm. The comparative analysis of the proposed MoPSO exhibits improved performance than the conventional PSO and DE. It is concluded that the design parameters of the proposed MoPSO is effective than the RGA and PSO.

1. Introduction

Optics and photonics is the ubiquitous technology that are adopted in information transmission in the internet through fibers for the application of smartphones, computing devices, optical fiber, precision manufacturing. In automated control methodology system analysis and design is the essential factor in the regulation of the plant for machine or industrial process with minimal human interaction. The automatic control system has been observed in a vast range of applications such as food processing, chemical, and aerospace industries [1]. The problem associated with the design of the automatic control is with the design of the optimal controller with the off-line and online application for industries to reduce the cost and other concerns to withstand operating constraints, physical factors to improve robustness etc [2]. With the advancement of digital technology, automated control provides a wide spectrum of control schemes. Almost, industrial controllers are 90% implemented based on the PID control algorithm based on simplicity, applicability, functionality, and ease of use for the PID controllers.

Robustness of the system ability involved in the maintenance of the stability in an adequate manner and performance in presence of the uncertainty inevitability in the system [3]. The uncertainty in the sources is observed in wide and varied aspects comprising the disturbance in the noise signal, model-parameters uncertainty or time-varying scenario, or unmodeled nonlinear dynamics at high frequency. In the conventional control system, it comprises the basic principles for control to achieve the desired robustness properties in the applications. In fact, the design of the classical opticss provides marginal gain and phase to the direct measure of the robustness in the system [4].

Proportional-Integral-Derivative (PID) is an efficient solution for resolving real-world problems in the simplest manner. The PID controller functionality relies on the efficient response in steady-state and transient responses [5]. The demand for the PID controller increases drastically for straightforward tuning of the controller. The optimum performance is achieved with the direct tuning of the controller. The Optimum parameter setting and control are achieved with the conventional controllers such as P, PI, and PID. The single-loop PID controller is Ziegler-Nichols (ZN), Lopez, etc are a few examples. With desirable features, the minimum parameters are tuned to derive the PID features [6]. The parameters considered for the PID controllers are proportional gain, derivative gain, and Integral gain. In PID controller comprises the PI controller through switching off to derive motion in the by-product. To achieve the robust PID controller to achieve specs overall performance for the particular gadgets relies on the controller tuning. The plant nonlinear devices comprise the different uncertainties for the tuning PID controller.

The design of a commercial controller design relies on the management of the PID algorithm [7]. The performance of the PID controller comprises of the different critical function for the elimination of the offset steady state for the anticipation of the deviation and technology of the corrective signal for the derivative movement. In real world, the problem associated with the external PID controller robustness and disturbances are need to be processed effectively to achieve desire performance solution [8]. The PID controller robustness relies on the capacity of the device to hold the functionalities for consideration of the different outer and inner parameters.

With PID controller design the manual running mode operates at the 30% for the set up and manual model comprises of the 65% those are automated controllers for poor tuning [9]. Additionally, it is observed that PID controller exhibits bad tuning value of 80% and Operating default factory setting value of the 25% those are tuned respectively. The analysis of the conventional tuning strategies does not exhibits significant impact on the economic aspects. The designed PID controller tuning exhibits hassle free tuning operator for proper regulations to withstand the issues PID controller for industrial applications [10].

In this paper presented a alternative approach for effective PID controller tuning for the industrial applications. The developed algorithm provides the robotic approach for tuning which research tries to provide an alternative approach for tuning PID controllers. The developed algorithm in these studies will robotically offer the designers with optimized PID parameters with less regulations of tuning. The developed approach is termed as the Multi-Optics Particle Swarm Optimization (MoPSO) for tuning PID controller. With incorporation of the MoPSO the controller are synthesis for computation of the nonlinearities with respect to saturation, limiter rate or zone, those strive from the traditional approach. The proposed MoPSO model exhibits the possibility with embedded restriction defined space.

2. Related Works

In [11] developed a single loop PID controller for the computation of the robustness performance and regulator tradeoff. Even though robustness performance are commonly considered for robustness the disturbances between input and output is considered for tradeoff in the regulator. In presented technique the features are final tuned with the expressions of the compromise the shifts. Another, factor considered are the plants stable and unstable in the unified manner. Finally, the obtained results expressed that the parameters controllers are concentrated based on the tuning those emphasis on the balanced regulation operation.

In [12] proposed a robust PID controller tuning scheme for motion control system with computation of the feedback velocity. The advantage of the proposed scheme is efficiency and simplicity in the practical application. The developed scheme is suitable for the high performance application with motion control system with desire robustness in the conventional PID controllers. The performance of the system is validated with the simulation and experimental results.

In [13] concentrated on the design of the Proportional Integral Derivative (PID) integrated with the derivative filter for the Magnetic Levitation System (MLS) those are nonlinear for the open loop system. The developed model MLS performance is evaluated with the MATLAB/SIMULINK. The simulation results expressed that the proposed model evaluate response in terms of step and sine wave. The performance of the proposed technique is comparatively examined with the conventional PID controller. The analysis expressed that the performance of the proposed PID controller with filter derivative exhibits a better response than the conventional PID controller.

In [14] presented a design of the efficient method for the PID controller with the MLS. The tuning in the PID controller uses the Genetic Algorithm (GA). The performance of the proposed scheme expressed than the proposed PID controller exhibits the improved performance than the conventional PID tuning such as i.e., Ziegler Nichols (Z-N).

In [15] comparatively examined the operators those are 16 and functions 24 benchmark. The identification of the best operator is difficult task to resolve the specific problem in the system. Through statistical analysis the operator concentrated on the estimation of the best performance. The analysis results demonstrated that the differences is efficient for the different crossover operators. And it depends on the fitness function distinctive properties. Additionally, the analysis results stated that the integration of the crossover operator exhibits significant results.

In [16] implemented a scheme for the Dynamic Crowding Distance (DCD) procedure integrated with the NSGA-II and MNSGA-II scheme. The proposed scheme is evaluated and tested in the IEEE 30-bus system for the practical 69-bus system those comes under the IEEE 118-bus. The performance is based on the consideration of the different MNSGA-II. The simulation results were comparatively examined with the MNSGA-II and NSGA-II validated with the Pareto through the conventional weighted sum integrated with the Covariance Matrix Adapted Evolution Strategy (CMA-ES). The comparative analysis is performed with the NSGA-II and MNSGA-II is evaluated based on the standard deviation, mean, best through multi-optics optimization model consideration of the spread, minimum spacing, gamma and Inverted Generational

Distance (IGD) for the independent 15 runs. The experimental results demonstrated that the MNSGA-II exhibits the potential solution for the RPP problem. With the implementation of the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for the decision-making procedure for identification of the best solution through Pareto solution implemented with the MNSGA-II.

In [17] proposed a non-dominated sorting genetic algorithm II (NSGA-II) combined with the BP model to achieve optimal parameter operation. The problem associated with the convergence and uneven distributions premature for the Pareto solution application for the NSGA-II and improves the crowded operator and crossover performance operation. The obtained results illustrated that the multi-optics optimization model exhibits significant performance for the MNSGA-II model.

In [18] developed a loop shaping design method for the automated robust controller to synthesize the uncertainty in the plant for the presence of the assumed uncertainties to ensure proper trade-off for the stability robustness and specification of the tracking performance of the different frequencies design. The PID controller uses the PSO technique comprises of the automated tuning and it significantly minimizes the computational effort compared with the graphical techniques. It is also stated that the proposed scheme involved in automated loop shaping to increase quality and usefulness for the optimal performance in the PID controller.

In [19] developed an intelligent optimization model for the PID controller for the cylindrical tank applications. The proposed scheme comprises of the system identification process implemented in step by step with test methods with First Order Plus Dead Time (FOPDT) model. Initially, the Proportional Integral Derivative (PID) controller is utilized with the Internal Model Controller (IMC). The performance of the controlled is comparatively examined with the PID with the PSO controller. The proposed scheme in the controller is validated for the robustness operation with the regulatory and servo disturbances model. The performance of the designed controller is examined based on the time-domain settings. The proposed model exhibits significant performance with the PSO based controller settings in the PID controller with the IMC.

In [20] developed a evolutionary algorithm those extended to the preference based approach to resolve multi-optics optimization model. The developed concept exhibited the interactive synchronous NIMBUS method those combined with the R-NSGA-II model for the evaluation. The developed synchronous R-NSGA-II algorithuses the decision maker information to achieve desirable solution to withstand the Pareto criteria. The evaluation is based on the solarizing criteria to derive the solution abour the information preference. The evaluation of the results expressed that the proposed R-NSGA-II exhibits improved performance than the conventional R-NSGA-II.

3. Structure Of Pid Controller With Mopso

The PID controller belongs to the class of fixed structures lies in the controller family denoted a PID controller. The controller is designed in such a way to provide robustness and is beneficial for the different applications. The performance of the PID controller with proposed MoPSO is defined as

P = (Proportional) I = (Integral) D = (Derivative)

PID controller exhibits the characteristics of the broad range of applicability with the SISO system. The examples of the PID controllers are time delay, nonlinear, linear and so on. Different MIMO systems are developed and decoupled from the different SISO loops in the PID controllers that comprise of every loop. The controllers with eh PID exhibits robust performance for industrial process in an acceptable range. With the proposed design of the controller the particular process in the system can be fine tuned [21] as it implies P,I & D are major parameters in the selection process. With proper selection of the parameters, instability is observed in the closed-loop system. The illustration of the PID controller is presented in Fig. 1.

In Fig. 1, the design of the PID controller is presented. The term $e(t)$ represents the error signal those are applied with the proportional, integral, and derivative those resulted signal are summed with formulation of the control signal $u(t)$ those applied over the plant model. In the design, the error signal processed for the input signal is represented as $e(t) = r(t) - y(t)$ and the reference signal is denoted as $r(t)$.

The standard PID controller transfer function is is given in Eq. (1)

$$G(s) = K_p + K_1\frac{1}{s} + K_D(s)$$

1

In ideal form, it is given as in Eq. (2)

$$G(s) = K_p\left(1 + \frac{1}{T_i s} + T_d s\right)$$

2

Where

$K_p -$ Proportional gain,

$K_1 -$ Integral gain,

$K_D -$ Derivative gain

$T_i -$ Integral time constant,

$T_d -$ Derivative time constant.

As the proposed MoPSO controller design comprises of the robust scenario to exhibits significant performance. The designed PID controller comprises of the certain weighted function applied with the conventional PSO [22]. In Fig. 2 the process involved in the PID controller robustness is presented.

The mathematical formulation of the PID is based on the weighted function to perform sum, integral or average element value weights or which influence on the remaining elements within the same set.

The variation in the perturbation on the plant is bounded by the factors those given in Eq. (3) $W_1(s)$ans $W_2(s)$.

$$\bar{\sigma}\left({\Delta}P\left(j\omega \right)\right)\le \bar{\sigma}\left({W}_{1}\left(j\omega \right)\right),{\forall }_{\omega }\left(0,{\infty }\right) \tag{3}$$

where $\bar{\sigma}\left(A\right)$ represents the singular value for the maximal matrix A

The controller design ${G}_{c}\left(s\right)$ comprises of the asymptotical stable nominal feedback based control system $\varDelta P\left(S\right)=0$ and $d\left(t\right)=0$ for the performance stability with desire robustness and disturbance in the system is evaluate the robust stability and disturbance performance based on the inequality constraints. The system complementary function is stated as $\left(s\right)$and $T\left(s\right)=1-S\left(s\right)$ represented as follows in Eqs. (4) and (5)

$$S\left(s\right)={\left(1+P\left(s\right){G}_{c}\left(s\right)\right)}^{-1} \tag{4}$$

(5)

The controller filter transfer function in the PID is stated as in Eq. (6)

$$K\left(s\right)={K}_{p}\left(1+\frac{1}{{T}_{i}s}+\frac{{T}_{d}s}{1+\left(\frac{{t}_{d}}{N}\right)s}\right) \tag{6}$$

where, ${K}_{p}$ - Proportional gain

${T}_{i}$ – constant time integral

${T}_{d}$ – Constant time derivative

${t}_{d}/N$- constant filter time

The PID controller zeros with the derivation filter is determined using the equation and the obtained zeros are presented as in Eq. (7)

$${T}_{i}{T}_{d}{S}^{2}+{T}_{i}\left(s\right)+1=0 \tag{7}$$

The zeros are stated as in Eq. (8)

$${Z}_{\text{1,2}}=\frac{\frac{1}{2}-{T}_{i}\sqrt{{T}_{i}^{2}-4{T}_{i}{T}_{d}}}{{T}_{i}{T}_{d}} \tag{8}$$

With the applied derivative filter concept the controller zeros solution in the equation is denoted as in Eq. (9)

$${T}_{i}{T}_{d}\left(1+\frac{1}{N}\right){S}^{2}+\left({T}_{i}+\frac{{T}_{d}}{N}\right)S+1=0 \tag{9}$$

The zeros are represented as in Eq. (10)

$$\stackrel{-}{{Z}_{\text{1,2}}}=\frac{\frac{1}{2}-{T}_{i}N-{T}_{d}\pm \sqrt{{\left({T}_{i}N-{T}_{d}\right)}^{2}-4{T}_{i}{T}_{d}{N}^{2}}}{{T}_{i}{T}_{d}(1+N)} \tag{10}$$

The utilization of the PID controller filter effectively improves the rejection distribution performance of the load with the appropriate energy control strategu for improvement.

The most important optics of robust PID controller design is to ensure robustness of the controller against uncertainities and attenuation in the system. This is closely related to the stability of the system. It is framed by combining the model attenuation and uncertainities are represented as in Eq. (11)

Minimize ${J}_{1}={\left({J}_{a}^{2}+{J}_{b}^{2}\right)}^{1/2}$ (11)

${J}_{1}$ – model robustness disturbance attenuation; ${\|{W}_{1}\left(s\right)S\left(s\right)\|}_{{\infty }}=$ robust stability performance; and ${J}_{b}={\|{W}_{2}\left(s\right)T\left(s\right)\|}_{{\infty }}=$ disturbance attenuation performance

Based on the trajectory time constant, the effect of user is evaluated based on the response speed with consideration of the changes in the point. Through specification the relative importance is evaluated for the control applications. The computed point changes need to be considered more important for the different application for the motion control systems is denoted as in Eq. (12) [23 & 24]

$${J}_{2}={\int }_{0}^{{\infty }} \left|r\right(t)-y(t\left)\right|dt \tag{12}$$

Where, $r\left(t\right)$ denoted as the input reference and $y\left(t\right)$ represented as the process in output variable. In control process, the PID controller performance is evaluated based on the specification with elimination of the load disturbance. It is defined as the measure of the integral performance to the unit step disturbance input where the remaining output are equal to zero. However, in the developed PID controller load disturbances are minimal than the expected frequency values in Eq. (13)

$${J}_{3}={\left.{\left.{\int }_{0}^{{\infty }} \right|}_{y\left(t\right)}\right|}_{dt} \tag{13}$$

where, y(t) = variable for the load disturbances process

The PID control strategy with the fouth performance is evaluated for the robustness. The computed total variation in the control energy with the control signal is represented as in Eq. (14)

$$J_{4}=\sum \left|U(k+1)-U(k)\right| \tag{14}$$

The variation provides the significant measure of the control signal smoothness that need to be minimal. TO achieve the higher degree performance in the control system it is necessary to provides the rapid and smooth response in the input variation.

The designed PID controller performance specification is based on the formulated individual optics function. The optics function is evaluated based on the minimization of the function. The robustness of the PID controller output is evaluated based on the summation o fthe individual function. Hence, the problem derived witht eh optics function is formulated with the minimizartion ation function as defined in Eq. (15)

$$J_{all}=\left\{J_{1}+J_{2}+J_{3}+J_{4}\right\} \tag{15}$$

J_{1} - disturbance attenuation with respect to the robustness of the model.

J_{2} – tracking set

J_{3} – Elimination of the distributed load

J_{4} – Energy control scheme

The PID controller optics function of the system is formulated with consideration of the robustness in the system to minimize $\left\{J_{1},J_{5}\right\}$ represented in Eq. (16)

– disturbance attenuation for the model uncertainities for robustness

J_{5} – Specification of the PID controller robust performance

$$J_{5}=J_{2}+J_{3}+J_{4} \tag{16}$$

The performance of the formulated optimization model for the multimodal and multioptics terms are evaluated for the performance. The constructed optimization model uses the generated offspring from the set of parents with consideration of the reandom number 0 and 1 those are calculated as follows in Eq. (17)

$${\beta }_{qi}=\left\{\begin{array}{ll}{\left(2u{u}_{i}\right)}^{\frac{1}{{n}_{c}+1}},& u{u}_{i}\le 0.5\\ {\left(\frac{1}{2\left(1-u{u}_{i}\right)}\right)}^{\frac{1}{{n}_{C}+1}},& \text{ otherwise }\end{array}\right.$$
17

${\beta }_{qi}$ denoted as spread factor and ${\eta }_{c}$ denoted as the crossover index. The evaluated children node in the PID controller is defined as, ${X}_{i}^{1,g+1}$ and ${X}_{i}^{2,g+1}$ using Eq. (18)

$$\begin{array}{rr}& {X}_{i}^{(1,g+1)}=0.5\left[\left(1+{\beta }_{qi}\right){X}_{i}^{(1,g)}+\left(1-{\beta }_{qi}\right){X}_{i}^{(2,g)}\right]\\ & {X}_{i}^{(2,g+1)}=0.5\left[\left(1+{\beta }_{qi}\right){X}_{i}^{(1,g)}+\left(1+{\beta }_{qi}\right){X}_{i}^{(2,g)}\right]\end{array}$$
18

The generated offspring with the crossover need to perform polynomial mutation operation with the polynomial function probability distribution function computation rather than the normal distribution. The offspring of the new population is defined as in Eq. (19)

$${y}_{i}^{(1,t+1)}={x}_{i}^{(1,t+1)}+\left({x}_{i}^{U}-{x}_{i}^{L}\right){\tilde{\delta }}_{l}$$
19

where, factor ' ${\delta }_{i}$ ' is found using Eq. (20)

$$P\left(\delta \right)=0.5\left({n}_{m}+1\right)(1-|\delta |{)}^{{n}_{m}}$$
20

The computed velocity of the model s s defined as through the estimation of the the velocity sa in Eq. (21) where, ${x}_{i}^{U},{x}_{i}^{L}$=The upper and lower limit values ${\eta }_{m}$ - Mutation index.

$${v}_{i}(t+1)=w\left(t\right){v}_{i}\left(t\right)+{c}_{1}{r}_{1}\left({p}_{i}\left(t\right)-{x}_{i}\left(t\right)\right)+{c}_{2}{r}_{2}\left({g}_{i}\left(t\right)-{x}_{i}\left(t\right)\right)$$
21

The swarm movement based on the particle position are computed using follows in Eq. (22)

$${x}_{i}(t+1)={x}_{i}\left(t\right)+{v}_{i}(t+1)$$
22

where, ${v}_{i}(t+1)$=Velocity at time$t+1$

${v}_{i}\left(t\right)$= Current velocity at time t

$w\left(t\right)$= Inertia weight with current velocity at time t

${p}_{i}\left(t\right)$= Particle's best position

${x}_{i}\left(t\right)$= Particle's current position.

${g}_{i}\left(t\right)$= Swarm's best solution at time t

${r}_{1}\&{r}_{2}$= random variables in the range $\left[\text{0,1}\right]$

${c}_{1}\&{c}_{2}$= cognitive and social parameters

Through the same process the iteration is performed those are not satisfied, till the iteration count repeat the processes.

The proposed MoPSO algorithm for the PID controller design is presented as follows

Algorithm 1: Pseudo Code for MoPSO

Input: Maximum function constraints for the constraints [$R_{D,\mathbf{min}}$,$R_{D,\mathbf{max}}$]**, with function evaluation** nfe_{max};

Output: Estimate the individual best X_{gbest}**, with fitness value** $f(X_{gbest})$**, function number evaluation as** nfe;

Initialize the size of population as *ps*, with probability of inheritance as *P and individuals are computed as* $X = \{X_1, X_2, \ldots, X_{ps}\}$, $p_{max} = 0.2$, $p_{min} = 0.05$, $G = 1$

while $nle \le nle_{max}$ do

for $i = 1$; $i \le ps$; i ++ do

Generate the population

if G > 2 then

Modify the size of population

Modify the size of storage A;

end if

Compute A_i for every individual;

Readjust the constraints for the boundary

Compute the evolution matrix M

Generate the population for traials based on evolution matrix M

Compute fitness value for the population;

$nfe = nfe + ps$

for $i = 1$; $i \le ps$; i ++ do

if $f(U_{i,G}) \le f(X_{i,G})$ then

else

$X_{i,G+1} = X_{i,G}$;

end if

end for

if $S_F \neq \emptyset$ then

Update $P(A = k)$ ($k = 1, 2, \ldots, D$);

end if

G = G + 1;

Algorithm 1: Pseudo Code for MoPSO

end while

$f(X_{gbest}) = f(X_{gbest,G}), X_{gbest} = X_{gbest,G};$

Return X_{gbest}, and $f(X_{gbest})$;

Non-dominated Sorting Genetic Algorithm-II (NSGA-II)

The proposed MoPSO comprises of the Multiple Optics optimization (MOO) algorithm known as Non-dominated Sorting genetic algorithm – II. The aim of the algorithm is to improve the population adaptive fit through Pareto front constraints based on the optics functions. The algorithm uses the evolutionary process comprises of the surrogate's computation process with evolutionary process comprises of selection, genetic mutation and crossover. Each group evaluated based on computation of each group through Pareto front and resulting similarity groups are used to promote diverse non-dominated solutions.

The sorting of the non-dominated GA multi-optimization algorithm uses the dual opticss to perform fitness assignment maintenance for the non-dominated solution with the appropriate sharing strategy. The fitness assignment computational procedure complexity governed with the non-dominated procedure sorting and implementation of the sharing function. The NSGA advantage comprises of the assignment of fitness through non-dominated sets based on rank and distance with diverse solution. The proposed MoPSO algorithm uses the NSGA-II procedure for the EMO procedures to find optimal Pareto optimal solution through multi optics optimization and features are presented as follows:

1. It comprises of the principle with an elitist
2. It involved in the diversity explicit preservation mechanism
3. It emphasizes on the solutions for non-dominated factors

Steps in MoPSO with NSGA-II
Step 1 : Start with the iteration generation count of t = 0
Step 2: Generate the population size S those are distributed uniformly
Step 3: Depends on the non-domination individual population those need to be sorted
Step 4: Assign the minimum fitness rank value for the each solution
Step 5: Generate the population offspring P with the binary selection to perform binary crossover and mutation polynomial.
Step 6: With population extended the combined size 2P evaluated with the parent and population of offspring.
Step 7: To extend the population again perform the non-domination sorting for the every population
Step 8: Compute best individual from the new population P size
Step 9: Create the population distance based on the crowding distance diversity
Step 10: Update generation number of,t=t+1
Step 11: Repeat the steps from 3 to 11 based on the computation of the stopping criterion.

Modified Non-dominated Sorting Genetic Algorithm (MNSGA-II)

With the non dominated uniform distribution necessary to perform the Paretofront optimization model. To overcome the limitation associated with the proposed MoPSO with NSGA-II need to be improved with the Controlled elitism (CE) to maintain non-dominated maintain diversity solution, Dynamic Crowding Distance procedure need to be implemented along with NSGA-II denoted as MNSGA-II.

The population estimation need to be compressed with consideration population and offspring. The elitism controller comprises of the individual number need to be maintained appropriately. The developed MoPSO integrated with the MNSGA-II involved in generation of the random population for control variables and sets generation count. The formulation of the offspring population is estimated.

The steps involved in the MNSGA-II approach are explained as follows:

Steps in MoPSO with MNSGA-II
Step 1: Generate initial population random size of N along with the limit control variable for the generation count of t = 0
Step 2: Formulate the offspring through selection of the crowded tournament.
Step 3: Compute the sorting through non dominated for initial and offspring population
Step 4: Apply elitism controller performance and maintain the individual number based on the non dominated fronts.
Step 5: If non dominated set value M is higher than the population size N, then dynamic crowding distance of individual is evaluated with MN else go to step 2.

4. Results And Discussion

All the simulations are carried out in MATLAB 7.10.0 on software Pentium 4 PC operating @2.16 GHz with 2 GB RAM. The PLL test system is simulated using MATLAB. Maximum function evaluation (Fevalmax) is fixed as 4000. Owing to the randomness of the evolutionary computation techniques, 20 independent trials have been conducted to check the robustness and the performance of PLL system using computation techniques. The convergence characteristics of single optics computation techniques such Real coded Genetic Algorithm (RGA), Multi-optics Particle Swarm Optimization (MoPSO) and Differential evolution (DE) are obtained for PLL system. The convergence characteristics are used to find the fastest technique which converges at minimum time.

Figure 3 clearly shows the variance of the convergence characteristics for single optics evolutionary computation technique. RGA, PSO and DE algorithms are simultaneously applied for designing the robust PID controller for PLL system with 4000 function evaluation, and 40 population sizes for 20 runs. From this experiment, it is noted that RGA is more suitable for designing robust PID controller for PLL system. The variances of the three different algorithms are spotted with different colors. In the Fig. 5.1, it is clearly shown that RGA converges faster than PSO and DE.

In Fig. 4, the output responses of RGA, MoPSO are DE are neatly illustrated with simulation. The output responses of PLL system with robust PID controller parameters are obtained out of 20 independent trials by using RGA, MoPSO and DE and they are also shown. From the Fig. 4, it is inferred that RGA based robust PID controller parameter output response has been acquired with less overshoot and minimum settling time compared to PSO and DE. It is observed that RGA performs better than MoPSO and DE.

The performance of the Pareto front framework model is partially evaluated based on the action set with assumption of the multi-dimensional output those are desirable with the partial ordering. The computation of the applied within the one process to achieve the better results form the all outputs. It is effective for the minimization of the all candiates in the process with analysis. Thus, the pareto front response is computed as utilized in the evolutionary computation technique for the effective tuning of the PID controller.

In Fig. 5 and Fig. 6, the simulation results are obtained between the robustness (J1) and performance of robust PID controller (J5) for NSGA-II and MNSGA-II. While comparing NSGA-II and MNSGA-II, the controller parameter values are considered for calculating (J1) and (J5). Where the values of J5#J2)J3)J4 are considered. Figures 5 and 6 clearly depict that MNSGA-II is better than NSGA-II. The statistical perforamcne of the PID controller with MoPSO is tested with the PLL are presented in Table 1.

Table 1
Robustness of PID controller with MoPSO in PLL system

Statistical Parameters	**RGA**	**PSO**	**MoPSO**
Best value	9.8757	9.9468	9.5789
Mean value	10.078	12.78547	10.0648
Worst value	15.6890	27.9530	14.8687
Standard deviation	1.3597	4.8575	1.0570

The Table 1 expressed that the statistical performance of the optimization model for different cases such as best, worst, mean and standard deviation value. The statistical analysis expressed that the proposed MoPSO exhibits significant performance as standard deviation value in all aspects is minimal for the proposed MoPSO. Similarly, the performance comparison of the optimization model for different J values are computed asn presented in Table 2.

Table 2
Performance Comparison of PLL

Algorithm	**RGA**	**PSO**	**MoPSO**
J1	1.1123	1.0865	1.2379
J2	0.1447	0.1346	0.15680
J3	4.7468	5.13579	4.8568
J4	3.8670	3.56895	3.4868
Jall	9.6359	9.94689	9.6796

The comparative analysis of the proposed MoPSO is examined with the conventional RGA and PSO. The comparative analysis of the J1, J2, J3, J4 and Jall expressed that the proposed MoPSO exhibits superior performance than the RGA and PSO. Similarly, the proposed MoPSO model is tested in NSGA-II and MNSGA-II with the PLL subsystem. The comparative analysis of the test system and statistical performance is presented in Table 3.

Table 3
Statistical performance of the MoPSO with PLL

Statistical Parameters for compromised value	NSGA - II	MNSGA – II
Best	1.5675	1.0657
Mean	1.6577	1.0857
Worst	1.8680	1.8546
Standard	0.9548	0.9635
Best Optics	1.2356	1.0689
Mean optimal	1.2467	1.1857
Worst Optics	1.9784	1.8957
Standard best optimal value	0.9857	0.6368

The compromised evaluation of the value expressed than the proposed MoPSO exhibits the effective performance for the PLL test bench. The statistical analysis is performed for the developed model based on the consideration of the MoPSO value in the tuning of the PID controller.

5. Conclusion

This paper presented a multi-optics PID controller for robust performance is evaluated with the tuning of the PID controller. The tuning in the PID controller is optimized based on the designed multi-optics particle swarm optimization MoPSO. In the conventional technique tuning of the PID controller is difficult due to higher system complexity that leads to poor tuning. To resolve the optimization problem MoPSO uses the global optimum convergence rate with consideration of the Phase Locked Loop (PLL) motor control system and Magnetic Levitation System (MLS), to evaluate the filter robustness validation. The performance analysis expressed that the proposed MoPSO exhibits improved performance than the conventional PSO and DE for tuning PID controller. The analysis expressed that proposed MoPSO exhibits robust performance for the PID controller for tuning.

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Figures

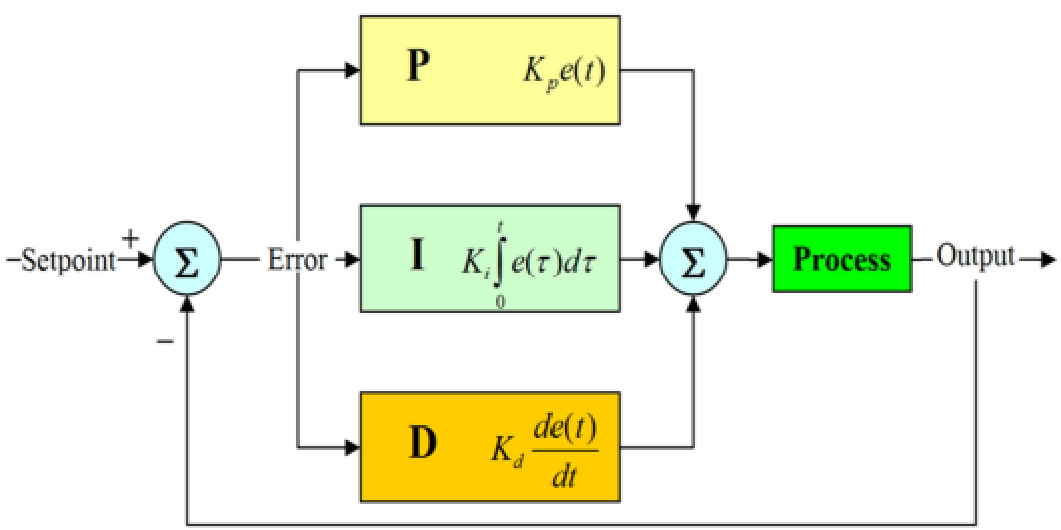

Figure 1

PID controller

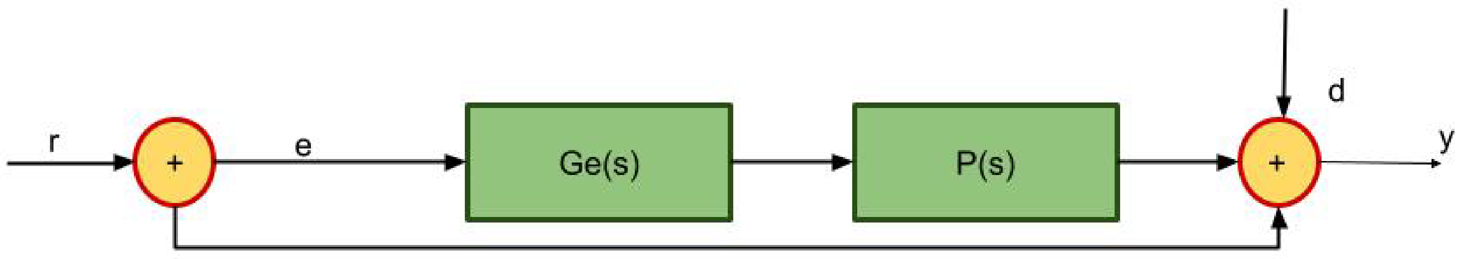

Figure 2

Robustness of PID Controller

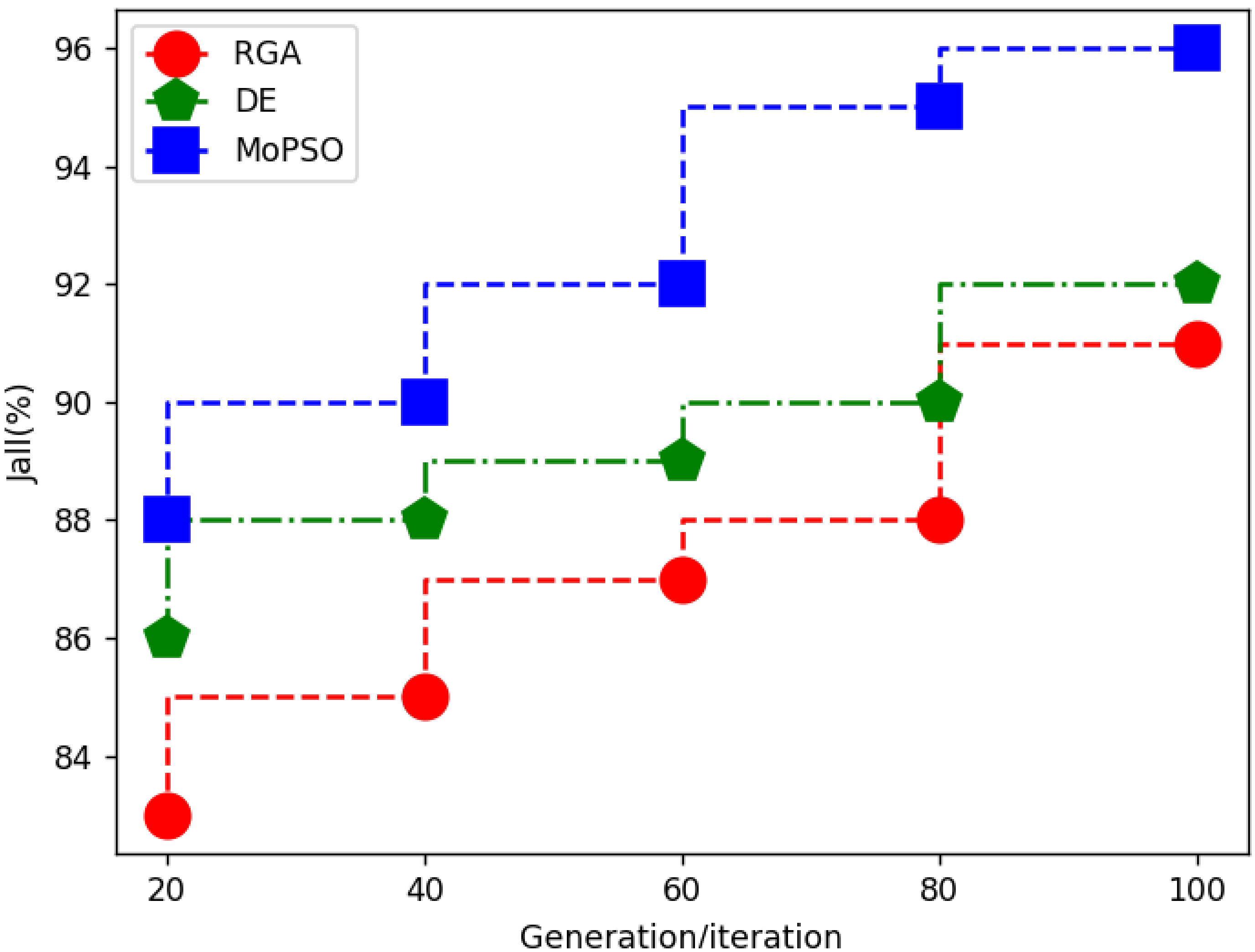

Figure 3

Comparison of Jall for output response

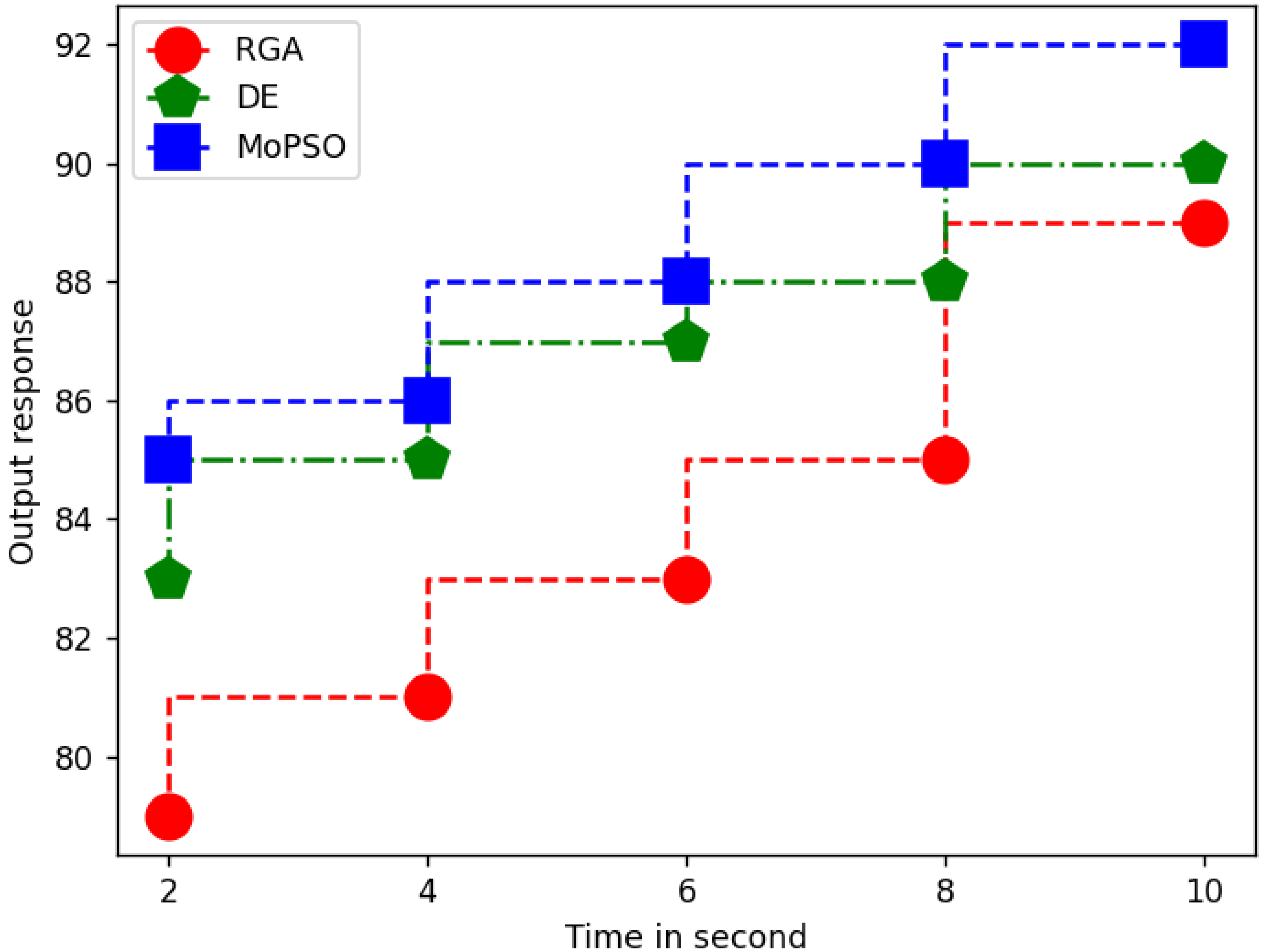

Figure 4

Comparison of Output Response

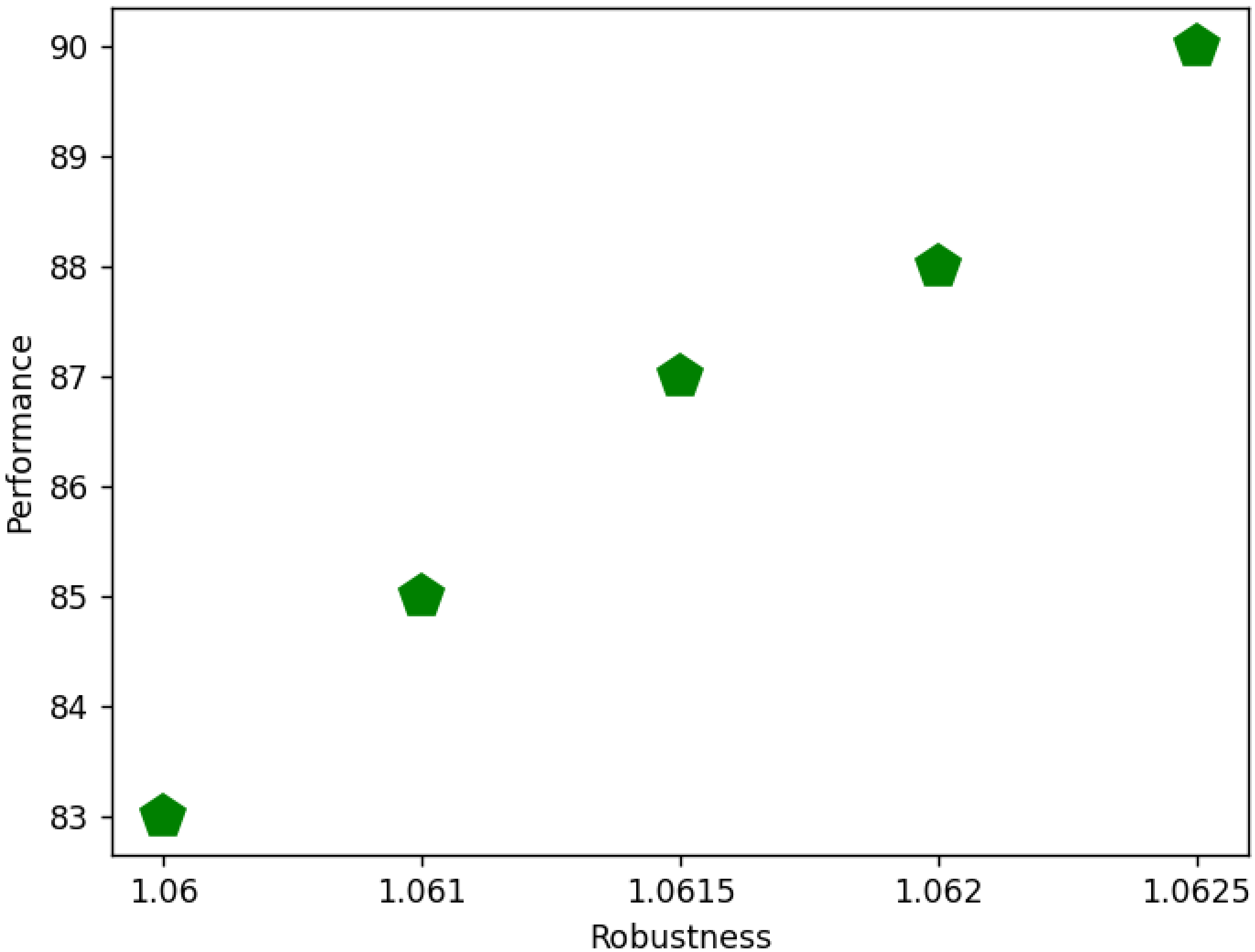

Figure 5

Robustness of MoPSO with NSGA-II

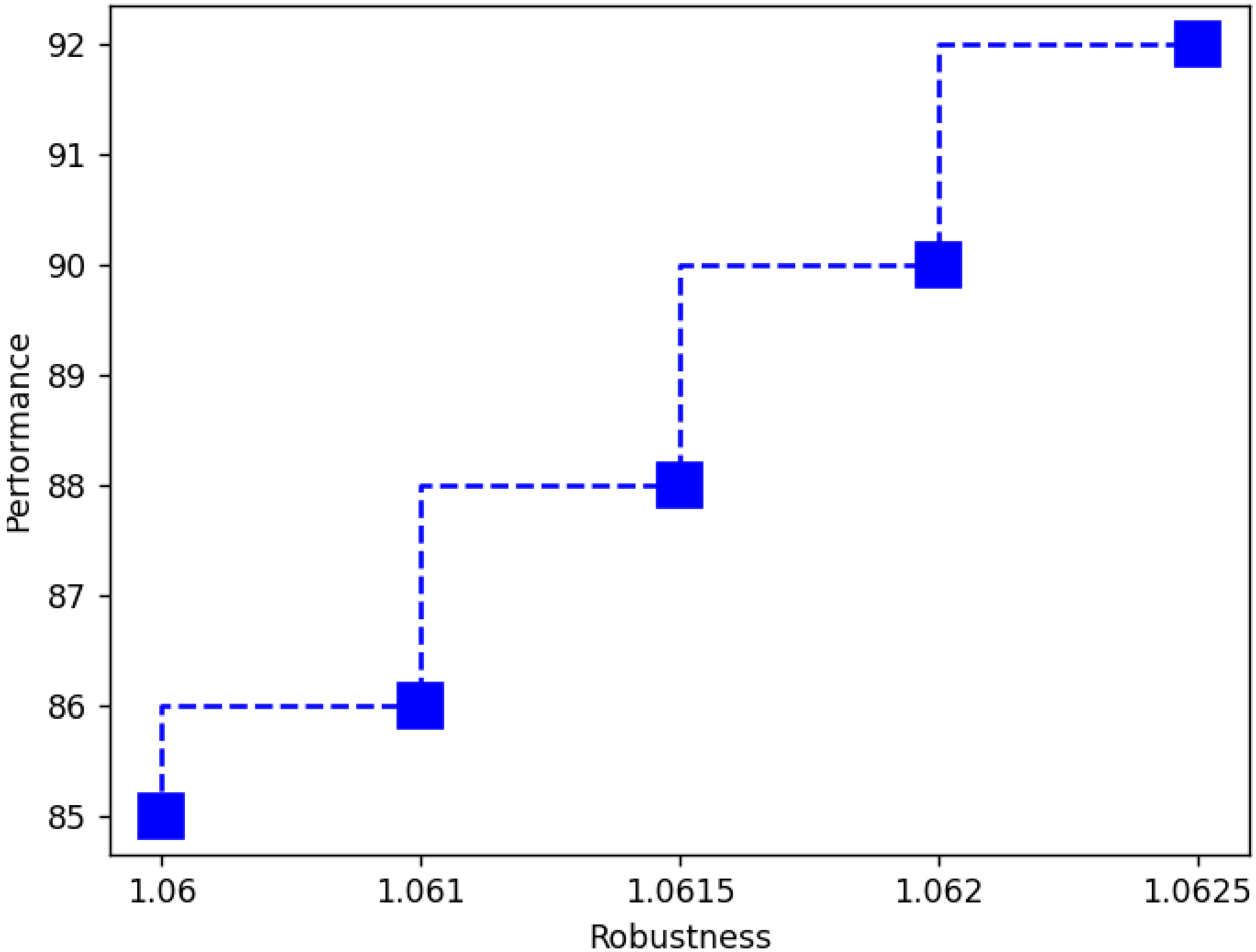

Figure 6

Robustness of the MoPSO with MNSGA - II