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PSO Based PID Controller for Hard Disk Controller

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Abstract: ***In today's fast growing world, there is an urgent need to increase the production rate in process industries which consists of numerous non-linear processes. Hence it is important to design a stabilizing controller. The aim of the paper is to design optimum***

model-based method where PID parameters are expressed as functions of process model parameters and we can get the result, without doing any experiment. Still, it requires verification, if the PID tuning is proper, by simulation. But all of the above mentioned tuning algorithms are comparatively intricate and pose a lot of difficulty in making the output response optimized with the worse vibration and overshoot.

Each particle is treated as a point in a N-dimensional space which adjusts its "flying" according to its own flying experience as well as the flying experience of other particles. Each particle keeps track of its coordinates in the solution space which are associated with the best solution (fitness) that has achieved so far by that particle. This value is called personal best, pbest. Another best value that is tracked by the PSO is the best value obtained so far by any particle in the neighborhood of that particle. This value is called gbest.

The basic concept of PSO lies in accelerating each particle toward its pbest and the gbest locations, with a random weighted acceleration at each time step.

A basic PSO algorithm is then:
1. Create a ‘population’ of agents (particles) uniformly distributed over X.
2. Evaluate each particle’s position according to the objective function.
3. If a particle’s current position is better than its previous best position, update it.
4. Determine the best particle (according to the particle’s previous best positions).
5. Update particles’ velocities:
v= inertia + cognitive + social
$v = v + c_1 * rand * (pBest – p) + c_2 * rand * (gBest – p)$
where
p: particle’s position
v: path direction
c_1: weight of local information
c_2: weight of global information
pBest: best position of the particle
gBest: best position of the swarm
rand: random variable
6. Move particles to their new positions:
p = p + v
7. Go to step 2 until stopping criteria are satisfied

There are many advantages of using PSO algorithm as it is insensitive to scaling of design variables, simple to implement, easily parallelized for concurrent processing, derivative free, very few algorithm parameters and very efficient global search algorithm

3. Approach for Solving This Problem

Following were the steps performed to execute this algorithm:

1. Implied a Ziegler Nicholas criterion on the given transfer function to find out the tuning parameters of the PID algorithm.
2. Then find out the timing parameters of the system.
3. Since the tuning parameters found out by the Ziegler Nicholas criterion does not provide the optimized solution, so we applied PSO algorithm on the PID with the range of ±10% in the values of the kp, ki and kd.
4. Then the timing parameters where calculated for each iterations and the list of the parameters calculated are:

- Overshoot value
- Rise Time
- Settling time
- Steady State Error

5. Compute the evaluation value of each and every individual present in the population with the help of the evaluation function
f=1/W(K)
where,
$min_{K:\ stabilizing}\ W(K)= (1- exp(-\beta)).(M_p+ E_{ss})+ exp(-\beta).(t_s- t_r)$

6. Compare each individual’s evaluation value with its pbest. The best evaluation value among the pbest is denoted as gbest.
7. Velocity Function as
$v_{j,g}^{(t+1)} = w.v_j^{(t)} + c_1^* \ rand()*(pbest_{j,g} - k_{j,g}^{(t)}) + c_2^* \ Rand()*(gbest_g - k_{j,g}^{(t)})$
j=1,2,3….
g=1,2,3….
where
$w= w_{max} - ((w_{max} - w_{min})/iter_{max}).\ iter$
where
itermax total number of iterations
iter current iteration value
t pointer of iterations (generations)
$v_{j,g}^{(t)}$ velocity of particle j at iteration t,
$V_g^{min} <= v_{j,g}^{(t)} <= V_g^{max}$
w inertia weight factor
c1, c2 acceleration constant
rand(), Rand() random number between 0 and 1
w_{max}, w_{min} upper and lower boundary for inertia weight factor

$pbest_j$ best location of particle j
gbest global best solution's location determined by all the particles

8. If $v_{j,g}^{(t+1)} > V_g^{max}$, then $v_{j,g}^{(t+1)} = V_g^{max}$ [8]
$v_{j,g}^{(t+1)} < V_g^{min}$, then $v_{j,g}^{(t+1)} = V_g^{min}$

9. Modify the member's position of individual K
$k_{j,g}^{(t+1)} = k_{j,g}^{(t)} + v_{j,g}^{(t+1)}$,
$k_g^{min} \le k_{j,g}^{(t+1)} \le k_g^{max}$ [9]

When the maximum number of iterations where reached the individual that generated the gbest was considered as the optimal solution and all the results were recorded.

A block diagram showing the overall work flow is given in the figure 1 shown below:-

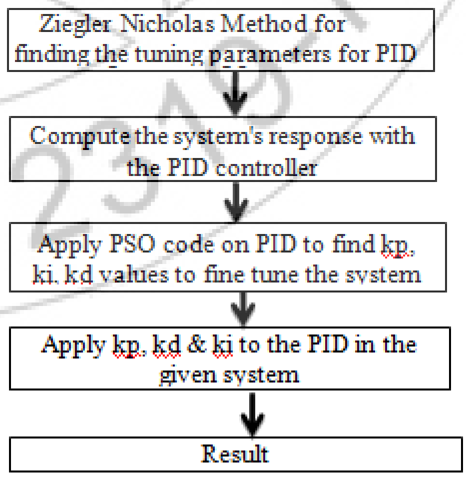

Figure 1: Block Diagram showing steps used in methodology

4. Problem Statement

Transfer Function of the position hand of Hard Disk Controller (shown below)

G(s) = (K * e (-theta * s)/ (T * s +1)

where, K=14.9, theta=80, T=360

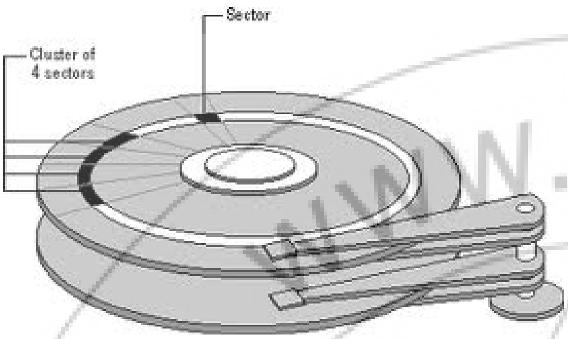

Figure 2: Hard Disk Controller

5. Simulation Results

1. kpmin=0.4; kpmax=0.6
2. kimin=0.04; kimax=0.06
3. kdmin=2.97; kdmax=3.1
4. population size = 50
5. inertia weight factor wmin=0.4 and wmax=0.9

Figure 3 and figure 4 explain the output characteristic of the system when operated with PID controller and PSO-PID controller respectively. Rise time, settling time, peak time, overshoot and peak value from the figures given below was calculated and the obtained results are shown in Table 1 given below.

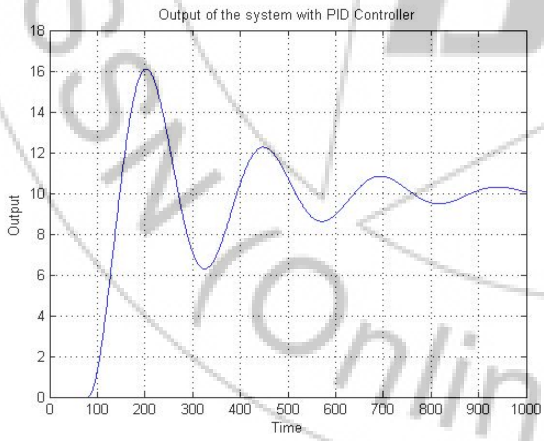

Figure 3: PID Algorithm result

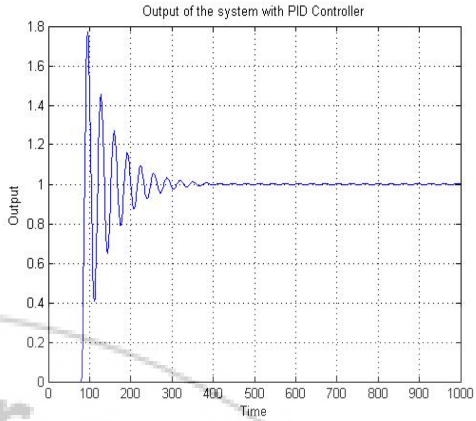

Figure 3: PSO-PID Algorithm result

Table 1: Comparison of Performance of PSO-PID and PID

Timing Parameters	Case I (PID)	Case II (PSO-PID)	Dominating Case
Rise Time	44.938011064	5.511056672	II
Settling Time	9.658126e+02	3.07139e+02	II
Overshoot	60.140771001	76.93830294	I
Peak	16.095665946	1.769383131	II
Peak Time	202	95	II

6. Conclusion

From the above table we can observe clearly that in case of PSO-PID, rise time, settling time, peak and peak time are much more improved than in the case of PID. Though the overshoot value of the case I (PID) is less than that case II (PSO-PID) but by the various values changes it is clear that the PSO applied PID gives a much better controlling results for the hard disk then the normal PID controlled hard disk. These results help us to reduce the irregularities presented by the hard disk controller and thus it can be controlled in an efficient manner. It will also help to have an optimal control of the various control systems.

7. Future Scope

In PSO-PID method overshoot value should be further decreased. So focus must be on overshoot value in order to improve this method. This method must be compared with all the other prevailing methods used in the controller of hard disk. It can effectively replace PID controllers.

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