DECISION SCIENCES INSTITUTE

Particle Swarm Optimization model for dynamic project monitoring and control processes

Perumalsamy Radhakrishnan
Emirates College for Management and Information Technology
Email: sp_radha@yahoo.com

N.Jeyanthi
Sri G.V.G. Visalakshi college
Email: profjeyanthi@gmail.com

ABSTRACT

Efficient and effective project management significantly improves the bottom line of the projects towards organization's competitive edge. The dynamic nature of the cost and schedule deviations of the various tasks of the project is a serious issue during project execution stage and the complexity of the problem increases when large scale projects with multiple tasks and longer duration are involved. In this paper, an optimization methodology is proposed that utilizes the Particle Swarm Optimization algorithm to generate essential predictive analytics to overcome the impasse in maintaining dynamic control towards effective project performance management.

KEYWORDS: Project management, Project Control, Performance modelling, Particle swarm optimization (PSO)

INTRODUCTION

Organizations of all types (profit, nonprofit, government) are increasingly carrying out projects to accomplish their business objectives. Effective project management results in competitive advantage for an organization to cope with a market that is rapidly changing due to global competition, shorter product life cycles, dynamic changes of demand patterns and product varieties. Competitiveness in today's marketplace depends heavily on the ability of a firm to handle the challenges of projects in terms of time and cost overruns as well as increasing customer service levels. All these factors have driven business organizations to resort to techniques and insights towards dynamic performance optimization on various projects undertaken.

LITERATURE REVIEW

Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan. The Monitoring –Controlling- Evaluation cycle is describes as follows:

Monitoring - Collecting, recording, and reporting information concerning any and all aspects of project performance

Controlling - Uses the data supplied by monitoring to bring actual performance into compliance with the plan

Evaluation - Project evaluation appraises progress and performance against standard and judgments regarding the quality and effectiveness of project performance

Monitoring and Controlling includes:

- Measuring the ongoing project activities
- Monitoring the project variables (cost, effort, scope, etc.) against the project management plan and the project performance baseline
- Identify corrective actions to address issues and risks properly to get on track again
- Implement only approved changes to the project so as to maintain integrated change control

In multi-phase projects, the monitoring and controlling process also provides feedback between project phases, in order to implement corrective or preventive actions to bring the project into compliance with the project management plan. Monitoring of activities assumes its greater importance during project execution in order to control the project activities to assure that the results meet expectations. Comparing the differences between desired and actual performance levels, and accounting for why such differences exist are all parts of the control process (Jeffrey K.Pinto, 2016).

Literature Review of Critical Ratio

Critical Ratio can help analyze a project and the technique integrates cost, time, and the work done to actually assess the project performance. Critical ratio can then be compared to actual project performance and planned project performance to determine project performance and predict future performance trends (Paley, 1993).Project schedule and budget overruns seem to be the norm rather than the exception, and outcomes often fall short of expectations. CHAOS 2006 report mentioned that substantial progress in Project Management had been made. Being able to manage a project with aplomb is a key leadership skill in today's business world. The task of managing project performance can be a major challenge for organizations which are faced with increasing pressures to execute projects in alignment with planned progress as well as in alignment with cost, time and scope considerations (Anbari, 2003). As the project has many tasks with respective planned schedules ,costs and scope, any major deviation will have huge impact on the total project performance. Critical Ratio plays a vital role in the in finding out the deviations and hence gives an inference for suitable risk mitigation strategies to control anticipated project deviations (Meredith Jack et al, 2016).

Literature Review of Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a population-based stochastic global optimization algorithm and the robust performance of the proposed method over a variety of difficult optimization problems has been proved (Alberto Moraglio, et al,2008). In accordance with PSO, either the best local or the best global individual affects the behavior of each individual in order to help it fly through a hyperspace (Lu, 2003). The ability of the particles to remember the best

position that they have seen is an advantage of PSO. An evaluation function that is to be optimized evaluates the fitness values of all the particles (Ling-Feng Hsieh et al, 2007).
.

MODEL

An organization usually may have more projects and more risk factors may be involved during execution of the project In this paper, it is assumed that the organization has 5 ongoing project tasks for illustrating the proposed model which is scalable to large scale projects with multiple tasks and longer duration. For each project task and for each period, Critical Ratio (CR) is calculated as follows:

Critical Ratio = (actual progress/scheduled progress) X (budgeted cost/actual cost)

A database consisting of these data values is created for each period and for each project during the course of execution of the project. Particle Swarm optimization methodology is developed to generate predictive analytics to move towards dynamic project control and management on various project tasks undertaken .

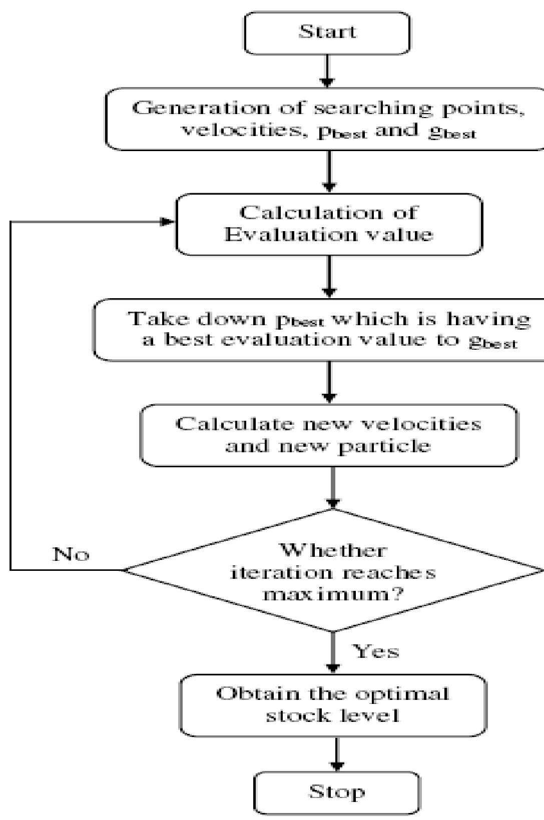

Fig. 1: Particle swarm optimization Methodology

METHODS

The PSO methodology is outlined below.

The individuals of the population including searching points, velocities, p_{best} and g_{best} are initialized randomly but within the lower and upper bounds of the CR values which have to be specified in advance.

Determination of Evaluation function

$$\mathrm{f(i)} = -\log\left[1 - \frac{n_{occ}(i)}{n_{tot}}\right]; \quad i = 1,2,3,\cdots,n$$

$n_{occ}(i)$ is the number of occurrences of the particle i in the record set

n_{tot} is the total number of records that have been collected from the past or total number of data present in the record set.

n is the total number of particles for which the fitness function is to be calculated.

For every individual, a comparison is made between its evaluation value and its p_{best}.The g_{best} indicates the most excellent evaluation value among the p_{best}. This g_{best} is an index that points to the best individual generated so far.

Subsequently the adjustment of the velocity of each particle a is as follows:

$$v_{new}(a,b) = w * v_{cnt}(a) + c_1 * r_1 * [p_{best}(a,b) - I_{cnt}(a,b)]$$
$$+ c_2 * r_2 * [g_{best}(b) - I_{cnt}(a,b)]$$

where,

$$a = 1,2,\cdots\cdots,N_p$$
$$b = 1,2,\cdots\cdots,d$$

Here, $v_{cnt}(a)$ represents current velocity of the particle, $v_{new}(a,b)$ represents new velocity of a particular parameter of a particle, r_1 and r_2 are arbitrary numbers in the interval $[0,1]$, c_1 and c_2 are acceleration constants (often chosen as 2.0), w is the inertia weight that is given as

$$w = w_{\max} - \frac{w_{\max} - w_{\min}}{iter_{\max}} \times iter$$

where,

$w_{\max}$ and $w_{\min}$ are the maximum and minimum inertia weight factors respectively that are chosen randomly in the interval $[0,1]$. Also $v_{\min}$ and $v_{\max}$ are the minimum and maximum limit for velocities respectively

$iter_{\max}$ is the maximum number of iterations

$iter$ is the current number of iteration

Such newly obtained particle should not exceed the stated limits. This would be checked and corrected before proceeding further as follows,

If $v_{new}(a,b) > v_{\max}(b)$, then $v_{new}(a,b) = v_{\max}(b)$

if $v_{new}(a,b) < v_{\min}(b)$, then $v_{new}(a,b) = v_{\min}(b)$

Then, as per the newly obtained velocity, the parameters of each particle is changed as follows

$I_{new}(a,b) = I_{cnt}(a,b) + v_{new}(a,b)$

Then the parameter of each particle is also verified whether it is beyond the lower bound and upper bound limits. If the parameter is lower than the corresponding lower bound limit then replace the new parameter by the lower bound value. If the parameter is higher than the corresponding upper bound value, then replace the new parameter by the upper bound value. For instance,

If $P_k < P_{L.B}$, then $P_k = P_{L.B.}$

Similarly, if $P_k > P_{U.B}$, then $P_k = P_{U.B.}$

This is to be done for the other parameters as well.

This process will be repeated again and again until the evaluation function value is stabilizing and the algorithm has converged towards optimal solution.

RESULTS

The analysis based on PSO for predicting project performance has been implemented in the platform of MATLAB .As stated, the detailed information about the CR_{ij} values for each project task i and for each period j is captured in the database. The sample data having this information is given in the Table 1.

Table 1: A sample data of Critical Ratios

PI	CR1	CR2	CR 3	CR 4	CR 5
1	0.3	0.6	1	1.3	1.3
2	0.8	0.8	1.2	1	1.3
3	0.9	0.6	1	1.1	1.5
4	1	0.7	1.1	1	1.4
5	0.8	0.9	1	0.8	1
6	0.9	0.8	1.2	1	1.1

As initialization step of the PSO process, the random individuals and their corresponding velocities are generated.

Table 2: Initial random individuals

	CR1	CR2	CR 3	CR 4	CR 5
Random Critical Ratio 1	0.3	0.6	1	1.3	1.3
Random Critical Ratio 2	1	0.8	1.2	1	1.3

Table 2 describes two random individuals. Similarly, Table 3 represents random velocities which correspond to each particle of the individual.

Table 3: Initial Random velocities corresponding to each particle of the individual

	CR1	CR2	CR 3	CR 4	CR 5
Initial Random velocities1	0.1350	0.1350	0.1350	0.1350	0.1350
Initial Random velocities2	0.0259	0.0259	0.0259	0.0259	0.0259

The simulation run on a huge database of 500 past records showing evaluation function improvement at different levels of iteration is as follows:

Simulation Result showing evaluation function improvement:

For iteration 50: evaluation function = 0.37;
For iteration 80; evaluation function = 0. 48
For iteration 150; evaluation function = 0.67;
For iteration 200; evaluation function = 0.96;

The final individual obtained after satisfying the convergence criteria is given in Table 4.

` Table 4: database format of Final Individual

CR1	CR2	CR 3	CR4	CR 5
0.8	1.1	1	0.9	0.7

DISCUSSION

The final individual thus obtained represents the most emerging pattern for the project deviation in terms of cost schedule performance levels for each task, providing essential information towards optimal project control. Based on the essential information provided by the final best chromosome, the following inference for the critical ratio control limits are arrived at. CR values between 0.9 and 1.2 indicates that the project tasks are performing as expected since the actual progress is close to scheduled progress as well as budgeted cost is close to actual cost. Accordingly remedial actions may be ignored for such tasks ; For tasks outside this limit , investigate immediately for major deviations to take mitigation measures to control the Cost or Schedule deviations so as to move towards project performance optimization. In this case, Task1 and Task5 are not meeting the expected performance level and requires intervention with remedial measures to control the Cost and schedule deviation so as to move towards project performance optimization.

CONCLUSIONS

Project control for effective and efficient performance management is an important component of project management. As the project has many tasks with respective planned schedules, costs and scope, any major deviation will have huge impact on the total project performance. Critical Ratio plays a vital role in the in finding out the deviations and hence gives an inference for suitable risk mitigation strategies to control anticipated project deviations. To tackle the complexity in predicting the deviations, we have proposed an innovative and efficient approach based on Particle Swarm optimization algorithm using MATLAB that is aimed at predicting the most probable deviation of the project for the forthcoming period necessitating intervention with remedial risk mitigation strategies to control the project deviation so as to move towards effective project performance optimization

REFERENCES

Meredith Jack R., Mantel, Samuel J.& Shafer Scott M (2016) . Project Management Managerial Approach. John Wiley & Sons.

Jeffrey K.Pinto (2016) Project Management :Achieving competitive advantage, Pearson.

H. Lu, (2002) Dynamic Population Strategy Assisted Particle Swarm Optimization in Multi objective Evolutionary Algorithm design," IEEE Neural Network Society, Final reports.

Paley,A.I (1993) Value Engineering and project management achieving cost optimization, AMA Handbook of Project management, New York: AMACOM

Alberto Moraglio, Cecilia Di Chio,Julian Togelius & Riccardo Poli,(2008) "Geometric Particle Swarm Optimization", Journal on Artificial Evolution and Applications.

Anbari F.T (2003). Earned Value project management method and extensions, Project Management Journal

Ling-Feng Hsieh, Chao-Jung Huang & Chien-Lin Huang (2007) "Applying Particle Swarm Optimization to Schedule order picking Routes in a Distribution Center, Asian Journal on Management and Humanity Sciences, vol. 1(4), pp: 558- 576.