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Particle swarm optimization approach to software project scheduling

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Abstract
Many software development organizations suffer from losses. One of the major reasons for these losses is failure of the software projects which is due to improper software project scheduling. Software project scheduling is thus one of the important activities of software development lifecycle which needs to be done efficiently in the beginning of software development. Of late many nature inspired techniques have come to use in software development lifecycle. Particle swarm optimization is one such technique. This paper concentrates on the importance of project scheduling and the use of particle swarm intelligence to schedule the project tasks.

Keywords: software project management, project scheduling, particle swarm intelligence

1. Introduction
It is very important to deliver good quality software in specified time limit. It should meet the requirements of the user. However there are many reasons for the late delivery of the software projects. A few of them are: changing customer requirements, technical issues, miscommunication amongst team members, improper time schedules, failure to analyze the risks involved, and underestimation of resources like man power, cost, effort, etc. Since with changing times the complexity, size of the software have also changed, it is very essential to analyze the software requirement and check for its feasibility.

1.1 Software Project Scheduling
Software project scheduling begins with the requirement analysis of software and on the basis of this estimation of the software size is made. The software project is then divided into smaller components which are known as tasks. The task network specifies the different tasks, their expected duration of completion and the dependency of different tasks on each other [1]. Next phase consists of estimating the resources required for completion of tasks. A project team is decided for every task. A timeline for every task is specified and it is important to keep a check on whether the software development is going along the specified time limit thereby monitoring and controlling the software development process.
Principles of software project scheduling are [2]:

i) Decomposition: It is the division of software development process into different activities.
ii) Interdependency: It is finding out the dependency of tasks on each other.
iii) Time allocation: It includes allocation of start time and end time for all tasks.
iv) Effort validation: It is estimating the man-months required to complete the tasks.
v) Team staffing: It is allocation of different tasks to different teams.
vi) Defining outcomes: It includes specification of deliverable.

2. Particle Swarm Optimization
Swarm intelligence was introduced by Gerardo Beni and Jing Wang [3]. It is based on the concept of many homogenous agents interacting with each other and their environment [4]. Examples of swarm intelligent natural systems include: fish school, bird flock, ant colonies, bee colonies, bacterial growth, etc. Optimization is finding the parameters that help in achieving maximum or minimum of a target function. Particle swarm optimization is swarm intelligent system which was introduced by Kennedy, Eberhart [5]. It is inspired by the system of bird flocks and school of fish. Particle swarm optimization is used in the field of telecommunications, neural networks, software effort estimation, signal processing, design, control, data mining, combinatorial optimization, power systems, etc.
Particle swarm optimization consists of a set of random particles in a search space that try to improve a candidate solution by iterations using a fitness criteria that contains a measure of quality [6, 7]. In every iteration two values are updated. These are particle best (pbest) and global best (gbest) which are the best solutions found by a particular particle and the best solution found by any particle in the search space respectively. Each particle has an associated position and velocity which are calculated as:

$$V_{i,d}(it+1) = V_{i,d}(it) + C1*Rnd(0,1)*[pb_{i,d}(it) - X_{i,d}(it)] + C2*Rnd(0,1)*[gb_{d}(it) - X_{i,d}(it)] \quad (2.1)$$

$$X_{i,d}(it+1) = X_{i,d}(it) + V_{i,d}(it+1) \quad (2.2)$$

where,
'i' is particle identifier,
'd' is dimension, each particle has a position and a velocity for each dimension,
'it' is iteration number,

'$X_{i, d}$' is position of particle i in dimension d,
'$V_{i, d}$' is velocity of particle i in dimension d,
'C1' is acceleration constant for the cognitive component,
'Rnd' a random value between 0 and 1,
'pbi, d' is the location in dimension d with the best fitness of all the visited locations in that dimension of particle i,
'C2' is acceleration constant for the social component,
'gbd' is the location in dimension d with the best fitness among all the visited locations in that dimension of all the particles.

2.1 Particle Swarm Optimization Algorithm

For each particle
    Initialize each particle's position, velocity and random number
End for
Do
    For each particle
        Evaluate the fitness function value
            If fitness value is better as compared to pbest value
            Set current value as pbest
    End
    Update gbest (global best amongst best fitness values of all particles)
    For each particle
        Update its velocity
        Update its position
    End
While minimum error criteria or maximum iterations are not achieved

3. Related Work

Koyuncu E. and Erol R. [8] used particle swarm optimization to schedule new project development (NPD) projects using overlapping process in order to reduce the time required for development thereby providing the new project faster. This approach was implemented on a project and it was observed that the efficiency of software was improved.

Mawchen R. [9] used particle swarm optimization technique in combination with justification technique for solving resource constrained project scheduling problem which is a NP-hard combinatorial problem. The results showed that the proposed JSPO (Justification Particle Swarm Optimization) was effective for solving resource constrained project scheduling problem.

Gonsalves *et al.* [10] used particle swarm optimization to minimize the average duration in multiple projects in Resource-Constrained Multi-Project Scheduling Problem (RCMPSP) where Resource constrained multi project scheduling problem consists of determining the task schedule taking into consideration precedence constraints, availability of resources while optimizing an objective. The results obtained showed that the particle swarm optimization was effective in solving resource constrained multi project as it provided good results.

Jia Y. H. [11] *et al* used a two-phase particle swarm optimization approach for search based software project management which uses workload assignment scheduling and a set-based representation for task scheduling and an integer representation for workload assignment scheduling to improve planning performance. The experiment was conducted on 83 instances which provided improved results

Hanchate D.B. and Bichkar R.S. [12] proposed the use of Particle Swarm Optimization for software project scheduling problem. The best solutions provided by particle swarm optimization technique were used as inputs to SPSM (Software Project Scheduling Management). The results of proposed model were compared with genetic algorithm and ant colony optimization and it was found that the results of proposed model were better as compared to others models in terms of minimum SCE (Software Cost Estimation) and time.

Gerasimou *et al*. [13] studied the use of particle swarm optimization algorithm to generate best project schedules by creating the best sequence for executing a project's tasks thereby minimizing the total project duration. The research also used particle swarm optimization to create best work teams for proper utilization of their skills. The results obtained showed that the proposed model provided with better project scheduling and staffing in software project management.

4. Conclusion

Project scheduling is one of the important activities of project management. It consists of decomposition of project into smaller tasks which need to be scheduled properly. Project scheduling if not done properly may result into overestimation or underestimation of budget, poor quality of software, lower morale of team members, project failure, etc. Particle swarm optimization and its variant have been widely used in the field of software engineering. This paper presents a review of particle swarm optimization and its use for project scheduling. It has been observed that particle swarm optimization has proved to be effective in providing better project schedules therefore helping the project managers to deliver the software projects on time.

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