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RESEARCH PAPER

Improving Time-Cost Balance in Critical Path Method (CPM) using Dragonfly Algorithm (DA)

Mohammad Anvar Adibhesami[1], Ahmad Ekhlassi[2]*, Amirhossein Mohebifar[3] & Ali Mohammad Mosadeghrad[4]

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ABSTRACT
The CPM (Critical Path Method) technique is used to search out the longest path to do required activities for compressing and cutting back the time it takes for a project, which finally ends up inside the creation of an identical and intensive network of activities inside the targeted work. This formal random simulation study has been recognized as a remedy for the shortcomings that are inherent to the classic critical path technique (CPM) project analysis. Considering the importance of time, the cost of activities within the network, and the rising calculation of the critical path during this study, CPM has been applied to improve critical routing intelligence. By simulating and analyzing dragonfly's splotched and regular patterns, this study has obtained a precise algorithm of attainable paths with the smallest amount of cost and time for every activity. This has been done to reduce the restrictions and enhance the computing potency of classic CPM analysis. The simulation results of using Dragonfly Algorithm (DA) in CPM show the longest path in the shortest amount of time with the lowest cost. This new answer to CPM network analysis can provide project management with a convenient tool.

KEYWORDS *CPM, Dragonfly algorithm, Simulation, The least cost and time.*

1. Introduction

Critical Path Methodology (CPM) is a programming methodology that will replicate all of the various interactions, communications, and defects of a path within the kind of a project network diagram [1]. One of foremost critical options of this designing methodology is to show a comprehensive image of all interactions, government shortcomings, work nodes, and relationships between them at the start of the project [2]. The CPM technique is to hunt out the longest path to do activities, thus compressing and reducing the time it takes for a project that ends inside the creation of an even intensive network of presidency activities inside the targeted surroundings [3].

* Corresponding author: *Ahmad Ekhlassi*
ekhlassi@iust.ac.ir

1. M.Sc. Hospital Engineering, School of Architecture and Environment Design, Iran University of Science and Technology, Tehran, Iran.
2. Assistant Professor, School of Architecture and Environment Design, Iran University of Science and Technology, Tehran, Iran.
3. Ph.D. Candidate in Urbanism, University Tarbiat Modares, Tehran, Iran.
4. Associate Professor, School of Public Health (SPH), Tehran University of Medical Sciences, Tehran, Iran.

The CPM is an elementary technique developed for project management assumption under unlimited resource convenience. In reality, project activities are scheduled under limited resources, restricted number of workers, restricted instrumentation, and restricted materials. The practical drawback to allocating resources over time to perform collective tasks arising in variety states of affairs and frequency of the hardware is that they should appreciate the trade-off between availability of resources and activity period. The first disadvantage of unraveling these issues by using mathematical models is that they may not solve larger or complicated issues. The programming of tasks and, therefore, the allocation of resources in medium- to large-sized schedule projects is an extremely onerous issue and a challenge to project management considering its quality. In CPM network calculations, it is assumed that each interaction occurs at a specific time [4].

It is required to calculate the time it takes to finish the total project, constituting a quantity of times spent performing all the specified interactions on the route(s) with respect to a number of essential conditions. By exploiting the network mapping activities, a pattern of behavior will be considered by using the essential path and performing necessary computations to compress the activities [5]. The reduction of the time that a project requires in every network is decided by setting the start-up time or performing many activities among fixed fundamental measures by the fixed essential methods, done by defrayment of the smallest amount of value of the minimum time required to perform a task [6]. To do this, by plotting the curve supporting the time-cost line, the gradient obtained throughout this curve may be used to do specified calculations.

Research hypothesis:

This study uses one rule among many simple algorithmic rules to simulate the calculation of the longest path; therefore, minimum amount of time is required to perform an activity from the dragonfly algorithm, and that the results can be examined. During this algorithmic rule, dragonflies behave in a series of activities that can be reminiscent of immigration or mass hunt. This behavior forms tiny or static teams that are united together and are susceptible to dynamic variables in the environmental conditions [7]. The study of the migratory behavior of insects has shown that their behavior is totally self-generated and is taken into account as a dynamic behavior, that is, a collective movement of dragonflies at least one facet at completely different distances. This dragonfly capability truly allows them to take advantage of and see the environmental conditions on stationary and dynamic substrates. Dragonfly behaviors essentially support the separation, coordination, coherence, distraction or food requesting. Among other dragonflies, every flies to at least one of the targets that indicates the search of those insects to unravel the matter [8].

Finding a critical path in static networks is very difficult, because the number of components and the number of relationships cannot be invariable[9]. Previous studies on the simulation of finding the critical path in activity networks have assumed that this network is static [10]–[13]. In this study, by using a dragonfly algorithm that can solve routing in several dimensions[14], critical path rout in both static and dynamic networks can be solved.

The results of the papers show that each of the planned dragonfly algorithms benefits from high exploration due to the planned static swarming behavior of dragonflies. Considering the importance of time, the price of activities within the network, and the rising calculation of the important path during this study, the dragonfly algorithmic rule as a swarm intelligence (SI) has been used. By simulating and analyzing dragonfly's regular patterns, this study has obtained the precise algorithmic rule of attainable methods with the smallest amount of cost and time for every activity.

2. Literature Review

Critical Path Method (CPM)

In the past, many authors have succeeded in exploiting CPM to calculate the time, resources, and value required for projects and events. Wallace Aghie (2015) used CPM to appear the value and time interchanges by activities that take a shorter time at an inexpensive price for the event project at Angels & Construction Ltd [15]. Adel Issa Elson 2014, in his self-study optimized time and price of the critical path technique in Parlure, fly over Sarasota. He reduced the project's period by ten days at a reasonable value with prosperity [16]. Rautela 2015, in her article, ended that CPM will be employed by any work as a way of meeting the delivery obligation to different relevant sectors, and thus reduces the interior delay drawback, that successively sends up in delays in delivery of the company's final product, in her case the corporate being footwear producing industrial plant [17].

Dragonfly Algorithm (DA)

It is very fascinating that creatures notice the simplest things and perform tasks expeditiously in groups. It's obvious that they have to be evolved over centuries to figure out such best and economical behaviors. Therefore, it's quite cheap that we have a bent to inspire from them to resolve our problems. Then often this can be the most purpose of study field said as swarm intelligence (SI).

SI refers to the unreal simulation of the collective and social intelligence of a gaggle of living creatures in nature [18]. Researchers throughout this field attempt to resolve the native rules for interactions between the folks that yield to the social intelligence. Since there is not any centralized management unit to guide the folks, finding the simple rules between a variety of them can simulate the social behavior of the complete population. The hymenopteron colony improvement (ACO) formula is in an exceedingly one in each of the first SI techniques mimicking the social intelligence behavior of Ants hunting in a hymenopteron colony [19].

This formula has been affected by the simple undeniable fact that each hymenopteron marks its own path towards food sources outside the nest by secretion. Once a hymenopteron finds a food offer, it goes back to the nest and marks the path by secretion to suggest the path to others. Once totally different ants perceive such secretion marks, they together attempt to follow the path and leave their own pheromones. The key purpose here is that they will vary ways to the food offer. Since associated degree of extended path and extended time of ants travel, however, the secretion vaporizes with the higher rate before it's remarked by totally different ants. Therefore, the longest path is achieved by just following the path with a stronger level of secretion and abandoning the ways with weaker secretion levels. Doringo initials affected these straightforward rules and projected the well-known ACO formula [20].

The particle swarm improvement (PSO) formula is, in addition, another well-regarded SI paradigm. This formula mimics the hunt and navigation behavior of bird flocks and has been projected by Eberhart and Kennedy[21]. The foremost inspiration originates from the simple rules of interactions between birds: birds tend to care about their fly direction towards their current directions, this point is obtained by the foremost effective location of food offer, and so the simplest location of the food that the swarm found to this point. The PSO formula just mimics these three rules and guides the particles towards the foremost effective solutions by each of the folks and so the swarm at an equivalent time. The substitute bee colony (ABC) is another recent and trendy SI-based formula. This formula another time simulates the social behavior of honey bees once hunt nectar and has been projected by Karaboga [22].

The excellence of this formula compared to ACO and PSO is that the division of the honey bees to scout, onlooker, and used bees. The used bees' unit answerable for locating food sources and informing others by a special dance. In addition, onlookers watch the dances, select one among them, and follow the path towards the chosen food sources. Scouters discover abandoned food sources and substitute them by new sources. Despite the many variations of recent publications throughout this field [23], their unit still totally different swarming behaviors in nature that haven't gained due attention. One among the ornate insects that rarely swarm unit dragonflies. Since there was no study at intervals the literature to simulate the individual and social intelligence of dragonflies [7], the paper aims to initially notice the foremost characteristics of dragonflies' swarms.

A formula is then projected supported the noted characteristics. The no gift (NFL) theorem together supports the motivation of that job to propose this optimizer since this formula may outgo totally different algorithms on some problems that haven't been resolved to this point [14]. It is the formula that we have a tendency to would like to use and implement throughout this paper to spice up vital path technique functions notice activities with the tiniest quantity costs and times then select the foremost time and economical route for the project.

3. CPM Simulation

In the classic CPM analysis, the earliest begin time atomic number 99, the latest begin time LS, the earliest end time EF, the latest end time radio frequency, and total float TF should be documented for each activity [24]. The criticality of AN activity will be determined supported TF. The classic CPM analysis is easy and effective for straightforward, small-scale CPM networks. However, once facing complicated, large-scale CPM networks with a good variety of nodes and activities, the classic CPM formula becomes cumbersome and inefficient for two reasons[12].

First, the period for all the activities should be caterpillar-tracked and hold on throughout the pass calculation to conduct the following backward pass calculations. Second, 5-time attributes (ES, EF, LS, LF, ANd TF) should be calculated before determinant the criticality of an activity. A true project might compass many distinct activities. To reveal the implicit schedule risk of every activity and of the total project, the simulation may have to be run many times.

4. Research Methodology

This study utilizes the dynamic and static group behavior of dragonflies in nature to obtain a dragonfly algorithm. The benefits of this approach are to use the dragonflies' behavior to achieve goals such as environmental identification and apply it to conduct behavioral models with the consideration of social intervention of dragonflies in routing, searching and avoiding danger, which we have used behavior to design an algorithm for routing. These activities are in the form of dynamic or static movement.

The patterns of dragonflies are as follows:

•splitting
•Settings
• Coherence
• Search for food
• Deviation from the enemy

The Dragonflies track in their behavior to evade the enemy is considered by the following equation, where X is the position of the current individual, and X^{-} shows the position of the enemy.

$$E_i = X^{-} + X$$

The behavior of dragonflies is assumed to be the combination of these five corrective patterns in this paper. To update the position of artificial dragonflies in a search space and simulate their movements, two vectors are considered: step (ΔX) and position (X).
Changing the makeup model of dragonflies is defined in one dimension, but it can also be considered in larger dimensions.
The method of calculating the dragonfly algorithm is as follows:
• S shows the separation weight
• Si shows the separation of the j-th individual
• Adjustment weight.
• A is the j-th's setting.
• C is the shrinkage weight.
• Ci is the coherence of the person j-th.
• F is a nutritional agent.
• Fi is the j-th person's food source.
• E is the enemy of the enemy.
• Ei The position of the enemy is the j-th.
• w is the inertial weight
• t is a repeat count.
Situational vectors are calculated by:

$$x_{t+1} = x_t + \Delta X_{t+1}$$

Where t is repetition.
The cosmetic behavior of dragonflies in different situations with separation, regulation, and coherence, search for food, and counteracting agents of the enemy (s-a-c-f-e) are considered heuristic behaviors and are used to calculate path length using this type of behavior analysis.
The way a dragonfly behaves towards the side dragonflies is important, which can affect the factors necessary for routing. Therefore, the limitations for each dragonfly are circular in a 2-dimensional state, the sphere in a three-dimensional space or a superior sphere in an n-dimensional space must be considered so that all the radiuses around each dragonfly are interacting Synthetic dragonflies behave artificially to calculate possible paths (11).
• Coherence and solidarity

$$Ci = \frac{\sum_{j}^{n}=1\ Xj}{N} - X$$

Where X is the current position of the insect. N is the number of neighborhoods, Xj shows the position of the rear insect j-th.

• Setting

$$Ai = \frac{\sum_{j}^{n}=1\ vj}{N}$$

The formulas for changing makeup are used to indicate the behavior of the insect in order to visualize the position under the influence of environmental factors and to search for dual exploratory spaces to find a new position with the following equation.

$$X_{t+1} = \begin{cases} \neg x_t \quad r < T\ (\Delta x_{t+1}) \\ x_t\ r \geq T\ (\Delta x_{t+1}) \end{cases}$$

Calculation of all target values for Search Agents, which targets two search options for food and escape from the enemy.

```
    Fitness(1,i)=fobj(X(:,i)');
     if Fitness(1,i)<Food_fitness
        Food_fitness=Fitness(1,i);
        Food_pos=X(:,i);
     end
     if Fitness(1,i)>Enemy_fitness
```

For these two modes, ub and lb are defined by two variables, which are large variables, such as search for food or smaller variables, such as escaping from the enemy.

```
if all(X(:,i)<ub') && all( X(:,i)>lb')
   Enemy_fitness=Fitness(1,i);
    Enemy_pos=X(:,i);
     End
```

In the end, if the search was unconditional, it would be zero.

```
  for i=1:SearchAgents_no
    index=0;
      neighbours_no=0;
```

5. Results

Separation from each other Si: To avoid the dragonflies from static collisions with other fellow humans. Coordination and alignment: Ai is the dragonfly's behavior to match speed with other fellow humans.

Coherence: Ci expresses the desire of dragonflies for collective behavior to move towards the goal.

Using the above definitions, we can consider a suitable weight for each dragonfly to adjust their behavior adaptive and ensure their convergence in order to achieve the goal and find the appropriate solution. Nevertheless, the radius of motion of each dragonfly compared to lateral dragonflies is considered a progression in optimizing the behavior of the insect.

Since finding the best path between the two nodes in a network is a very complicated issue, instead of central processing, it can be used to maintain the grid structure of the search method for the best path, change the peripheral arrangement of the network, and remove a number of barriers (the end of the network connection) to increase Performance in performance and reducing the time required for each activity. For this, in the first step, we need to know the efficiency of each node relative to the other nodes in order to create a series of chain reactions temporarily in the network and continue this until the network structure Reached again. This method can be an organized method to maintain the structure of the network and simplify the search for the best route.

For a better understanding, look at Figure 1 below:

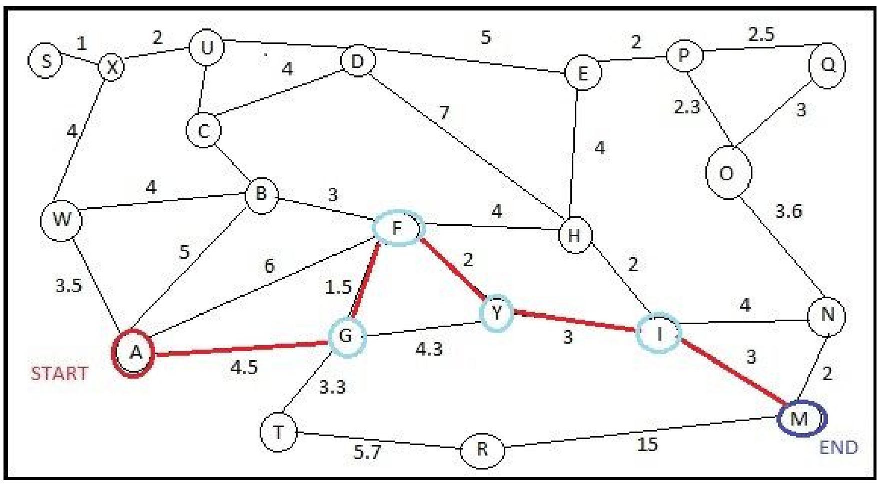

Fig. 1. Simulation of CPM to find the longest route in shortest time

There are 20 nodes in this network. For example, the cost of connecting from A to G is 4.5 and also for connecting A to node Y, we can use the longest route with the lowest cost, A to G to F. Dragonfly algorithm has been used to find this path and by implementing this algorithm, the best route is obtained with the least cost and time.

The starting node is the node A, and the target node is also considered as the node M. The least costly route between the middle nodes A and G is then the lowest cost path from the node G to F and we go from the node F to Y. And from the nodes of the closest, the node Y to I and finally the same M from I to the destination node.

Generally, the process of implementing the proposed algorithm is as follows:

Step 1: Data entry (a network of nodes with different paths)

By default, the data is there has 20 activities in a network, each of which has three defined attributes

Step 2: Determine and define the status of each node.

Two Radjecancy Radiation and Kadjenancy Radius Definition codes are used.

Stage Three: Determining the attributes of communication nodes between nodes for use in Dragonfly algorithm and optimizing it.

Step Four: Find the best route from the source node to the destination.

6. Simulation Results

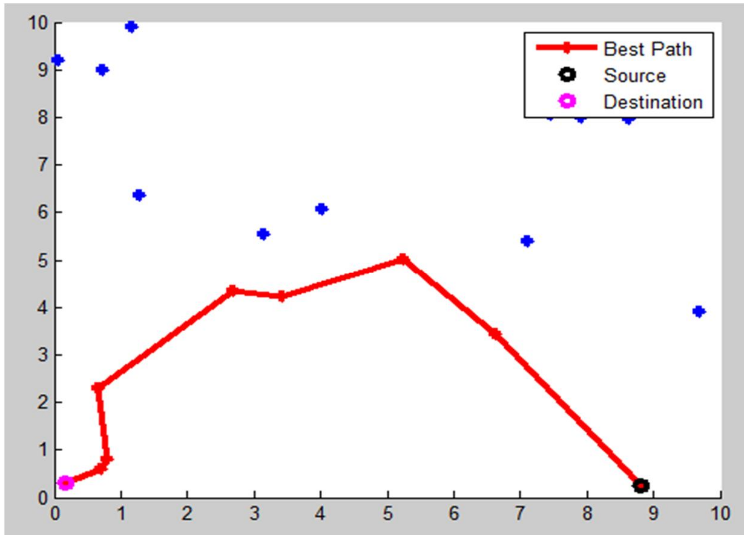

Fig. 2. Route Searching results between source and destination

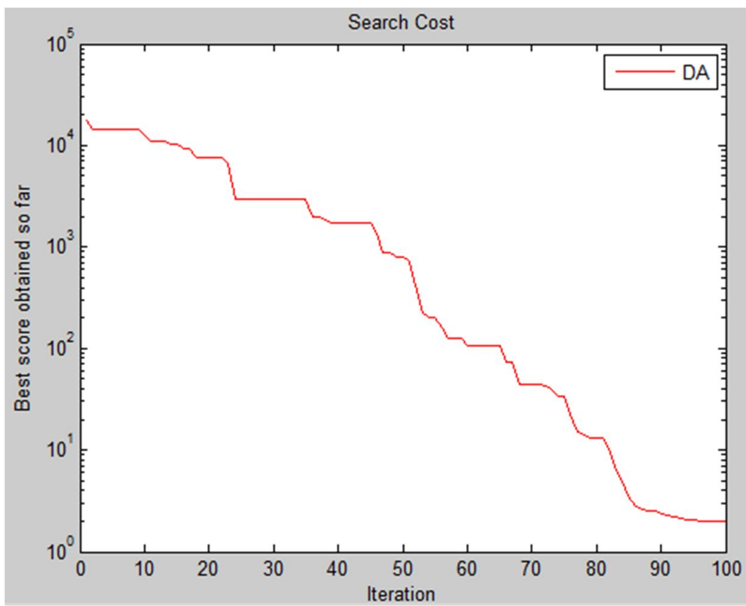

Fig. 3. Route searching cost between source and destination using DA algorithm

7. Discussion

Most of the ventures are target-oriented and arranged endeavors, whose objective is to create, recreate or change different offices. These kinds of ventures include dynamic processes which will be isolated into four stages: conceptualization, definition, realization, and utilize the improvement office. Significant reserves are blessed inside the realization of those phases. The last mentioned characterized by the support of a considerable number of firms, foundations, and organizations, and by the utilization of the correct savvy amounts of changed assets and machinery. The conclusion of these sorts of ventures is as a rule of time-consuming, and temporary workers are required to wrap up extension inside the narrowed time, in agreement with best quality benchmarks, and at the least doable costs. This will be why participants in ventures are confronted with the matter of the way to optimize development time, minimize development costs, and regard other significant criteria.

Together with the method of improving the colony of hymenopterous insects, the method of improving the colony of bees and the method of random diffusion search, "dragonfly algorithms" belong to the cluster of swarm intelligence methods. These methods supported the principle of socio-psychology. Swarm intelligence systems created by populations made up of simple members (particles) who move with each other and their environment. They observe and understand their environment and can act to maximize the chance of success. These systems incorporate swarms of bees, flocks of birds, fish schools, herds of animals, bacteria, etc.

The maneuver is galvanized by the similarity between their behavior and the socio-psychological behavior of people who have experienced various problems. Increasing results compared to previous CPM SI techniques, this paper provides a new methodology for improving time-cost, which could be a new swarm intelligence technique (SI) wherever the matter is resolved by the dragonfly rule. This rule, usually used to determine optimum solutions in many areas, is adapted in this case to solve the problems of time-cost improvement, which according to figures 1 and 2, outperforms very well.

8. Conclusions

The dragonfly rule is successfully intended to optimize the conclusion. We have used this technique to solve these problems, taking into account project cost, activity duration and activity correlations in the required path diagram. The projected procedure, given its simplicity and accuracy, performs well and offers various blessings and various old mathematical programming methods compared to the methods that support the use of simplex algorithms for mathematics. The use of this technique is usually recommended for the improvement of world crucial path diagrams for projects with a smaller variety of project-significant activities.

This paper has utilized an SI calculation propelled by the conduct of dragonflies' swarms in nature. Inactive and energetic swarming practices of dragonflies were actualized to investigate the look space, individually. The calculation was prepared with five parameters to control cohesion, arrangement, partition, fascination (towards nourishment sources), and diversion (outwards adversaries) of people within the swarm. The demonstrated projects that are connected algorithms benefit from more investigations, which is due to the proposed inactive swarming conduct of dragonflies.

This algorithm is capable of solving a large number of time and cost equations in activity networks, and even if several nodes are interrupted and the network organizes itself again, this algorithm can find its own path.

Actually, this study uses all the sensory activity behaviors and interactions of the dragonfly from the setting to succeed in the group's goals to produce an algorithmic rule of behavior and relates it to the activities within the work. In different words, the patterns of the movements of those insects will be generalized to figure patterns within the work so as to realize special coordinated ways that area unit extremely coordinated, to scale back the time required for every activity.

By taking the dragonfly algorithmic rule and incorporating a simplified important activity identification technique, the planned simplified CPM simulation model is valid through the comparison with the classic CPM analysis and is well-tried to be much more economical and sturdier. The simulation results of a dragonfly algorithmic rule in CPM show longest path in shortest time with the lowest price. This new answer to CPM network analysis will give project management with a convenient tool to assess different eventualities supported model and risk analysis.

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