Application of the Intelligent Squirrel Swarm Algorithm to Manage Project Tasks in Software Engineering

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Abstract: The most important tasks in building software are managing software projects at the present time. Correct management, advance planning and identification of customer requirements and key functions of a software project. All this facilitates the recognition of the factor of time, money, human resources, capabilities and the possibility of finding quick solutions in the event of a problem during the production of the software project and thus achieving success for the project. The project manager is responsible for planning and identifying the critical points facing the project and finding alternatives in the event that a problem arises that may be in human resources, for example, the illness of a programmer, or the need for programmers who possess skills in a particular field, or the need to rely on special tools, etc., as he determines Software project manager the tasks assigned to the employees according to their own skills and experience to carry them out and also to determine how each task relates to another. In this paper, the squirrel algorithm is relied on in software project management.

Keyword: Software Engineering, Project Scheduling, Swarm Intelligence Algorithms, Squirrel Swarm Algorithm.

1. Introduction

The management building a software project depends on the skills and experience of the employees in the areas of software and on the basis of that they are assigned special tasks depending on their skills to complete each task to achieve results according to the required specifications and very importantly deliver the project within the specified time, depending on the project planning by the project manager, where the successful management Is to adhere to the specified time and the required specifications within the specified budget, all this falls on the responsibility of the project manager and team work. Therefore, we need to plan and manage the right solution in advance by defining the critical task and the skills of each programmer. The project manager and the work team should develop more than one action plan in case of problems. Problems should be anticipated and addressed as quickly as possible by developing solutions in advance, and it should be taken into account that there is no conflict in the tasks performed. The problem of scheduling the software project is a very accurate process by defining the exact tasks of the project and the skills of each employee and taking into consideration reducing the project time as much as possible and according to the budget (cost), In terms of accurate identification of the tasks of project personnel on the basis of the principle of reducing project time and cost, which are the two most important goals in software engineering project scheduling and in the software project scheduling process. [6][10].

2. Significance Of The Study

Working on managing a successful software project according to the standards, achieving customer requirements and delivering the software system on time is the concern of companies and among their work priorities is to develop a solid and flawless software project management. mistakes. The squirrel's lifestyle was simulated as the goal of producing robust software project scheduling.

3. Review Of Related Studies

Many different and varied techniques were used in order to achieve the best and best scheduling of the project. In 2014, a group of researchers, including Yao Xin (2014), presented an experimental study. In order to achieve results in the SPSP problem using an improved design of the evolutionary algorithm in terms of run-time analysis, and they found that this study was effective in terms of solution quality and modification rate on generation members where it was 100% correct [13], Use the Peugeot Finder. A (2015) together with others, the differential evolution method by developing a new breakthrough technique in solving the SPSP problem, they used randomly generated data for testing the algorithm and got the best results in a shorter time than compared with the rest of the algorithms [6]. A group of researchers, including researcher Minko Leandro in the year (2016), suggested many different ways to choose the crossing and mutation processes when using the evolutionary hyper-inference algorithm in order to find the best solution to the SPSP problem, and the results proved that these methods can solve the problem efficiently [19].

In 2021, Firdews A. Al-Salman, Baraa Mustafa Mustafa, the research presented a scheduling study for 36 software projects, the number of skills is 10, where each task has 6-7 different skills, and the number of skills for each employee is 6-7 different skills, based on swarm's algorithms. Where they used the bat and dolphin algorithm, and these two algorithms have proven good results compared to other algorithms [6] [10]

4. Objectives of The Study

• Achieving more diversity of results, as it is considered the most important measure for evaluating the performance of the algorithm and calculating the average value of the large volume index.

• Accurate project scheduling process that reduces costs and time

5. Population and Sample

Data were extracted from 36 groups, each group representing one project. Where each group has 10 different skills in the project crew, each employee possesses 6-7 random skills out of a total of ten skills, and each group is a group of employees responsible for a particular task. [10] Table (1) shown the similar and different characteristics of the groups.

Table 1. the similar and different characteristics of the data sets

Traits	Description
The total number of groups	36 groups
The total number of skills	10 different skills
Number of skills for each task	6-7 different skills
The number of skills per employee	6-7 different skills
The total number of tasks	Equals one of the following values (16, 32, 64, 128, 256 ,512)
The amount of effort	Each task has its own random voltage value
The total number of employees	Equals one of the following values (8, 16, 32, 64, 128, 256)
The amount of the salary	Each employee has their own random salary value
Task appearance diagram	Different random scheme for each project

Table 2. General description of each group of data

Dataset	General Description
16*8	consists of 16 task and 8 employees
16*16	consists of 16 task and 16 employees
16*32	consists of 16 task and 32 employees
16*64	consists of 16 task and 64 employees
16*128	consists of 16 task and 128 employees
16*256	consists of 16 task and 256 employees
32*8	consists of 32 task and 8 employees
32*16	consists of 32 task and 16 employees
32*32	consists of 32 task and 32 employees
……	……………………..
256*256	consists of 256 task and 256 employees

6. Intelligent Squirrel Swarm Algorithm

Jain et al. in year (2019) proposed and developed a squirrel search algorithm inspired by the behavior of nature squirrels, This algorithm showed a high convergence rate when compared to other swarm intelligence optimization algorithms, such as PSO, ABC, Bat Algorithm (BA), and Firefly (FF). It simulates the dynamic behavior of squirrel movement (gliding). Flying squirrels are assigned a random initial location in the forest (random solutions).

The fitness function of each squirrel depends on the location of the squirrel, where fitness is the best tree that provides food in terms of its presence or absence (relevancy of solutions). Depending on that, a number of squirrels move towards the optimal source of natural food, and also taking into account the presence of a predator and the exploitation of this behavior A flying squirrel moves from one normal food source to another ideal source, And this step of the squirrel swarm algorithm: [4]

1. Initialize the Population

Depending on the population is N, the upper and lower limits of the search space are FSU and FS_L. N According to Equation (1), individuals will be randomly generated

$FS_i = FS_L + rand(1, D) \times (FS_U - FS_L)$ .... (1)

D is the dimension of the problem.

rand is a random number between 0 and 1;

where FS_i represents the i-th individual, (i = 1 ....N);

2. Classify the Population

Each squirrel is scattered across a tree, N is the total number of squirrels, therefore, all trees contain one nut tree and oak trees contain N squirrels, Nfs (1 < Nfs < N); dimension, maximum number of iterations, static slip Gc, air density ρ, lift coefficient CL, drag coefficient CD, velocity V, height of Hg, [5]

A. f_h individuals existing on hickory trees.

B. f_a individuals existing on acorn trees.

C.f_n individuals existing on normal trees. The squirrel individual has a minimum fitness value is f_h, the individuals that have the fitness position from 2 to Na + 1 is f_a, and the residual individuals are indicating as f_n.

3. Dynamic foraging behavior

A mathematically represented moveable foraging behavior can be three cases as follows [21]:

A. Flying squirrels locations that are sliding from "acorn trees" to "hickory tree" (fs_{at}) are modified as:

$$\begin{cases} FS\ i\ t{+}1 = FSt\ i + dg \times Gc \times (F\ h\ t - FSit) & if\ \ r_1 > Pdp \\ random\ location & otherwise \end{cases} \quad ....(2)$$

Where d_S is the random sliding distance, fs_{ht} is the position of individuals that arrived "hickory nut tree", t refers to the existing iteration and Gliding constant $\boldsymbol{Gc}$=1.9 according to rigorous analysis for the proposed algorithm.

B. The remaining flying squirrels' locations, that are sliding from "normal trees" (fs_{nt}) to "acorn nut trees" are adjusted as:

$$\begin{cases} FS_i^{\,t+1} = FSt\ i + dg \times Gc \times (F\ ai\ t - FSit) & if\ \ r2 > Pdp \\ random\ location & otherwise \end{cases} \quad .... (3)$$

C.Get the new location of squirrels that are in "normal trees" and used a "corn nuts" may occur about to "hickory nut tree" because save "hickory nuts" may be used at the time of food lack. can get as follows:

$$\begin{cases} FS\ nt\ t{+}1 = FS\ nt\ i + ds \times Gc \times (F\ nt\ t - FS\ nt\ t) & if\ \ r3 > Pdp \\ random\ location & otherwise \end{cases} \quad ....(4)$$

r is a random number between 0 and 1; Pdp valued at 0.1 represents the predator appearance probability; if r ≤ Pdp, the predators appear, the squirrels are forced to narrow the scope of activities, the individuals are endangered, if r > Pdp, then no predator appears, the squirrels glide in the forest to find the food, and the individuals are safe; and their positions are relocated randomly, where r1,r2,r3 is a number randomly, Gc is the constant with the value of 1.9; Fai (i = 1,2, Nfs) is the individual randomly selected from Fa; dg is the gliding distance which can be calculated by equation (5), when t represents the current iteration;, between [0,1] and $\boldsymbol{pdp}$ = 0.1 is the likelihood of a Predator presence.

The sliding distance d_S can be computed by:

$$d_s = \frac{hg}{\tan(\phi)} \qquad ……………..(5)$$

where h_g is the loss in height after gliding corresponds to its original paper and Φ is the glide angle, generate random locations for p number of flying squirrels using following equation (6)

$$\tan(\phi) = D/L \quad \text{.............}(6)$$

$$D = \frac{1}{2p_v{}^2 sc_D} \qquad L = \frac{1}{2p_v{}^2 sc_L}$$

Where p represent the density of air, v is speed, s is the surface area, c_D is defined as drag coefficient and c_L is defined as lift coefficient [22]

3. seasonal acclimate intelligence

The behaviors of search food in squirrels influence by seasonal fluctuation. The SSA eschews local optimal solutions. The squirrels are more efficacious in autumn and less efficacious in winter. the seasonal acclimate intelligence has computed seasonal constant (Sc) using Eq.(7)

$$S^t{}_c = \sqrt{\sum_{k=1}^{d} \left(SS^1{}_{at,k} - SS_{ht,k} \right)^2} \text{..................}(7)$$

Where i = 1,2,3. The less value of a seasonal constant is computed by using Eq.(8):

$$S_{min} = \frac{10E^{-6}}{(365)\frac{t}{(tm/2.5)}} \text{..........}(8)$$

The big value of S_{min} support exploration while the minimal value enhance the ability of the squirrels algorithm.

4. random re-location at the end of the winter

In case $Sc\ \ t\ \leq Smin$ the winter is ended. In this case position of the flying squirrels are randomly re-location by using Eq.(9) [10].

$$fs^{new}{}_{nt} = fs_L + Le'vy(n) \times (fs_u - fs_L) \text{...................}(9)$$

Levy distribution enhances the universal exploration power and gets new results out of the way from the current better results. The Levy flight has computed by Eq.(11):

$$Levy(x) = 0.01 \times \frac{n}{|r_2|^{1}/a} \times y \quad \text{...............}(10)$$

Where β is a fixed number equal 1.5, Ra and Rb random numbers between [0,1] and σ is computed by Eq.(11):

$$y = \left(\frac{r(1+a) \times Sin(0.5\pi\alpha)}{r\left(\frac{1+\alpha}{2}\right) \times \alpha \times 2^{0.5(\alpha-1)}}\right)^{\frac{1}{a}} \text{.........}(11)$$

where r_1 and r_2 are random numbers in the range of (0,1), α is a constant value equal to 1.

5. Estimate the location of each flying squirrel.

6. According to the fitness value of each squirrel arrange its location

7. Identification of flying squirrels on walnut tree, walnut and ordinary trees i.e., The best fitness function for a flying squirrel is considered the best bird to reach the goal, then the next three values for flying squirrels will be on oak trees and then remain on normal trees. [7].

8. Flying squirrels are randomly selected on regular trees that move towards the walnut tree and the walnut tree.

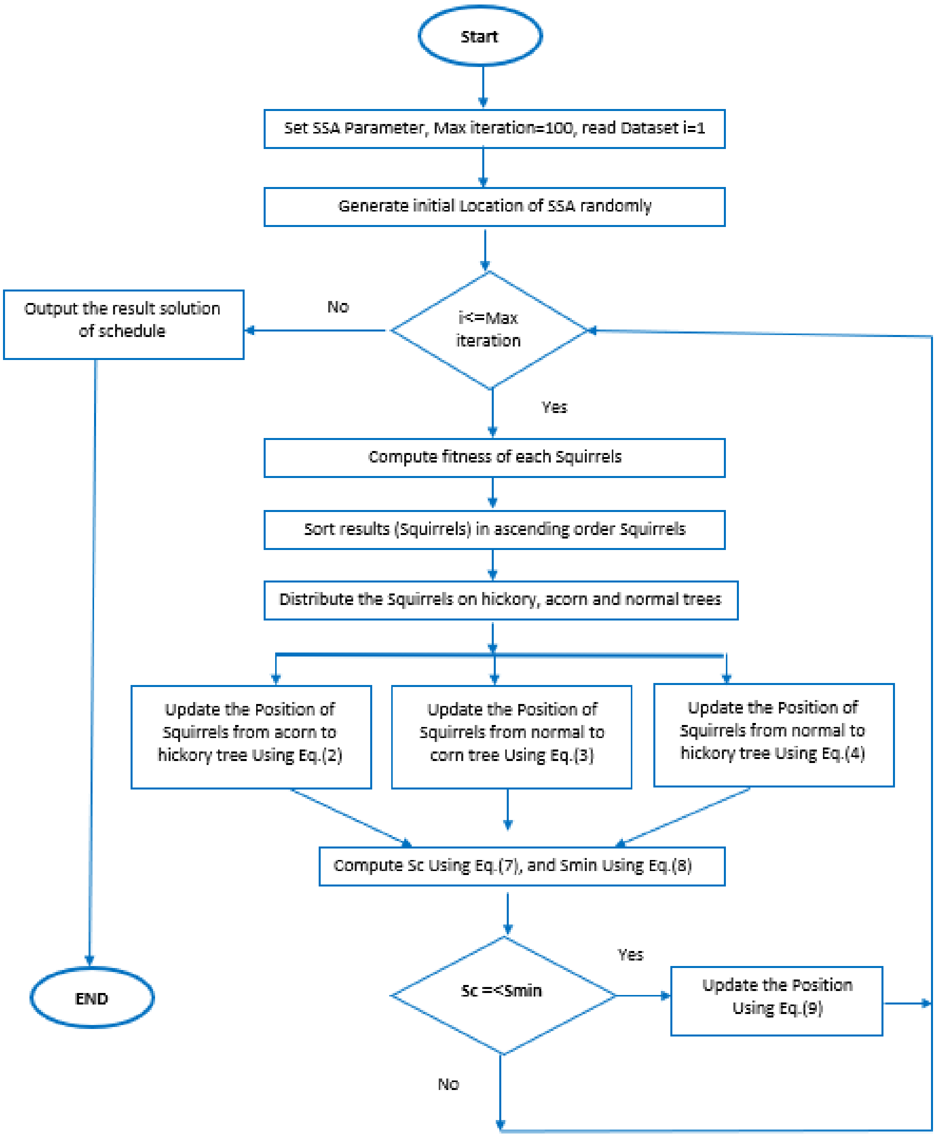
9. Update the minimum value of seasonal constant (S_{min}) by making m=m+1 and go to step 3.

10. If the stopping criteria (ite < ite_{max}) is satisfied algorithm will be stop.

11. Putting a flying squirrel on a walnut tree is the best solution.

7. Squirrel algorithm representation

Figure.1: Intelligent Squirrel Swarm Algorithm (SSA)



8. RESULTS AND DISCUSSION

The squirrel algorithm was implemented using Matlab R2017a and on a Windows 10 Pro laptop with a Core(TM) i5-4200U 160GHz-2.30GHz CPU with 4GB of external memory. Where the comparison was made with the artificial dolphin and fish algorithm [10],as for the variables used in the algorithms, they can be shown in Table 4.

Table 4.The values of the variables of the SSA algorithms

Variables	SSA
static slip	1
air density	1.5
Loop	1000
lift coefficient	20
drag coefficient	20
Velocity	100
Height	100

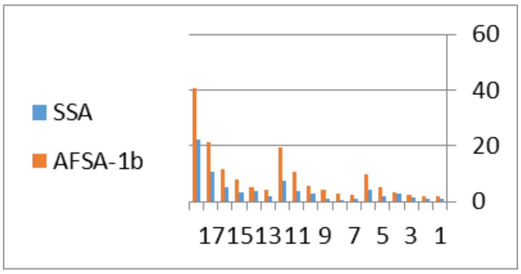
Using the SSA algorithm, the following results were obtained:

1. Execution time results: the average execution time in seconds for comparison algorithms for all the same data sets, The results of the execution time obtained using the swarm squirrel algorithm (SSA) and compared with the

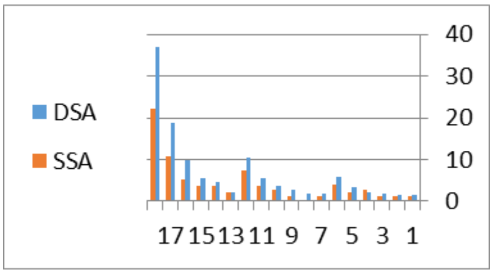
results of the developed and The Dolphin Swarm Algorithm (DSA) and the Artificial Fish Swarm Algorithm (AFSA). Table 5 shows and Figure 2 shows the comparison in average execution time between the three algorithms SSA , DSA and AFSA.

Table 5 .Average execution time in second

Data	DSA	SSA	AFSA-1b	Data	DSA	SSA	AFSA-1b
16*8	1.537	1.256	1.743	128*8	6.770	4.124	8.479
16*16	1.621	1.175	1.791	128*16	6.005	5.683	7.150
16*32	1.728	1.327	2.427	128*32	9.873	9.381	11.535
16*64	2.004	2.895	3.179	128*64	19.894	13.150	22.234
16*128	3.502	2.157	5.211	128*128	28.689	20.046	43.809
16*256	5.886	4.047	9.678	128*256	55.984	40.813	88.986
32*8	1.680	1.214	2.616	256*8	9.509	6.074	15.916
32*16	1.853	0.329	2.963	256*16	11.894	8.618	22.943
32*32	2.627	1.091	4.196	256*32	18.552	11.201	32.529
32*64	3.556	2.896	5.698	256*64	43.472	36.731	56.922
32*128	5.564	3.635	10.694	256*128	68.370	50.480	97.271
32*256	10.483	7.358	19.680	256*256	105.122	94.334	194.133
64*8	2.108	1.985	4.293	512*8	25.53	19.081	44.399
64*16	4.561	3.634	5.041	512*16	41.621	33.705	65.938
64*32	5.596	3.543	7.976	512*32	56.728	41.760	71.861
64*64	9.767	5.264	11.777	512*64	102.004	95.004	127.558
64*128	18.773	10.768	21.337	512*128	169.502	104.042	205.791
64*256	36.823	22.238	40.783	512*256	244.886	174.193	413.649



(A)



(B)

Figure 2. Average execution time in second for (A) SSA and DSA , (B) SSA and AFSA, Algorithms

2. Diversity of results: It is the most important measure of performance evaluation, where the squirrel swarm al

gorithm (SSA) solves the problem of software project scheduling management. Table 6 shows the average HV value of the SSA algorithm, and solutions with the HV index value have been shown for most of the datasets. [10] [6]

Table 6. the mean value of the oversize index

Data	SSA algorithm	DSA algorithm	Data	SSA algorithm	DSA algorithm	Data	SSA algorithm	DSA algorithm	Data	SSA algorithm	DSA algorithm
16*8	0.407	0.266	32*64	0.395	0.169	128*8	0.275	0.137	256*64	0.097	0.075
16*16	0.324	0.270	32*128	0.567	0.292	128*16	0.380	0.163	256*128	0.104	0.065
16*32	0.567	0.364	32*256	0.451	0.175	128*32	0.105	0.071	256*256	0.348	0.124
16*64	0.327	0.195	64*8	0.304	0.142	128*64	1	0.171	512*8	0.070	0.025
16*128	0.4`78	0.227	64*16	0.400	0.162	128*128	0.107	0.093	512*16	0.173	0.048
16*256	0.264	0.198	64*32	0.255	0.148	128*256	0.348	0.139	512*32	0.096	0.039
32*8	0.347	0.131	64*64	0.354	0.181	256*8	0.204	0.098	512*64	0.190	0.048
32*16	0.587	0.287	64*128	0.406	0.106	256*16	0.460	0.132	512*128	1	0.057
32*32	1	0.855	64*256	0.365	0.158	256*32	0.189	0.067	512*256	0.095	0.045

3. The swarm squirrel algorithm depends on the coordinates of the place in searching for food and according to its speed and ability, knowing that the squirrel has a strong memory to save the places of food such as grain trees and nuts, and attempts are made each time according to the speed, location and memory in storing the food locations, and by comparing the correction factor the ratio between the swarm squirrel algorithm and the algorithms Used in the two sources[6][10] for scheduling a problem software project .shown Table (7).

Table 7: The percentage of applying the correction factor

Data	SSA	IBS	AFSA-1b	Data	SSA	IBS	AFSA-1b
8*16	4.304	6.485	11.63750	**16*128**	1.342	3.458	7.1435
16*16	0.799	1.586	6.358	**32*128**	1.052	2.254	3.9715
32*16	0.661	1.896	3.7995	**64*128**	1.046	1.245	2.3835
64*16	0.081	1.210	2.3145	**128*128**	0.102	0.128	1.581
128*16	0.260	0.569	1.558	**256*128**	0.021	0.048	1.133
256*16	0.061	0.253	1.176	**8*256**	6.579	9.875	14.3575
8*32	5.150	8.145	13.5045	**16*256**	1.766	3.865	7.158
16*32	1.003	2.859	6.7635	**32*256**	1.608	2.486	3.9965
32*32	1.014	2.893	3.873	**64*256**	0.604	0.896	2.354
64*32	0.302	1.230	2.33	**128*256**	0.132	0.158	1.5815
128*32	0.081	98.2825	1.516	**256*256**	0.100	96.7775	1.197
256*32	0.104	97.8605	1.1725	**8*512**	3.724	96.4925	15.442
8*64	5.566	99.848	13.3925	**16*512**	1.682	96.4495	7.396
16*64	2.301	96.5285	6.8875	**32*512**	1.532	99.977	4.072
32*64	1.144	99.181	3.8965	**64*512**	0.304	99.982	2.414
64*64	0.255	96.479	2.402	**128*512**	0.042	96.5215	1.618
128*64	0.024	97.8575	1.5625	**256*512**	0.011	96.4395	1.171
256*64	0.040	97.587	1.113	**16*128**	1.548	99.832	7.1435
8*128	5.034	99.871	14.258	**32*128**	1.978	99.9375	3.9715

Table (8) represents the goal values for the scheduling issue (time and cost), the first value represents the project completion time (Time) and the second value represents the project cost (Cost). And compare it with the artificial fish algorithm.

Table (8) represents the goal values

goal values for the scheduling issue	SSA	AFSA-1b
Cost	16548	36947
TIME	132.887	421.694

9. Recommendations

The squirrel algorithm provided accurate solutions to the problem of scheduling a software project according to the following recommendations:

• The smart squirrel algorithm presented a study when changing the values of its variables, the effect of which is clearly reflected on the efficiency of the solution, the accuracy of the results and achieving the best results in solving the problem of the software project, ideal variable values must be found.

• To find effective results for solving complex problems, it is proposed to hybridize the squirrel algorithm with another intelligent swarm algorithm.

10.Conclusion

Depending on the algorithms that were applied in this research, the results were as follows:

1. The smart squirrel swarm algorithm achieved accurate results for example in a batch (32*256) within an execution time of (7.358) seconds, which is a relatively record time. Compared to the two algorithms (AFSA-DSA) which took (19680, 10.483) for the same data set respectively

2. The smart squirrel swarm algorithm achieved its ability to find different solutions, where the average values (HV) of high effort in the data set (64 * 64) (0.354), which achieved a good diversity in finding solutions compared to other algorithms in finding accurate scheduling, process such as dolphin (0.181) and fish (0.103).

3. The smart squirrel swarm algorithm is easier to implement than the AFSA-1b algorithm and bat algorithm, as it needed to apply the correction factor of (0.102) when resolving the data set (128*128), This indicates the change ease of operations when solving the same dataset that the proposed algorithm[6][10].

3. Reducing time and cost, as the cost and time, respectively, when applying the squirrel algorithm is (16548) (132.887) compared to the cost when applying the fish algorithm (36947), (421.694)

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