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Improving Wireless Network Routing Performance Using Stingless Bee Foraging Behavior Algorithm

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ABSTRACT

Because stingless bees forage in a unique way, an optimization algorithm needs to account for this behavior. Stingless bees, whether they forage in groups or alone, have a particular way of doing so. Within bee groups, foraging behavior differs from group to group. Based on the unique behaviors of stingless bees, we created an optimization algorithm in this study. The proposed stingless bee algorithm was then put to the test in order to tackle the challenge of wireless network routing optimization while accounting for residual energy. Accurate calculations of the performance of the stingless bee algorithm were performed by selecting variables for some of the nodes we worked on. used in this work—5, 10, 15, 20, and 25,When there are more nodes, there are more possible solutions. The most crucial elements of the designed stingless bee algorithm are the reduction and early termination procedures. The algorithm differs from other bee-swarm-based algorithms due to these two principles.

1. INTRODUCTION

Among other groups, including honeybees (Apini), bumblebees (Bombini), and orchid bees (Euglossini), stingless bees are members of the Meliponini of the Apidae group. In Figure 1, the classification is displayed. As a component of an intelligent swarm, stingless bees exhibit an intriguing foraging pattern that may be figured out in an optimization program. The best example is the " Krboga, 2005" algorithm, which was very similar to the artificial bee generation algorithm.and a few additional algorithms "Nakrani and Tovey, 2003", "Teodorovic and Dell'Orco, 2005", and "Yange, 2005" will make use of this crucial Apini foraging pattern. Because of the way honeybees forage, a population-based search method was developed to identify the best answer. This method was initially introduced by D. Krboga in 2005 "Krboga, 2005". The algorithm works to find new ways to search for food within bee colonies. The artificial bee"A.B.C" algorithm has been subjected to actual study and analysis by the scientist Krboga and his team.. Krboga and Pastork examined how well the A.B.C method performed on numerical implementation issues that were either unconstrained "Pastork and Krboga, 2006", confined "Krboga and Pastork, 2007b", or unrestrained "Krboga and Pastork, 2007a, 2008".

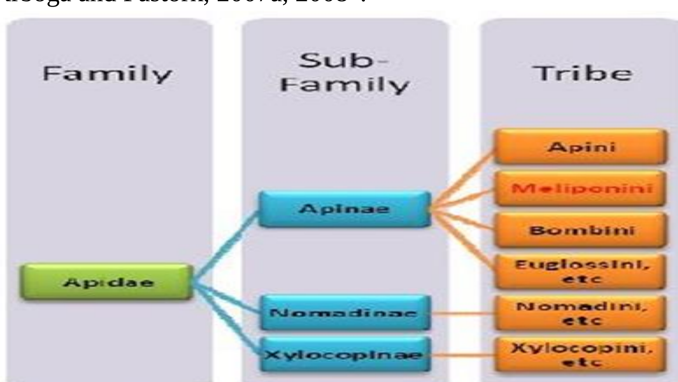

Figure 1. The taxonomic Tree of Meliponini in Apidae group

In addition, there are many who use these methods using this algorithm, including “Krboga et al. (2007)” A.B.C algorithm, which succeeded in training neural networks. It was thought to be a context-based artificial bee ensemble A.B.C algorithm to optimize the framework in (Hadidi et al., 2010). Zhang et al. (2011) used the A.B.C algorithm for a number of purposes, including facial pattern estimation (Zhang and Wu, 2011b), cluster analysis (Zhang et al., 2011b), multi-level optimal cycling "Zhang and Wu, 2011a", Analysis and diagnosis of information shown in the MRI, and two-dimensional protein folding (Zhang and Wu, 2012). (Alfonso et al., 2016) examined the use of the honeybee algorithm in intelligent frequency processing with feedback control. Since its initial publication, the honeybee algorithm put forth in Krboga (2005) has drawn a lot of interest. Another honeybee method was developed by Nakrani and Tovey (2003 2010" and "Chitra and Subbaraj 2010" examined a number of algorithms that draw inspiration from the behavior of honeybees. A comparison between honeybee and stingless bee species was reported in an Australian study (Heard, 1994). According to the study, stingless bees spent less time visiting flowers to take advantage of them than honeybees did within the same time frame. Stingless bees send a wider variety of information through contrast transmission (Nieh, 2004). Stingless bees are quite selective in their feeder investigation and, in addition to vibrating tones in their nests, they also use chemical communication by showing a particular aroma in, around, or at certain points along the way to the feeder.

Compared to honey-content bees, stinger bees use and share more information. According to research on three Sumatran stinger bees (found on the Indonesian island of Sumatra), stingers that fly to take advantage of floral resources also explore even if the supplies are not completely utilized (Inouye et al., 1985). On the other hand, honey-containing bees keep taking advantage of it until they run out " Vone Fricsh, 1967". Depending on the type of bees working in this way, which produces honey, the nectar and its quantities are only provided., stingers provide floral resource data that includes nectar direction, elevation, and quantity (Nie, 2004). By embracing the distinctive characteristics examined on "Hearde, 1994", "Niehe, 2004", "Inuoe et al., 1985", "Vone Fricsh, 1967", "Roseline and Hancir, 2012", "Kakatuni et al., 1993", "Jarou et al., 2004", "Riechla et al., 2013", "Jcubos and Jadith, 2004", "Peater et al., 2010", "Jarou, 2009", and "Sanches et al., 2008", Final analyses of the optimization algorithm based on the foraging behavior of stingless bees showed that it was much more efficient than the common honeybee, which searched for food with less effort. The stingless bee algorithm "S.B.A" was developed to visit fewer flowers within a given time. The likelihood of potential solutions is decreased by using the behavior of stingless bees. It differs from the popular random bee method primarily in that part of the reduction is altered. The suggested algorithm is then put to the test in order to determine the optimal path for a wireless sensor network routing optimization problem.

2. STINGLESS BEE ALGORITHM

By imitating the swarm behavior of foraging and utilizing floral resources in the natural, bee self-optimization algorithms have been created. Honeybees and stingless bees share several characteristics. Bee foraging behavior can be divided into two categories: individual behavior and group activity (Heard, 1994, Nieh, 2004). The behavioral behaviors of the many tribes in the Apidae family also exhibit both similarities and distinctions. Two bee species—the honeybee (Apini) and the stingless bee (Meliponini)—have been compared in a number of entomological investigations (Heard, 1994, Nieh, 2004). Stingless bees exhibit the following foraging behaviors, which include both individual and colony behavior.

2.1. Colony Behavior

Buzzing bees, stingless bees, and honeybees are closed social groups that divide tasks among group members when foraging (Sanchez et al., 2008). However, the majority of this group stays at home, with only a small portion going out at a time. Those in the group who stay at home—lazy, idle, or inexperienced people—wait for foragers to tell them about floral resources. In addition, a lot of foragers that search for and discover floral resources enlist other group members to take use of already-existing floral resources. While some foragers go out into the world to locate the feeder, others stay behind to record any information these foragers bring back. Bees use visual and occasionally chemical communication to exchange information with one another. Waggling motion offers a visual means of communicating feeder position and profitability information. The waggling motion of honeybees during foraging is demonstrated by The basic working of the artificial bee algorithm component "A.B.C" is " Krboga,2005". Another visual communication method that stingless bees employ to train observer bees is waggling. But compared to honeybees, stingless bees' waggling action is more varied and includes more information. It offers comprehensive information on pertinent nutrients "Jarau, 2009". Stingless bees can communicate by waggling or by sending out chemical signals. Additionally, this motion offers odorant guidance, which gives other group members information about the direction and profitability of floral resources "Roslino and Henser, 2013; Sanchez et al., 2008". A variety of smells are used by stingless bees to communicate different kinds of information.

2.2. Individual Behavior

During foraging, active stingless bee individuals are able to make decisions. Even if the present food sources are not depleted, foragers have been seen to take advantage of resources and transition to foraging while traveling (von Frisch, 1967). A solitary stingless bee forager can locate one or more feeders using odor as a deterrent signal to avoid other members visiting those sites, in contrast to the behavior of honeybees, which even the day after the food source is depleted, return to the same locations (Heard, 1994; von Frisch, 1967). This illustrates how stingless bees use preselection when foraging. Additionally, scent diffusion allows individual foragers to create a full or partial path between the nest and the feeding site "Rosellino and Henser, 2013".

2.3. An algorithm with characteristics of food finding by a fierce bee.

Using the effective information exchange during the search, an algorithm modeled after the behavior of stinging bees in food searching is taken into consideration. The following definition must be provided before the algorithm is described:

Definition:

An applicant who does not satisfy the minimal requirements for permanent selection is considered permanently disqualified.

• Temporarily ineligible applicant: A candidate who, while not meeting the minimal requirements for a certain circumstance, theoretically satisfies the requirements for becoming a workable alternative.

• Our research Includes an algorithm based on stingless bee foraging behavior. The model of the method used is shown in the flow chart as illustrated in Figure 2.

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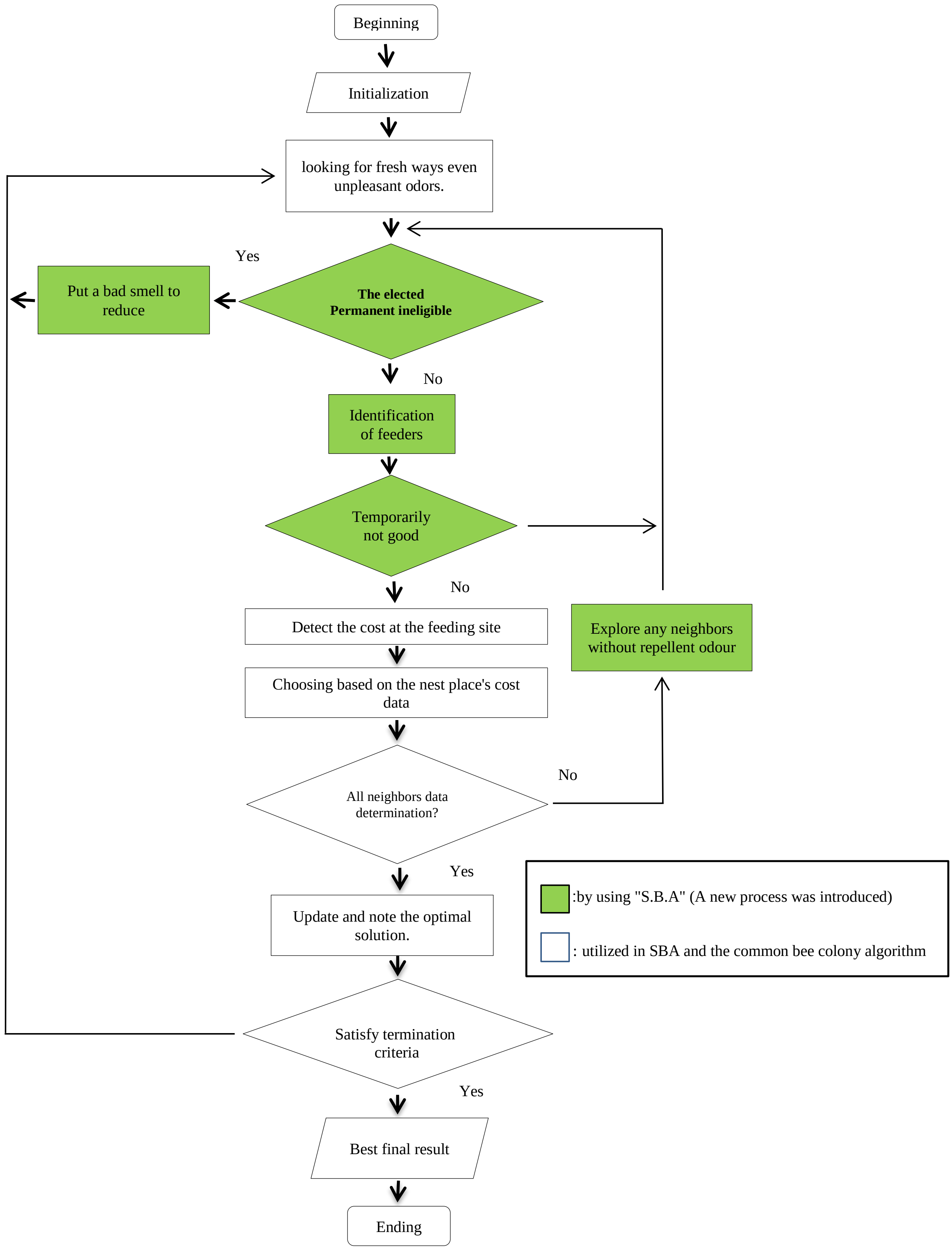

Figure 2. Flowchart showing the stingless bee algorithm, along with typical algorithms for bee swarms.

The number of observable characteristics (or potential solutions) that can be found can be greatly decreased by using the stingless bee algorithm (S.B.A). This has a beneficial effect on the computational approach as a result. Reducing the amount of inappropriate solutions with unpleasant smells is the crucial step in the stingless bee algorithm that yields the optimum outcome. In order to avoid investigating inappropriate food in the wrong place, explorer bees are able to make selective selections regarding the group. Explorer bees use unpleasant cues to locate several foraging locations. This illustrates how forager bees can weed out inappropriate feeders to keep other foragers from spotting them. Sending information home does not always result in a collective reaction. The method is based on stingless bees' foraging behavior, which is marked by a higher degree of variance in information sharing, as seen in the flowchart in Figure 2. The impact on the program is supposed to come from the bee, using an algorithm written by " Krboga in 2005". The algorithm used is a stinger-like bee, which reduces the number of applicants by permanently eliminating unqualified candidates. There is no need to take part in a second selection procedure after all of this. In real-time applications, this approach is a highly helpful way to speed up searches and minimize processing effort. Additionally, the decrease process was, It is regarded as a method for early termination. Moreover iteration process does not have to continue until the computation is finished For early transition to the strong-sting bee algorithm, the method will move transitioning from the current process to the next seamlessly halting the process within empty circle.

while the detected solution applicants are determined to be momentarily inappropriate, this algorithm can be helpful. It is not necessary to account for applicants who are temporarily unfit in a later step. In contrast to permanent unqualified applicants, they can be allowed in the next loop since temporary unsuitability is momentarily unacceptable. Two mechanisms have been added to the "S.B.A″ algorithm under consideration: the early termination in comparison to the A.B.C algorithm and the reduction in the number of candidates. Along with the "A.B.C" algorithm, The "S.B.A" algorithm has two phases in both methods. A range of heuristic and/or classical techniques have been used in recent years to construct multi-strategy algorithms. For instance, these methods have demonstrated good performance when used to solve combinatorial optimization issues, nonlinear function problems, and large-scale, high-dimensional regression datasets. "El Sehiemy et al. 2013" investigated a multi-criteria process founded on a fuzzy logic algorithm to successfully tackle reactive power management in a real-world scenario in order to demonstrate this. The strategy addresses reactive power support's technical and financial facets.. A parallel genetic algorithm was presented by "Osaba et al. 2013" to address issues with enhancing harmonic convergence. Migration, or inter-subset communication, has been demonstrated to improve the algorithm's performance. Using gravity search algorithms (GSAs), Prekob et al. (2013) created a technique for decreased parameter sensitivity that increases search accuracy by minimizing the objective functions of sorted optimization problems. Using an approximate Takagi-Sugino-Kang fuzzy system, Jakto et al. A two-step procedure for producing suitable fuzzy modeling in high-dimensional regression scenarios was examined in (2014). A post-processing step that functions as rule selection, learning using inductive rules and evolutionary database training, and tuning the membership functions of the selected solutions based on the rarefaction factor, which involves using an efficient Kalman filter to estimate the coefficients of the resulting boundary function within the rules of the fuzzy system, is a key part of the implementation steps. For large-scale, high-dimensional regression datasets, the methods at both stages result in better optimization accuracy and quick convergence in optimization problems.

3. FORMULATION AND IMPLEMENTING ALGORITHMS FOR PROBLEMS

3.1. Formulation of the Problem

Considering an private network with "N" nodes, transmission coverage range of each node is equal to "λ". At k, nodes are scattered. "k = {k1; k2; k3;…kn}, where k1, k2,…,kn stand for the coordinates of the node". (x,y) location. The set e represents the leftover energy of each node, which is thought to exist. $e = \{e_1;e_2;e_3;\ldots e_n\}$. The energy required to move from the source position to the destination location is determined by the cost function, C, is what optimization aims to minimize. The following is a mathematical expression for the optimization problem:

Minimize $\mathbf{C}$ (1)

where

$$\mathbf{C_t} = \boldsymbol{aD_t} + \frac{\mathbf{1}}{\mathbf{e_t}} \tag{2}$$

$$\mathbf{D} = \sum_{(i,j)\in N} \mathbf{d_{ij}A_{ij}} \tag{3}$$

$$\mathbf{Aij} = \begin{cases} \mathbf{1, if\ 0 < |kj - ki| \leq \lambda} \\ \mathbf{0, else} \end{cases} \tag{4}$$

In Equation (2), the remaining energy value at a node at time t is represented by et, while the cost factor of the distance between the current node and the next node at time t is represented by Dt. D_{ij} is the distance between nodes *I* and *J*, and it will be determined if and only if the distance d_{ij} satisfies the range transmission condition, which is $d_{ij} \le \lambda$, as indicated on A_{ij}. Since the primary focus of this work is energy cognition, By "D" the distance cost over the entire transmission length is given. As mentioned in the equation (3), the "a" factor acts as a multiplier to greatly reduce the value of the distance cost compared to the energy cost.. A is a matrix that displays the connection availabilities in relation to each sensor node's coverage transmission. Aij, it will become zero if the guidelines are not followed.

3.2. Utilizing the algorithm process of the stingless bee

P, which comprises certain partial solutions, is an expression for a harmonic solution. A set Pt represents a series of nodes that contribute to forming a complete path starting from a source node and ending at a destination node. The equation that follows defines p_t:

$$P_t =[\, lb + \emptyset\ (ub - lb)] \Leftrightarrow t > 1 \quad (5)$$

and

$$P_t = p_s \Leftrightarrow t = 1 \quad (6)$$

The source node in this instance is p_s, the lowest index node is *lb*, and the highest index node is *ub* The random number φ, which ranges from 0 to 1, is used in equation (5). The remaining nodes are indexed at random, while the source node has the lowest index in the range, while the destination node has the greatest index. Since all indexes are integers, integer numbers in the equation, such the node's index's integer value within its range—are maintained by using the ceiling bracket ([•]).In their quest to learn more about the food sources they come across, stingless bee explorers will decide whether to mark them with a repellent fragrance or warn the supervisor in the place of their danger. The condition for repelling odor It is the only available path if fails to fulfill both the original constraint, expressed by Aij = 0, Equation (4) and the additional constraint in Equation (7).

$$D_{ij} = d_{ij} \le \frac{\lambda}{2} \quad (7)$$

$$R_{ij} = \begin{cases} 1, if\ d_{ij} > \frac{\lambda}{2} \\ 0, else \end{cases} , \ d_{ij} = \left| k_j - k_i \right| \quad (8)$$

There will be fewer edges thanks to equation (7). The repelling odor $R_{ij} = 1$ Consequently, some solution routes with one or more unmarked edges will be eliminated. In other words, $R_{path} \ge 1$ will be disregarded if the whole path solution has an offensive smell in one or more edges.

$$R_{path} = \sum_{i,j \in N} R_{ij} \quad (9)$$

The *C* value must then be determined using the function in equation (2). The selecting stage will proceed in this step only if the path is devoid of the repulsive odor from the previous stage. Meanwhile, the observant bees, It have waiting in the nest with C value are informed during the exploitation phase, in order for the worker bees to fly around and seek for additional food sources, where equation (10) expresses the process of exploring the surrounding areas:

$$q_{ti} = [lp + \varphi\ (ub - lb)\ ] \Leftrightarrow q_t \ne p_t \ne p_s \quad (10)$$

The cost of neighboring solutions is computed using the cost of the bees seen in the nesting area. Next, the least expensive option is selected as the new one.

When an inappropriate temporary feeder is recognized, The process is stopped in a loop using the early termination technique. As a result, the procedure moves straight on to the following iteration and does not have to wait until the final computation. In this instance, a candidate whose residual energy is less than the average residual energy γ of one of the nearby nodes is an inappropriate temporary feeder.

$$f_{it} = \begin{cases} 1, \text{if } E(qt) \geq Y \\ 0, else \end{cases} \tag{11}$$

Temporary unsuitability is the term used when a node is appropriate in one neighborhood set but inappropriate in another.

4. SIMULATION RESULTS

To evaluate the suggested stingless bee algorithm's ability to produce solutions, a simulation was run in MATLAB. The findings are displayed in Figure 3, which has 158 edges and 25 nodes. Each node can have until to 21 passes to Node 22.

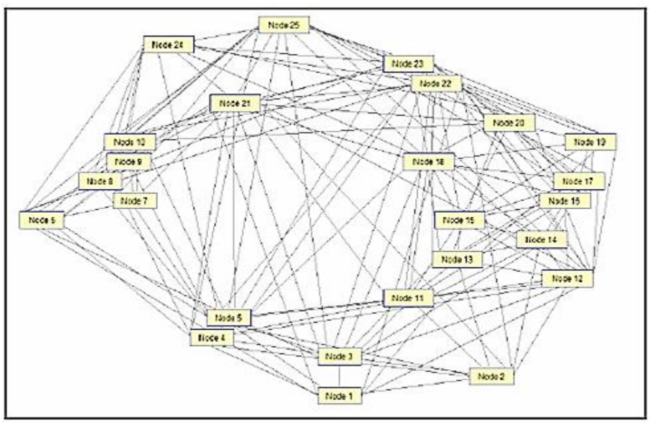

Figure 3: Network accessible link depending on each node coverage transmission

At each node, the residual energy value is set to 15 J at the start of the experiment. As seen in Figure 4, the technique is used in this instance to determine the best route between nodes 18 and 25.

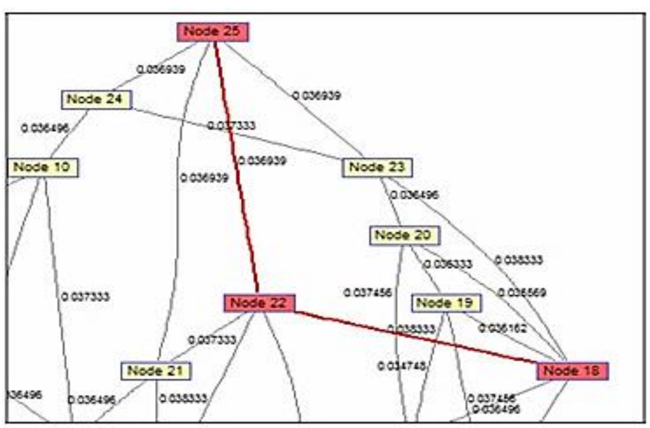

Figure 4: Emulation the good routing transfer process between nodes 18 and 25

The outcome is displayed in Figure 4,and In the first simulation, the good path between nodes 18 and 25via node 22 from the outside. Following scenario is conducted in which the remaining energy value at node 22 shifts from 15 J to 14 J in order to test the algorithm's capacity to identify the best course of action. Figure 5 illustrates how the course is altered in this situation.

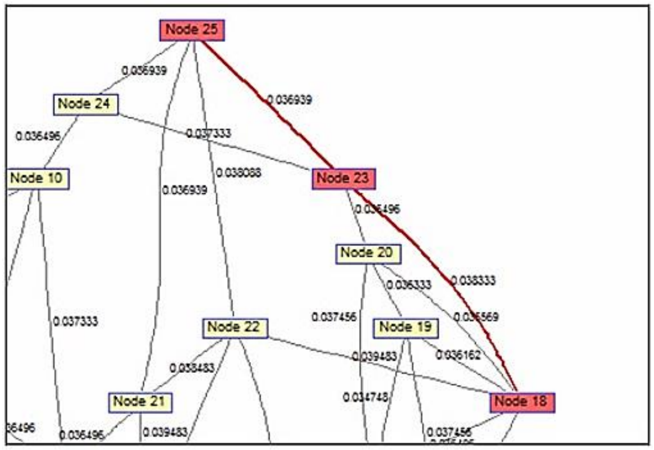

Figure 5: The second simulation provides the good path between nodes 18 and 25

Path between nodes 18 and 25 was obtained, According to the simulation results. It is clear that the algorithm can determine the best course of action by choosing the path via the node with the highest residual energy. When the remaining energy value at node 22 dropped, the algorithm looked for a different solution. Initially, the optimal path was 18-22-25. The new answer, 18-23-25, was discovered to be a neighbor of the old solution.

The selected nodes in the following simulation were positioned sufficiently distant from the drain node that the simulation could be finished with significantly lower residual energy levels at both nodes. for this work, Node1 was selected source node and node 25 as destination. 15 *J* of leftover energy was allocated to every node. Figure 6 displays the simulation outcome for this scenario.

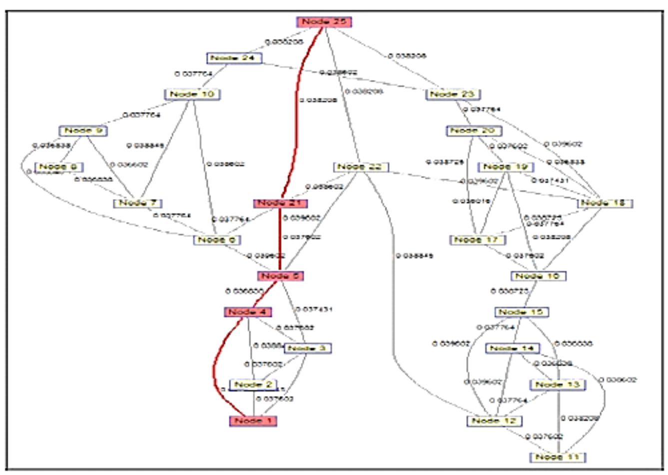

Figure 6: Simulation of the first scenario to determine the good route between nodes 1 and 25

Figure 6 presents emulation results and shows the good way from between nodes 1 and 25 using the 1;4;5; Until 21;25 route. In this instance, the total value of each element in the energy matrix e is 15 J.

The path from source node 1 to drain node 25 was the subject of a second simulation in order to adequately test the method. The remaining energy levels at nodes 4 and 21, which were 15 J, are changed to 7 and 5 J, respectively, to execute the second scenario. The purpose of the emulation is to verify the algorithm's ability to produce a new path as an efficient solution. if the residual energy level of the previous one decreases. The path differs in the simulation results for this case, Assemble in below figure 7.

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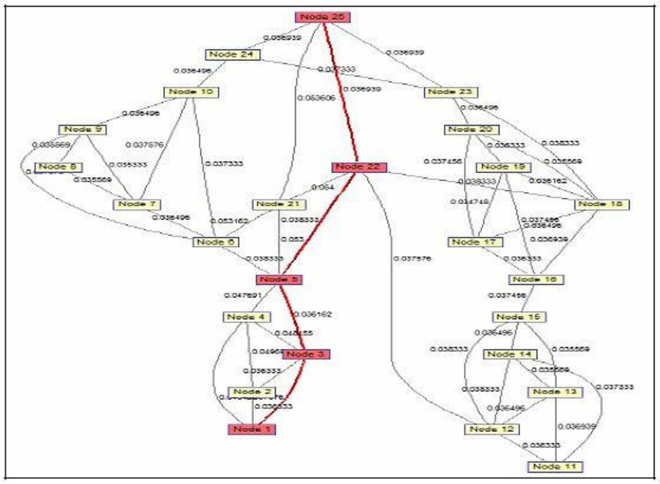

Figure 7: Scenario 2 emulation for the best path from node 1 to node 25

There were twenty-five nodes in the aforementioned scenarios. Table 1 indicates a decline in the number of potential solutions the algorithm employs. The decrease in possible solutions leads to fewer observable extremities. Early ending and stage less method in the stingless bee algorithm reduces execution time to achieve optimal performance.

Table 1: Simulation performance of algorithms

Ambit	Value	
	Initial Value	algorithm for stingless bees "with decrease"
The quantity of nodes that were seen	25	25
Count of edges seen	158	50
The most neighbor nodes possible	21	6
The bare minimum of neighboring nodes	8	3

Several situations with different numbers of nodes (5, 10, 15, 20, and 25) are used to test the algorithm. The algorithm's running time, or the amount of time needed for the search process, is ascertained by this test. Results are presented in Table 2 and Figure 8.

Table 2. Simulation results for the time consumed

Nods / Run	5 nods	10 nods	15 nods	20 nods	25 nods
1st	0.924242 s	1.246056 s	1.930345 s	2.082515 s	2.660982 s
2nd	0.934926 s	1.231706 s	1.811620 s	2.0711 s	2.649988 s
3rd	0.800292 s	1.207067 s	1.803980 s	2.030205 s	2.559148 s
4th	0.778147 s	1.192856 s	1.730543 s	2.004044 s	2.444356 s
5th	0.768284 s	1.18622 s	1.720150 s	1.967594 s	2.330154 s
Average	0.841178 s	1.212783 s	1.799328 s	2.031111 s	2.528926 s

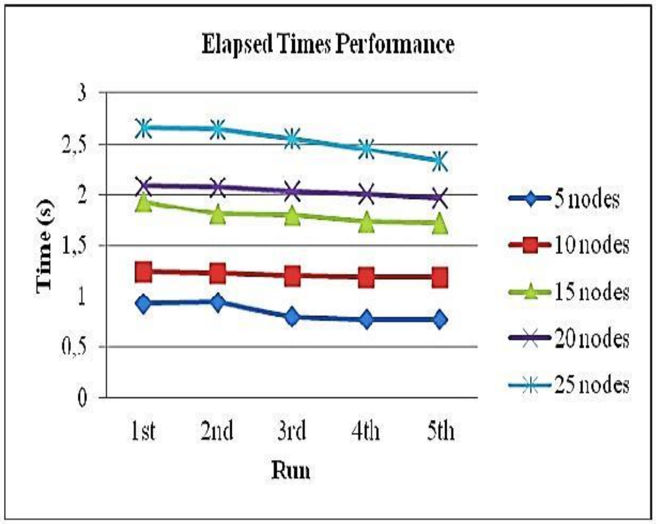

Figure 8 shows the stingless bee algorithm's computing performance over time

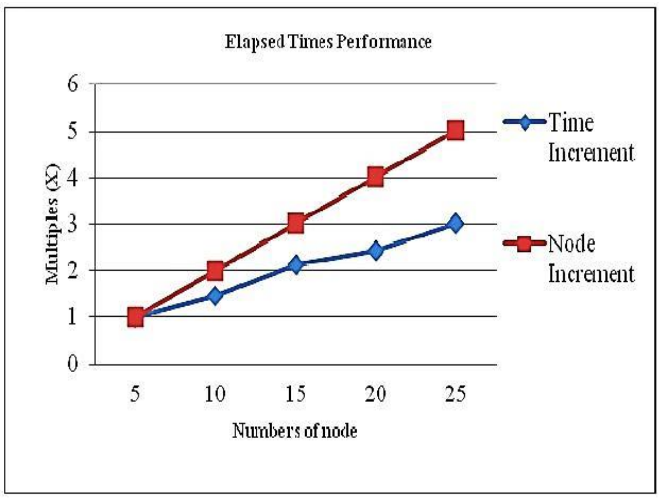

Figure 9. The average elapsed time multiples to the node increment

The stingless bee algorithm's search speed decreases with the number of nodes, as seen in Figure 8 and Table 2. However, as Figure 9 illustrates, the number of connected nodes increases linearly whereas the rise in elapsed time is not.

To determine the optimal route between nodes 1 and 6, the following test was run. All potential routes were defined using (MATLAB) in the first test, as shown in the table below:

rout1 = [1 2 3 4 5 6];	rout14 = [1 4 3 2 5 6];	rout27 = [1 2 4 3 6];	rout40 = [1 4 5 3 6];	rout53 = [1 3 4 6];
rout2 = [1 2 4 3 5 6];	rout15 = [1 4 3 5 2 6];	rout28 = [1 2 5 3 6];	rout41 = [1 4 5 2 6];	rout54 = [1 3 5 6];
rout3 = [1 2 4 5 3 6];	rout16 = [1 4 2 5 3 6];	rout29 = [1 2 4 5 6];	rout42 = [1 4 2 5 6];	rout55 = [1 4 2 6];
rout4 = [1 2 5 4 3 6];	rout17 = [1 4 5 3 2 6];	rout30 = [1 2 5 4 6];	rout43 = [1 5 3 2 6];	rout56 = [1 4 3 6];
rout5 = [1 2 5 3 4 6];	rout18 = [1 4 5 2 3 6];	rout31 = [1 3 2 4 6];	rout44 = [1 5 2 3 6];	rout57 = [1 4 5 6];
rout6 = [1 2 3 5 4 6];	rout19 = [1 5 4 3 2 6];	rout32 = [1 3 2 5 6];	rout45 = [1 5 4 2 6];	rout58 = [1 5 2 6];
rout7 = [1 3 2 4 5 6];	rout20 = [1 5 4 2 3 6];	rout33 = [1 3 4 2 6];	rout46 = [1 5 2 4 6];	rout59 = [1 5 3 6];
rout8 = [1 3 4 2 5 6];	rout21 = [1 5 3 4 2 6];	rout34 = [1 3 5 2 6];	rout47 = [1 5 3 4 6];	rout60 = [1 5 4 6];
rout9 = [1 3 2 5 4 6];	rout22 = [1 5 3 2 4 6];	rout35 = [1 3 4 5 6];	rout48 = [1 5 4 3 6];	rout61 = [1 2 6];
rout10 = [1 3 4 5 2 6];	rout23 = [1 5 2 3 4 6];	rout36 = [1 3 5 4 6];	rout49 = [1 2 3 6];	rout62 = [1 3 6];
rout11 = [1 3 5 4 2 6];	rout24 = [1 5 2 4 3 6];	rout37 = [1 4 3 2 6];	rout50 = [1 2 4 6];	rout63 = [1 4 6];
rout12 = [1 3 5 2 4 6];	rout25 = [1 2 3 4 6];	rout38 = [1 4 2 3 6];	rout51 = [1 2 5 6];	rout64 = [1 5 6];
rout13 = [1 4 2 3 5 6];	rout26 = [1 2 3 5 6];	rout39 = [1 4 3 5 6];	rout52 = [1 3 2 6];	rout65 = [1 6];

These 65 fixed pathways served as the foundation for the algorithm's implementation. The second test was entirely random and did not follow any predetermined routes.

By looking for all potential routes and calculating them at random, we were able to determine the optimal one. In ten testing, the identical path (1 - 3 - 2 - 4 - 6) was generated by both fixed and random paths; nevertheless, SBA's performance was different. Figure 10 illustrates how SBA identifies the optimal path more quickly than random paths when path parameters are fixed. Three times faster than the 0.69 seconds for random paths, the average elapsed time for defined path parameters is 0.20 seconds. In contrast to random pathways, SBA with fixed path parameters necessitates additional work, including expanding memory and manually updating all pre-defined factory combination paths. It takes more work to locate nodes when more are added. The algorithm is more adaptable when using SBA with random parameters, particularly when working with a large quantity from nodes.

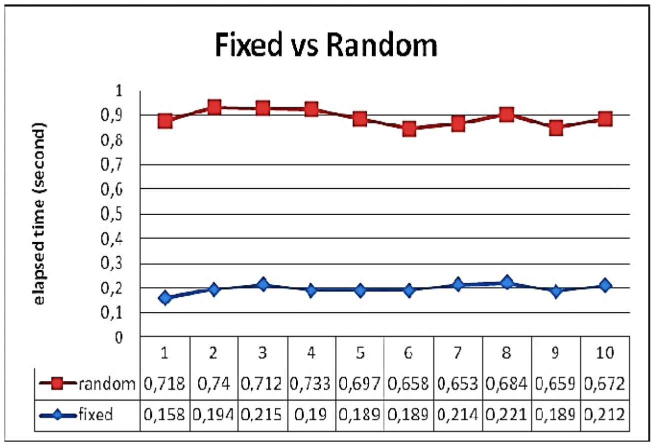

Figure10. The time it took you to complete the ten tests.

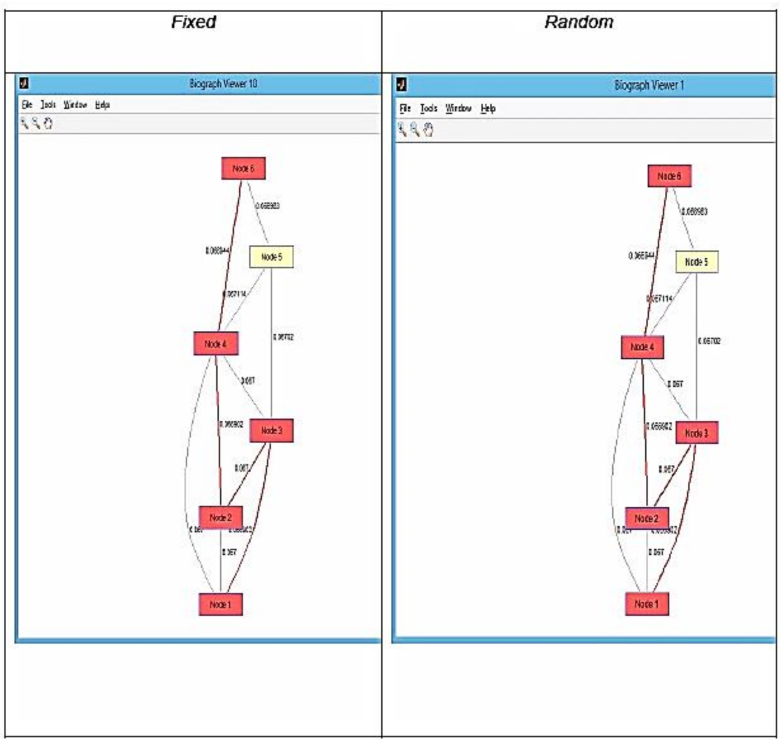

Figure11. Simulation results

5. CONCLUSION

This study discusses the development of an algorithm inspired by the foraging method of stingless bees.. The basic idea of the proposed approach is to combine two mechanisms: a reduction mechanism and an early termination mechanism. The early termination mechanism aims to mimic the behavior of stingless bees when they leave a feeder during the exploitation phase, with the goal of discovering new and more suitable food sources, whereas the reduction mechanism imitates the foraging activity of stingless bees by detecting inappropriate feeders. The suggested stingless bee algorithm effectively and swiftly determines the best course of action in the face of environmental fluctuations, such as shifts in the amount of residual energy dispersed throughout the network. The suggested algorithm only uses two of the stingless bees' foraging strategies. Actually, there are still a lot of stingless bee foraging techniques that can be studied and improved in the future to make the algorithm better. The goal of future research is to create an ideal algorithm by taking use of additional foraging behaviors.

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REFERENCES

[1] Bernardes, Rodrigo Cupertino, et al. "Toxicological assessment of agrochemicals on bees using machine learning tools." Journal of Hazardous Materials 424 (2022): 127344.

[2] Purwanto, Hari, RC Hidayat Soesilohadi, and Manap Trianto. "Stingless bees from meliponiculture in South Kalimantan, Indonesia." Biodiversitas Journal of Biological Diversity 23.3 (2022).

[3] Truong, Thu Huong, et al. "A deep learning-based approach for bee sound identification." Ecological Informatics 78 (2023): 102274.

[4] Tarapoulouzi, Maria, et al. "Insight into the recent application of Chemometrics in quality analysis and characterization of bee honey during processing and storage." Foods 12.3 (2023): 473.

[5] da Silva Cruz, Larissa Farias, et al. "Storage conditions significantly influence the stability of stingless bee (Melipona scutellaris) honey." Journal of Apicultural Research 62.3 (2023): 530-541.

[6] Ismail, Asrul Harun, Wegie Ruslan, and Duc Truong Pham. "A user-friendly Bees Algorithm for continuous and combinatorial optimisation." Cogent Engineering 10.2 (2023): 2278257.

[7] Ramos, Joseph Louis Michael Calangian, Judy Lhyn Porlaje Sarmiento, and Edwin Romeroso Arboleda. "Innovative hive intelligence: Stingless bee products and machine learning advancements in agriculture and medicine: A review." World Journal of Advanced Research and Reviews 21.1 (2024): 2686-2719.

[8] Miftahul, Ilmi. Pest inventory of stingless bee colonies in biology education and research forest (berf) and education farm (edufarm) universitas andalas. Diss. Universitas Andalas, 2024.

[9] Leão, Kamila Leão, et al. "Colony size of amazonian stingless bees and its assessment through intrinsic parameters." Journal of Apicultural Research (2024): 1-10.

[10] Requier, Fabrice, et al. "First large-scale study reveals important losses of managed honey bee and stingless bee colonies in Latin America." Scientific Reports 14.1 (2024): 10079.

[11] Abou-Shaara, Hossam. "Using maximum entropy algorithm to analyze changes in the distribution of the stingless bees, Tetragonisca angustula (Latreille, 1811), in response to future climatic conditions." Journal of the Entomological Research Society 26.2 (2024): 281-295.

[12] Kanazoe, Issaka Wendpanga, et al. "Compositional Profile of Honeys from Stingless Bees and Honeybee Honey from a West African Country Using 1H NMR Spectroscopy." ACS Food Science & Technology 5.1 (2024): 227-233.

[13] Bakar, Mohd Fadzelly Abu. "A sweet-tangy solution to obesity: Evaluating the efficacy and mechanistic insights of stingless bee honey and its potential clinical applications." Trends in Food Science & Technology (2024): 104454.

[14] Vit, Patricia, et al. "Stingless bee honey: Nutraceutical properties and urgent call for proposed global standards." Trends in Food Science & Technology (2024): 104844.

[15] Katipoğlu, Okan Mert, Babak Mohammadi, and Mehdi Keblouti. "Bee-inspired insights: Unleashing the potential of artificial bee colony optimized hybrid neural networks for enhanced groundwater level time series prediction." Environmental Monitoring and Assessment 196.8 (2024): 724.

[16] Ratnayake, Ashan Milinda Bandara, et al. "Machine Learning-Based Acoustic Analysis of Stingless Bee (Heterotrigona itama) Alarm Signals During Intruder Events." Agriculture 15.6 (2025): 591.

[17] Wang, Yongji, et al. "Prediction of the potentially suitable areas of Elymus dahuricus Turcz in China under climate change based on maxent." Scientific Reports 15.1 (2025): 1-14.

[18] Waldschmidt, Ana Maria, et al. "Nidification and nest architecture of the stingless bee Scaptotrigona postica (Latreille, 1807) in Caatinga, Bahia, Brazil." Journal of Apicultural Research (2025): 1-8.

[19] Otesbelgue, Alex, et al. "The missing queen: a non-invasive method to identify queenless stingless bee hives." Apidologie 56.2 (2025): 28.

[20] Noiset, Pierre, et al. "Ecological and evolutionary drivers of stingless bee honey variation at the global scale." Science of The Total Environment 969 (2025): 178945.

[21] Ja'afar, Nor Liyana, et al. "A narrative review on the physicochemical profiles, bioactive compounds, and therapeutic potentials of stingless bee honey." Discover Food 5.1 (2025): 1-21.

[22] Dias, Lucas R. de O., et al. "Influence of Chemical Profile on the Antioxidant Capacity of Brazilian Stingless Bee Honey." ACS Omega (2025).

[23] Bogo, Gherardo, et al. "Current status of toxicological research on stingless bees (Apidae, Meliponini): Important pollinators neglected by pesticides' regulations." Science of The Total Environment 959 (2025): 178229.

[24] Ocaña-Cabrera, Joseline Sofía, Sarah Martin-Solano, and Claude Saegerman. "Environmental Sources of Possible Associated Pathogens and Contaminants of Stingless Bees in the Neotropics." Insects 16.4 (2025): 350.

[25] Alsuwat, Hatim, and Emad Alsuwat. "Energy-aware and efficient cluster head selection and routing in wireless sensor networks using improved artificial bee Colony algorithm." Peer-to-Peer Networking and Applications 18.2 (2025): 1-24.

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