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Smart Self-Pollination for Future Agricultural-A Computational Structure for Micro Air Vehicles with Man-Made and Artificial Intelligence

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Abstract: As pollination is an important role in agriculture to yield many fruits. This is diminished due to the use of fertilizers. This leads the honeybee does not get attracted with the flowers with its colours and odour. So smart self-pollination is applied using Micro Air Vehicle (MAV) like MAV Pollinators (MPrs). In this the movement of the bees are not happening in a sufficient way due to the absence of artificial intelligence. Further the mean square error is not calculated. Also, if there are a greater number of bees it may fly in the same direction due to the absence of mentioning the direction. Also, from the fly the information is not carried directly to the environment. This leads to a decrease in the rate of pollination. This is remedy by proposing a new micro air vehicle with robobee. In this clustering is made for finding the centroid. Based on the formation of the clusters, the robobee is let to fly. Now the direction for the robobee needs to be determined in each cluster. This is done by using particle swarm optimization. Based on which the findings like dimensions, number of boids and the number of Epochs is found and based on the calculations the robobee was let to fly. As the wings and body in the robobee is connected on the basis of artificial intelligence, it will help to update periodically and the pollination will happen smartly without any human intervention.

Keywords: *Pollination, pollinator, robobee, sensor, vehicle, Artificial Intelligence*

1. Introduction

As Internet Of Things (IOT) has improved in the poultry and farming, it too improved in field of agriculture. If there is no trustworthy communication infrastructure, then the data attained cannot be transmitted over the wireless sensors. This results in introducing the Unmanned Aircraft Vehicles (UAV) as an alternative. This stays and connects through the wireless sensors range done in large areas to yield data for additional processing besides analysis. Besides, UAVs [1], improved version as drones close-fitting with high-resolution cameras as well as exact sensors. As the coverage of forest related forms are crucial as it need to cover large areas. But the use of drones covers thousands of hectares of farms. Satellite and airplanes are the two ways to obtain the image captured. This is helpful in view of macro views. This is not sufficient for the analyses and decision making because of the poor quality of the images. Also, the other drawback in this technique is the frequency in which the images are collected. It is not often carried out as it is difficult. In addition to the above issues, it was found that due to the bad weather condition to the image gets disrupted. This is overcome by the UAV which was implemented to perform in the area or farms. The quality of the image is increased based on the camera which is attached to it. As there is an option for changing the camera, it is flexible to fit the camera with the resolution needed for capturing the images. It is easy to do weed mapping, leaf assessments, etc., which will provide the situation. Thus, it is easy for the former to take action accordingly. This will overcome the drawbacks which are mentioned like frequency and weather condition. In the case of frequency, it is easy to record the images frequently as and when required. Also due to the weather condition it is not affected unless it is rainy. So, UAVs are measured as the future of precision for agriculture.

The UAVs are classified into two types like fixed wing as well as multi-rotor drones. In terms of cost, hardware differences as well as the payload capacity it will range accordingly. As they fly for the long range, for large areas the fixed wing is used. Multi-rotor drones set up are easy and faster. It will collect the images by using the light reflected from them. Thermal as well as hyper-spectral sensors are used based on the interest of the farmers. Thermal sensors are used to sense the water level in the leaves of the plant. Hyper-spectral based sensors or cameras record the wavelengths of together visible and invisible lights using the reflected light. This is used to sense the unwanted herbicide as well as weeds. The drawback in this mechanism is the power. This will decrease the time in which it is flying. So, the refilling mechanism is applied. Also, the optimum path selection is critical to choose. Also connecting this is crucial when UAV is considered. To remedy this UAV tethering is applied. Based on the mechanism, a long power cable is used to fly for a long distance rather than carrying heavy batteries. Thus, it resolved many dominant and long-lasting issues in this field.

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2. Related Works

Tom Duckett et al., [2] introduced about the robotic vision in the agriculture. This needs robustness to variations in weather circumstances, image background as well as object appearance. Many factors are required for the robotic decision-making as well as control. For the same it is necessary to allow open-ended learning, enabling adaptation to seasonal variations, new emerging diseases and pests, new crop varieties, etc. Long-term operation is not possible with this approach. Semi-supervised learning is also an open challenge in this.

Yi Chen [3] proposed an autonomous MAV pollinating that affords an intelligent solution to great competent pollination. Through this technique, flower recognition by computer vision techniques as well as robotic MPrs system has been talked. It is categorised into 6 configurations to achieve the autonomous artificial pollination. This improves the artificial pollination in the agricultural field. Even though it failed to focus on the implementation of experimental verification and validation for the autonomous pollination using MPrs, for flapping wings, to develop a CIAD framework, to produce the autonomous robotics, autonomous pollination and so on.

Stephan De Spiegeleire et al., [4] categorized the artificial intelligence in agriculture in to three categories like Artificial Narrow Intelligence, General Intelligence as well as Super Intelligence. On the basis of the findings, it failed to have the robustness, long range etc.

Partha Pratim Ray [5] combined the agricultural and farming domain and found a remedy for the issues. The aim is to improve the system throughput by reducing the cost and hardware or software. But the equipment's needed to build the machines need to be imported. The other issue needs to get overcome is standardization. The process as well as the data is not standardized. Security standards, communication standards and identification standards are the other issues to be faced. In addition, the issue like heterogeneity is considered. This requires collaboration of hardware and software as it involves many works to be done. The next is context awareness. As there are huge amount of data, it is not that easy for the users to handle all the data. Also, the required data need to be identified for the usage. The other is Middleware. Applications are performed through the whole data set as well as query be processed in a centralized manner over the connected devices. The next issue addressed is IoT node identity. As there are huge number of nodes connected, it is not as easy as to find the received data came from which node. So, it needs the collaboration of the current technology to make the identity. The other issue addressed was energy management. Energy management is the other crucial one which IOT is facing. The power needs to be enhanced for a long time. But it is not possible with the source it is possessing. So, the non-conventional energy sources are accompanied to reduce these issues. The last issue is need of real-time solution. As it needs to be notified in real time it is the requirement in this field.

Dr. Vineeth N Balasubramanian et al.,[6] introduced high throughput plant phenotyping methods. This method enhanced the plant breeding as well as agricultural crop management. This developed various image analysis tools to detect plant traits. This too leads to certain issues like dependence of deep networks on large datasets, large variations cannot be captured, and capital and maintenance are expensive in developing countries.

3. System Analysis

Pollination is a fascinating process in the natural world. Pollination is the process in which flowering plants will reproduce. This is the pollen transformation from the male to the female parts of the same or another plant. Plants and their pollinators are benefitted by each other. Some plants pollinate with the help of pollinator. The parts of the flower are described in the following figure 1.

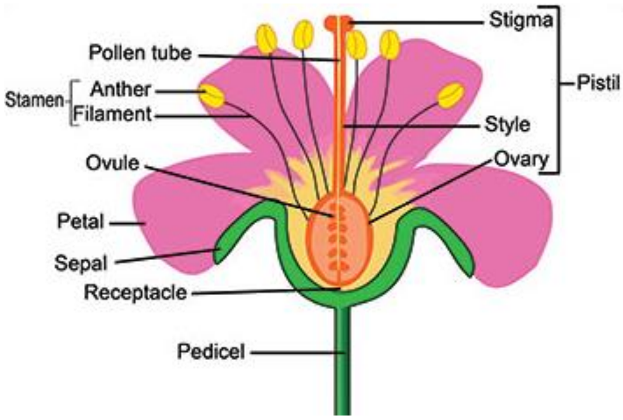

Figure 1. Parts of a flower

Angiosperms or flowering plants are the reproductive structures of flowers. Angiosperms contain food and fiber crops. Pollination is essential to produce seeds and fruits in flowers. Other terms used to describe flowers are complete, incomplete, pistillate and staminate. The shapes of flower are also shapes essential in pollination as certain insects attract to certain shaped flowers.

Plants which are animal-pollinated flowers are bright coloured as well as fragrant. However, wind-pollinated flowers are smaller, dull in colour and unscented. A flower offers food through nectar as well as pollen. Nectars are produced by nectaries. These floral nectaries are contacted by pollinators when sipping the nectar which leads to pollination. Pollinator species are classified as dietary specialists or generalists.

As the fertilizer are getting increased usage in the plants, the natural pollination also getting reduced.[17] Also the pollination is happening by attracting the insects through the shape and odour. This too is not happening in a large range. This is remedy using the implementation of robobee. The properties of robobee[7] are it half the size of a paper clip, weigtless that weighs one-tenth of a gram, and flies using "artificial muscles" compromised of materials that contract when a voltage is applied. But in the earlier methods MAV pollinators are used which has a stiff muscle so that it won't fly. The RoboBee development [8] is generally divided into three main constituents: the Body, Brain, and Colony. Body development will help to move and fly in a flexible way [15]. Brain development acts as a smart sensor. The Colony's focus on the coordination of all. The artificial muscles are capable of beating the wings 120 times per second [16].

RoboBee's [9] wingspan is 3 centimeters (1.2 in). The wings can flap 120 times per second and be controlled remotely in real time. Each RoboBee weighs 80 milligrams (0.0028 oz).[10]

As it is impossible to do the pollination with a single robo bee it is essential to check it through some mechanism and allot the same. So clustering is the one which was chosen for doing the same. Based on the clustering it will cluster and choose a centroid. Based on the formation of the clusters the number of robobee was choosed.

After clustering the errors are calculated and in each cluster particle swarm optimization is implemented using Rastrigin function. The implementation is discussed in section iv.

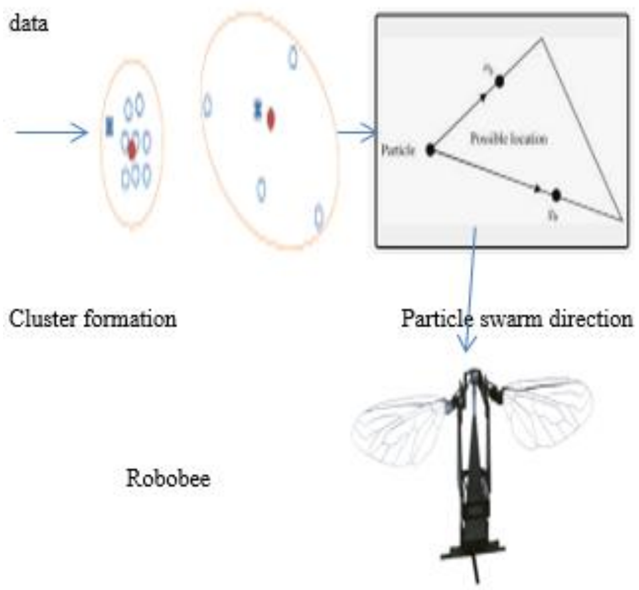

Figure 2. System model

4. Results and Discussion

Robobees are highly intelligent to handle artificial pollination.[11] To achieve the goal of swarm intelligence it is implemented using C++ or python for plotting using mathlib [12]. RoboBees provide surveillance and also it detects the harmful chemicals.[13] As it is impossible to do the pollination with a single robo bee [14] it is essential to check it through some mechanism and allot the same. So clustering is the one which was chosen for doing the same. Based on the clustering it will cluster and choose a centroid. Based on the formation of the clusters the number of robobee was choosed [18]. In the clustering mechanism first, it is subjected to k-partitions.

Finding a *k-partition* of a set *S*, is defined as finding *k* subsets of *S. The rules involved in that are:*

- The intersection of any distinct of those subsets is equal to the empty set.
- The union of all ***k*** subsets is equal to *S.*

The original data set is plotted in the figure 3 below. After partitioning it is converted into partitions of cluster with k=2 as in figure 4.

As in figure 3 the original data which is taken as the input was subjected to partitioning as clusters into groups. According to the Robobee which is available with the farmer, the number of clusters is formed as in figure 4. Now the robobee need to be directed so that without any error it will move in the cluster. For which particle swarm optimization is carried out. So that the direction the bee needs to travel was suggested and based on which it was let to move in the farm. From the collan which is in the robobee it will collects the pollen from one flower to the other which will lead to the pollination. Thus, the pollination happens automatically.

Based on the partitioned clusters and the centroid it is classified as two clusters as in figure 5.

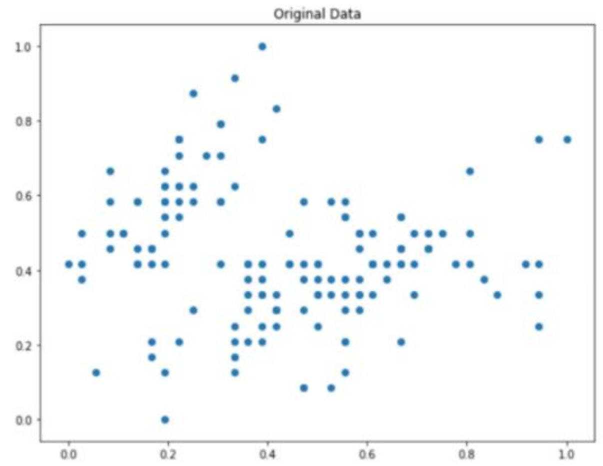

Figure 3. Original data

Figure 4. partitioned data with k=2.

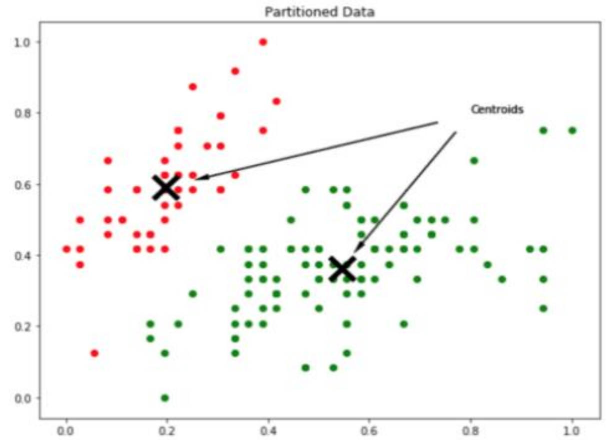

Figure 5. Cluster formation

If *k-partition* are required then it requires *k* centroids. The centroids are also points on the search space defined by our data, and since each centroid defines a group, each data point will be assigned to the closest centroid from it.

Modifying the Artificial Bee Colony for Clustering is used for implementing the clustering mechanism. The normalization was carried out on entire dataset with the [0, 1] interval, and define our objective function as having the boundaries from 0 to 1.

In the partitional clustering approach, maximize the distance among two distinct groups, and minimize the inner distance inside a group. *Sum of Squared Errors (SSE) are calculated plotted as in figure 6.* Formula for calculating the *Sum of Squared Errors.*

$$SSE = \sum_{k=1}^{K} \sum\nolimits_{\forall xi \in Ck} ||xi - \mu k||2$$

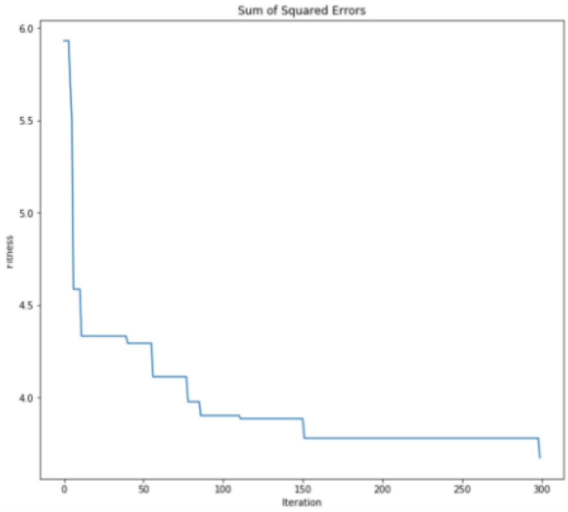

Figure 6. Sum of Squared Error

After finding the squared error, swarm algorithm is implemented using Rastrigin function. Particle Swarm Optimization (PSO) is a powerful algorithm based on Stochastic Optimization [19] and inspired by the rules involved in large flocks of birds.[20] Finally, the implementation of a mathematical model of these principles for the numerical optimization problem will be described and then realized using Python to find the global minima of Rastrigin Function. Velocity is calculated as a vector of partial derivatives of an error function. The velocity is calculated as in the following figure:

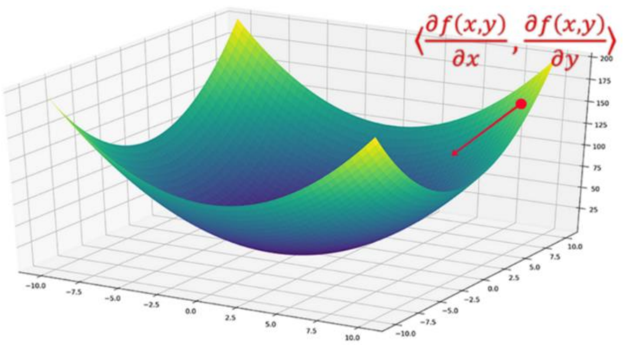

Figure 7. Velocity calculation

For the calculation of velocity, the surface plot of f(x)= x^2+y^2 function. For the robobee it is essential to find the position in which it needs to swarm and perform the pollination in each cluster. This calculation is depicted in figure 8 below.

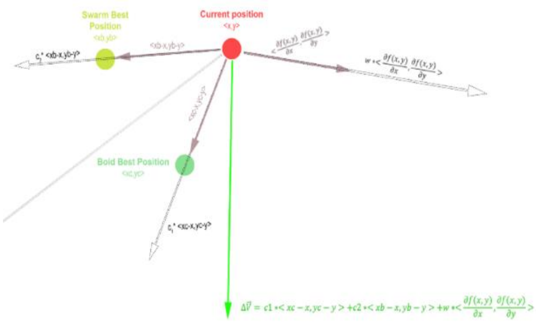

Figure 8. Vector representation of calculating delta V

$$Vboid = \langle \frac{\partial f(currX, currY)}{\partial x}, \frac{\partial f(currX, currY)}{\partial y} \rangle$$

$$\Delta V = w * Vboid + c1 * BoidBestPos + c2 * SwarmBestPos$$

$$\langle newX, newY \rangle = \langle currX, currY \rangle - learningRate * \Delta V$$

In the equations above:

- w — is the inertia that determines to what extent the current velocity of boid will affect to ΔV
- c_1, c_2 — defines how boid's and swarm's best-recorded position will affect to ΔV respectively

w, c_1, c_2, learningRate —are the hyperparameters that should be finetuned during the optimization process.

Based on the above calculation the positions were found and the best position and best-known error for each Epoch was caLcuated as in figure 9 below. This is implemented using C++.

```
Epoch: 0 | Best position: [ -22.2808, -13.9024 ] | Best known error: 703.454
Epoch: 1 | Best position: [ -1.1983, 24.7828 ] | Best known error: 630.385
Epoch: 2 | Best position: [ -12.5027, -9.93395 ] | Best known error: 275.849
Epoch: 3 | Best position: [ -12.262, -7.90953 ] | Best known error: 225.245
Epoch: 4 | Best position: [ -6.2603, -10.9761 ] | Best known error: 170.426
Epoch: 5 | Best position: [ -9.7161, -3.06886 ] | Best known error: 116.856
Epoch: 6 | Best position: [ -5.22463, -3.61352 ] | Best known error: 66.3293
Epoch: 7 | Best position: [ -5.22463, -3.61352 ] | Best known error: 66.3293
Epoch: 8 | Best position: [ -5.22463, -3.61352 ] | Best known error: 66.3293
Epoch: 9 | Best position: [ -5.22463, -3.61352 ] | Best known error: 66.3293
Epoch: 10 | Best position: [ -5.22463, -3.61352 ] | Best known error: 66.3293
Epoch: 11 | Best position: [ -6.94554, -1.80288 ] | Best known error: 58.8092
Epoch: 12 | Best position: [ -5.77672, -0.995949 ] | Best known error: 42.6948
Epoch: 13 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 14 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 15 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 16 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 17 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 18 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 19 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 20 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
Epoch: 21 | Best position: [ -3.0837, -0.969816 ] | Best known error: 11.9802
```

Figure 9. Snapshot of finding best position

Based on the swarm optimization technique, the bee which are pollinating is depicted in three figures 10, 11 and 12.

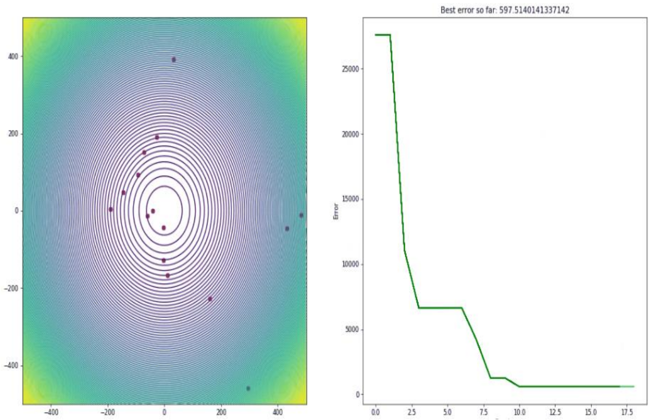

Figure 10. Robobee optimization screenshot 1

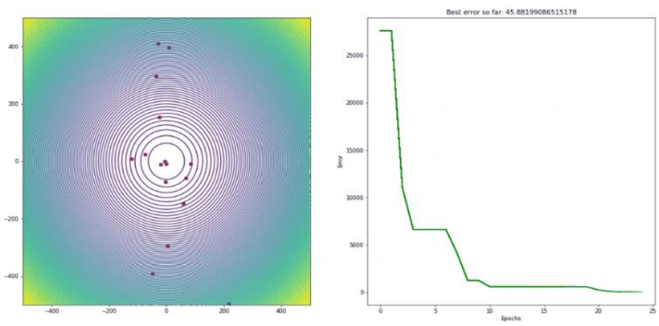

Figure 11. Robobee optimization screenshot 2

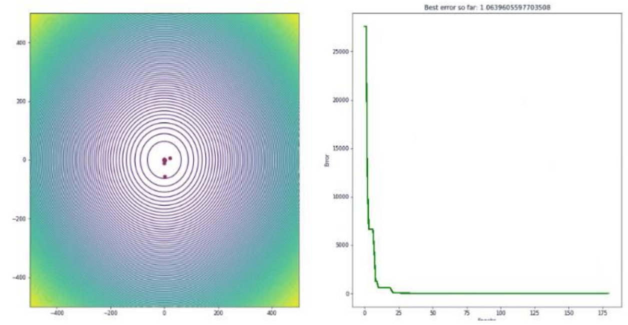

Figure 12. Robobee optimization screenshot

Thus, the pollination happens in a smart and intelligent way as the robobee contains the sensor in the colony where it will sense all the information and the same will be accessed immediately.

5. Conclusion

In this approach, the existing drawback which happened in MAV pollinators like the lack of implementation and the absence of movement like the flies are overcome by introducing the robobee. In this the first stage was clustering which is made for finding the centroid. Based on the formation of the clusters, the robobee is let to fly in each cluster. According to the number of clusters for each field the number of robobee are chosen. Now the direction for the robobee needs to be determined in each cluster. This is done by using particle swarm optimization. Based on which the findings like dimensions, number of boids and the number of Epochs is found and based on the calculations the robobee was let to fly and the pollination will happen smartly and in an intelligent way without any human intervention.

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