The design project of a device to solve the problem of pollination connected with bee extinction

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Abstract. The extinction of bees is a real challenge for the world ecosystem. It is estimated that honey bees pollinate about 80% of all flowering plants, including more than 130 types of fruits and vegetables, therefore, the extinction of honey bees could lead to the change of the whole biological chain. In this research, the danger of bee destruction and its consequences are discussed. Parallels are drawn between modern technical and conceptual solutions to the problem. The result of the research is the design project of a pollinating device developed by the group of specialists from NUACA (National, University of Architecture and Construction of Armenia), as a real technical solution to the problem mentioned above. The main characteristic features such as bionic and technical solutions of the device are presented as well. The predicted results of the device implementation are discussed.

1 Introduction

The greening process in agriculture is one of the mandatory conditions for prospering, safe and sustainable development of modern society. Nowadays, special approaches are needed in agricultural production to ensure growth without large additional costs.

In this regard, beekeeping provides invaluable assistance in increasing crop production. Bee pollination of many agricultural crops provides a significant increase in yield.

By participating in cross-pollination, bees contribute to the reproduction and formation of the vegetation cover of the Earth. They provide all other living organisms with plant food, replenish the atmosphere with free oxygen, and free it from carbon dioxide.

This is the only unique technique that successfully combines the interests of agronomists and beekeepers. On the one hand, the agronomists are mostly interested in increasing yields; on the other hand, the beekeepers are interested in having honey; thus, these interests are achieved by one technique - bee pollination (Figure 1) (Sanchez-Famoso, Etxegarai-Legarreta 2022).

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2 Bees' extinction and consequences

Humanity has caused enormous damage to nature through its activities, but this has not been left without consequences, and catastrophic problems have appeared.

One of the main problems is the threat of complete destruction of bees. This will disrupt the food chain of nature and lead to the disappearance of some plants, animals and birds (Hung, Kingston, Albrecht, Holway 2018).

The main reasons for bee's extinction are presented below:

• Changes in weather conditions play a role in this process.

• Scientists note that the immunity of bees has plummeted, and they have become more vulnerable to various diseases.

• Global warming leads to the spread of "Varrora" type ticks, which spread a virus that deforms the wings of insects. Pesticides and the "colony collapse" syndrome contribute to the fact that worker bees leave the hive for some unknown reason.

• Some entomologists claim that the destruction of bees is associated with an increase in electromagnetic radiation. This affects the nutrition and memory of insects. Experiments were conducted during which bees were exposed to electromagnetic radiation for 24 hours, as a result of which the bees' nutrition decreased by 1.2 times, and memory by 1.6 times. A violation of the bees' nutrition leads to an infraction of the pollination function. Short-term irradiation, 2–6 hours, has no effect on insects (Figure 2) (Eduardo, Zattara, Marcelo, Aizen 2021).

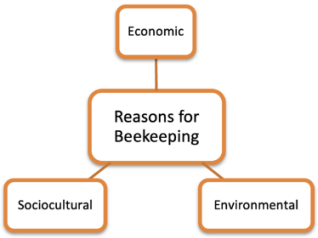

Fig. 1. Reasons for beekeeping.

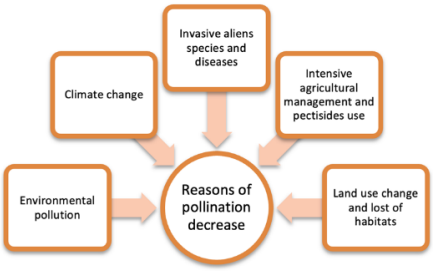

Fig. 2. Reasons of pollination decrease.

The destruction of bees affects not only the elimination of bee products, but also the destruction of many plants (Figure 3). All the mentioned above problems will soon lead to the destruction of birds and animals that feed on these plants. As a result, the food chain will also be disrupted. The animals and birds for which the bee serves as food will partially disappear. The biological balance will be disrupted, which will undoubtedly affect the life and activities of mankind (Wakgari, Yigezu, Moral 2021).

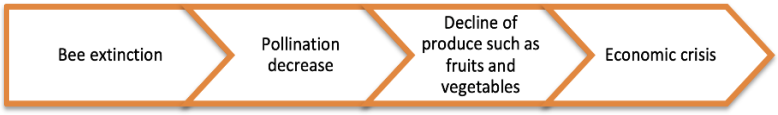

Fig. 3. Bee extinction consequences.

3 Proposed solutions to the problem

Humanity is advancing day by day in the field of science. Therefore, the solution of the problem is leaning on modern technologies, particularly in robotics. Engineers are

experimenting with various small bee robots that will be able to duplicate the originals and perform the same function of pollination.

Humanity will be able to produce artificial pollination to some extent, but this is associated with huge finances. In some countries, this process has begun. For example, in some areas of China, bees are completely extinct, and pollination of trees is carried out by humans. Humanity can partially pollinate with its own resources, but what nature has managed for free, from now on, will require huge financial resources (Cheptou 2021).

The project of plants pollinating device designed by a Master's student of NUACA (National University of Architecture and Construction of Armenia), A. Movsesyan, supervised by Dr A. Atsharyan, Prof. A. Baghdasaryan, Prof. A. Melikyan and Dr T. Paytyan, proposes an artificial pollinator equipped with the latest technologies based on an unmanned aerial vehicle, bionic purpose and design, which will be able to perform the function of bees-pollinating plants and trees, restoring balance in nature.

The goal of the project is the particular prevention of those catastrophic consequences. The task arises to replace bees to some extent, to maintain stable yield indicators, to create products available to the consumer.

In the current conditions, original pollinators have completely disappeared in some cities and the device is a modern and irreplaceable solution equipped with the latest technologies.

In the conditions of Armenia, the "indigenous" species of bees have also completely disappeared and bees are imported from other regions.

The project offers a drone-based pollination device that will completely "change the world". Compared to all existing concepts, it has many advantages: it does not require large production costs and can be mass-produced, which will greatly benefit nature, gardeners and humanity (Altschuld 2021).

3.1 The role of UAVS in agriculture

The use of unmanned aerial vehicles in industry is growing. Drones are widely used in agriculture, mainly for the distribution of fertilizers. The next step towards the large-scale use of drones in agriculture is pollination. Such drones are a necessity since the number of bees is infinitely decreasing, therefore, pollination volumes are decreasing, which leads to a reduction in agricultural products. After realizing the global problem of bee destruction, steps are being taken to use drones for pollination.

As you know, bees are the main pollinators; and produce 80-90% of the total pollination, and the rest is done by other insects. While flying, bees are negatively charged, whereas pollen is positively charged. Therefore, when approaching the flowers, the anthers are automatically attached to the legs and body of the insect.

The proposed bionic equipment performs dust collection in the same way. It collects the anther with the help of negative charges, like a "vacuum cleaner", in a special compartment. Bees also spread part of the pollen during collection, thus pollination occurs. The anthers are constantly circulating in the equipment storage and are distributed along with the collection. Pollen distribution is carried out with the help of screws, which significantly increases the pollination area.

The proposed equipment is very small in size, lightweight based on racing drones, equipped with two engines for maximum ease and controllability.

The proposed equipment has very small size, lightweight, based on racing drones that are equipped with two engines for maximum ease and controllability. The devices have a corresponding point where they automatically return due to battery discharge or any malfunction of the GPS system. In case of a device failure, you can easily find the device. Due to the lightweight and robust design of the device and the structure of the screws, the probability of damage as a result of an accident is very small.

Obviously, everything in agriculture is automated, and you can control it remotely using smartphones.

Therefore, thanks to modern technologies, the proposed equipment is controlled using an application. That is, the device operates in a predetermined area, and you can control the pollination rate to achieve the desired result. In addition, the device has a remote control. After completing the work, the device automatically returns to the base, occupies the part intended for it, which is also equipped with a charging system. The base is equipped with a certain number of drones.

As it was mentioned above, the device has the ability to navigate the territory and avoid obstacles by 360 degrees, which is necessary to prevent collisions with insects, birds, and other objects.

The device also has "vision," or the ability to recognize different kinds of flowers, trees, and crops. This ability is crucial for pollination because different cultures use different methods of pollination.

The wings of the device are foldable. Thanks to this function, it is convenient for packing and transportation.

The basis of the function of the proposed bionic device is a bee, so the device should resemble a bee in appearance and color, but at the same time maintain the basic structure of the drone.

4 Pollinating device technical characteristics

The device is an unmanned aerial vehicle based on a twin-engine V-Copter. The main advantage of a two-winged drone over other drones is energy saving and a record flight time of more than 50 minutes. Therefore, the device can work without problems in endless fields.

The pollinating device is equipped by the modern technologies that make the task easier and more efficient.

Two wings are attached to the drone. The wings are first opened by special equipment used to enter the flight mode. For drones, the act of opening and shutting their wings is crucial. The device is incredibly small and practical for packaging and transit when closed.

The device is equipped with double screws (Figure 4). When a quicker engine reaction is required and traction is not as crucial, fewer blades are preferred. For professional use, experts employ propellers with two blades. Such bolts are perfect for receiving a quick response from the engine because a relatively light device does not require a lot of thrust force. Propellers with three or more blades offer great balance and traction.

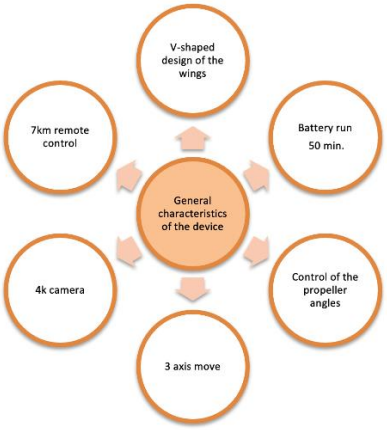

Fig. 4. General characteristics of the pollinating device

Polycarbonate is the most typical material used to make propellers since it is strong and flexible. They also make use of ABS material, which is durable and elastic. ABS plastic propellers break upon impact, whereas polycarbonate ones flex. Although it can be fixed, an imbalance during flight causes vibration. Furthermore, fiberglass-reinforced plastic propellers exist, although these too break under forceful impacts.

The choice of material depends on the weather conditions. For winter flight, ABS plastic is preferable, which hardens and becomes more brittle. For flying in the heat, it is preferable to propellers reinforced with fiberglass, while maintaining strength, since plastic and polycarbonate become soft from the effects of heat and lose traction.

It is convenient to utilize fiberglass-reinforced plastic screws for engines since the equipment is made for pollination, which is typically done in hot weather.

In the design of the drone are used:

- composites reinforced with carbon fiber,
- thermoplastics,
- aluminum,
- lithium-ion charger.

Four engines make up the drone: two rotate the propellers and two tilt the aforementioned engines. The device uses brushed motors.

By switching the polarity, the rotation's direction can be changed (you need to change two of the three wires). Both acceleration and deceleration happen quickly (sharp).

Advantages	**Disadvantages**
High rotation speed	Cost
Wear resistance	Complex repair
Protection from external influences	

The design of the brushed motor can be different.

- "Inrunner" – standard, in which the stator with windings and permanent magnets are fastened together,
- "Qutrunner" - in this case, the stator is coiled with windings, and the body serves as the rotor.

The more energy, the more the battery grows. Everything is simple here. The higher the weight, the more powerful and slower is the device. It is important to remember that the weight of the engine itself should be considered as the weight it has to lift.

A complicated idea that additionally needs a battery, a regulator, a screw, and possibly even wire. The better, the higher. A 70% efficient engine uses 70% of its energy for propulsion and 30% for ambient heating as it gets closer to the heat death of space. The norm for brushed motors is 90%, and for unbrushed 70%.

In practice, propellers create load and air resistance. It follows that rotations will be lower or they will not be at all, because the torque depends on the HF. The higher the KV value, the less power the motor develops.

Since the motor runs at a certain frequency due to the polarity reversal of the electromagnets, KV essentially describes the frequency of the reverse of the magnets with which the permanent magnet is attracted. Let's assume that a permanent magnet is mounted on the rotor. If all goes according to plan, the rotor moves from one variable magnet to another, then reverses polarity, and so on.

If the polarity is changed too often or the load is increased, the rotor simply does not have time to accelerate and overcome the desired path, and it will begin to retract or not move at all. It's like spinning a car wheel on ice. The greater the rotation speed and the car's weight, the more it will slip and the less effort it will develop.

Pollen spreads from the top of the device and over the wings. Paths for the spread of pollen pass along the entire wing.

Pollen is pushed towards the wings at high speed, passes, and leaves the intended area (Figure 5).

Fig. 5. Diagram showing the phases of opening thr drone's wings.

The part intended for ejection of pollen is transformable; it opens during operation to exclude the possibility of foreign objects entering the device. The opening is illuminated with white LED lighting for design. Transformation is provided by flexible metal legs that can be folded and unfolded, providing the necessary opening for pollen to exit. This opening system is another innovation inspired by the 2020 Mercedes-Benz AVTR concept.

Protective frames cover the device wings because it constantly flies through vegetation and trees, spreading pollen in automatic mode, and this system cannot accurately control the device in bottlenecks. The screws are the most vulnerable part of the device. To avoid the damage additional protective frames should be used.

The lightweight and strong frame allows the drone to fly while maintaining agility, comfort, safety and adds stability to all the benefits of a drone. The frame is non-removable and practically does not affect the flight characteristics of the drone, reliably protects sensors and blades from collisions, turning it into an “indestructible” industrial drone that can hit a wall without harming itself or others.

The frames are made of carbon fiber, and the total weight does not exceed 80 grams.

Pollen is dust, and it does not require large space to store it in. To spread pollen throughout the garden, a supply collected from one tree is enough, and it is not necessary to collect pollen from all the flowers of the tree.

The device has two containers for spreading pollen. The first container is extra charged from the back with pre-collected pollen. It is connected to the main container by channels, and if necessary, these channels are opened and the pollen is poured into the main container. An additional container can have two functions.

The first function, as mentioned above, is to contain additional pollen for the main container, since the device has a fairly long flight time and can spread pollen to thousands of plant species during that time.

You can add more pollen to another container if necessary. This will allow for the simultaneous pollination of two different plant species or the production of hybrids, saving both time and resources.

As shown in the picture, the main container is attached to the device from the bottom, and the additional container is attached from the top and connected to the main container by means of channels.

The mechanism for collecting and spreading pollen is connected to the upper part of the main tube and was inspired by the innovative "Dyson Supersonic" hairdryer that can pass air through it.

It strengthens from the upper part of the main wing and, together with the air passing through it, also carries pollen along with it and carries it with great force. There are holes on the main container to prevent vacuum and subsequent problems.

The device has a front-facing air supply source that is powered by a motor and equipped with a suitable air filter.

Pollen spreads from the top of the device and along the wings. The device for pollination is connected to the areas intended for resettlement by the appropriate number of channels. Pollen is pushed into the channels at a very high speed, travels a certain path and leaves the designated areas. High-speed blades that spread pollen over a wide radius play a crucial part in this process.

Moreover, the device can pollinate two different plants in one flight. Charged pollen spreads through the upper part of the device and over the Wings: pollen from the wings is pushed to the wings and spreads over the maximum surface.

The battery is one of the most important parts of a drone. It makes up about 60% of the total mass of the device. The battery capacity is 4000 mAh, thanks to which the device can stay in the air for more than 50 minutes.

The device uses a lithium-polymer rechargeable battery. This power supply is especially popular for airplanes, helicopters, quadcopters, and other drones. When used appropriately, the battery offers a practical, dependable, renewable, and reasonably priced source of electricity.

LiPo batteries have five main advantages that make them the best choice for drones and especially quadcopters over conventional types like NiCad or NiMH.

Advantages	Disadvantages
light weight, different shapes and sizes	expensive
large capacity	don't have a long life
maintains a constant output voltage/power	security issues
high discharge rate	

This is the general appearance of the battery. There are special handles on both sides, which are designed for a comfortable grip and a hermetically fit of the battery in the device. There are latches on both sides of the handles, which are intended for attaching and removing the battery. Several latches are also present on the battery, which serve to hermetically fix the battery.

In the lower part of the battery, there is a power indicator with "LED" lighting.

Landing supports. It is hard to imagine a drone without landing gear and crutches to balance it in neutral position before flying.

This is the general appearance of the crutches. They are attached to the battery handle by provided latches.

It has a light structure. The upper part is made of carbon fiber, which connects to the battery handle. The inner parts, the legs, are elastic, made of aluminum. The elasticity of the crutches is an important factor. It allows you to land on uneven terrain and make soft landings thanks to elasticity, without causing any damage to the drone.

The upper part of the crutches and the back part of the legs are reinforced with shock absorbers for maximum elasticity and to maintain balance.

Smart technologies in the device. The drone has a remote-control camera and a plant species identification device.

The drone cannot fly and navigate in the environment without sensors; therefore, they are very important. Let's introduce the used sensors.

In hold mode, the pilot can regulate roll, pitch, and bank while maintaining altitude. If one wishes to adjust the pitch, they can increase or decrease its intensity.

By examining the pressure data obtained from a specialized barometric sensor, the capacity to maintain altitude is ensured. The majority of contemporary flight controllers come with this sensor.

The pressure sensor's operating theory is based on the fact that atmospheric pressure decreases with height. In low altitudes, indoors, or if the weather changes or the pressure changes, barometer sensor data is not always reliable.

Other sensor types, like an ultrasonic sensor or a sonar, are utilized at low altitudes (up to 10 meters) to increase measurement precision.

Another type of sensor that helps the drone fly is the visual positioning sensor. This sensor is actively used in modern drones. In fact, this is a camera that analyzes the surface under the drone in real time It also has a few disadvantages because it performs poorly on extremely bright or dark surfaces.

As the drone generally flies outdoors, it is equipped with GPS/GLONASS receivers to maintain altitude and position orientation in the environment.

The main camera of the drone has ability to differ features of plant and tree species. Therefore, by the additional software, the device can easily choose the species for pollination.

SENSOR	ADVANTAGES	DISADVANTAGES
Barometer	At a height of more than 1-2 meters	At low altitudes, in bad weather
GPS	In the open sky	In a space whithout satellites
Ultrasonic sensor	At low altitudes (up to 10 meters), in closed spaces	At high altitudes hen flying over sound-absorbing surfaces When flying over sloping surfaces (which reflect the signal away from the aircraft)
Visual positioning sensor	Indoors and outdoors at heights (0.3 to 10 meters)	At high altitudes (more than 10 meters) When flying over water or transparent media When flying over surfaces that are too dark or too bright While flying over a solid surface (eg. snow) While flying over surfaces that do not have clear borders or texture

In the endless fields, one drone will not be enough for the proper pollination. Therefore, databases are created. The drones work one by one, until they run out of energy, they automatically return to base, and the next one flies. When energy runs out, the drone takes its allotted place and charges wirelessly. This is a huge time saving.

Drones distribute pre-collected and stored pollen. The stock collected from one tree is enough to pollinate the entire garden.

The gardener can specify in advance with the help of a special program which part of the field needs to be pollinated and the device starts automated work. The application indicates the position of the device in the field, the dusty space, the operating time and the amount of battery power. After the operation is completed, the device, as noted, automatically returns to the base, takes its place, which also has the possibility of wireless charging.

The pollinating device is equipped with camera to avoid obstacles and differ plants. The device is generated by software that contains a list of plant species; therefore, the device can distinguish them (Figure 6).

The device solves a global super-task, partially replacing bees and increasing productivity. It is charged with pre-collected pollen, which is gathered from flowers, dried,

and can be stored for a year without losing its properties. There are two containers for filling with pollen: the main one and an additional one. The basis of the overall design and color solutions are the characteristic and bionic features of bees.

The drone control app is available on both Android and iOS. It provides detailed weather conditions in the user's region. The app provides information about wind, precipitation, visibility, cloud cover, and more. Users can easily know if the weather is suitable for drone flight. It provides a live HD view from the drone. It tracks flight data and offers multiple automated intelligent flight modes. Users can record and share videos. Easy-to-use features, such as buttons on both the remote control and the smartphone app, allow take-off and landing. The map is easy to use, so one can easily track the position of the drone (Figure 7). This app saves flight data. This makes it immediately available to operators.

Fig. 6. The structure of the brushled motor.

Fig. 7. *Wing cut.*

The software provides the following functions:
• Flight control at high and low levels.
• The state of the drone avoids obstacles using telemetry and sensor data.
• Camera control to shoot according to your needs.
• Live video streaming.
• Remote access to media stored on the camera.
• Flight control.
• Battery management, remote control.

The working range of the device is the endless plains. It is possible to instruct the drone in advance about the working area and the preferred path through which it should pass.

Device Detail	Material used
Case	Carbon fiber
Propellers	Fiberglass reinforced plastic
Front of the case Pollen storage	Heat-resistant fiberglass
Battery	Lithium polymer
Chassis	Carbon fiber Aluminum
Loops Decorative shiny details	Polished aluminum
Structural elements of the device	**Function**
Case	Serves as a support for mechanisms Aerodynamic value Design solution
Wings	Supports for engines

	Ability to become a compass by opening and closing Contains pollen distribution channels as well as transformable distribution platforms.
Engines	Ensure the rotation of the propellers. Providing direction and altitude
Propellers	Detail for movement Promotes the spread of pollen
Protective frame	Protection of the propellers Protection of plant species from drones
Chassis	Maintaining balance Safe takeoff and landing
Battery	Energy source
Battery indicator	Shows the energy available in the battery
Containers	Collection, storage and distribution of pollen
Transformable platforms	Open the way for pollen propagation by transformation When closed, prevents external bodies from entering the device
Details with LED backlight	Scenery
Cameras	Live broadcast Shoot videos Differentiation of plant species Virtual perception of the outside world Avoiding obstacles
Sensors	Height control Orientation in the environment Height adjustment due to pressure Location orientation Avoiding obstacles Virtual perception of space and terrain in the present tense
USB, Type C connector	Exchange of information with other equipment
Latches	For fixing individual parts

5 Conclusion

From the points mentioned above the conclusion can be driven that the solution of plant pollination is one of the most essential tasks for modern science. Pollination is vital for plant species. Except for self-pollinated and wind-pollinated plant species, all other plant species need cross-pollination. Day by day, humanity is more often resorting to artificial pollination. It is the result of a drastic decrease in the number of bees in some places, bees have disappeared again, and in many places, gardeners rent beehives to avoid crop losses. Artificial pollination is carried out using a brush and a cotton swab. This is the most common version,

which is used mainly in greenhouses, mainly for cross-breeding and obtaining new species. However, with this option, it is not possible to pollinate the endless plains.

The design project of the plants-pollinating device with the use of modern technologies comes to solve the problem mentioned above. Drones are developing day by day, and there are many varieties that are used in almost all fields. Drones are also widely used in agriculture. They are used mainly for field control and spreading of fertilizers.

The article proposes a drone-based pollinator. It will completely change the world. Compared to all existing concepts, it has many advantages, as it does not require large costs for production and can be mass-produced, which will greatly benefit nature, gardeners and humanity. The device solves a global super-problem, replacing bees to some extent and increasing yields. The device is charged with pre-collected pollen, which is collected from flowers, dried and can be stored for a year without losing its properties. The basis of the external design and color range was the bee, which is the main pollinator and a symbol of hard work.

As it was presented the device is a kind of a drone, which will be brought to life, to some extent softening the consequences of the destruction of bees. The drone will come to life to soften the consequences of the destruction of bees. In large volumes, they will be used for pollination of both Endless plains and greenhouse plants. Thanks to this, yield indicators will increase indomitably, new hybrids will be obtained.

The gardener can use a special program to indicate in advance which part of the field needs to be pollinated, and the device switches to automated work. The application shows the position of the device in the field, the distance covered, the working time and the amount of battery power. After finishing the work, as mentioned, the device automatically returns to the base, takes its place, which also has the possibility of wireless charging.

A gardener can buy several such devices and use them for years, which is incomparably more profitable than renting hives for each season.

The device is relevant, equipped with the latest technologies and serves to solve a global problem. It has an advantage over all the presented concepts in terms of efficiency, flight time, availability of materials used for manufacturing, and is ready for production.

Disclosure statement

No potential conflict of interest was reported by authors.

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