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ROBOBEES: THE FUTURE OF CROP POLLINATION

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Around three-quarters of all crop species, from apples to almonds, rely on bees and other insects for their pollination. Pesticides, land clearing, and climate change, on the other hand, have caused a decline in many of these animals concerning farmers. Pollination is required for flowering plants to reproduce. In order to form seeds, pollen grains are to be transferred to the stigma of a pistil from the anther. The stamen spills pollen directly onto the pistil in self-pollinating plants. Cross-pollination, on the other hand, entails pollen transport from one plant to another. When bees and other insects eat on flowers, pollen sticks to their bodies and is then deposited on the next plant they visit. It has the advantage of increasing genetic variability and improving crop quantity as well as quality over self-pollination.

Honeybees are referred to as the keystone species because they play a disproportionate function in an ecosystem in comparison to their population size. TheYale University research indicates that one-third of the crops are directly dependent on honey bee pollination. This figure does not include the crops that benefit indirectly from bee pollination. Honeybees and other related insects provided about $29 billion to the agriculture industry in the United States alone in 2010. So, what distinguishes these pollinators from others?

Each plant species necessitates its own pollinator. While mammalian or bird pollinators are too huge, a colony of 50,000 bees gives an exact efficiency. According to the United States Department of Agriculture's Forest Service, the distinctive hairs that encircle many bee species, as well as honeybees' devotion to each owner, allow for effective cross-pollination that promotes healthy future plant generations.

Colony collapse disorder (CCD) is caused by external factors such as the overuse of hazardous chemicals, habitat degradation, and parasites. When worker bees leave the hive and never return owing to infections, hazardous chemicals, or an abrupt shift in habitat, this is known as colony collapse. Food supplies eventually run out, and the queen is left to fend for herself, often dying and forcing the hive to shut down completely. Some colonies have lost up to 80% of their population as a result of CCD. Many farmers are at a loss for what to do because honeybees are failing to live due to a variety of factors. The agriculture industry may suffer major implications as the population declines. Food production will decrease, resulting in a significant loss of money and affecting many socioeconomic categories. A group of Harvard University researchers hopes to provide an automated answer to this looming dilemma.

Recent Developments

When it comes to efficient pollinators, Harvard's Wyss Institute has so far reproduced most of nature's design— with some tweaks. Overall, Robert Wood and his Wyss Institute colleagues seek to create "autonomous micro-aerial vehicles capable of self-contained, self-directed flying and large-group coordination behaviour". The Robobee will be able to pollinate as well as assist in search and rescue efforts. The robot's construction design is divided into three parts: the brain, the body, and the colony. The brain will be made up of "smart" sensors that resemble the eyes and antennae of a bee. Furthermore, the brain is built to sense and respond to the environment in real time.

When combined with a small power source, the body allows the robotic insects to fly on their own. The most recent Robobee model weighs less than a tenth of a gramme and is half the size of a paper clip. To give specific aerodynamic qualities, the overall shape of the body was largely inspired by the physiology of a horse. The instrument's submillimetre anatomy and two wings allow it to flap its wings 120 times per second, allowing it to hover, steer, and lift off vertically. Pollen is collected using three-pronged feet attached to the main component of the body, with accommodations made to hold more weight. Furthermore, researchers discovered a means to strengthen the robotic insects' bodies by allowing them to switch between air and water. Developers have constructed lightweight electrolytic plates that manufacture oxyhydrogen from water using varied propulsion techniques that may overcome various physical restrictions. The oxyhydrogen is subsequently ignited by a sparker, allowing the bees to transfer from water to air as the robot takes off impulsively (Yang,2020).

The Robobee's colony feature allows it to communicate with other insect robots and act as a single entity. This is critical because bees are most efficient when they collaborate with their colony. According to papers produced by Robert Wood's team, the ultimate goal is to develop fully independent colonies, albeit there are still issues.

Structure and functions of a Robobee

On the surface, the task appears to be practically impossible. Millions of years of evolution have moulded bees into magnificent flying machines. Their tiny bodies are capable of flyingfor hours, maintaining equilibrium during wind gusts, searching for flowers, and avoiding predators. A robot hive might be used for a lot more than just pollination (although agriculture is one potential use). Small, agile, basic, and inexpensive robots could, in fact, accomplish a greater number of tasks than a few highly proficient ones. Consider a rescue worker carrying a crate containing 1,000 Robobees, which would weigh less than a kilogramme. The Robobees might be deployed at a natural catastrophe scene to look for survivors' heat, sound, or exhaled carbon dioxide signature. The swarm will be successful if just three of the robots complete their assignment while the others fail.

A colony of robotic bees, on the other hand, faces a slew of technological problems. These small robots would be only a few centimetres long and weigh around half a gramme, less than a tenth of the weight of the world's lightest autonomous flying craft. Each bee's flight mechanism, electronic brain and vision system, and the controls that govern how that bee

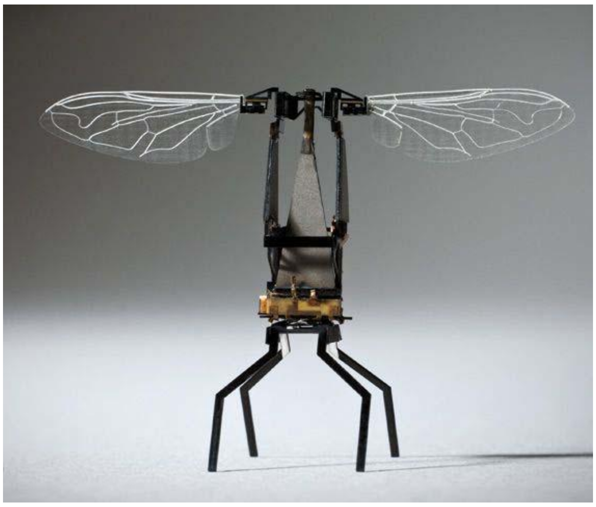

Fig 1: Different types and structure of Robobees

interacts with other members of its colony must all fit into that tiny container. These aims are becoming more attainable, thanks to recent advances in materials science, sensor technology, and computational architecture. Even if it doesn't have a complete image of the environment, a colony of thousands of Robobees will have to efficiently divide duties among people. The hive has been given the task of finding and pollinating flower fields. Individual Robobees begin by exploring various places. The new information changes where future workers will go as they return to the hive with information about where flowers are growing. More robots will be assigned to locations where there is more work to be done. Even though bee-to-bee communication is limited due to power limits, the hive-based technique allows bees to show collective intelligence.

Conclusion

It has proven increasingly difficult to "integrate a compact power source "in the quest to produce a tool as small as a honeybee. Because the robot is so small, it is more vulnerable to environmental stresses such as wind, rain, and unforeseen conditions. The only way to resolve some of the concerns outlined is to get more power. Materials science has come a long way in the last several years in attempting to overcome some of these issues, but researchers working on the project will require a long-term and stable power supply in order to give functionality for the intended purpose of pollination. Kevin Ma, a Wyss researcher, estimates that we won't see the Robobee in action for another ten years. While the effort still has a long way to go, several project critics have provided a fresh perspective on the concept in the meanwhile.

The Robobee's ultimate purpose is to help with not only pollination but also search and rescue operations and environmental monitoring. Some argue that introducing additional technology will not fix the agricultural industry's problems. Will we become complacent in our fight for environmental conservation and protection in our attempt to fix an issue that has grown as a result of several man-made variables? As colony collapse disorder continues to decimate bee populations, farmers may find themselves with little choice but to rely on Robobees to meet our urgent needs in the not-too-distant future.

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