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27020 Interdisciplinary bioengineering

Investigation of artificial pollinators

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1 Introduction

"If the bees disappear from the surface of the Earth, man would have no more than four years to live" - Albert Einstein

Our world is facing plenty of problems related to climate change but one of the very significant ones is the continuous decrease in the number of species capable of pollinating plants, especially bees. The growth and development of plants is strongly dependent on the pollination process and one out of three of human meals is made possible purely by the existence of bees. The situation is very alarming, and since 1988 half of the bees' hives have disappeared in, what is called, the "colony-collapse disorder" [1]. As the world without bees is unlivable there is a need for new thinking.

Of course, the ideal solution would be to save the bees. Unfortunately, with the pace at which our climate is changing, this might not be possible on the long run. One of the alternative options is an introduction of artificial pollinators, robotic bees, into the ecosystems. They could undertake the tasks that natural bees cannot perform anymore. Small, flying robots carrying a little brush or covered in sticky substance could transport pollen from one plant to another, preventing humankind from mass starvation and an agricultural doomsday.

These robots could additionally monitor conditions of different environments and be used as members of research-rescue teams by entering small spaces that are inaccessible for people. But in this investigation our main focus is on the robots' ability to transport pollen.

We want to investigate how realistic the usage of artificial bees on a greater scale is. We will take under consideration environmental, economic and technological factors. We will analyse possible limitations and suggest ways to overcome them. By the end of this project we would like to have an answer to the question:

"Can we use artificial pollinators to help obtain food security and maintain biodiversity?"

We hypothesize that it is possible to introduce artificial bees to help solve the problem of declining pollinators - but at the beginning on a smaller scale in order to take the environmental repercussions needed and develop the technology.

2 Proposed solution

This topic was researched on the basis of scientific papers found on the internet mainly using search engine "Google Scholar" [2]. In those papers, when the topic of food production is broad up, many scientists mention that some of the already existing food sources are being endangered. On top of that, land that can be used for agricultural purposes, such as greenhouses, is decreasing over time and the available space is reaching its limits.

Digging more into this topic, plenty of research papers raise the awareness about the modern bee colonies extinction problem. This is a very popular discussion within its field, due to the importance of bees presence in the environment as well as the significant role they play in the humans' nutrition sources.

Knowing that the imbalance in the habitat of bees cause them to get nutritional stress, a small number of researchers have tried to solve the problem by using artificial intelligent technology. Beginning with a bee-sized drone and evolving the technology such that the drone is able to perform some of the actions of a bee, such as collecting pollen, making honey off nectar and so on, has slowly made its way to autonomous flying mechanical micro-robots.

Since the technology on an insect-scale is still not in a mass production, different ideas and approaches for achieving such product are still in the process of testing. The motivation of developing such technology often comes as a solution to the "colony-collapse disorder" namely by pollinating flowers, but the applications have taken a more wide range as the process got along.

Technologies of autonomous flying micro-robots are in process by for instance Wyss Institute at Harvard University who developed "RoboBees" and at Japan's National Institute of Advanced Industrial Science and Technology, where the development is on an earlier state.

Researchers at Wyss Institute have managed to achieve impressing results by using so called "artificial muscles" which is made up from material that contracts with the presence of voltage from an electric field [6]. Furthermore the approach to achieving autonomous micro aerial robots, that are capable of both self-contained and self-controlled flight, Wyss Institute has divided the development into 3 components: body, brain and colony. The body involves the production of a physical robot capable of using build-in power source in order to fly with the two wafer-thin wings. The brain regards all sensors and electronics needed for correctly working coordination in space. Lastly, the focus on colony involves unification of separate robots to achieve effective collective work. It means that despite the extreme constraints of the "RoboBees", they are able to navigate and function as a part of a larger collective and are therefore used for monitoring, rescuing and more.

At Japan's National Institute of Advanced Industrial Science and Technology the research began with an ionic liquid gel mainly made of water [8]. The gel is tested to be both bio-compatible and eco-friendly to be certain that it doesn't harm the nature. By applying the gel (together with horse hair) on top of an bee-sized four-propeller drone the sticky residue was shown to collect pollen from flowers. By adding an electric charge to the drone the grains of pollen are held more strongly when collected from the flowers. For this technology the part of collecting pollen is well developed, but the technology of the bee-sized drone is still remotely controlled by humans. To solve the remote-control problem the researchers are looking into incorporating a navigation system and cameras in further prototypes.

So though there is research ongoing towards the creation of autonomous robotic bees, there is plenty of issues to be resolved before we manage to obtain a highly desired functional artificial bee.

Furthermore, it is difficult to program micro drones in such way that they can live up to bees'

capabilities. Bees are able to work as one organism: they can communicate, share tasks between each other and find the best route to their destination. Replicating that kind of behaviour through programming is a challenging task and requires plenty of time as well as incorporation of machine learning and artificial intelligence, which can additionally increase the costs of robotic bees' development [7].

Another technological obstacle is the micro environment in which the robots need to work. Artificial bees should be ideally of the same size as the natural ones. This means that all the sensors, cameras and generally electronics have to be really small. It can be generally difficult to coordinate all elements on such a small scale but the greatest obstacle is making the bees autonomous. They cannot be fully powered by battery technologies that are now available as they would simply be too large and too heavy. The solution here could be the usage of solar cells, as the Wyss institute is suggesting, but then the robots are dependent on the presence of sunlight or any other wireless energy source. This part of the artificial bees' project definitely requires further technological development.

3 Impact

Considering the impacts of integrating artificial pollinators into the existing natural ecosystem, we need to reflect on our hypothesis both technically and ethically.

As mentioned earlier the trend of bees dying constitutes a huge threat to the worlds ecosystems namely the basis of human agriculture and food production. In order to make the bees more resistant as the specie is very sought-after, the addition of artificial bees in the present environment could contribute to an improvement in pollination, and thereby make the production of natural resources more sufficient and less wasteful. This also achieves the United Nations Sustainable Development Goal (referred to as SDG) number 2[3] regarding food security and sustainable agriculture. Additionally it also ensures the natural bees a more stable habitat of living and avoiding them to get stressed as a result of overworking.

Technically, if the bees go instinct, we need to find another solution for pollination. Based on the technologies discussed in our proposed solution, introducing artificial bees into certain ecosystems could be one of them - with the premise of further development in the lacking areas of the existing technologies. In order to make a fundamental difference for food security in the world, the artificial bees would need to be produced on a very large scale. But this solution could also impose a threat against SDG number 12 of responsible consumption and production patterns [4], due to the large amount of micro-robots needed for obtaining an actual global impact in food security. For implementation of the technology as a mass production the global focus on nature preservation should be taken under consideration. Therefore it should be considered whether other adjustments to the ecosystems would not be more sustainable than trying to complement bees with robots when taking the focus on conservation of nature into account.

Ethically, the addition of an artificial version of a natural organism to an ecosystem, like an artificial bee, would affect several different species, not just the bees themselves. Considering the interaction between natural bees and the robotic alternative, one could be afraid that the artificial bees would out-compete the natural ones or scare them. Also there is a risk that birds such as mockingbirds and thrushes, which are potential bee-eaters, would suffer from eating the non-organic materials of the artificial bees. The last obvious environmental problem is the waste product if all the micro-robots that are made of non-organic materials have to decompose in the nature.

In case the micro-robots have to be introduced as full scale replacement for natural bees and thereby taking over all of the work done by bees, it would contribute in maintaining the SDG number 15[5]. Their implementation could potentially make sure of a well functioning ecosystem and thus preventing other living organisms from extinction.

4 Discussion

Our proposed solution could be significantly effective but we need to incorporate some adjustments.

The limitations to the robotic bees' prototypes needs to be resolved. One of the largest issues with the development of the flying robots is making them simultaneously small and autonomous. The research needs to be focused on minimizing the size and the weight of all the components as well as on the development of new power sources.

Another obstacle is the impact of that kind of technology on the environment. Our ecosystems can be quite fragile and introducing a completely foreign, artificial element on a large scale could result in a tragic effect.

We cannot be completely certain about the outcomes of such robots implementation and therefore we need to be careful with our actions. At the same time, we need to somehow resolve the problem of disappearing bee colonies and our robotic ones could possibly do that. In order to strike the right balance, we could introduce the artificial bees' on a smaller scale.

Thus, to avoid compromising the sustainability of the artificial bees it could be considered to integrate them in an enclosed greenhouse environment instead of into the existing ecosystem of Earth. This allows to sustain or increase the food production without negatively effecting the present ecosystems. Whilst the production of the micro robots could be held on a smaller and more realistic scale. The controlled ecosystem using artificial bees would contribute to an increase in the efficiency of the overall pollination, but would not be transferred to a direct improvement in the pollination in the rest of the ecosystems in the world. Stating this the research of pollination by artificial bees could be improved such that it could eventually be introduced into the natural ecosystem if the crisis of colony-collapse disorder becomes too much of a problem for the organisms to solve itself.

5 Conclusion

In our investigation we mentioned the problem of decreasing population of bees and how it impacts everybody's life. We explained how life on Earth is almost impossible without bees and how some actions need to be undertaken. Our suggested solution was the implementation of artificial bees overtaking some of the natural bees' responsibilities. We have realised that simply mixing artificial and natural bees could be dangerous to the environment. Instead, we suggest to continue the development of artificial bees and usage of them primarily in closed spaces, such as greenhouses. This could increase the food production without endangering the environment.

References

[1] URL: https://www.youtube.com/watch?v=GqA42M4RtxE. (accessed: 22.11.2022).
[2] URL: https://scholar.google.com. (accessed: 21.11.2022).
[3] URL: https://sdgs.un.org/goals/goal2. (accessed: 22.11.2022).
[4] URL: https://sdgs.un.org/goals/goal12. (accessed: 22.11.2022).
[5] URL: https://sdgs.un.org/goals/goal15. (accessed: 22.11.2022).
[6] Wyss Institute at Hardvard University. *RoboBees: Autonomous Flying Microrobots*. URL: https://wyss.harvard.edu/technology/robobees-autonomous-flying-microrobots/. (accessed: 14.11.2022).
[7] Jacqueline Hicks. *Robotic Bees: The Next Best Thing?* URL: https://natoassociation.ca/robotic-bees-the-next-best-thing/. (accessed: 21.11.2022).
[8] Crystal Ponti. *Rise Of The Robot Bees: Tiny Drones Turned Into Artificial Pollinators*. URL: https://www.npr.org/sections/thesalt/2017/03/03/517785082/rise-of-the-robot-bees-tiny-drones-turned-into-artificial-pollinators. (accessed: 16.11.2022).