Analysis and Design of Drone-Based Pollination

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Background

Vertical Farming

- Vertical farming is an indoor way of growing plants and crops in a controlled environment by taking advantage of vertical space instead of horizontal space.[1]
- The plant industry is looking for solutions to produce more yields efficiently because decent land for agriculture can be expensive and hard to find. [1]
- Through innovative techniques in vertical farming, farmers can develop great quality yields by precisely controlling the temperature, the amount of light, and the amount of nutrients.[1]

Pollination

- Pollination (the transfer of the pollen grains from the male reproductive organ (anther) to the female reproductive organ (stigma)) is an essential part of the reproduction of the plant, which produces seeds, fruits, vegetables and oilseeds. [2]

The Issue

- Natural pollinators (insects, wind, and animals) are not easily available indoors.
- In vertical farms it is difficult to pollinate using bees and humans because bees have trouble navigating under artificial light and pollinating by hand is time consuming and expensive. [3]
- Farmers and gardeners are looking for a more dependable way to pollinate flowers at any time. [4]

Drone-Based Pollination

- Drones offer a promising alternative to traditional pollinators in vertical farming because they resemble bees, they are accessible, and they are relatively easy to adopt. [5]
- UAV (unmanned aerial vehicles) are drones that function on their own thanks to AI technology. By using micro drones that are precisely made and programmed for the pollination need at hand, farmers and gardeners can rely on technology to ensure the success of pollination. [5]

Motivation

- Addressing the need for better pollination in vertical (indoor) farming by researching drone-based technology and designing an attachment for drone-based pollination.
- Inspire others to continue researching this topic and keep exploring, innovating and trying to find better solutions to this growing issue.

Objectives

- Inform the reader on drone-based pollination by explaining the background of the issue and showing what others are doing in the field.
- Look at past research and create a design idea for the future of artificial pollination.
- Inspire further research in this field.

Existing Research

Aerial-Based Technologies

Pollination Method	Design	Pros	Cons
Using the wind created by the propellers to pollinate.[6]	 Figure 1 – flying drone over field [6]	• Many uses for the propellers • Minimal technology • Easily reach lots of flowers • No need to collect pollen before	• Can not precisely pollinate individual flowers
Using a gel like substance on animal hairs to mimic bees and their hairs that sticks to pollen[7]	 Figure 2 – close up of hairs on drone [7]	• Precise pollination through physical contact • No need to collect pollen before hand	• More time required to touch each flower • Need to obtain animal hairs in order to build
Letting go of pollen a little at a time from a containment of pollen[8]	 Figure 3 – drone and pollination system [8]	• Able to control amount of pollen coming out • Able to utilize the wind to disperse mass amounts of pollen to many plants	• Need to collect pollen before using • Wasteful towards pollen
Using a containment method that releases pollen that is then dispersed through the air[9]	 Figure 4 – drone in the air[9]  Figure 5 – guy holding the tank of pollen while pollen is spewing out [9]	• Able to control amount of pollen coming out • Able to utilize the wind to disperse mass amounts of pollen to many plants	• Need to collect pollen before using • Wasteful towards pollen
Using a rotating plate inside a cylinder that drops pollen when the holes align[10]	 Figure 6 – drone in indoor garden [10] Figure 7 – design of pollination attachement [10]	• Able to precisely pollinate flowers • Minimal waste of pollen	• Need to collect pollen before using • More time required to pollinate each flower
Spraying dissolved pollen onto the plants from above [11]	 Figure 8 – drone spewing pollen from the air onto plant [11]	• Able to pollinate a large area quickly	• Need to collect pollen before using • Need to dissolve the pollen • Wasted pollen during spraying due to its inaccuracy

Ground-Based Technologies

Pollination Method	Design	Pros	Cons
Using an arm attachment on a robotic base with wheels to pollinate Kiwifruit[12]	 Figure 9 – drawing outline of ground-based pollinator [12]	• Precise pollination method that can move around • Automatic • Lightweight	• Constraints for variety of plants able to be pollinated • Need to collect pollen before using
Autonomous ground-based robotic pollination system that uses an arm with an attachment to pollinate[13]	 Figure 10 – real life picture of ground-based pollinator [13]  Figure 11 – design of the pollination attachement [13]	• Precise pollination method that can move around • Autonomous	• More time spent on each flower • Constraints for variety of plants able to be pollinated
Using a self controlled robot in an indoor farming environment to pollinate flowers [14]	 Figure 12 - picture of ground-based pollinator[14]  Figure 13 – pollination attachement[14]	• Precise pollination method that can move around	• Time consuming process • Constraints for variety of plants able to be pollinated

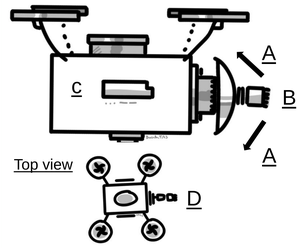
Methods

- Through the research of different types of technologies related to pollination in an indoor and outdoor environment, a design was able to be created that drew inspiration from previous innovations.
- Many research papers were found by using the University of Alberta's various databases and putting in words such as : aerial, flying, drone, robot, pollination, micro, small, mini, aircraft, agriculture, vertical, indoor, farming, greenhouse, technology, UAV, unmanned, independent, autonomous, and artificial.
- The information collected about artificial pollination methods was used to make a table showcasing diverse technologies in the field as well as their pros and cons.
- By using SolidWorks (a CAD (computer-aided design) software used for creating, simulating, drawing and managing 3D models in engineering and design work.) and digital art, a design of a system for artificial pollination was able to be created.

Results

This section shows the created concept idea for indoor artificial pollination.

Side view



Top view

Figure 14. concept drawings of design idea (illustrated by Danielle Too (2023))

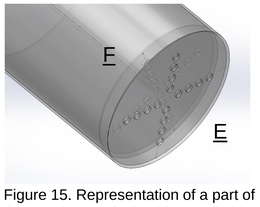


Figure 15. Representation of a part of the attachment design idea made in SolidWorks, two stacked cylinders that have holes at the bottom of both

(A) The attachment needs to be able to pollinate flowers found at diverse angles by doing a 180 rotation. The drone itself could also rotate to certain angles. The attachment and the drone work together to effectively reach the flowers.

(B) The addition of the hairs coated in a gel helps mimic other natural pollinators in the wild like bees. When the flowers that are facing downwards need to be pollinated, the hairs will have caught some of the pollen and will be able to pollinate through direct contact with the flowers when gravity is no longer a helpful tool in the pollination method showcased in Figure 15.

(C) The design allows room for a power supply and technology to make the pollination system independent and functional.

(D) The rotors are far enough away to not interfere with the plants and the pollination process.

(E) The rotation of the outer container allows for the pollen to be dropped periodically when the holes on the bottom align. The circular rotation also allows for the hairs to make circular motions on the flower whilst the pollen is being dropped.

(F) Having pollen in a tank ready to be spread eases the pollination process.

Conclusions

- The main points of the created design could be used in different ways or be a source of inspiration for others trying to accomplish drone-based pollination for vertical farming.
- With the development of more vertical farms, pollination will become a bigger issue that will want to be solved more efficiently.

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