

Development of an Automated Pesticide Sprayer Conceptual Design using Drone Technology for Agriculture

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ABSTRACT – Pesticide spraying mechanism with drone technology is a promising technique in agriculture. Manual pesticide spraying has several negative consequences on health, crop quality, and yield production. Drones can be adapted to automate pesticide spraying, despite the rare application of drones in crop spraying. Therefore, this paper aims to present the development of an agricultural drone with the concept screening and scoring approach. As a result, a functional prototype has successfully been fabricated.

1. INTRODUCTION

Drones, also widely recognized as unmanned aerial vehicles (UAVs), are commonly associated with military, industrial, and other specialized operations; however, with recent advances in sensor and information technology over the last two decades, the scope of drones has expanded to other areas such as agriculture. Agricultural practices are evolving due to drones sending agricultural intelligence to farmers and advisors. Drone applications in agriculture and precision farming consists of mid-season crop health monitoring, irrigation equipment monitoring, mid-field weed identification, variable rate fertility, and cattle herd monitoring [1]. Puri et al. [2] and Devi et al [3] reported a few pesticide spraying mechanism using UAV in different quadcopter. However, according to Tsourus et al.[4], an application of UAVs in precision agriculture that is more rarely met is crop spraying. The main spraying equipment used in conventional farming are the manual air-pressure and battery-powered knapsack sprayers.

Pesticides and fertilizers are essential components in controlling insects and crop development. According to Kurkute et al. [5], a survey conducted by WHO estimated that every year about 3 million workers are affected by pesticide poisoning, of which 18000 die. People who spray pesticides and fertilizers by hand can develop tumours, hypersensitivity, allergies, and other illnesses [6]. In Malaysia, most Malaysian farmers complain about the hot weather and pest management on the farm, and this difficulty prompts them to pause, affecting crop yield production and quality. Furthermore, manual pesticide spraying requires longer to accomplish, causing discomfort due to the heavy spraying device, which can lead to musculoskeletal disorders (MSDS). Integrating UAV with sprayer system results in the potential to provide a platform for

pest management and vector control [7]. Therefore, the study aims to develop an automated pesticide spraying mechanism using drone technology for agriculture.

2. MATERIALS AND METHODS

In this study, farmers' feedback was gathered and used to establish the product specifications. House of quality was adopted in translating the final specifications, and three conceptual designs were developed with the help of a morphological chart. Then, the most appropriate concept was chosen using the concept screening and scoring approach. Finally, the 3D design was created and used to fabricate the prototype.

3. RESULTS AND DISCUSSION

Figure 1 shows the morphological chart of this project, consisting of the tank, sprayer position, pattern of the fan, the main body, and the landing legs. Figures 2-4 illustrate the initial conceptual designs. Tables 1 and 2 represent concept screening and scoring matrices which shows that concept 1 was chosen after the concept selection phase. The quadcopter configuration gives the best thrust-to-weight ratio to balance the entire system, considering the mass of the battery in front and the mass of the liquid tank at the back. Figure 5 displays the 3D design, while Figure 6 exhibits the developed working prototype of the pesticide spraying system.





















Concept	Solution 1	Solution 2	Solution 3	Solution 4
Tank	 Cylinder tank	 Square tank	 Hemisphere tank	 Bulk square tank
Sprayer position	 Sprayer in front of tank.	 Sprayer in front of tank but pointing downward.	 Sprayer under tank.	 Sprayer under tank but pointing to the front
Fan's pattern	 4 direction fan	 4 direction fan	 4 direction fan	 6 direction fan
Drone's body	 Oval body	 Circle body	 Hexagon body	 Follow the fan direction shape
Landing leg	 Double leg with centre and lower support	 One leg each side with hard support under the leg	 Double close leg with hard support under it	 Double leg with centre support

Figure 1 Morphological chart

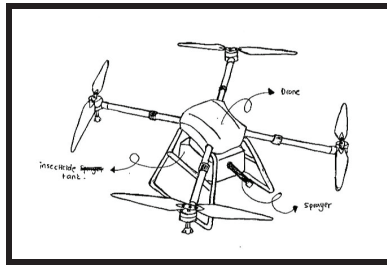


Figure 2 Concept 1 (2-1-2-3-1)

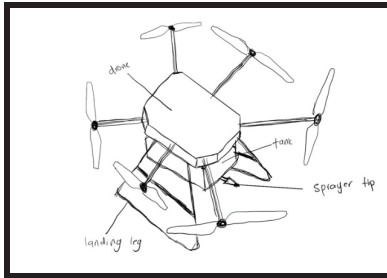


Figure 3 Concept 2 (2-4-4-3-1)

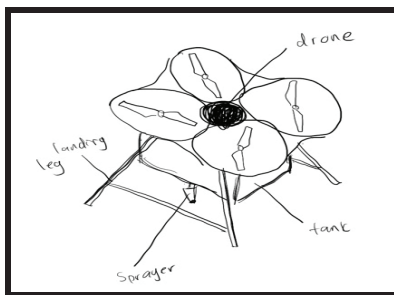


Figure 4 Concept 3 (2-3-3-2-4)

Table 1 Concept screening

Selection Criteria	Base Concept	Concept 1	Concept 2	Concept 3
Design	0	++	0	0
Eco-friendly	0	+	+	--
Aesthetic	0	0	0	-
Affordability	0	0	--	0
Dimension	0	+	+	+
Safety	0	++	+	+
Sum of +	0	6	3	2
Sum of 0	6	2	2	2
Sum of -	0	0	2	3
Net score	0	6	1	-1
Rank	3	1	2	4
Continue	No	Yes	Combine	No

Table 2 Concept scoring

Selection Criteria	Weight	Concept 1		Concept 2	
		Rate	Score	Rate	Score
Design	20	5	1	4	0.8
Eco-friendly	15	3	0.45	3	0.45
Aesthetic	20	5	1	4	0.8
Affordability	10	4	0.4	4	0.4
Dimension	15	4	0.6	3	0.45
Safety	20	3	0.6	3	0.6
Total	100%	4.05		3.50	
Rank		1		2	
Continue?		Yes		No	

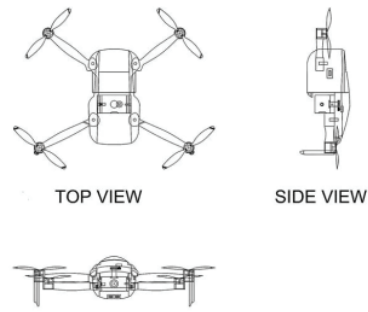


Figure 5 Final design



Figure 6 Working prototype

4. CONCLUSIONS

To conclude, the development of a pesticide spraying mechanism using drone technology was successfully conducted and presented in this study.

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