Anti-Predator Mechanisms of Animals and Design of Anti-Predator Drones

Savannah Bradley, Mostafa Hassanalian
Mechanical Engineering Department
New Mexico Tech

Abstract

Avian flight and animals' behaviors can be considered as very efficient mechanisms; thus bio-inspired designs offer potential benefits for drones. One of the interesting aspects of avian flight and animals' behaviors is how natural flyers, such as birds, or other animals, can be anti-predator. The considered anti-predator behaviors which are utilized by prey animals are, avoiding detection, warding off attack, safety in numbers, fighting back, and escaping. Inspiring from the mentioned behaviors, different anti-predator systems for different types of drones are proposed and for each defense behavior, a well-defined mechanism is implemented.

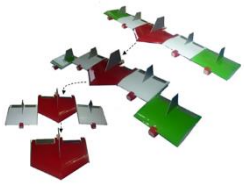
Introduction

Drones are changing the world's view of aviation. As such, there is an ever-growing need for different types of drones with various capabilities for both civilian and military applications[1]. Military surveillance and border patrolling are common missions for drones. In these settings, however, drones face many dangers including detection by radar, hacking, and tracing and attacking by predator rockets[2]. These risks delay or even stop the drone from completing the mission. Many organizations are looking for ways to mitigate these risks. For example, Amazon recently proposed a new idea to give their drones "anti-hacking" protection when completing deliveries[3]. In their design, they created a mesh network where multiple drones share information with each other. If there seems to be a discrepancy within the data, then it can be concluded that a drone on the team has been compromised[4].

Another way to protect drones is by adding stealth features. Stealth drones are more difficult for conventional radar systems to detect and/or track them efficiently[5]. Stealth features are commonly composed of passive low observable features and active emitters. The drone pilots also carefully select their mission plan in order to avoid known radar frequencies. Nowadays, stealth drones also apply skins which are made from radar-absorbent materials[6]. Furthermore, various methods have been used to attack drones including hacking, drone on drone contact, being shot out of the sky, lasers, microwaves, and birds attacking drones. Different companies and agencies have spent a lot of time developing techniques to mitigate these risks. While these are all fantastic methods, it is important to look back at our roots and see what nature has to offer.

Avian flight and animals' behavior can be considered as very efficient mechanisms when looking at predator avoidance. Due to this, bio-inspired designs offer benefits for drones. Many animals employ anti-predator tactics. Examples of these tactics include escaping, autotomy, camouflage, and playing dead. All these tactics can be used by drones. There are four stages predators must carry-out when attacking a drone: detection, tracking, targeting, and attacking. To create an efficient anti-predator drone, these stages must be avoided. Depending on the size and type of drone, there are different techniques that can be inspired from nature for predator avoidance. Nature can give us guidelines on how to create more efficient drones. By developing new systems and algorithms, drones would have the capability to avoid many different types of threats. An overview of proposed concepts can be viewed in the table below.

Table 1. Proposed concepts for anti-predator drones

Anti-predator mechanism	**Escaping**	**Autotomy**	**camouflage**	**Playing dead**
				
Inspired concepts for drones	Deep learning for maneuverable drones	Sacrificing drones (separation flight)	Drone with capability of changing colors	Apparent fall of drones
				

Summary and Conclusions

In conclusion, by examining the ways animals have evolved to keep themselves safe from harm, it is possible to develop drones which employ similar tactics. This is especially valuable to the military which uses drones for dangerous and sensitive missions. By keeping these drones safe, their tasks will be completed in a timely manner without compromising valuable information.

References

1. Hassanalian, M and Abdelkefi, A., "Classifications, applications, and design challenges of drones: a review", *Progress in Aerospace Sciences,* Vol. 91, pp. 99-131, 2017.
2. Wesson, K. and Humphreys, T., "Hacking drones". *Scientific American,* Vol. 309, No. 5, pp. 54-59, 2013.
3. URL: https://www.techradar.com/news/amazon-patent-outlines-anti-hacking-measures-to-protect-deliverydrones
4. Michel, A.H., "Amazon's Drone Patents", September 2017. www.dronecenter.bard.edu
5. Rao, G.A. and Mahulikar, S.P., "Integrated review of stealth technology and its role in airpower", *The Aeronautical Journal,* Vol. 106, No. 1066, pp. 629-642, 2002.
6. URL: https://www.nytimes.com/1997/08/23/world/the-2-billion-stealth-bomber-can-t-go-out-in-the-rain.html

SAVANNAH BRADLEY

Savannah Bradley is an undergraduate student in Mechanical Engineering Department at New Mexico Institute of Mining and Technology. Bradley works with Dr. Hassanalian in his lab and research team. Her research focus is aerodynamics, biomimetics, bioinspired aircrafts, aircraft optimization, and aircraft efficiency.

MOSTAFA HASSANALIAN

Dr. Hassanalian currently serves as an Assistant Professor of Mechanical Engineering at New Mexico Institute of Mining and Technology. Dr. Hassanalian runs the Autonomous Flight and Aquatic System Laboratory at New Mexico Institute of Mining and Technology. His research interests include biomimetics and bioinspired aerial and aquatic vehicles, design and optimization of aerial vehicles, and new concepts for planetary and space exploration.