Project Phase-1 Report

Dragonfly Inspired Drone Designed for Tranquilizer Delivery

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BONAFIDE CERTIFICATE

This is to certify that the report entitled **"ProjectTitle"** is a bonafide report of the seventh semester Project Phase-1 [ECD415] done by **MANUEL BENNY- AJC21EC056, NEETHU JAISAN- AJC21EC069, RIXON JOHN MATHEW- AJC21EC083, SHWETHA B PILLAI- AJC21EC090,** in partial fulfillment of requirements for the award of degree of Bachelor of Technology in Electronics and Communication Engineering from APJ Abdul Kalam Technological University, on November 2024.

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ABSTRACT

The Dragonfly-Inspired Drone project aims to develop a biomimetic drone designed specifically for wildlife tranquilization. Drawing inspiration from the unique flight mechanics of dragonflies, the drone is engineered to achieve high maneuverability, stability, and precision. This innovative approach addresses the limitations of traditional wildlife tranquilization methods, which often cause stress and risk to both animals and operators.

The primary focus of Phase 1 is a comprehensive literature review, exploring existing wildlife tranquilization technologies, the principles of biomimicry in drone design, and the mechanics of dragonfly flight. This foundation informs the design and development of a drone equipped with a precise tranquilizer delivery system, high-resolution navigation cameras, and robust control algorithms.

Future phases will involve the design, prototyping, and testing of the drone, with the goal of achieving safe, efficient, and humane tranquilization of wildlife. The project promises significant contributions to conservation efforts by enhancing the safety and efficacy of wildlife management practices.

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CHAPTER 1

Introduction

By utilizing the special flying abilities of dragonflies, the "Dragonfly-Inspired Drone for Tranquilizer Delivery" project offers a novel method of managing wildlife by developing a highly mobile and effective drone system. Traditional techniques of tranquilizing animals, especially big and potentially dangerous ones like elephants, can put human personnel at serious risk and give the animals a great deal of anguish. Particularly in rocky and densely forested areas where animals are hard to get, these approaches are frequently ineffective. In order to provide safe and efficient tranquilization from a distance, this project intends to create a remote-controlled drone that can effortlessly navigate difficult environments, drawing inspiration from the agility, accuracy, and stability of dragonflies.

The drone will include a sophisticated tranquilizer dart system that can provide precise dosages, decreasing the need for intimate human contact and the animals' stress. The drone will be able to manage unexpected circumstances and retain high precision in a variety of scenarios by integrating adaptive behaviors and real-time environmental mapping using LiDAR data. Numerous applications, such as tracking animal movements, doing health evaluations, and supporting conservation initiatives, will be supported by this adaptable instrument. In order to guarantee that the drone is commercially feasible, environmentally friendly, and advantageous to nearby communities, the project also places a strong emphasis on cost-effectiveness, environmental sustainability, and community involvement.

The goal of the project is to improve the safety, efficacy, and efficiency of wildlife management and conservation techniques by following legal requirements and encouraging best practices, which will ultimately help to safeguard and improve animal populations.

CHAPTER 2

Project Objectives

The goal of the project is to create a remote-controlled drone that reduces the hazards to human personnel during tranquilization procedures, thereby revolutionizing wildlife management. Drawing inspiration from the remarkable flying abilities of dragonflies, the drone is engineered to maneuver through intricate spaces with dexterity and accuracy, guaranteeing secure operation in thick forests and rough terrain. The idea aims to increase efficiency by giving the drone the ability to swiftly traverse broad regions and get to animals in hard-to-reach places. Through the use of a tranquilizer delivery system that reduces the animals' tension and discomfort, the drone lessens the need for intimate human contact, which in turn lowers the animals' stress levels.

With its precise tranquilizer dart mechanism, the drone will be able to provide precise dosages from a safe distance while adjusting to different situations and conditions. Versatility and adaptability are important goals, as the drone is made for a variety of uses, such as tracking animal movements, evaluating health, and aiding in conservation initiatives. By offering a tool that improves animal population management and protection, the initiative also seeks to advance wildlife conservation by enabling non-intrusive behavior and health studies and data collection. A top concern is cost-effectiveness, which guarantees that the drone's construction and upkeep are financially feasible for extended use. By employing eco-friendly materials and energy-efficient technology, the project also highlights environmental sustainability. Additionally, it fosters community participation by incorporating local communities in the drone's development and deployment. Finally, by following pertinent regulations and collaborating with regulatory organizations to develop best practices for the use of drones in animal conservation, the initiative guarantees regulatory compliance.

CHAPTER 3

Literature Review

A. **JaeHyung Jang, Kyunghwan Cho, and Gi-Hun Yang, *"Design and Experimental Study of Dragonfly-Inspired Flexible Blade"*, IEEE ROBOTICS AND AUTOMATION LETTERS, VOL. 4, NO. 4,OCTOBER 2019.**

   This paper investigates the design and experimental study of a dragonfly-inspired flexible blade for drones. The research demonstrates that the incorporation of flexible blades enhances safety during operation while maintaining performance levels comparable to traditional rigid blades. This innovative design approach aims to minimize the risk of injury and damage, making it suitable for various applications in aerial robotics.

B. **Victor Casas,Francisco Ramirez,William Stewart, *"Insect Inspired Self Righting for Fixed- Wing Drones"*, IEEE ROBOTICS AND AUTOMATION LETTERS, VOL. 6, NO. 4,OCTOBER 2021.**

   This paper explores the application of insect-inspired design in fixed-wing drones, focusing on the use of the elytron, a rigid forewing structure. The study demonstrates how the elytron provides additional lift during flight, helping to mitigate the structural weight of the drone. This design innovation enhances aerodynamic efficiency and stability, contributing to improved performance in various flight conditions.

C. **Yupan Zhang, Yiliu Tan,Yuichi Onda, Asahi Hashimoto,Takashi Gomi,Chenwei Chiu,Shodai Inokoshi., "*A tree detection method based on trunk point cloud section in dense plantation forest using drone LiDARdata*".,Forest Ecosystems -10**

   The paper introduces a novel approach for tree detection in dense plantation forests by focusing on the under-canopy structure. This innovative method leverages drone LiDAR data to analyze trunk point clouds, specifically targeting the sections of the trunks that lie between 1 to 7 meters in height. By splitting the under-canopy sections into these height ranges, the method processes these sections to determine a suitable height threshold for accurate tree detection.

D. **Robert Gorkin I, Kye Adams Matthew J Berryman, *"Sharkeye: Real-Time Autonomous Personal Shark Alerting via Aerial Surveillance"*, MDPI, journal , 2020.**

   This paper introduces "Sharkeye," a system designed for real-time autonomous aerial surveillance to alert users about the presence of sharks. The study focuses on shark spotting techniques that provide critical information to prevent unwanted encounters with wildlife, enhancing safety for beachgoers and water sports enthusiasts. By utilizing aerial surveillance, the system aims

to improve monitoring and awareness of shark activity in coastal areas, contributing to better wildlife management and public safety.

E. **Paulo Henrique Maia, Lucas Vieira, Matheus Chagas, Yijun Yu, Andrea Zisman, *"Dragonfly: a Tool for Simulating Self-Adaptive Drone Behaviours"*,IEEE/ACM 14th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS), 2019.**

This paper presents "Dragonfly," a tool designed for simulating self-adaptive drone behaviors using aspect-oriented programming. The study evaluates the behavior of drones under both normal and exceptional situations, highlighting the importance of adaptability in dynamic environments. By providing insights into self-managing systems, the research aims to enhance the resilience and reliability of drone operations in various operational contexts.

F. **Bo-sun Kim, Silvirianti, Soo Young Shin, *"Bio-inspired Evasive Movement of UAVs based on Dragonfly Algorithm in Military Environment"*, J. Inf. Commun. Converg. Eng. 17(1): 84-90, Mar. 2019.**

This paper explores bio-inspired evasive movement of UAVs based on the dragonfly algorithm in military environments. By mimicking the irregular movement patterns of dragonflies, the study aims to enhance the unpredictability of UAV positions. This approach improves evasive maneuvers, making it more challenging for adversaries to anticipate UAV trajectories and increases the effectiveness of military operations.

G. **Naga Praveen babu,Prashanth Kumar Babu, *"Development of Semi-autonomous Dragonfly based UAV in Free Flight Conditions"*, International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON),2021.**

This paper discusses the development of a semi-autonomous dragonfly-based UAV designed for free flight conditions. The research highlights the use of a bioinspired quad-wing design, which significantly reduces the power required to flap the wings. This innovative approach aims to enhance the efficiency and performance of UAVs while mimicking the flight characteristics of dragonflies, leading to improved maneuverability and energy conservation in aerial operations.

H. **Shahzad Hameed, Qurratul-Ain Minhas, Sheeraz Ahmad, *"Connectivity of Drones in FANETs Using Biologically Inspired Dragonfly Algorithm (DA) through Machine Learning"*, Hindawi Wireless Communications and Mobile Computing Volume 2022.**

This paper addresses the connectivity of drones in Flying Ad-Hoc Networks (FANETs) using a biologically inspired Dragonfly Algorithm (DA) integrated with machine learning techniques. The study demonstrates that the application of the Dragonfly Algorithm significantly improves connectivity within FANETs by optimizing communication paths and enhancing network reliability. This approach leverages the natural behaviors of dragonflies to

inform algorithms that can adaptively manage drone networks in dynamic environments.

I. **Dinh Quang Nguyen; Giuseppe Loianno; Van Anh Ho, *"Towards Design of a Deformable Propeller for Drone Safety"*, 3rd IEEE International Conference on Soft Robotics (RoboSoft),2020.**

This paper discusses the design of a deformable propeller aimed at enhancing drone safety. The research indicates that deformable propellers can reduce the risk of injury and damage compared to traditional rigid propellers by allowing for controlled flexing upon impact. This innovative design seeks to improve overall safety in drone operations while maintaining effective propulsion performance, making it a promising advancement in aerial robotics technology.

J. **Farooq Aftab, Ali Khan, and Zhongshan Zhang, *"Bio-inspired clustering scheme for Internet of Drones application in industrial wireless sensor network"*, Sage Journals, November 22, 2019.**

This paper presents a bio-inspired clustering scheme for Internet of Drones applications within industrial wireless sensor networks. The study highlights how this approach improves network energy consumption and increases the probability of successful data delivery. By leveraging bio-inspired techniques, the research aims to enhance the efficiency and reliability of drone networks in industrial settings, facilitating better communication and operational effectiveness.

K. **Yuliu,Kaixiao Nie, Yaohui Liu , *"Boundary-Aware Supervoxel Segmentation for Indoor 3D Point Clouds"*, IEEE Access July 10 2023 .**

By concentrating on maintaining structural bounds, the paper offers a novel approach to 3D point cloud segmentation in interior settings. Conventional supervoxel segmentation techniques frequently suffer from noise and outliers, which results in imprecise border preservation.With this method, the sampling is guaranteed to be precise and representative of the same structure. To achieve the best segmentation results, the method uses an energy descent strategy for iterative refinement and grouping.

L. **Javaan Chahl , Nasim Chitsaz Timothy McIntyre, Blake McIvor andErmiraAbdullah4 , Titilayo Ogunwa, Jia-Ming Kok, *"Biomimetic Drones Inspired by Dragonflies Will Require a Systems Based Approach and Insights from Biology"*, MDPI article, 2021**

This paper discusses the development of biomimetic drones inspired by dragonflies, emphasizing the need for a systems-based approach and insights from biology. The study focuses on flapping-wing drones modeled after large insects to perform mixed missions effectively. By mimicking the flight mechanics of dragonflies, these drones aim to achieve enhanced maneuverability, stability, and efficiency in diverse operational scenarios.

M. Nithidol Buranapim Pawinee Kulnanan Kullapassorn Chingpathomkul, *"Dexmedetomidine Effectively Sedates Asian Elephants"*, MDPI article, 2022.

This study investigated the sedative effects of dexmedetomidine in Asian elephants, focusing on its efficacy and safety through medical observation and animal experimentation. The findings demonstrate that dexmedetomidine effectively induces sedation in these large mammals, providing a reliable option for veterinary procedures. The research highlights the potential for improved animal handling and care during medical interventions.

N. Shiqin Jiao, Guiyang Zhang, MEI Zhuou, Guoqi, *"A Comprehensive Review of Research hotspots on battery management systems for UAVs"*, IEEE Access, July 2023.

This paper provides a comprehensive review of research hotspots on battery management systems (BMS) for UAVs, covering various aspects such as energy efficiency, safety, and longevity. It highlights the latest advancements in BMS technology and identifies challenges in current systems. The study also proposes potential future trends and areas for further research, emphasizing the importance of developing more robust and efficient BMS solutions to enhance UAV performance.

O. N.González,M. Solera, F. Ruiz, C. Gijón, M. Toril T, *"A quality of experience model for live video in first-person-view drone control in cellular networks"*, Elsevier article ,2023.

This paper presents a study on FPV drone control in BVLOS scenarios, focusing on the integration and evaluation of UAVs using LTE and WiFi networks. It tests three connectivity schemes and characterizes telemetry, control, and video traffic for FPV services, proposing a methodology to estimate QoE based on image quality and video latency. The results highlight the potential of this QoE model to enhance the reliability and user experience of UAV applications in cellular networks.

P. Abhishek Gupta , Xavier Fernando, *"Simultaneous Localization and Mapping (SLAM) and Data Fusion in Unmanned Aerial Vehicles: Recent Advances and Challenge"*, MDPI 2022.

This paper explores recent advances and challenges in Simultaneous Localization and Mapping (SLAM) and data fusion techniques for unmanned aerial vehicles (UAVs). The study emphasizes the importance of SLAM for achieving precise navigation and targeting capabilities in complex environments. By integrating various sensors and data sources, the research aims to enhance the accuracy and reliability of UAV operations, addressing key challenges in real-time mapping and localization.

Q. XUKAI MU,WEI GAO, XIAOLEI LI,AND GUANGLIANG LI , *"Coverage Path Planning for UAV Based on Improved Back-and-Forth Mode"*,IEEE Access,October 23.

This paper presents an improved back-and-forth (IBF) algorithm for coverage path planning in unmanned aerial vehicles (UAVs). The study focuses on optimizing the drone's flight path to enhance operational efficiency by reducing both flight time and energy consumption. By implementing the IBF algorithm, the research aims to improve the effectiveness of UAV missions in tasks such as surveillance and mapping, leading to more sustainable drone operations.

R. Luis F. Gonzalez , Glen A. Montes ,Eduard Puig ,Sandra Johnson ,Kerrie Mengersen and Kevin J. Gaston, *"Unmanned Aerial Vehicles (UAVs) and Artificial Intelligence Revolutionizing Wildlife Monitoring and Conservation"*, MDPI ,14 January ,2016.

This paper discusses how unmanned aerial vehicles (UAVs) and artificial intelligence (AI) are revolutionizing wildlife monitoring and conservation efforts. It highlights the use of UAVs to collect aerial wildlife data, while AI techniques are applied to automate the detection, classification, and analysis of this data. The integration of UAVs and AI provides a groundbreaking and efficient solution for enhancing wildlife conservation efforts, enabling more effective monitoring and management of animal populations and habitats.

S. Jan C, van Gemert ,Camiel R. Verschoor ,Pascal Mettes ,Kitso Epema ,Lian Pin Koh ,Serge Wich, *"Nature Conservation Drones for Automatic Localization and Counting of Animals"*, Springer Journal January 1 ,2016.

This paper explores the use of drones and machine learning for the automatic detection, localization, and counting of animals in conservation efforts. The study demonstrates how these technologies can enhance wildlife monitoring by providing a highly efficient and non-invasive approach to data collection. By integrating drones with AI capabilities, the research aims to revolutionize wildlife conservation practices, improving the accuracy and effectiveness of population assessments and habitat management.

T. Shahzad Hameed ,Qurratul-Ain Minhas,SheerazAhmad,FaseeUllah Atif Khan ,M.Irfan Uddin ,andQiaozhi Hua , *"Connectivity of Drones in FANETs Using Biologically Inspired Dragonfly Algorithm (DA) through Machine Learning"*, Wiley, 28 January 2022.

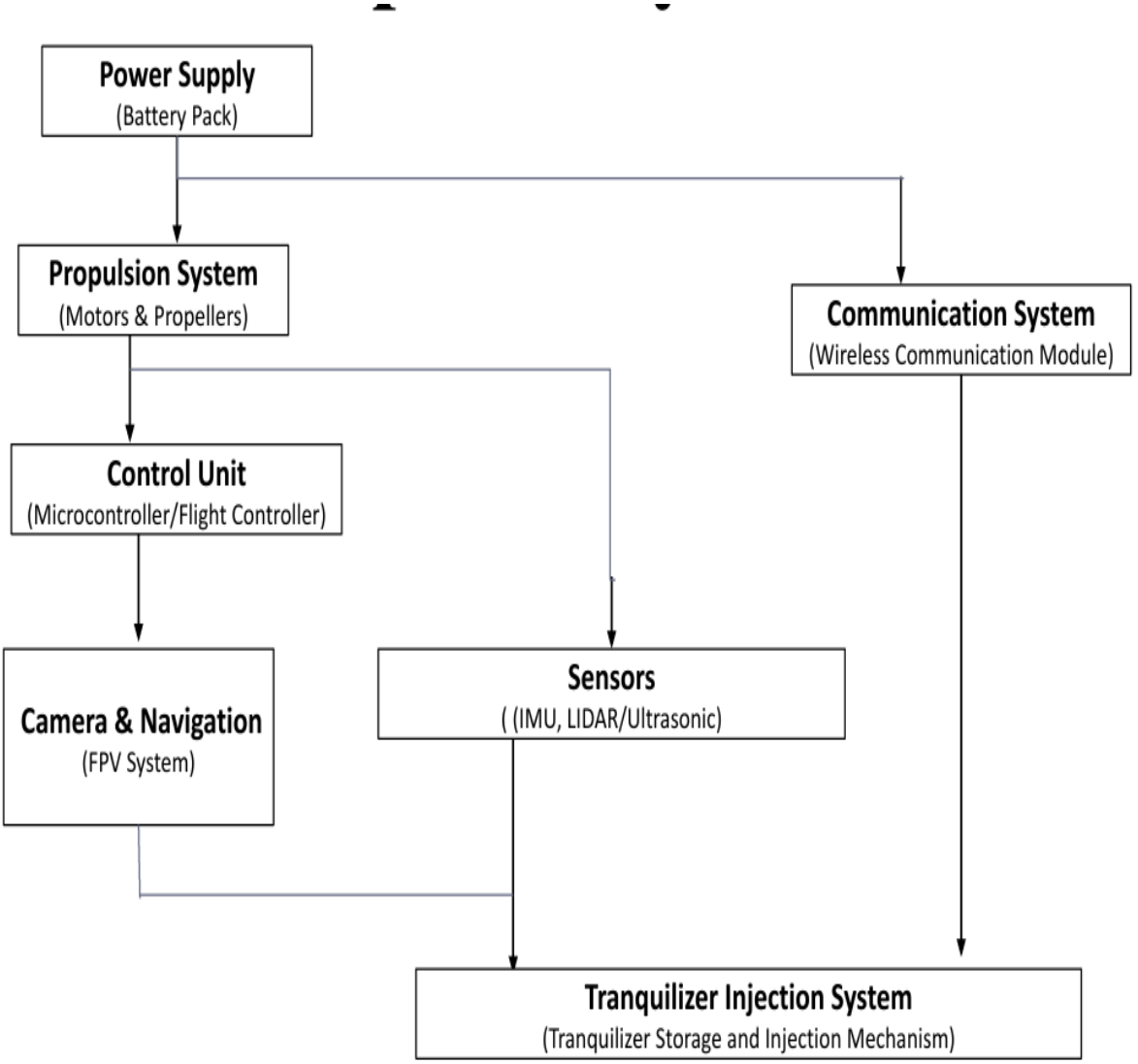
This paper investigates the use of the Dragonfly Algorithm combined with machine learning to optimize drone connectivity and network performance in Flying Ad-Hoc Networks (FANETs). The research demonstrates that this innovative approach significantly enhances connectivity and overall efficiency within FANETs, addressing common challenges in network communication and coordination among drones. By leveraging biologically inspired algorithms, the study contributes to the advancement of more reliable and effective drone network systems.

CHAPTER 4

System Design

Designing a miniaturized dragonfly drone, inspired by the physical structure and flight dynamics of a dragonfly, is a fascinating and challenging task. This system would require a multidisciplinary approach, combining aspects of aerodynamics, materials science, microelectronics, and control engineering.

4.1 Block Diagram



1.Power Supply: Provides the necessary electrical power to all components of the drone.

2.Control Unit: Acts as the brain of the drone, coordinating its movements, responses, and operations.

3.Propulsion System: Enables the drone to achieve flight and maneuver in the air.

4.Camera and Navigation: Provides visual feedback and assists in navigation.

5.Communication System: Enables remote communication between the drone and the operator or base station,

6.Sensors: Gather data on orientation, distance, and surroundings to ensure safe and stable flight.

7.Tranquilizer Injection System: Stores and delivers the tranquilizer dose to the target animal.

CHAPTER 5

Expected Outcome and Future Scope

This project envisions the development of a highly maneuverable, dragonfly-inspired drone capable of safely and efficiently tranquilizing wildlife. By leveraging biomimicry, the drone aims to overcome the limitations of traditional methods, enhancing both accuracy and animal welfare.

9.1. Expected Outcome

The Dragonfly-Inspired Drone is expected to revolutionize wildlife tranquilization by providing a safe, efficient, and minimally invasive solution. The drone will offer enhanced precision in tranquilizer delivery, reducing stress and potential injury to animals. By leveraging biomimetic design, the drone will achieve superior stability and maneuverability, allowing operators to navigate challenging terrains and environments effectively. Successful implementation will demonstrate the viability of using advanced drone technology in wildlife management, offering a significant improvement over.

9.2. Future Scope

The future scope of the project includes expanding the drone's application beyond tranquilization to broader wildlife monitoring and conservation efforts. Potential enhancements involve integrating advanced sensors for health monitoring, tracking endangered species, and supporting habitat studies. Additionally, the technology could be adapted for other fields such as search and rescue operations, agricultural monitoring, and environmental research. Collaboration with conservation organizations and government agencies will further extend the impact of this innovation on global wildlife management practices.

CHAPTER 6

Conclusion

This project has effectively illustrated how biomimicry can be used to improve wildlife management techniques. The team has created a highly efficient and agile drone system that can navigate challenging areas like dense forests and rough terrains by taking inspiration from the remarkable flying abilities of dragonflies. The remote-controlled drone makes it possible to deliver tranquilizers precisely from a safe distance, minimizing hazards to human staff and reducing stress on animals. Adaptive behaviors, real-time environmental mapping utilizing LiDAR data, and sophisticated stabilizing technologies are integrated to guarantee the drone's precision and dependability in a variety of situations.

The initiative is made more viable and impactful by its focus on community involvement, environmental sustainability, and cost-effectiveness. By offering a flexible instrument for tracking animal movements, performing health evaluations, and aiding conservation initiatives, the project makes a substantial contribution to the preservation and welfare of animal populations. All things considered, the endeavor is a major step forward for wildlife management, providing a more secure, effective, and compassionate method of tranquilizing animals.