GESTURE DRIVEN UNMANNED VEHICLE

A Project report submitted in partial fulfilment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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DECLARATION

I/We declare that the project phase-1 work contained in this report is original and it has been done by me under the guidance of my project guide.

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This is to certify that SANDHYA KURAM, KUMPATI RAKESH, NUNNAKARTHIKEYAN bearing RegNo:BU21EECE0100165,BU21EECE0100506,BU21EECE0100478has satisfactorily completed project phase 1 Entitled in partial fulfilment of the requirements as prescribed by the university for the VIII semester, Bachelor of Technology in “Electronics and Communication Engineering” and submitted this report during the academic year 2024-2025.

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INTRODUCTION

1.1 Overview of the problem statement

Controlling unmanned vehicles (UVs) in dynamic environments requires a more intuitive and efficient method than conventional controls like remotes or voice commands. This project aims to develop a machine learning-based system that enables UVs to recognize and respond to human hand gestures in real time. The system must accurately detect and interpret various hand gestures under challenging conditions, such as different lighting, backgrounds, and user characteristics, while maintaining high accuracy, low latency, and robustness, and running efficiently on the vehicle's onboard computational resources.

1.2 Objectives and Goals

The objectives of this project are to develop a machine learning-based gesture recognition system for controlling an unmanned vehicle (UV) with high accuracy and low latency, ensuring real-time, intuitive user interaction. The system aims to achieve a recognition accuracy of at least 95% across diverse conditions, such as varying lighting and different hand shapes, while remaining robust against noise and environmental challenges. It should be optimized for efficient use of the UV's limited computational and battery resources and integrate seamlessly with the vehicle's control unit for reliable command execution. The goals include maintaining a response time under 100 milliseconds, ensuring broad usability, promoting energy efficiency, and guaranteeing safety and reliability through comprehensive validation and testing in real-world environments.

LITERATURE REVIEW

1)Title of the paper: “Hand Gesture Recognition for Drone Control”

Author: Mehrdad Ghaziasgar, James Connan, Reg Dodds

Year: 2017

Summary: This paper presented a system that uses a gesture basedinterface to control a UAV drone. Specifically, the system uses input from a web cam to automatically find, track and isolate the user’s hand, followed by recognising the user’s hand shape.Depending on the hand shape, a specific flight command is issued to the drone. The proposed system was shown to be able to effectively recognise eight hand shapes. It was also shown to be very robust to variations in test subjects.

2)Title of the paper: “Hand Gesture Controlled Drones: An Open Source Library”

Author: Kathiravan Natarajan, Truong-Huy D. Nguyen, Mutlu Mete

Year: 2018

Summary: This study aims to develop a hand gesture-based control mechanism for drones that achieves high accuracy even with mediocre models lacking high-resolution cameras. The proposed framework, tested on the Parrot AR.Drone 2.0 using a dataset of 8,302 images and a cascaded AdaBoost algorithm with Haar features, demonstrated an average accuracy of 0.90 for gestures performed within 3 feet, regardless of lighting or background conditions. The results indicate that accuracy improves with closer proximity, better lighting, and a clear background, and could be further enhanced using higher-resolution cameras. Future work will involve analyzing the framework's effectiveness in various environments and with different hand poses.

3)Title of the paper: " Real-Time Human Detection and GestureRecognition for On-Board UAV Rescue"

Author: Chang Liu and Tamás Szirányi

Year: 2021

Summary: This paper proposes a real-time human detection and gesture recognition system for UAV rescue operations, which detects, tracks, and counts people while recognizing ten predefined rescue gestures, including two key dynamic gestures, "Attention" and "Cancel," for initiating or terminating communication. Utilizing the YOLO3-tiny for human detection and a deep neural network for gesture recognition, the system achieves high accuracy (99.80% on testing data) and adapts its resolution to improve recognition as the drone approaches the user. Despite successful laboratory results, challenges remain in real-world applications due to weather conditions, resolution limits, and UAV positioning. Future work will focus on expanding gesture datasets, outdoor testing with advanced GPUs, and exploring gesture-based communication without predetermined vocabularies.

4)Title of the paper: " Hand Gestures For Drone Control Using Deep Learning"

Author: Soubhi Hadri

Year: 2018

Summary: The system comprises three modules: a hand detector, gesture recognizer, and drone controller. A deep learning-based Single Shot MultiBox Detect (SSD) network is employed to detect hands, while gesture recognition uses image processing, allowing new gestures to be easily added without retraining. The drone controller uses Ardupilot for seamless communication among modules, tested with the Ardupilot SITL and Gazebo simulators. The system, compatible with any MAVLink-supported drone, offers a robust, efficient solution for drone control via hand gestures without requiring specialized hardware.

5)Title of the paper: "UAV manipulation by hand gesture recognition"

Author: Shoichiro Togo And Hiroyuki Ukida

Year: 2022

Summary: This paper compares two methods for UAV control using human gestures: the FB method, which uses color information and Fourier-transformed data for gesture recognition, and the ML method, which employs skeletal data from Open Pose and an LSTM framework. The FB method shows higher accuracy under specific conditions, but its performance drops in unpredictable environments. Conversely, the ML method is more robust across various settings and better suited for recognizing a broader range of gestures, though it may have some accuracy issues with wrist positioning. Overall, the ML method offers greater flexibility and adaptability for diverse applications.

Chapter 3: Strategic Analysis and Problem Definition

3.1 SWOT Analysis:

- A SWOT analysis highlights the project's strengths, weaknesses, opportunities, and threats:

Strengths:

- Innovative and user-friendly control interface using hand gestures.
- Real-time gesture recognition enhances user experience and operational efficiency.
- Applicable in diverse environments such as hazardous zones or public spaces.

Weaknesses:

- Privacy concerns related to hand gesture recognition and data collection.
- The system may face competition from existing joystick or voice-controlled systems

Opportunities:

- The project has the potential to revolutionize industries like healthcare (assistive robots) and security (surveillance drones).

Threats:

- Privacy concerns and possible misuse in public spaces could slow down adoption.
- Competing technologies may develop faster or more effective control systems

3.2 Project Plan - Gantt Chart

The project timeline is divided into two main phases:

- **Current Semester**: Focus on learning machine learning algorithms and testing them on hand gesture data.
- **Next Semester**: Develop a functional prototype that integrates hardware (vehicle control) with gesture recognition, ensuring that commands are accurately translated into vehicle movements.

3.3 Refinement of Problem Statement:

The refined problem statement for the project is:

"To create a gesture-controlled unmanned vehicle system that improves user experience, safety, and operational efficiency, particularly in environments where traditional control methods are not viable."

Chapter 4: Methodology

4.1 Description of the Approach

1. The system is designed to detect hand gestures using sensors like accelerometers and gyroscopes.
2. Machine learning algorithms process the data to classify and interpret the gestures.The key machine learning techniques used are:

- KNN (K-Nearest Neighbors): Classifies gestures based on their similarity to a set of labeled training data.
- SVM (Support Vector Machine): A classifier that creates a decision boundary between different classes of gestures.
- CNN (Convolutional Neural Networks): Used for image-based gesture recognition, detecting spatial patterns in gesture images or video frames.

4.2 Tools and Techniques Utilized

- Python: The primary programming language used for implementing the algorithms.
- Sensors: Accelerometers and gyroscopes are employed to capture hand motion data.
- Machine Learning Models: The models, including KNN, SVM, and CNN, are trained to classify gestures and convert them into vehicle control commands

4.3 Design Considerations:

Design considerations include the system's ability to handle real-time data and the scalability of the solution to different vehicle types. Another factor is the need for the system to maintain high accuracy while minimizing delays in response time, particularly in critical applications like search and rescue.

Chapter 5: Implementation

5.1 Description of How the Project was Executed

The project was executed through iterative testing and development of machine learning models. Gesture data was collected and processed using Python. The KNN, SVM, and CNN models were trained on this data to recognize specific gestures accurately. The team worked collaboratively, with each member responsible for a different aspect of the project. Weekly evaluations helped fine-tune the models for better performance.

- Kumpati Rakesh handled the coding and algorithm implementation in Python.
- Nunna Karthikeyan focused on gathering relevant datasets and assisting with model training.
- Sandhya Kuram conducted extensive research on machine learning algorithms and publications to inform the project.

5.2 Challenges Faced and Solutions Implemented

- **Challenge 1**: Achieving real-time gesture recognition with minimal delay.
- **Solution**: Optimized the models and reduced the complexity of data preprocessing to improve speed.
- **Challenge 2**: Ensuring high accuracy in gesture classification across diverse environmental conditions.
- **Solution:** Increased the dataset size and diversity during training, which improved model robustness and generalization.
- **Challenge 3**: Integrating obstacle detection with gesture control.
- **Solution:** Implemented additional sensors and algorithms for detecting and avoiding obstacles while responding to gestures.

6.1 Outcomes

The system successfully demonstrated the potential to control unmanned vehicles through hand gestures. The machine learning models provided accurate and timely gesture recognition, allowing for seamless vehicle operation. The project achieved its primary goal of creating an intuitive, hands-free control interface.

6.2 Interpretation of Results

The project results indicate that hand gestures can be used effectively to control unmanned vehicles, particularly in applications where fast, hands-free control is needed. The models implemented (CNN, SVM, and KNN) showed a high degree of accuracy in recognizing gestures, making them a viable alternative to traditional control mechanisms.

6.3 Comparison with Existing Literature or Technologies

Compared to traditional control methods like joysticks or voice commands, gesture-based systems offer a more natural, intuitive form of interaction. This is especially useful in scenarios where operators need to focus on the environment, such as disaster recovery, where time and attention are crucial.

Chapter 7: Conclusion

The project demonstrates that hand gesture recognition is a practical and efficient method for controlling unmanned vehicles. The use of machine learning techniques such as CNNs, SVMs, and KNNs enables accurate and responsive gesture interpretation, enhancing the vehicles' operational effectiveness. This system holds potential for numerous applications, particularly in dynamic and hazardous environments where traditional control methods may not be practical.

Chapter 8: Future Work

There are several areas for future development:

- Algorithm Improvement: Further optimization of machine learning models to improve the accuracy and speed of gesture recognition.
- Hardware Integration: Implementing communication between the hardware and software systems, including selecting a vehicle that can respond to gesture-based controls.
- Additional Gestures: Expanding the system to recognize a wider range of gestures, making it more versatile for different applications.

Chapter 9: References

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