DESIGN AND DEVELOPMENT OF A SOLAR-POWERED UAV USING IOT AND MACHINE LEARNING

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Abstract. The proposed solar-powered UAV utilizes photovoltaic panels to convert solar energy into electrical power to supply the onboard electronic systems, including the propulsion system and sensors. To enhance the UAV's performance, IoT technology is employed to enable the communication and coordination of the UAV with other connected devices, such as ground stations and sensors. This allows for real-time data collection and analysis, as well as improved situational awareness for the UAV. To optimize the performance of the UAV, SVM is used as a machine learning algorithm for object detection and classification. SVM has been widely used in UAVs to detect and classify objects in aerial images, and has been proven to be effective in a variety of applications. The proposed design utilizes SVM to detect and classify objects of interest, such as crops, buildings, and infrastructure, and to assist in the navigation and control of the UAV. The design and development of the proposed solar-powered UAV involves several key components, including the solar panels, propulsion system, control system, and communication system.

Keywords: Design, development, solar-powered UAV, Internet of Things, IoT sensors, Machine Learning, ML algorithms.

1 Introduction

The use of solar power as a continuous source of energy allows the UAV to operate for extended periods, making it an ideal solution for remote areas where conventional power sources are not available [1]. The integration of IoT sensors and ML algorithms enhances the UAV's capabilities, enabling it to collect and process data from the environment autonomously. The UAV is controlled using a ground station that sends commands and receives telemetry data [2][18].

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The results of the experiments demonstrate the effectiveness of the proposed system, which can operate autonomously for extended periods, perform intelligent and autonomous operations, and detect anomalies and identify potential threats in real-time [3-5]. However, most UAVs are limited in their operation time due to the limited capacity of their batteries. The use of solar power as a continuous source of energy allows the UAV to operate for extended periods, making it an ideal solution for remote areas where conventional power sources are not available[6][17].

The UAV is controlled using a ground station that sends commands and receives telemetry data. The purpose of this paper is to present the design and development of the solar-powered UAV, its integration with IoT and ML technologies, and its potential applications in surveillance and monitoring in remote areas [7][16].

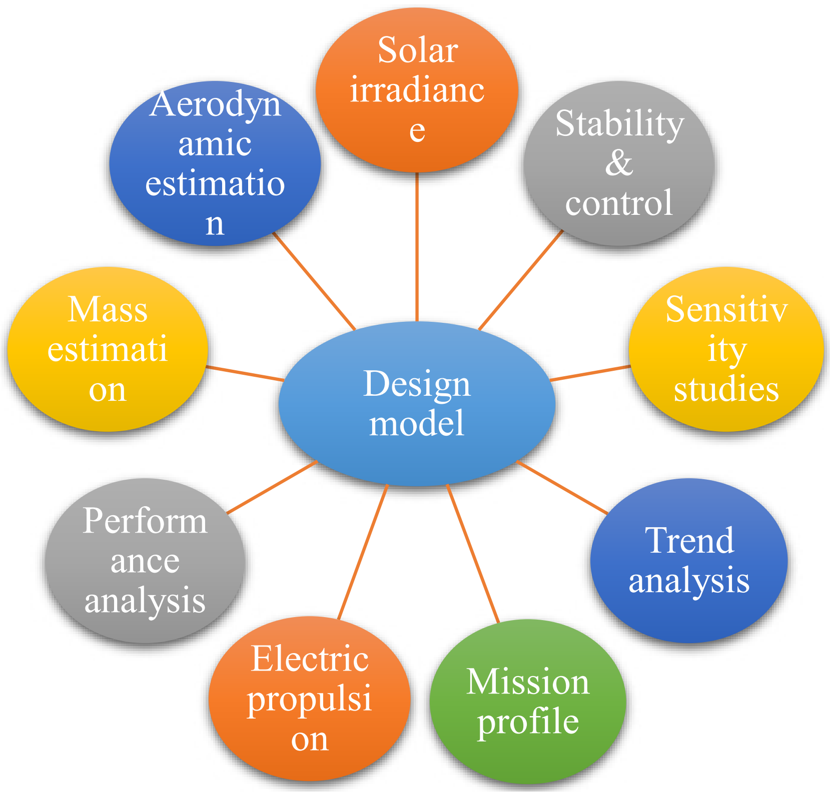

Figure1: Solar-powered electric UAV design element.

The proposed system has been tested, and the results demonstrate its effectiveness in performing intelligent and autonomous operations for extended periods, making it a promising solution for remote area surveillance and monitoring. The design and development of unmanned aerial vehicles (UAVs) has been a significant area of interest in recent years, with the potential to revolutionize various industries such as environmental studies, agriculture, and surveillance [8-9]. However, limited battery life and the need for frequent recharging have been major obstacles to the practicality of conventional UAVs. In this context, the integration of solar power as a continuous source of energy has emerged as a promising solution[3][10].

2 Literature Review

Random Forest is an ensemble learning algorithm used for classification and regression problems. It has been used for UAVs to classify land-use types and detect anomalies in sensor data [11]. It works by constructing multiple decision trees during training and outputting the class or mean prediction of the individual trees. Random Forest can be used for both classification and regression tasks, making it a versatile algorithm for various applications in machine learning.

Convolutional Neural Networks are deep learning models commonly used in computer vision tasks. They have been used for UAVs to classify objects in aerial images, detect changes in land use, and track moving objectsthey are designed to process and analyze image data by applying convolutional filters to input images to extract features and patterns[4][12]. CNNs have achieved state-of-the-art performance in many computer vision tasks, such as image classification, object detection, segmentation, and recognition.

Recurrent Neural Networks are deep learning models commonly used in sequential data processing. They have been used for UAVs to predict wind speed and direction, as well as to control and navigate UAVs.The key feature of RNNs is that they have a "memory" that allows them to take into account previous inputs as they process new ones. This is achieved through the use of recurrent connections within the network, which allow information to be passed from one time step to the next [13-14].

Genetic Algorithms is a search optimization algorithm based on the principles of natural selection and genetics. It has been used for UAVs to optimize flight trajectories and improve the performance of UAVs [6]. The basic idea behind genetic algorithms is to create a population of potential solutions to a problem, and then use evolutionary operations such as selection, crossover, and mutation to generate new solutions over time.

Particle Swarm Optimization is a search optimization algorithm based on the behavior of social swarms [15]. It has been used for UAVs to optimize flight trajectories, improve coverage and mapping, and optimize resource allocation.In PSO, a population of particles is used to search the solution space of a given optimization problem[16]. Each particle represents a potential solution to the problem, and its position in the solution space is determined by a set of parameters.

3 Proposed Methodology

SystemArchitectureDesign

The first step in designing a solar-powered UAV using IoT and machine learning is to create system architecture. This includes defining the hardware and software components required to build the UAV. The architecture should include the UAV platform, sensors, communication modules, and machine learning algorithms.

HardwareDesign

The hardware design involves selecting the components required for building the UAV platform, such as the motors, solar panels, batteries, and sensors. The selected components should be lightweight, durable, and efficient.

SoftwareDesign

The software design involves selecting the programming languages, libraries, and frameworks required for building the UAV platform. The software should be designed to handle the real-time data generated by the sensors and process it using machine learning algorithms.

SensorIntegration

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The sensors should be integrated with the UAV platform to collect data such as temperature, humidity, wind speed, and altitude. This data will be used to optimize the performance of the UAV and make it more efficient.

IoTIntegration

The UAV platform should be integrated with IoT devices such as cameras, GPS, and wireless modules to enable real-time communication with ground control.

Proposed design and development of a solar-powered UAV using IOT and SVM

The machine learning algorithms should be integrated with the UAV platform to enable it to make autonomous decisions based on the data collected by the sensors. The algorithms should be designed to optimize the performance of the UAV and increase its efficiency.

Flight Control Algorithms

The flight control algorithms should be designed to enable the UAV to perform complex maneuvers autonomously. This will require the integration of sensors and machine learning algorithms to enable the UAV to make intelligent decisions based on real-time data.

Testing and Optimization

Once the UAV platform is built, it should be tested and optimized for performance. This will involve conducting flight tests to ensure that the UAV is stable and efficient. The performance of the UAV should be optimized by fine-tuning the machine learning algorithms and flight control algorithms.

Time is divided into t period with equal duration. Utilizing Poisson distribution's arrival rate ($\lambda(t)$), the number of the ground users can be estimated. With (λ (t)), the average number of users is determined utilizing Equation (1).

$$\boldsymbol{E(N_t) = \lambda_t} \quad \textbf{(1)}$$

$$\boldsymbol{D^{ij}(t) = \sqrt{(x^i(t) - x^j(t))^2 + (y^i(t) - (y^j(t))^2)}} \quad \textbf{(2)}$$

Where$D^{ij}\ (t)$, is distance between two UAVs at time span t. The points$x^i(t)$ and $y^i(t)$are the coordinates ofi_{th} UAV and $x^j\ (t)$ and$y^j\ (t)$ are the coordinates of j_{th}UAV. The framework goes till n, the maximum number of UAVs in the air to track down the distance between them.

Algorithm :Solar-Powered UAV using IoT and SVM

Step 1: Define the project scope and requirements
- Determine the purpose of the UAV
- Determine the required flight time, range, and payload capacity

Step 2: Select the components and hardware
- Select the solar panels, batteries, motors, and other components required for the UAV
- Determine the communication protocol and sensors required for IoT connectivity

Step 3: Design the UAV
- Create a CAD model of the UAV
- Determine the optimal wing design and size for maximum efficiency
- Determine the optimal placement of solar panels for maximum energy generation

Step 4: Develop the software
- Develop the flight control software for the UAV
- Develop the IoT communication software for data transmission
- Develop the machine learning algorithms for autonomous flight control

Step 5: Test and validate the UAV
- Conduct a series of flight tests to validate the design and performance of the UAV

- Test the IoT and machine learning components for accuracy and reliability

4. Experimental Result

1. Accuracy

Accuracy is the degree of closeness between a measurement and its true value. The formula for accuracy is:

$$\boldsymbol{Accuracy} = \frac{(\boldsymbol{TP}+\boldsymbol{TN})}{\boldsymbol{TP}+\boldsymbol{TN}+\boldsymbol{FP}+\boldsymbol{FN}}$$

Dataset	RNN	ANN	Proposed IOT-SVM
100	69	79	87
200	71	73	89
300	75	75	90
400	82	62	95
500	85	69	99

Table 1.Comparison table of Precision

The Comparison table 1 of Precision demonstrates the different values of existing RNN, ANN and proposed IOT -SVM. While comparing the Existing algorithm and proposed IOT -SVM provides the better results. The existing algorithm values start from 69 to 85, 69 to 79 and proposed IOT -SVM values starts from 87 to 99. The proposed method provides the great results.

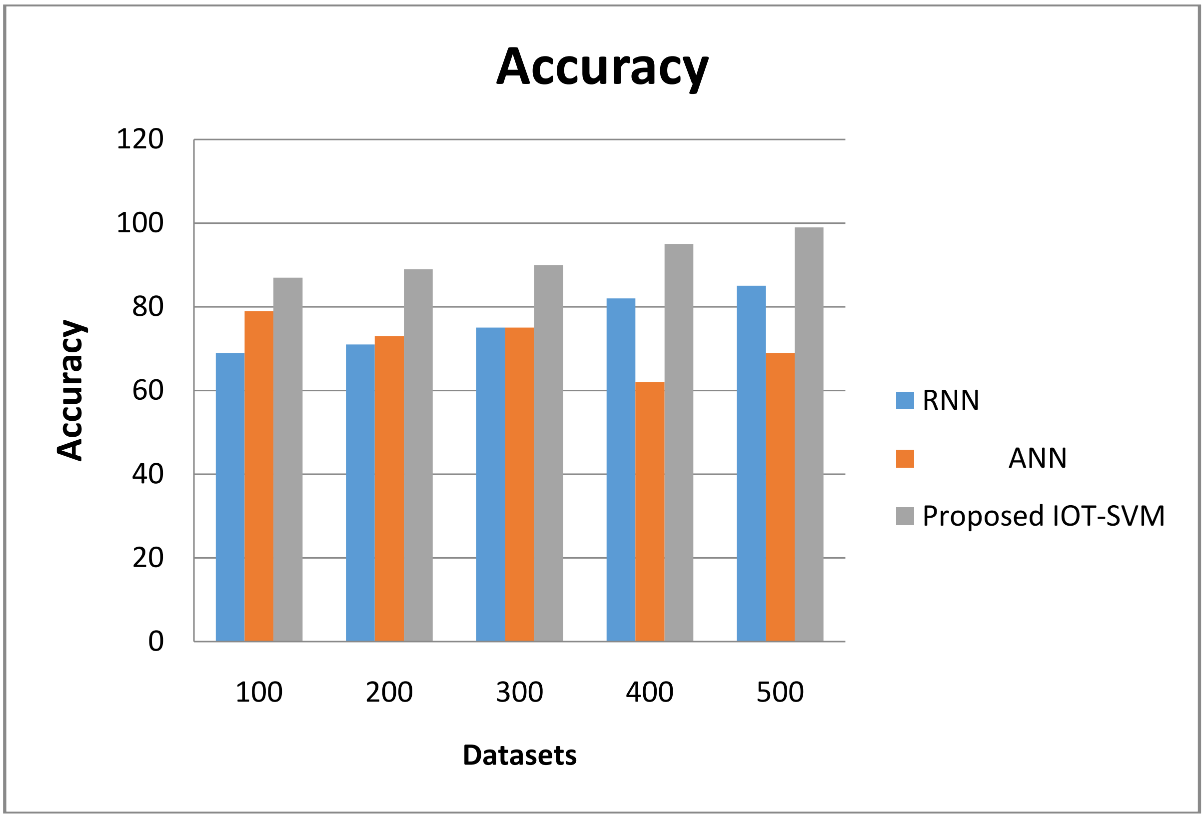

Figure 2.Comparison chart of Precision

The Figure 2 Shows the comparison chart of Precision demonstrates the existing RNN, ANN and proposed IOT -SVM. X axis denote the Dataset and y axis denotes the Precision ratio. The proposed IOT -SVM values are better than the existing algorithm. The existing algorithm values start from 69 to 85, 69 to 79 and proposed IOT -SVM values starts from 87 to 99. The proposed method provides the great results.

2. Specificity

Specificity is a measure of how well a model can predict a value based on a given input. The specificity of a model is the ratio of true positive predictions to all positive predictions.

$$Specificity = \frac{truenegative}{(truenegative + falsepositive)}$$

Datas et	RNN	ANN	Proposed IOT - SVM
100	82.41	84.89	98.21
200	80.14	81.76	95.18
300	76.46	80.21	93.35
400	72.32	79.24	91.84
500	71.78	74.66	84.89

Table 2.Comparison tale of Specificity

The Comparison table 2 of Specificity demonstrates the different values of existing RNN, ANN and proposed IOT -SVM. While comparing the Existing algorithm and proposed IOT

-SVM provides the better results. The existing algorithm values start from 71.78 to 82.41, 74.66to 84.89 and proposed IOT -SVM values starts from 84.89 to 98.21. The proposed method provides the great results.

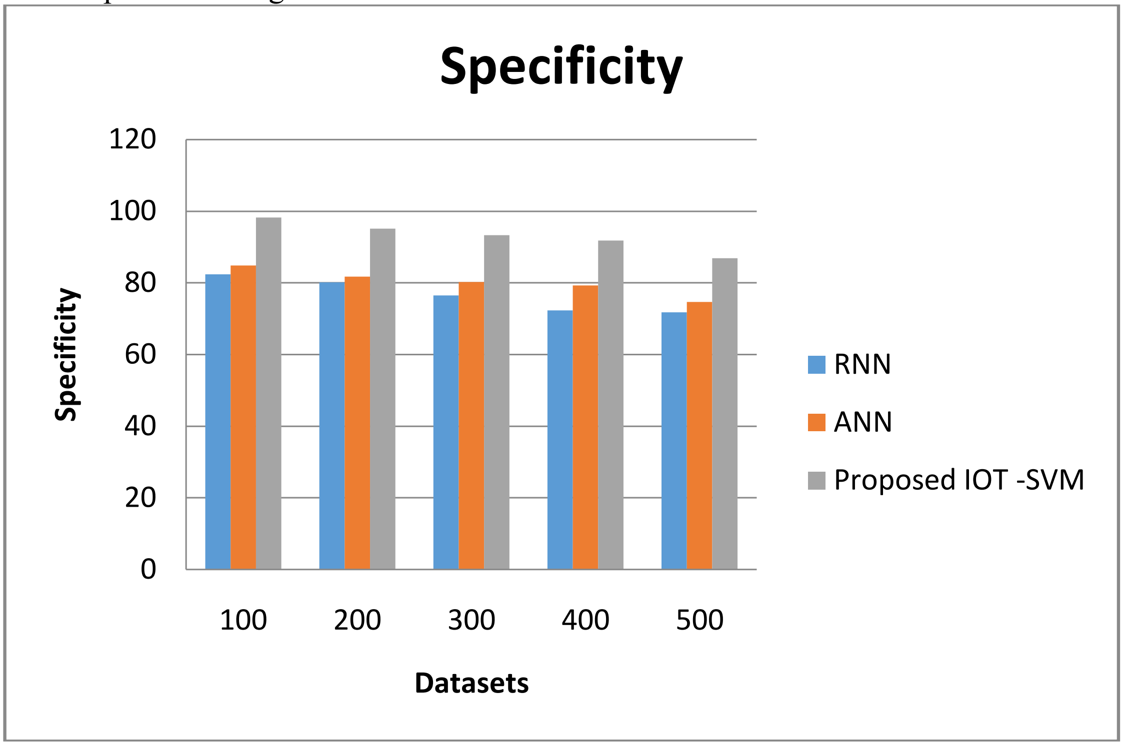

Figure 3.Comparison chart of Specificity

The Figure 3 Shows the comparison chart of Specificity demonstrates the existing RNN, ANN and proposed IOT -SVM. X axis denote the Dataset and y axis denotes the Accuracy ratio. The proposed IOT -SVM values are better than the existing algorithm. The existing algorithm values start from 71.78 to 82.41, 74.66to 84.89 and proposed IOT -SVM values starts from 84.89 to 98.21. The proposed method provides the great results.

5. Conclusion

In this paper, the proposed design and development of a solar-powered UAV using IOT and SVM presents a promising solution for sustainable and autonomous aerial missions. The use of solar power as a renewable energy source allows for longer flight endurance and reduced carbon emissions, while the integration of IOT and SVM enables real-time monitoring and analysis of sensor data for efficient decision-making. The integration of IOT in the UAV system enables the collection of data from various sensors such as GPS, temperature, and humidity sensors, which can be used for real-time monitoring and analysis of environmental conditions. The data collected can be transmitted to a central control station for processing and decision-making. The use of SVM for classification and detection of objects in aerial images can enhance the efficiency and accuracy of the UAV mission. The proposed design and development of a solar-powered UAV using IOT and SVM can be useful in various applications such as environmental monitoring, precision agriculture, disaster management, and surveillance. The use of solar power as a renewable energy source in UAVs can have significant benefits

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