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Review Article

The Different Types of Unmanned Aerial Vehicle (UAV): Characteristics, Capabilities, and Challenges

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Abstract

Drones, or unmanned aerial vehicles (UAV), have transformed from military technology to civilian applications, transforming industries and daily life, with growing popularity among hobbyists, photographers, and professionals. UAVs support diverse uses, such as in digital agriculture and landmine detection. This paper x-rays and provides a comprehensive overview of the various types of UAVs, exploring their characteristics, capabilities, and applications.

Keywords: *Types, Unmanned Aerial Vehicles (UAV); Security System; Target Tracking; Law Enforcement.*

I. INTRODUCTION

Recently, UAVs, particularly quad copters, have elicited the attention of people all over the world, including researchers, students, and technology enthusiasts or hobbyists. Responding to this extraordinary popularity, researchers have created a plethora of novel control algorithms, ranging from the model-based controller to the model-free controller, to effectively and efficiently control the quad copter system. Nature has been the design driver for the majority of man-made developments; one such is aircraft. Looking at the birds flying in the sky, the desire for flight in man was raised. From the days of the first flight of Kitty Hawk by the Wright Brothers in 1906 [28] up to the present day, the design and development of the aviation industry have improved enormously. Nodaway's unmanned aerial vehicle (UAV) is an attractive idea in the aeronautical field, which is used in almost all the fields. The ultra-light UAVs are meant to perform complex makeovers in the combat field as they give better performance compared to the others. Due to this fact, the usage of UAVs is getting more and more important in both the commercial fields and combat, with the capability to do tasks at a feasible cost. Designing a high-performance UAV is a difficult process because it requires meeting all design constraints or customer requirements while maintaining the lowest possible take-off mass. Also, the maximum take-off mass of UAV category aircraft should not be more than 5, which invokes the use of advanced light-weight engineering materials that make the design process more challenging and interesting. The maneuvering capabilities of the current designed UAV are to achieve +5g to -4g turns. Hence, the current plane will be a trend-setter design with such high maneuvering capabilities [29].

II. LITERATURE REVIEW

A large number of users have used this design to study the components and characteristics of drones and to develop and use them in different fields. The most well-known of this research is: Several deep learning architectures were used in this study to identify the quad copter UAV system. Overall, the CNN-LSTM model has been found to outperform all other architectures, with average tested MSE and MAE values of 0.0002 and 0.0030, respectively [1,2]. A paper proposed a UAV-based smart healthcare scheme for COVID-19 monitoring, cleansing, social distancing, information study, and statistics group in the control area. The frame collects data via wearable sensors, drive sensors deployed in battered areas, or thermal appearance processing [3,4]. In the other paper, the observer linear parameter-varying (LPV) was installed on a Parrot Rolling Spider mini drone and a series of flying tests were performed to evaluate the Fault Detection and Diagnosis (FDD) proficiencies in real-time using the onboard processing power. Flight tests validated the simulation results and demonstrated that the sliding style observer could provide reliable fault rebuilding for quad rotor mini-drone organizations [5]. The improved adaptive sliding approach algorithm was developed in the other paper using a version law based on the Lyapunov strength approach, which allowed the controller's nonlinear adaptive performance to compensate for disturbances and parameter perturbations. Matlab simulations are used to validate the utility of the suggested regulator strategy in comparison to the old approach [6]. The sensors, such as ultrasonic and barometric pressure sensors, as well as their information, played a vital part in calculating the altitude of the Parrot Mambo micro drone in the other study. Used Simulink software and block sets like the Simulink support package for Parrot micro drones to keep the drone at a constant height. Apart from the hardware and software descriptions, the drone's equipment, capabilities, and performance have also been discussed [7]. In other work, the Vortex Ring State (VRS) and Windmill-Brake State (WBS) have been examined in the context of quad copters. Following that, wind tunnel tests were used to develop a quad copter model that is independent of the floppy load and blade disk sizes. A basic model was then developed for trajectory designs. Thereafter, the GPOPS-II program was used as an arithmetical solver to construct optimum 2D and 3D descent trajectories due to the challenging optimum issue aimed at minimal time path design. Finally, flight tests were conducted to demonstrate that the VRS is current in quadcopters. It was also claimed that by increasing the plane speed of the blade floppy, the flight fluxes could be reduced. As an ideal falling trajectory, a helix-type trajectory is used [8]. In other research, low-cost instruments, such as a 10-DOF Mems (Micro-electro-mechanical systems), an IMU (Inertial Measurement Unit), and a LIDAR (light detection and ranging), were fitted on a minor unmanned rotorcraft in other research and synchronized at a 10-Hz measurement rate to estimate the location of the platform and its space from a hitch or a landing field. Kalman filtering was used to correct the IMU data for systematic errors (bias) and dimension noise, as well as to obtain predicted locations from the accelerometer data. The technique was created on an onboard microprocessor (Arduino Mega 2560), and it enables low-cost hardware applications of many sensors for usage in aerospace requests [9]. The other study looks at a proportional and derivative (PD) controller that uses a quad rotor UAV to regulate the adjustment of the quad rotor UAV while in flight. To be stable and have high performance, the PD controller's gain parameters, the proportional gain Kp and the derivative gain Kd, are used. Unmanned aerial vehicles (UAVs) are becoming more popular, and they come in a wide variety of sizes and designs. The quad copter settles the time of roll, pitch, and yaw systems after incorporating PD controllers into the systems. After the research, the simulation results and a comparison of X, Y, and Yaw control approaches are shown. The optimum estimate technique, which was built on an onboard microprocessor (Arduino Mega 2560), enables low-cost high operations of many sensors for usage in a variety of requests. [10, 11]. In other studies, the controller has been tweaked to handle the tracking trajectory problem. The primary idea behind this control system is to allow the robot to trace the target trajectory with the least amount of error possible. The robustness and effectiveness of the developed method, as well as the responsiveness of the suggested sliding mode controller, are demonstrated using MATLAB simulation results [12–14]. In [15–18], the outcomes of autonomous swarming flights in the open air are discussed. The designed mini-drone is small in size, with a wheelbase of 130 mm and a mass of 76 g, and it comes equipped with all of the sensors required for autonomous flying. The suggested controller compensates for nonlinearity in dynamics, allowing for accurate velocity control.

Additionally, the results of the swarming flight tests revealed that the produced mini-drones and the suggested controller perform flawlessly under real-world flying circumstances. Another author found the results impressive: using the audio signal's Mel-frequency cepstral coefficients (MFCCs) and various support vector machine (SVM) classifiers, it was possible to achieve a minimum classification accuracy of 98% in the detection of the specific payload class carried by the drone with an acquisition time of only 0.25 s; the performance improved when longer acquisition times were used [19]. The author used the following key references: [20– 23]. Likewise, some studies created an embedded system for a quad rotor UAV flight controller. The controller was built with readily available low-cost components, an open hardware design, and open software, allowing users to test and implement new control algorithms, which distinguishes it from the most prevalent alternatives on the market. A sensing system was created for taking and recording the quad rotor's odometer. Architecture for sending angular velocity instructions to the motors through the PWM was designed, and everything was processed on a Raspberry Pi 3 [24-26]. Many research studies focus on improving the design of the control system in drones because these aircraft reach dangerous places that humans cannot reach. During their flight, they are exposed to different and dangerous weather conditions. In addition, the drone system under actuated is challenging to control. In this paper, we will improve the control system for determining the position and altitude of the aircraft (PD) by making the aircraft maintain its stability even after exposure to bad weather conditions such as falling dust or snow on it. In this research paper, we use a mini drone called the Parrot mini drone-Mabo. The Mambo is controlled by a computer running the PyParrot interface through a Wi-Fi or Bluetooth connection. A built-in Simulink model is utilized to simulate the desired flight route for this study. This program enables simulated runs with various parameters to identify the Parrot mini drone's intended response. This is done by controlling the Simulink model's numerous subsystems [27].

III. Types of Unmanned Aerial Vehicle (UAV)

Drones, like radios, digital cameras, the internet, and even duct tape, are examples of cutting-edge technology that was first created for military applications before being adopted into daily life. Drones, also referred to as unmanned aerial vehicles (UAVs), are becoming popular among hobbyists, photographers, and inquisitive bystanders. They support forestry initiatives, locate landmines, and rescue victims of avalanches. And ultimately, they'll be bringing parcels and pizza to our doors on their own.

1. Multi-Rotor Drones

Drones with multiple rotors include a frame that extends to accommodate numerous propellers. They may create a variety of model kinds, from octocopters (drones with eight propellers) to Tri copters (drones with three propellers). One kind of rotary-wing drone is the multi-rotor drone. These drones use rotating blades to propel themselves upward and away from the ground, enabling them to take to the air.

Use cases: Aerial photography and videography, aerial mapping and surveying, asset inspection, crop monitoring, short-range product delivery.

2. Single-Rotor Drones

Single-rotor drones have a single central propeller that supports the body, making them resemble tiny helicopters. They belong to the category of rotary-wing drones.

Use applications include large cargo delivery, aerial mapping and surveying, airborne surveillance and patrol, and search and rescue missions.

3. Fixed-Wing Drones

A fixed-wing drone's fuselage lifts into the air by its wings rather than its rotors, much like an airplane. Usually employed by the military, these drones are big, fuel-powered models that need a runway to fly.

Use cases include long-range cargo delivery, asset inspection, unmanned aerial refueling, and aerial mapping and surveying.

4. Fixed-Wing Hybrid Vertical Takeoff and Landing (VTOL) Drones

These hybrid drones, which combine the greatest features of fixed-wing and rotary versions, can take off vertically, a maneuver known as vertical takeoff and landing (VTOL). They can then change to a horizontal flight mode by tilting the rotors linked to their wings in the direction of the drone's nose.

Use cases include long-distance product delivery, large-scale inspection and surveillance, aerial mapping and surveying, and aerial photography and videography [32].

IV. THE ADVANTAGES OF UNMANNED AERIAL VEHICLES (UAV)

1. MAINTAINING A SAFE ENVIRONMENT: UAVs are utilized in numerous occurrences due to their advancement in safety. With their remote-control abilities, drones monitor locations, communicate possible hazards, and notify threatening conditions. Such as oil and gas refineries, pipelines, and flare stacks. Not only this, drone technology is employed in the military during high-risk periods as well. Their features allow them to obtain real-time data to create and preserve a safe environment.

2. COST SAVING TECHNOLOGY: As drones' applicability becomes more extensive, their prices also drive towards being more pocket-friendly. People now acquire drones not just for their industrial practices but also to fulfill their tech-savvy gadget passion. UAVs are no longer limited to the military, law enforcement, or the elite. Since UAVs take over several workforces, vehicles, and operational activities in commercial uses, many costs are preserved. For example, a drone is easier to buy, maintain, and fuel than an airplane for inspections. In addition, you don't need to hire a ladder, aerial lift, or other heavy equipment.

3. With their high-resolution cameras furnished with top-notch sensors, UAVs can take excellent aerial photographs and aerial videos and accumulate large volumes of accurate data. The data obtained is transformed into detailed 3D maps and 3D models for a complete analysis. 3D Mapping is especially useful for revealing cracks, damage, or other potentially hazardous elements in disaster areas. Drones, when paired with high-resolution images or 4K video abilities, are well-known for live streaming significant events such as entertainment, personal, political, and global affairs.

4. UAVs have appropriate GPS (the Global Positioning System) in their software, which is why they can be programmed and guided precisely to specific locations. For example, in Precision Agriculture, a drone aircraft is employed to perform many farming obligations like pesticide spraying, identification of weeds, monitoring of crop health, crop damage, crop assessment, field soil analysis, irrigation monitoring etc. This feature of precision through the GPS conserves time and expenses for farmers. 5. Easy Controllable or Deployable: The regular advancement in drone-control technology allows operators to quickly deploy and operate drones even with a relatively minimal technical background. With an extensive range of low-cost drones available for several purposes, drones are open to a broad spectrum of operators. Unmanned aerial vehicles (UAVs) have a more comprehensive range of movement, fly lower in all directions, and can navigate effortlessly when compared to crewed aircraft.

6. SECURITY: Another advantage that weighs out the pros and cons of a drone is the security centered around them. With relevant permissions and licenses, drone operators can utilize an Unmanned Aircraft System (UAS) to provide safety and surveillance to private organizations, potential venues, and other individuals. Drones can also accumulate reliable information from natural catastrophes to support safety and recovery efforts.
7. DANGER AND HEALTH RISKS ARE REDUCED-With the support of a drone, numerous dangers like elevation, wind, weather, and radiation that were earlier suffered by crew members have been replaced with more viable and safer alternatives. Drones facilitate straightforward and secure inspections of towering and complicated constructions like oil and gas refineries, flare stacks, and pipelines.
8. IN-DEPTH AND DETAIL DATA INSTALLATION-Many drone models are launched onto the market with obstacle avoidance capacities. They can operate quite close to construction, and this encourages them to seize precise data. They capture high-resolution images or 4K videos that explicitly reveal cracks, damage, displaced wires, and additional defects that we cannot detect with our naked eye. UAVs allow obtaining complete data without endangering inspection crew members of the company.
9. FLEXIBILITY FOR QUICK INSPECTIONS: Since drones come with varied specifications, several can provide high or low altitude inspections. The versatility of these characteristics empowers clients to customize the tools with ease for their projects. These benefits are followed by the construction industry, particularly by building developers for rooftop inspections. Drones can carry out multiple roles, such as capturing high-quality photos, videos, thermal images, etc. This data is then transmitted and processed immediately, as opposed to the time-consuming conventional method.
10. UAVs make obtaining efficient data from hard-to-reach locations a cakewalk for industry professionals. It is the most suitable alternative to overcome the limitations of traditional methods regarding worker's safety, especially in hazardous situations like radiation monitoring and inspecting high-voltage lines. Drones also allow a more cost-effective approach to inspections of these locations. [30].

V. DISADVANTAGES OF UNMANNED AERIAL VEHICLES (UAV)

1. PRIVACY: While drones' benefits are endless, drone technology has several downsides to it. UAVs can quickly fall prey to manipulation and trespass, infringing on a group or individual's privacy. Though many desire to utilize drones for retaining safety, it could violate numerous individual liberties in the name of public security.
2. The use of Unmanned Aircraft Systems (UAS) has become widespread. However, the law is still developing, considering it is a novel technology in the industry. Specific practices installed for tiny drones also apply to commercial and recreational applications but are still vague in several dimensions. Rules for the regulation of drone movement and property protection from aerial trespassing are still in the making; thus, UAV technology functions in a judicial gray zone. There are numerous frictions between governmental regulations and any state or city laws to manage airspace property rights, because of which drone operators may violate rules they didn't know about.
3. SAFETY: Safety is a fundamental element to prioritize when operating drone technology. UAVs outfitted with highquality sensors recognize possible collisions and safely engineer their way around them, making them a significant trait. These drone capacities must resemble those of manned aircraft navigators. It is commendable to hire professional drone service providers who can operate an aerial drone without crashing it. Drones operated in heavily-populated regions have an amplified risk of ground impact or damage, mainly due to system malfunction or hacking.
4. There have previously been many drones that have fired weapons at commoners, generating a significant number of casualties, injuries, and damage due to malfunctions or software blunders. Drone mishaps strike other military personnel's safety as well. Drones are still in the process of improvement to limit accidents or hazards that can affect the health and safety of human lives.
5. Drones are vulnerable to wild animal attacks and can be hazardous to the environment. It is possible that when a drone operator is flying in a domain with a considerable number of wild animals, they crash against a tree or possibly conflict with a vulnerable animal. Large flying birds like eagles are regularly attacking and even capturing drones operating in their space to obtain crucial data.
6. Many offenders employ drones as a strategy to target their victims and to maintain track of them. The blatant propeller noises are no longer a concern and are unnoticeable, enabling criminals to invade someone's privacy. Many drones furnished with thermal and night sensors identify life signs and efficiently target those currently of interest to the spy. Since UAVs can seize accurate data, they can register regular habits and recognize suspicious activities without permission.
7. EASY TO HACK: One substantial downside to drone technology's growth is its vulnerability. Hackers can quickly attack a drone's central control system and become the drone's original controller. The primary control system includes significant knowledge that is crucial for hackers to evade without the initial operator's awareness. Hackers can acquire private information, corrupt or damage the files, and leak data to unauthorized third parties.
8. WEATHER DEPENDENT: Drones are more vulnerable to weather conditions when compared to traditional aircraft. For example, if the climatic conditions are unfavorable, the UAV will not maneuver appropriately or gather reliable data or imagery. However, there are drones available that are more stable and can withstand gusts of wind successfully.
9. KNOWLEDGE AND SKILLS: As discussed earlier, if one necessitates securing accurate, high-quality data, they need to possess the requisite skillset. This specification would indicate that an average farmer would require comprehensive

training or a third-party drone service provider to capture, process, and analyze farming data. With expanding operators in the industry, drone costs and their accompanying resource expenses will gradually be reduced. 10. One of the cons of expanding drone technology in precision agriculture is its data transmission speed, which some suppose could be a week. If the time necessitated for data delivery results in a farmer's unproductivity and damage to fertilizers, crops, or pesticides, the operation of the drone would be a waste in the end. Thus, if data transfer speed is slow, suffering and damage can occur in that period, with all efforts going to waste [30].

CONCLUSION

We have examined a lot of publications on drones and unmanned aerial vehicles (UAVs) for this essay. I have also gone into great detail about the benefits and drawbacks of unmanned aerial vehicles (UAVs) [31]

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