Student's Name: AHMED MOHAMED HASSAN

G2121004

Professor's Name: KAMEDA

Technology-Driven Agility in Unmanned Aerial Vehicle Systems

Automation technology (AT) has gained popularity in many industries worldwide, particularly autonomous vehicles. This technology, often referred to as unmanned aerial vehicles (UAVs), have diverse applications, such as military, construction video mapping, medical search and rescue, hidden area exploration, oil rigs, and aerial surveillance (Mohsan et al. 1). Due to the rapid development of the technological world, the UAVs have gained attention since they have peculiarities, like payload capabilities, swift mobility, and remote access. Consequently, this paper explores the capabilities and emerging applications of UAVs. While errors in the use of drones have caused several challenges or risks to the safety of individuals in various sectors of its applications, my goal in this paper is to examine how to use a counter UAV system that protects personal, commercial, public, or military facilities from uncontrollable UAVs.

Problem Statement

UAV technology has changed many industries. However, despite all its benefits, it has a few drawbacks. Despite the fact that drones focus on perfection, they are crafted flawlessly. UAVs can easily and quickly become manipulated and trespass on an individual's privacy. Moreover, the use of drones has been criticized for causing safety downfalls (Nawaz et al. 87). Safety is a primary element that should be prioritized when operating drones. UAVs that are outfitted with high-quality sensors identify probable collisions and securely avoid obstacles. The failure to navigate barriers can lead to harm not only to humans but also to their properties due to the collisions and related risks.

Moreover, UAVs are susceptible to software issues or malfunctions. Some of the drones have fired weapons at civilians, thus leading to notable levels of casualties, harm, and damages due to blunders with software patches or malfunctions. The technology used in drone design is still being improved to alleviate accidents or dangers that can influence the health and safety of human lives. Drones are also susceptible to wild animal attacks. Furthermore, they are also at times dangerous to nature (Nawaz et al. 89). When a drone operator moves in a domain with a notable number of wild animals, it is possible to crash against a tree or probably conflict with a susceptible animal. Therefore, as much as evidence reveals the advantages of using UAVs, there appear to be some drawbacks that have to be addressed.

Rationale for Focusing on UAVs

A survey of UAVs reveals an issue with the use of drones due to the dangers they pose. A counter UAV system should be used to safeguard personal, commercial, public, or military facilities from the uncontrollable UAVs. The reason for selection of UAVs is that their utility has been growing across different sectors (Mohsan et al. 147). Both software and hardware of the devices are susceptible to certain risks, including security issues. Considering the wide range of applicability of drones, one should anticipate that security is a top priority for professional UAVs. Studies depict that professional UAVs are not as safe as one could anticipate. Some studies have also revealed that by learning the way the UAV communicates with the remote controller, one can execute an attack and potentially assume control over the UAV (Mohsan et al. 147). Hence, UAVs have a wide array of matters that need to be understood and addressed.

Related Literature

In recent times agriculture presents an ample scope for drone development because it reduces economic costs in the sector (Rahman et al. 1). The study illustrates that drones can spray pesticides and fertilizers, perform field analysis, and seed and soil sowing during farming. When used in this method, the farmers would reduce the health concerns from using pesticides and fertilizers. Besides, the number of workers would reduce, helping the farmers to reduce the cost of farming. Another related work for the application of drones is in protecting various systems from uncontrollable UAVs. According to Kang et al., implementing drones for different functionalities, such as military or personal use, may present challenges like intentional malfunctions or attacks (168671).

This research reviews the UAVs for application and capabilities. UAVs are systems operated remotely to perform tasks depending on the requirements. In examining the popularity of UAVs, Kim et al. opine that they first gained popularity for use in military reconnaissance, intelligence, surveillance, and target acquisition applications (3). However, the recent exploration of drone technology has gained an exceptional range of applications because of the technologically savvy environment. Increased drone technologies have enabled scientists to develop agile drone systems with a wide range of applications.

Figure 1: Example of a multi-rotor UAV (Kakarla and Ampatzidis par. 5).

Technologies Components of Drones. The main technological components of drones include an accelerator and GPS (global positioning systems). The accelerometer plays a critical role in estimating the orientation and the drone's position during flight. This system enables the drone operator to know the exact position and orientation of the drone. Additionally, the GPS plays a pivotal role in enabling drones to use fixed satellites to obtain location information. Without the GPS, the drones would be unable to navigate long distances and, return "home" safely, after losing connection with the controller.

Payload Capacity of Drones. The payload capacity of a drone is the weight that it can carry. It often determines the drone's features and its operational capabilities. A particular aspect of payload capacity is that it is often counted outside the drone's weight and takes account of packages for delivery, cameras, or sensors. Payload capacity varies from one drone to another based on the primary purpose for which a drone was developed.

Figure 2: Example of a fixed-wing UAV (created by UF researchers, Gainesville, FL, US) (Kakarla and Ampatzidis par. 7).

Drone Control System. Ideally, the control system comprises two loops: the inner and the outer loop. These two loops provide the drones with the ability to function as expected. While the inner loop is responsible for controlling its angular velocity, the outer loop is responsible for controlling the altitude. This feature indicates that the inner loop enables drones to move in any horizontal direction while the outer loop enables them to move in a vertical direction. Therefore, it would be impossible for drones to fly without the two control loops.

Figure 3: Example of a hybrid VTOL UAV (Kakarla and Ampatzidis par. 10).

Applications of Drones. Drones have a wide application area, such as civil defense protection, power-line inspection, and road transportation monitoring. They act as first responders in civil defense protection, augmenting the civil defense forces' ability to respond to emergencies. Furthermore, they are applied in power-line inspection to offer uninterrupted power supply by constantly inspecting power lines, especially in inaccessible locations. Finally, they are used to monitor the existing road transport networks for effective traffic management and future planning of road networks. These application areas refer to the current trends in drone technology to improve the processes within various fields.

Capabilities of UAVs

UAVs have divergent capabilities that enhance their utility. UAVs can remain on station or near a combat area far beyond the capacities of manned systems. Even though there exist practical and theoretical limitations of the technology, by using a small number of vehicles, the capabilities push for near-progressive surveillance for essentially definite periods. UAVs have deck-cycle flexibility (Idrissi et al. 7). The feature enhances the advantages of long endurance that can be translated into more than the amount of time on station across an area. The drones also have timeline flexibility capabilities since they can execute complex operations many hours before the main ones. The drones also enhance distributed control as the user with the ideal circumstance awareness or the most immediate one can assume direct control when required to do so.

Applications of UAVs

Considering their various capabilities, UAVs have a wide array of applications. Escape UAVs are effective and are the only tool that backs up disaster management. In nuclear incidents and accidents, several foremost information squares measures sturdy the emission. Drones can also be applied for fireplace identification, observation, and conjointly for the process of post-fire execution. UAVs have also a wide array of applications in medical sciences (Idrissi et al. 8). The drones can provide first aid to the team, including dispensing to remote locations. Quick evacuation during earthquakes is possible since drones can facilitate fast relocation of people and direct them to secure places. UAVs identify areas damaged by earthquakes and evacuate victims to safe places. UAVs also play a significant role in monitoring the weather conditions (Idrissi et al. 9). The drones also have their applicability across the agricultural sector, especially in helping improve yields. UAVs are mostly utilized in the developed nations for smart farming.

Discussion

The technological innovation in the drone kit is the reason for its highly agile unmanned aerial flights. The first functionality that enables the drone to work seamlessly is the motherboard, containing the hardware components for processing the software transactions. The primary components of the drone include the aircraft, payload, power supply, controller, and sensors (Jankowska 119). One of the significant components of the drone is the brushless motors which generate higher torque for the same weight as the brushed motors. Another significant element of the drone motherboard is the electronic speed controllers (ESC), offering high power, frequency, and resolution 3-phase to the motors. The motherboard powers the other components of the drone through software components.

Table 1: Examples of the hardware elements of the UAVs (Rahma et al. 16)

Name of the Hardware	**Objective**
Camera (RGB/Infrared/Thermal)	Capturing images.
Brushless Direct Current (BLDC)	Movement control.
Electronic Speed Controller (ESC)	Adjusting BLDC velocity.
Global Positioning System (GPS)	Navigating.
Wireless Sensor Network (WSN)	Monitoring circumstances
Altimeter	Measuring altitude
Accelerometer	Acceleration grading
Magnetometer	Measuring the strength/direction of the magnetic field.
Battery	Retaining power.

Despite the hardware functionality of drones, the software components are significant to enable them to perform the operator's actions and other intended functions. The first software component that the drone kit uses is the Pix4D mapping software for image analysis based on the maps and the photographic capture of the drones. Another software component that powers the drone is the Pixhawk. It is a software component that runs various hardware components in a drone toolkit. It acts as an Arduino or Raspberry Pi. Thus, the software component of drones ensures that the hardware works as required.

Table *2*: Examples of Commonly Used UAV software (Rahma et al. 16)

UAV Software	**Objective**
Adobe Photoshop	Distortion emendation
GIS	Capturing and analyzing spatial and geographic data
ArcGIS	Connecting humans, locations, and information by using interactive maps.
MavLink	Communicating with UAVs.
Python	Controlling
MATLAB	Image-processing and analysis
Pix4D, QGIS	Vegetation calculation and 3-D models construction.
C++	Image processing

Recommendation

Various strategies can be used to improve and develop a new vision for drones. One of the new vision areas is around regulation. The laws that facilitate drone functions are complicated. The rules should account for all the ways that UAVs are presently being used and how they could be applied in the coming days (Stampa et al. 7). Developing laws that push for innovation, but restrain infringements on privacy and misapplication of airspace would be necessary. The other recommendation is on automation. Hence, automating drone flight patterns launches several additional challenges, including developing a way to navigate barriers and make sure that two drones to not interrupt each other (Stampa et al. 8). Drones also need to have a higher degree of reliability before they are utilized for deliveries or related applications.

Of the three recommendations, the ideal one would be automation. Proper automation of the drones should be enhanced to make sure that they are safe for use. Automation, although not completely devoid of human control, should be minimal. In this regard, there is a need to make sure that the software and hardware used on the drones are efficient and not susceptible to failure. Proper automation would help in alleviating launch failures, navigation errors, or interruptions.

Research Goals

The research focuses on the improvement of the application of drones across divergent sectors, including disaster management and control. The study is aimed at developing solutions for both software and hardware that would enhance the efficiency and effectiveness of the application of UAVs. The main focus is on developing innovative solutions that would reduce human errors in controlling drones.

Most evidently, the research so far has been amicable. The use of surveys across different applications of drones and their capabilities have revealed that there is still much that should be done. Secondary research has been done across different platforms, including news articles, which have provided detailed information regarding the applications and capabilities of drones across different segments. The research outcomes have also shown the need for detailed research across the drone segment.

Further research will focus on the integration of UAVs with other innovations and how they can help improve their functionality. The other future research aspect is to use primary data, especially through expert interviews to determine the issues around the use of UAVs. The primary data should also reveal some of the improvements that can be made.

Conclusion

Drones have recently gained tremendous popularity because of their capabilities and applications in various fields. It was first used in the military for various functions such as reconnaissance to provide a super military city without endangering individuals during battle. Nevertheless, it is currently used in agriculture, photography, security, and medical search and rescue. The various technologies identified in drones include the GPS, payload capacity, and control system. The findings of this research also identify the software and hardware functionality of the drones, including the components of the motherboard and their connections or integrations with the software system to enable it to run.

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