AUTOMATED DRONES USING ARTIFICIAL INTELLIGENCE

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ABSTRACT: Unmanned aerial vehicle (UAV) applications have grown in popularity in recent years due to their ability to combine a wide range of sensors while maintaining low operating costs, simple deployment, and high mobility. Remotely controlling UAVs in complicated environments, on the other hand, restricts their capabilities and reduces overall system efficiency. As a result, a number of academics are working on autonomous UAV navigation, which enables UAVs to move and accomplish tasks based on their surroundings. Artificial intelligence (AI) applications have grown in popularity as a result of recent technological advancements. Autonomous UAV navigation is one application in which AI plays a critical role in providing essential human control features. As an outcome, several researchers have adopted a range of artificial intelligence (AI) technologies to increase the efficiency of autonomous UAV navigation. Among the several Model-based learning and mathematical-based optimization are two AI techniques. Furthermore, the features, kinds, navigation models, and applications of unmanned aerial vehicles (UAVs) are described to make AI implementation clearer.

Keyword: Using automated drone for monitoring and sensing the objects.

1. INTRODUCTION

As a consequence of the high degree of interest in drones and the development of everyday drones, the drone company has expanded its consumer base to include average people. Nevertheless, as the use of drones by more people became more prevalent, worries about safety and security grew as accidents—such as losing control and colliding with people or violating secured properties—became significantly more regular. For safety reasons, both onlookers and drones must be aware of an incoming drone. We present a full machine learning-based drone detection system in this study. This technology is designed to function with camera-equipped drones. Based on machine classification, the algorithm infers position from camera pictures and the vendor model of the drone.

Drones, commonly referred to as unmanned aerial vehicles (UAVs), are frequently employed in land mapping, resource discovery, air sampling, environmental monitoring, and traffic control and other disciplines. UAVs are frequently used for tasks like geographic surveying, preventing forest fires, spraying pesticides, and other long-duration missions since they can go to inaccessible places.

According to the features of the body construction, UAVs may be broadly separated into two types: unmanned fixed wing aircrafts and unmanned rotor aircrafts. The wheel-type landing gear is frequently used in fixed-wing unmanned aircraft.

Owing to the fact that visual navigation technology dominates in many elements of UAV landing operations, which are currently the subject of extensive research.

An effort was made to model an autonomous unmanned aerial vehicle (UAV) system capable of detecting individuals within the deepest forest zone. The autonomous artificial intelligence UAVs were built with laser-range detectors for precise position evaluation and pathway finding. While hovering in the area, the UAV creates a customized 3-D map of its surroundings. The primary goal of this research is to investigate the scientific opportunities available for artificial intelligence unmanned aerial vehicle (Drones) modelled with machine learning (convolution neural network) on the Internet of Things (IoTs) framework and adapt it to transform the mission on environmental & remote sensing, security surveillance, rescue, and search missions.

1.1 HOW AI CAN BE USED IN DRONE?

Drones are surprising the technology and gadget industry. Many officials are taking part in this new age by using drones for inspection, monitoring, and maintenance. Drones were formerly piloted by humans. Artificial intelligence has made an appearance in the recent past. Drones, also known as unmanned aerial vehicles (UAV), have played an important role in war operations and border monitoring. The manned component of the drone business is being phased out by artificial intelligence. Businesses are focused on building AI-powered drones that outperform humans. NASA's Jet Propulsion Laboratory researchers put human talents to the test against an AI-powered drone. The findings placed the ball in the hands of the AI.

AI is intended to be a tool for problem-solving and assistance. Science discoveries are intended to be a blessing to humanity rather than a threat to its survival. The potential advantages are enormous, but the unintended consequences of widespread AI implementation for drones can be disastrous. It is undeniably a breakthrough since it enables for battle to be carried out from a safe distance, but the destruction may be equally profound.

While developments in battery and engine technology are critical for extended flight periods, the weight of unmanned aerial vehicles is also a factor. Longer flying periods can be achieved by developing and manufacturing lightweight parts for drone systems.

AI may be used to automate drone operation, including navigation and movement. This may be accomplished by a variety of techniques, including as GPS tracking, computer vision, and machine learning algorithms.

1.2 HOW DOES AN AUTOMATED DRONE FLY?

As shown in figure 0.1, The researchers designed the drones using relevant and intricate algorithms that allow the drone to fly at faster speeds while while navigating obstacles. The drone was smoother and quicker than the person, and it detected the barrier faster. Autonomous drones rely on inherent algorithms to perform without human supervision. As a result, installing a camera allows them to operate in tight locations for safety inspections, such as a warehouse or a concentrated area. Aviates Systems, a GE company, has used AI-powered drones to evaluate infrastructure and transportation. The high-resolution cameras not only inspect but also gather data, which is then analyzed. ALPHA, a new AI that promises to overcome human pilots in battle, has just been developed. It already outperformed the previous AI version in the first round of testing. ALPHA was discovered to be responding quickly and strategizing how to overcome hurdles in the road. It outperformed human pilot abilities. Because the AI was designed primarily for military warfare, studies revealed that it could readily switch between offensive and defensive modes as needed. Better outcomes were obtained with more regressive testing. ALPHA is capable of processing sensor data and planning movements for four combats in less than milliseconds, which is impressive. It does not require any sophisticated computer or supercomputer to work. On a standard PC, it works flawlessly. ALPHA's choices are not based on statistics, but on a "fuzzy logic" that progressively minimizes the stages in decision making. It is generated using a genetic algorithm. All of this being said, there is a gap in everything that appears to be functionally pleasing. Recall how nuclear science was founded for scientific discovery and other causes relating to its discovery? It ended up putting the human race in danger with the introduction of nuclear weapons. Similarly, the development of self-driving drones capable of overcoming barriers and being employed in military operations might have disastrous consequences. Likewise, the development of self-aware drones capable of overcoming hurdles and being utilized in military operations might have disastrous consequences. It has the potential to kill millions in the blink of an eye. It has been observed in the experiments that an AI-powered drone trained itself to investigate 20 various settings by trial and error in

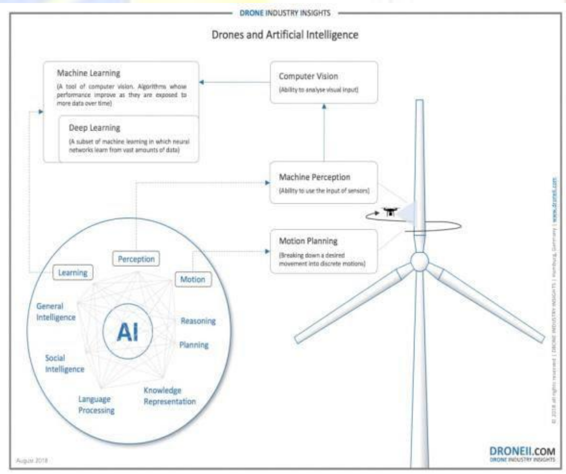


FIGURE:0.1-Drone and artificial intelligence approximately 40 hours of time. It's as lovely and heartbreaking as it sounds, but it's also terrifying and terrible. Such conduct may result in uncontrolled actions and worsening situations.

1.3 TYPES OF DRONES

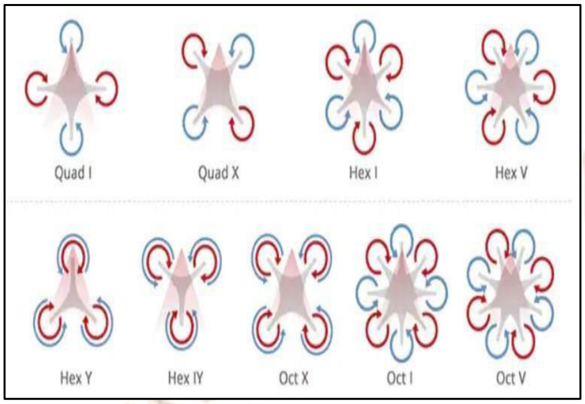


FIGURE:0.2- Types of Drones

A. SINGLE ROTOR DRONE:

The far more prevalent construction in rotary type drones was multi-rotor designs with several rotors for holding its position, however in the case of a single rotor model, there is only one rotor inside. Another example is a tail rotor, which just assists in regulating the heading.

B. TRICOPTER:

A Tri copter contains three types of strong motors, three controllers, four gyros, and just one servo. The motors are simply put at the extreme ends of

three arms, each of which has a location sensor. When you need to raise your tricopter, you must first move the throttle lever. The gyro sensor will quickly receive the signal and send it directly to the controller, which will regulate the motor rotation. A Tri copter can stay on course because it is outfitted with several traditional sensors and technological components. You do not need to perform any manual corrections.

C. QUADCOPTER:

When a multirotor is created with four rotor blades, it is referred to as a quadcopter. These gadgets are often driven by specifically built brushless DC motors. Two of the motors rotate in a clockwise manner, while the other two rotate in a anticlockwise way. It aids in determining a safe landing for a quadcopter. A lithium polymer battery was formerly used as the source of power for such gadgets.

D. HEXACOPTER:

With its six-motor system, the hex copter may be used for a variety of purposes. Three of the motors rotate clockwise, while the other three rotate anticlockwise. As a result, these gadgets have greater lifting power than quadcopters. You do not need to be concerned about its mechanism because it is meant to be an exceedingly safe landing craft.

E. OCTOCOPTER:

Octo means eight, thus the octocopter will serve you with its strong eight motors, which will deliver power to eight working rotors. This craft has far more flying capabilities than the units detailed above, and it is also quite stable. Octocopters can provide steady film capturing at any height. These gadgets are used in the field of professional photography.

2. ANALYSIS OF DRONE

2.1 UAV Design and Development:

Throughout the previous two decades, information on UAV types and growth has now been acquired by studying Web of Science and Scopus discoveries. The data is given in the form of a graph to facilitate comprehension. The bar graph indicates that the number of helicopters is slowly decreasing from 48, 38, and 28 to 20. It is owing to its design and control, air mobility, and inexpensive cost. The number of Tri-copter articles stayed 0 until 2004, then increased to 8 in 2005-2009, 15 in 2010-2014, and 39 in 2015-2021.2 because to their limited functionalities and payload carrying (Up to 2021 February).

The most striking change in the bar graph is the increase of quadcopters from 7 in 2000 to 2004 to 509 in 2021. 2 due to its adaptability and multi-functionality in a variety of applications. Quadcopters are being employed in the transfer of commodities and medications in hospitals and businesses. Transnational corporations such as Amazon, eBay, McDonald's, and KFC intend to employ quadcopters to deliver items to customers in order to save time.

Research articles in the field of hexa-copter remained 0 until 2009, then the figure grew to 11 in 2010-2014, and again in 2015-2021. It increased from 2 to 259. Similarly, the number of publications in octa-copter stayed at 68 until 2014, then increased from 2015 to 2021. There were 2, 359 articles on octa-copters found. The reason for the increased interest in

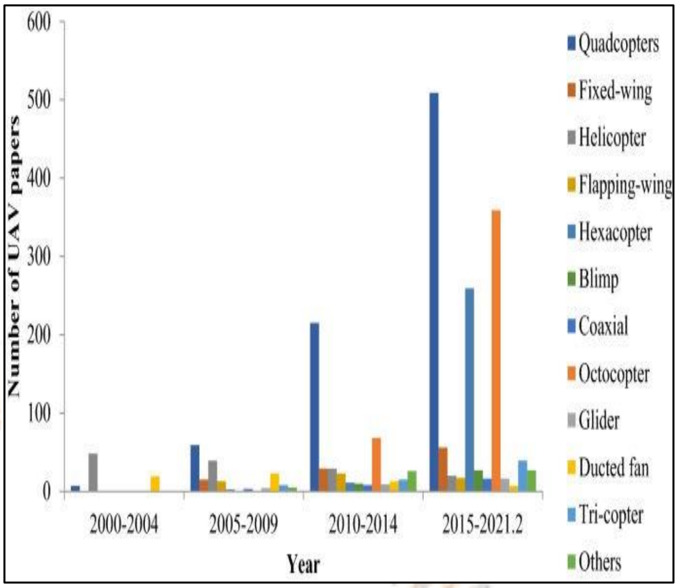


FIGURE:0.3- Overgrowth of drones

hexa-copters and octa-copters is because the manner of control is simple in these copters, i.e. if one of these copters' motors breaks while hovering, the copter doesn't really malfunction and can be safely landed. Also, the control algorithm is simple.

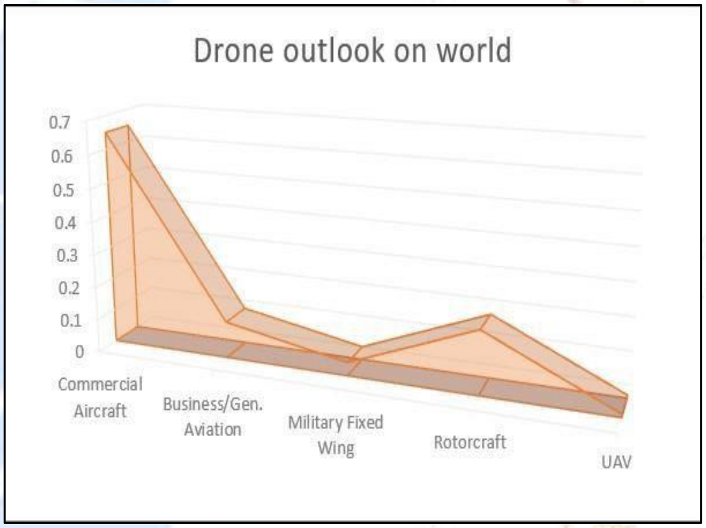


FIGURE:0.4- Outlook on world

A real-world perspective on drones includes In 2016, 110,000 million commercial aircraft were expected to be sold. Commercial drone sales reached 170,000 in 2017. According to Commercial Aircrafts, its growth has reached 64.90%. Business and Generation Aviation is predicted to increase at a rate of 11.0%. A Drone with a set of Military Fixed Wings can reach up to 4.7%. In recent years, the results of a Rotorcraft drone are projected to be 18.80%, whereas the results of an Unmanned Aerial Vehicle are expected to be 0.8%. the same as those used for professional film or photography. Wide-angle lens cameras, such as the GoPro, are immensely popular for video and photography. Nevertheless, these lenses produce distortion that is unsuitable for mapping work and must be removed in post-processing, indicating that they are not well suited to this type of job. The same fisheye concern applies to proprietary cameras used in some commercial UAVs, such as the DJI Phantom Vision and Vision+ product lines. Canon's lightweight S100 and SX260 models are very popular for UAV mapping due to their integrated GPS capabilities. These may be used in conjunction with the Canon Hack Development Kit, which allows you to programme the camera to shoot images at predetermined intervals, based on distance, or upon reaching a predefined waypoint. There are several methods for mounting the camera on the drone. Because drone mapping is often conducted at only one or two angles, gimbals may be simpler than those used by filmmakers. Image stabilization is provided by motorized gimbals, which can assist correct for turbulence and generate sharper pictures. Gimbals are also utilized to change the camera's angle from vertical (straight down) to oblique.

3. PROBLEM STATEMENT

One challenge in automating drones is that they have to operate in unstructured environments. This means that they need to be able to adapt to their surroundings on the fly and make decisions based on incomplete or changing information.

The second main challenge will be its battery, using heavy batteries will need high energy to carry and it increases the battery consumption. This means that the Drones are unable to complete its work because of its inefficient battery power.

SOLUTION:

Using AI in Drones will make it easier to analyze the outer environment by its own and fly by avoiding obstacles. Artificial Intelligence in Drones can also help it to travel a particular path and store the travelled path accordingly every time, it does not need to analyze the path every time it travels. we can use lightweight battery to avoid high battery consumption. lightweight battery can last long when compared with heavy weight batteries.

4. ARCHITECTURE OF DRONE

As shown in figure0.5, Drones that are inexpensive can create detailed maps. Tiny, portable drones may be deployed rapidly. They travel with little digital cameras capable of capturing high-quality photographs. These cameras may be programmed to snap images at predetermined intervals, and digital memory is inexpensive and plentiful. Following

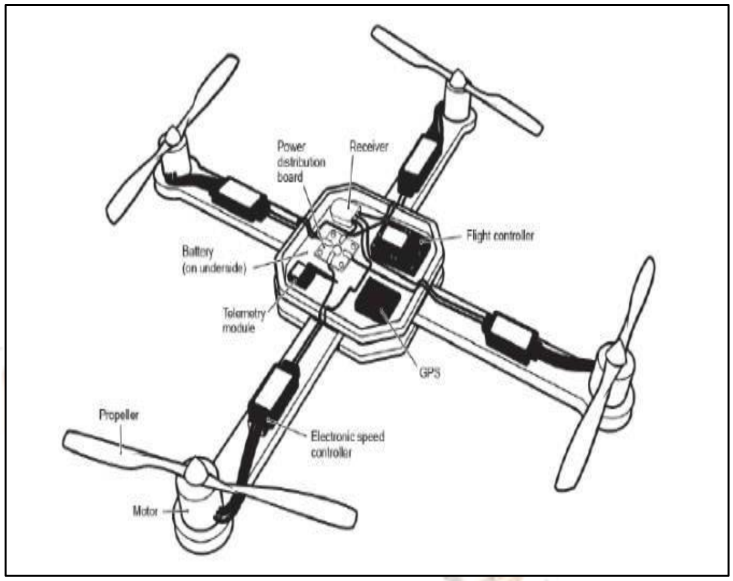


FIGURE:0.5- ARCHITECTURE OF DRONE

landing, the images can be refortified orthomosaics, which means they can be mathematically corrected to a consistent scale, altered to comply to a common geographical coordinate system, and knit together. Drones can provide spatially accurate maps because to lightweight GPS systems. Drones do not need to carry data cables that add weight and complexity because there is no requirement for the information in real time. Instead of relying on centralized mapping authority, such drones may be employed at the local level to build maps. They are used to supplement other mapping approaches and to bridge image gaps left by satellite mapping and conventional surveying. While drone mapping is a relatively new profession, practitioners all over the world are already incorporating this new type of aerial footage into their work. In this work, we demonstrate the technique of geo mapping using drones and discuss relevant software.

4.1 FLIGHT PLANNING

A variety of factors must be considered while planning a mapping operation. A first-order decision is whether the flight will be autonomously controlled between GPS waypoints or manually controlled. In any instance, prior to liftoff, it is critical to examine the area to be mapped. Before the mission begins, the location should be toured, driven about, or otherwise examined to detect potential hazards such as electrical lines, huge trees, sensitive regions, or other potential problems. Lastly, using current satellite images to plan a trip before takeoff is an excellent idea. Several factors influence whether to utilize manual or autonomous control, but arguably the most crucial is to distinguish clearly between real-time inspection or monitoring of events or situations and gathering information to generate a static record like a map or a 3D model once the flight is over. Both types of missions can be flown in either mode, or in a hybrid of the two; however, manual control is generally more useful

When attempting to fly in a systematic manner to produce a map, autonomous control is often more useful. Although the majority of UAV mappers use autonomous control, some pilots fly their missions entirely manually, relying on their own talent and judgement rather than the computer's. Even if they want to use their UAV mostly for autonomous missions, pilots must be capable of flying it appropriately. UAVs should stay inside the pilots' visual line of sight unless they have proper competence, a specific need, or regulatory permission. If the autonomous system fails, the pilot should be able to take manual control or engage an appropriate fail-safe, such as an emergency parachute, to maintain flight. Commercially available autopilots currently lack advanced sense-and-avoid features and can only fly from one predefined waypoint to another. (But, algorithmic sense-and-avoidance skills are increasing.) Some who opt to fly their missions manually, in whole or in part, claim that this is due to the fact that software for autonomous flying is not always trustworthy under all conditions. GPS interference, inclement weather, or a simple mechanical fault can all cause the UAV to act unpredictably. Manual flight advocates also point out that it is simpler to fly a UAV manually in particularly tight and unexpected environments, such as beneath forest canopy or in congested metropolitan areas, because manual control allows for faster adjustments in course and altitude. Supporters of autopilots believe that using one is safer since it reduces the possibility of human error as well as radio interference interfering with the link between a manual controller on the ground and the drone. Some countries require UAV operators to maintain manual control at all times in the event of a software breakdown or other issue. Before flying, it is necessary to research the limits in your desired operating area.

4.2 DESIGNING A FLIGHT ROUTE

A. ALTITUDE

Aircraft route planning is a critical component of UAV mapping. This is frequently performed via software packages; many drone manufacturers provide proprietary software with their drones. Mission Planner, an open-source software tool, is the most common alternative. Several competitor software programmes offer characteristics that are basically equivalent. UAV mapping flights are frequently flown in a certain pattern of parallel lines known as "transects," which are connected to a number of "waypoints"—imagine a connect-the-dots pattern of parallel lines, or the lawn-mowing pattern. Altitude is a significant problem while flying a mapping UAV, both for practical reasons and in the interest of flying safely and legally. Although increased altitude leads in lesser resolution, it allows the UAV to fly more distant tracks. Higher-altitude photography can also assist to lessen distortion in photos of buildings and other ground-based things. Lower-altitude photography enhances the GSD and consequently the image quality, but it also increases the time necessary to map a specific region. Other from method trade-offs, legality is the most important factor to consider while deciding on an operating height. Flying beyond 500 feet (400 feet in some situations) or 150 meters is forbidden in several nations.

B. SENSOR

Drone map makers use several cameras to fulfil their tasks. Most UAV mapping cameras are lightweight and may be programmed to take photos at predetermined intervals or operated remotely. Specialized electronics that may be installed on a UAV include LIDAR (light detection and ranging) sensors, infrared cameras with thermal imaging capabilities, and air-sampling sensors. The cameras required for precise mapping are not usually the same as those used in professional cinema or photography. Wide-angle lens cameras, such as the GoPro, are extremely popular for recording and photographs. Yet, these lenses cause distortion that is inappropriate for mapping work and must be eliminated in post-processing, suggesting that they are unsuited for this sort of work. The same concerns about fisheye apply to proprietary cameras used in some commercial UAVs, such as the DJI Phantom Vision and Vision+ product lines. Because of their inbuilt GPS capabilities, Canon's lightweight S100 and SX260 models are highly popular for UAV mapping. These may be used in conjunction with the Canon Hack Development Kit, which allows you to programme the camera to shoot images at predetermined intervals, based on distance, or upon reaching a predefined waypoint. There are several methods for mounting the camera on the drone. Because drone mapping is often conducted at only one or two angles, gimbals may be simpler than those used by filmmakers. Image stabilization is provided by motorized gimbals, which can assist correct for turbulence and generate sharper pictures. Gimbals are also utilized to change the camera's angle from vertical (straight down) to oblique.

C.VIEW

The two aerial views most commonly used in UAV mapping are nadir (overhead) and oblique. Nadir photographs are shot from directly above the subject, with the camera facing down. This is the most typical viewpoint associated with a traditional map. Oblique photos are ones that are taken at an angle to the subject below, as opposed to directly overhead. They can be captured from a high or low perspective, providing information about the topography that above photographs cannot, and vice versa. Photogrammetry software (such as Agi soft Photos can or Pix4D31) may merge photos taken from these two distinct angles to create images that allows users to see and modify various views in a single computer-generated model. Among other things, such three-dimensional models may be utilized for post-disaster damage assessment, realistic urban modelling, and developing more accurate flood simulations. The camera angle should not change throughout each trip, as this will make the subsequent photographs much more difficult to analyses.

4.3 GEOREFERENCE AND GPS

Georeferencing is necessary if you want your UAV map to be true to scale. The process of supplying geographical coordinates to data that is spatial in nature but lacks a clear geographic coordinate system can be characterized as geo referencing. While it is possible to create maps without employing georeferencing, these maps do not relate to reality and cannot be used for measurement. Geo referenced UAV maps are also much easier to work with since they can be overlaid on top of existing coordinates in software, as seen in the image. Georeferencing is almost always included in professional UAV mapping efforts.

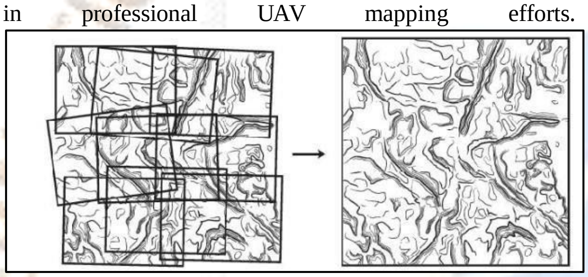


FIGURE:6 - Several images are combined into a single orthomosiac image by processing software, which may then be geometrically rectified and modified to comply to a real-world coordinate system (geo referenced)

The image processing programme must know the real-world GPS coordinates of a limited number of visually visible sites in the gathered aerial data in order to carry out the georeferencing procedure. In the context of UAV mapping, these coordinates are referred to as "ground control points," and knowing how to gather them and why is a crucial element of comprehending the process. It is critical to establish the level of precision required for each task, as both overdoing it and underdoing it might have major consequences. The same GPS chip used for navigation is utilized by GPS recorders, such the Flytrex Core 2 Flight Tracker, to record longitude, latitude, and altitude values during flight. The data collected may be used to create georeferenced maps. Certain digital cameras, such as the Canon S100, can track the GPS location of where each image was recorded, generating data that may later be used to geo reference the image using processing software—though the positional precision is not as good as with ground control points.

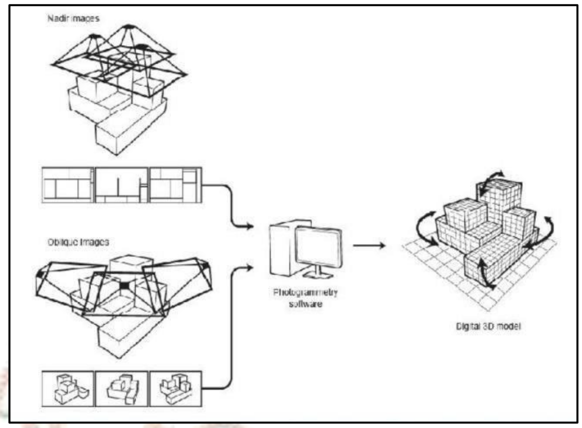
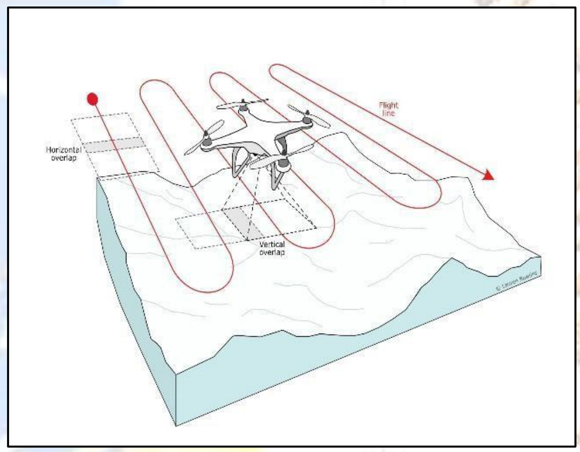


FIGURE:7- Photogrammetry software combines information from multiple images taken from both overhead and to the side to create 3D models.

4.4 PROCESSING SOFTWARE

"Creating photographs is not the same as having a map," argues Humanitarian OpenStreetMap Project UAV mapper



Cristiano Giovando, and he's right. To create a map, the photos must be processed on a computer. Your budget, available processing power, and goals all play a role in deciding on a software package. The processing software used for UAV mapping varies, and the industry is growing as UAVs gain popularity. As of this writing, the two most common paid aerial imaging and photogrammetry processing alternatives are Pix4D and Agisoft PhotoScan, both of which have relatively simple user interfaces and clear instructions, as well as an established track record of use for professional aerial mapping applications. These packages are continually updated and enhanced as the need for UAV mapping and the market for photogrammetry software grows. Nevertheless, paid photogrammetry software is expensive and might take a lot of processing power to run, so it should be incorporated into mapping expenditures. Open-source software, such as MapKnitter from Public Lab, OpenDroneMap, and Visual Software from Motion, is another option for aerial images post-processing.

5. ALGORITHM

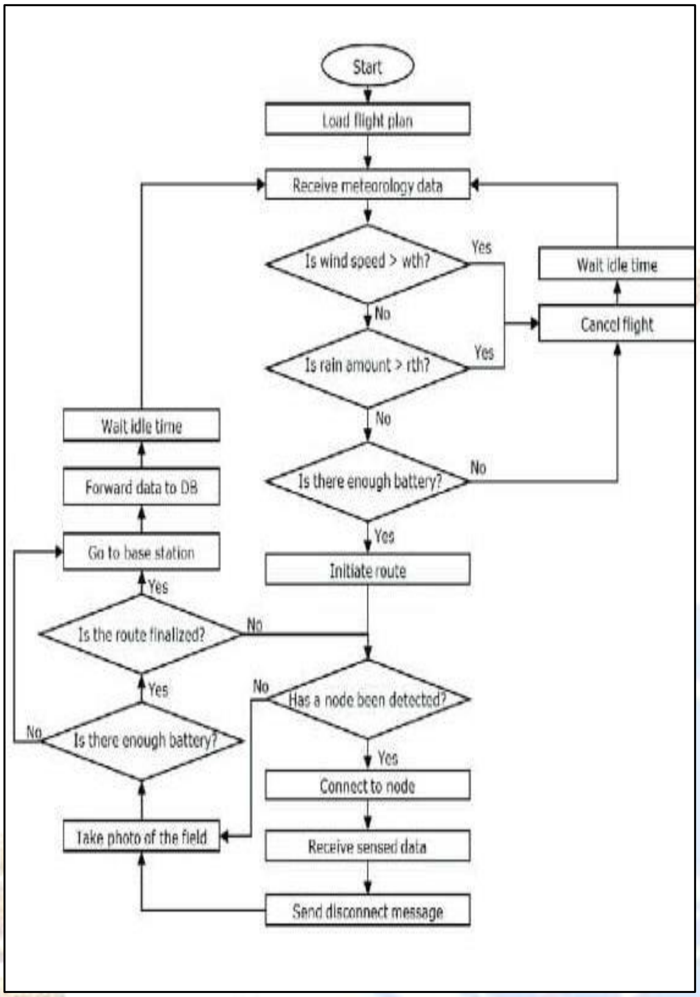


FIGURE:8- Algorithm of drone

Figure 8 depicts the working algorithm of the drone. Then, the drone uploads the flight route, which may be created using existing flight plan design tools while taking crop requirements into consideration. Upon setup, the drone requests weather data from the weather station. The flight is aborted if the wind speed exceeds the threshold value (with), and the drone waits for the next planned trip. The amount of rain is determined if the wind speed is correct. The flight is also cancelled if the threshold value (rth) is surpassed. If everything is in order, the drone checks the amount of energy available. If there is enough energy left in the drone, it will resume its trek through the fields. The quadcopter then checks to see whether any nodes are requesting a connection. If there is no node with which to connect, a The field is photographed, and the available energy is re-evaluated. When a node is discovered, a connection is established, and data is transmitted to the drone. After the drone receives all of the data, it sends a disconnect message to the node, signaling that the connection has been severed and that the node should enter sleep mode and not attempt to connect to the drone for the time provided in the settings. This eliminates any interferences caused by other nodes put in fields within the Appl. Sci. 2020,10, 6668 12 coverage regions of 23drone. Although interferences among nodes for the configurations of node coverages for orchards of fruit-bearing trees, as envisaged in this scenario, would only be attainable with a node density of 1 node per 60 m2. The drone then takes another oblique photo of the field and looks for another node. When the path has been determined, the drone returns to the base station and transmits the data to a remote database for further analysis. The drone then waits at the station until the next scheduled flying time arrives.

Each sensor's data is unique, and as previously said, it must be sent to a remote location where the data center is placed. Due to the limitations of the deployed network, which has limited processing and storage capacity, limited power availability, and a short time interval for communication between the node and the drone, we examine a system composed of soil monitoring nodes. These remote sensing drones collect video and images of the fields and data from the nodes, the node's base station, which contains a gateway to transport the data to a remote site, and the data center, which is located at a faraway place and where the data is stored and processed.

CONCLUSION

By combining AI techniques like as machine learning and computer vision, engineers will be able to construct drones that are far smarter and more autonomous than anything on the market now. This will allow you to

1. Gathering flight data from a drone pilot

2. Algorithm for Supervised Learning

Drones are outfitted with a slew of sensors that can capture massive amounts of data. This data may be used to build a supervised learning system to automatically fly the drone.Overall, utilizing artificial intelligence to operate drones offers various advantages. It can assist in avoiding obstructions, increasing flying efficiency, and saving time and money.

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REFERENCES

1. H. Sedjelmaci, S. M. Senouci and N. Ansari, "A Hierarchical Detection and Response System to Enhance Security Against Lethal Cyber-Attacks in UAV Networks," in IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 48, no. 9, pp. 1594-1606, Sept. 2018, doi: 10.1109/TSMC.2017.2681698.
2. H. Kim, L. Mokdad and J. Ben-Othman, "Designing UAV Surveillance Frameworks for Smart City and Extensive Ocean with Differential Perspectives," in IEEE Communications Magazine, vol. 56, no. 4, pp. 98-104, April 2018, doi: 10.1109/MCOM.2018.1700444.
3. S. Ross et al., "Learning monocular reactive UAV control in cluttered natural environments," 2013 IEEE International Conference on Robotics and Automation, Karlsruhe, Germany, 2013, pp. 1765-1772, doi: 10.1109/ICRA.2013.6630809.
4. J. Tiemann and C. Wietfeld, "Scalable and precise multi-UAV indoor navigation using TDOA-based UWB localization," 2017 International Conference on Indoor Positioning and Indoor Navigation (IPIN), Sapporo, Japan, 2017, pp. 1-7, doi: 10.1109/IPIN.2017.8115937.
5. C. Hui, C. Yousheng and W. W. Shing, "Trajectory tracking and formation flight of autonomous UAVs in GPS-denied environments using onboard sensing," Proceedings of 2014 IEEE Chinese Guidance, Navigation and Control Conference, Yantai, China, 2014, pp. 2639-2645, doi: 10.1109/CGNCC.2014.7007585.
6. M. H. M. Ghazali and W. Rahiman, "Vibration-Based Fault Detection in Drone Using Artificial Intelligence," in IEEE Sensors Journal, vol. 22, no. 9, pp. 8439-8448, 1 May1, 2022, doi: 10.1109/JSEN.2022.3163401.
7. J. Kim, S. Kim, J. Jeong, H. Kim, J. Park and T. Kim, "CBDN: Cloud-Based Drone Navigation for Efficient Battery Charging in Drone Networks," in IEEE Transactions on Intelligent Transportation Systems, vol. 20, no. 11, pp. 4174-4191, Nov. 2019, doi: 10.1109/TITS.2018.2883058.
8. V. Hassija et al., "Fast, Reliable, and Secure Drone Communication: A Comprehensive Survey," in IEEE Communications Surveys & Tutorials, vol. 23, no. 4, pp. 2802-2832, Fourthquarter 2021, doi: 10.1109/COMST.2021.3097916.
9. C. Pu, A. Wall, K. -K. R. Choo, I. Ahmed and S. Lim, "A Lightweight and Privacy-Preserving Mutual Authentication and Key Agreement Protocol for Internet of Drones Environment," in IEEE Internet of Things Journal, vol. 9, no. 12, pp. 9918-9933, 15 June15, 2022, doi: 10.1109/JIOT.2022.3163367.
10. T. Huynh-The, Q. -V. Pham, T. -V. Nguyen, D. B. D. Costa and D. -S. Kim, "RF-UAVNet: High-Performance Convolutional Network for RF-Based Drone Surveillance Systems," in IEEE Access, vol. 10, pp. 49696-49707, 2022, doi: 10.1109/ACCESS.2022.3172787.
11. H. Kim, J. Ben-Othman, L. Mokdad, J. Son and C. Li, "Research Challenges and Security Threats to AI-Driven 5G Virtual Emotion Applications Using Autonomous Vehicles, Drones, and Smart Devices," in IEEE Network, vol. 34, no. 6, pp. 288-294, November/December 2020, doi: 10.1109/MNET.011.2000245.

12. M. A. Arshad et al., "Drone Navigation Using Region and Edge Exploitation-Based Deep CNN," in IEEE Access, vol. 10, pp. 95441-95450, 2022, doi: 10.1109/ACCESS.2022.3204876.
13. D. Hernández, J. -C. Cano, F. Silla, C. T. Calafate and J. M. Cecilia, "AI-Enabled Autonomous Drones for Fast Climate Change Crisis Assessment," in IEEE Internet of Things Journal, vol. 9, no. 10, pp. 7286-7297, 15 May15, 2022, doi: 10.1109/JIOT.2021.3098379.
14. Safa et al.A, "A Low-Complexity Radar Detector Outperforming OS-CFAR for Indoor Drone Obstacle Avoidance," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 14, pp. 9162-9175, 2021, doi: 10.1109/JSTARS.2021.3107686.
15. S. Sawadsitang, D. Niyato, P. S. Tan, P. Wang and S. Nutanong, "Shipper Cooperation in Stochastic Drone Delivery: A Dynamic Bayesian Game Approach," in IEEE Transactions on Vehicular Technology, vol. 70, no. 8, pp. 7437-7452, Aug. 2021, doi: 10.1109/T