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(Review Article)

Use of drone technology in animal health and management

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Abstract

In recent years, drone technology has become an important tool in animal health and management. In this study, the use of drone technology in animal health and management is analyzed and prominent applications are discussed. Drones have been observed to be useful in various fields such as monitoring the health status of animals, early diagnosis of diseases, monitoring grazing areas, search and rescue, animal census and inventory management. However, some challenges and limitations still need to be overcome for the effective application of drone technology. In conclusion, although the positive effects of drone technology on animal health and management are evident, further steps are needed to expand the application areas and to fully utilize the potential of the technology.

Keywords: Drone technology; Animal health; Animal management; Animal search and rescue

1. Introduction

Unmanned aerial vehicles (UAVs) are flying robots that can range from the size of an insect to the size of an aircraft and are described by many different terms such as drone, UAV, UAV System, and Remotely Piloted Aircraft System. Except for certain technical specifications, the terms drone and UAV refer to the same system, and small UAVs are often referred to as drones. A drone is an unmanned aerial vehicle and a flying robot. Air vehicles that do not carry a human operator are considered to be vehicles that are controlled by remote control by a pilot on the ground or fly autonomously and carry lethal or non-lethal payloads [1, 2, 3].

The increase in the hardware diversity and capacities of UAVs due to technological developments makes them indispensable for military, civilian and commercial uses [4, 5]. The lack of a pilot operating UAVs in the air eliminates the risk of human loss. On the other hand, UAVs are capable of low-cost operations, long-term flight and surveillance activities, and vertical take-off and landing [6].

By installing payloads on UAVs; plate detection systems, face recognition systems, infrared cameras, motion and speed detectors, sensors equipped with 3D video operating systems, weapons, chemical receivers (thermometer, hydrometer, altimeter) can be installed. It can overcome obstacles such as walls and smoke, a wi-fi breaker can be added, and it can detect nuclear and chemical explosives [4]. In addition, search and rescue, fire, earthquake, floods, such as natural disasters such as fire, earthquake, natural disasters, such as determining the scene of the incident and delivering aid, in the seas, in order to prevent environmental pollution in rural areas, to carry out environmental cleaning activities, to deliver emergency medicine, to intervene quickly and effectively without getting stuck in transport problems such as traffic, fisheries, UAVs are used in hobby activities such as nature photography and wildlife observation, for the protection of species in danger of extinction, to detect and prevent poaching, to share the data obtained with the relevant

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units, and to ensure security in organizations such as rallies, concerts and open-air meetings with wide participation. For this reason, many countries around the world are adopting and using UAV technology.

UAVs are classified according to their technical characteristics, intended use and flight range/altitude. The classifications proposed by the European UAV Association (EUROUVS) provide four main categories including micro/mini, tactical, strategic and special purpose UAVs, as well as parameters [7]. Bento [7] also proposed four main categories as micro/mini, tactical, strategic and special purpose UAVs. These categories are categorized according to flight altitude, maximum flight weight, flight duration and data transmission range. Civil UAVs are generally classified according to their wing types and are divided into three main groups as fixed wing, rotary wing and hybrid types [8].

When classifications by wing type are considered, fixed-wing UAVs are as widely used as rotary-wing UAVs. Fixed-wing UAVs generally have a simpler airframe design and longer flight times than rotary-wing UAVs. In addition, since they can benefit more from aerodynamic principles (gliding) and have a high payload carrying capacity, they are frequently preferred especially in photogrammetry studies [9].

Fixed-wing UAV models have some operational problems such as the need for a runway for landing and take-off, the necessity of a parachute system, problems with hovering, insufficient sudden maneuvering capabilities, camera angles are generally unidirectional, and gimbal problems. However, they have advantages in terms of flight time, payload capacity and adaptability to harsh weather conditions [8]. The advantage of rotary wing aircraft is that they can take off and land vertically and hover in the air. However, they have disadvantages such as low flight speed, short range and hover time [9]. Since aircraft combining vertical and horizontal flight are suitable in terms of flight stability, energy efficiency and controllability, the design of double rotary-rotor and four rotary-rotor vehicles is preferred [10].

With the increasing use of drones, countries are updating regulatory frameworks and establishing legislation in this area to ensure safe and orderly drone use. Drone regulations generally include five key elements: flight restrictions, pilot license requirements, drone registration, radio frequency compatibility and insurance requirements. These rules are generally applied to ensure user safety and regulate air traffic. They differ depending on the conditions and needs of the countries. They are also updated regularly, considering technological developments and changes in the industry.

2. Drone Components and Payload Types

In the drone design or purchase process, several important factors must be considered in order to make a choice that suits the user's needs. Among these factors, the selection of materials and processing procedures suitable for the intended use of the drone are at the forefront. Lightweight yet durable materials are generally preferred in the design of aircraft. In addition, flight duration should be determined according to the user's expectations; camera selection should be orientated towards high resolution and special shooting needs. While flight modes offer the user a variety of control options, ease of use and durability ensure that the drone is long-lasting and reliable. Furthermore, spare parts availability improves the user experience by facilitating repair and maintenance processes. As a result, taking these factors into account ensures that the drone meets the user's expectations in the best way [11].

The main components of drones are Frame, Motors, Propellers, Electronic Speed Control (ESC), Flight Controller, Battery and Transmitter and Receiver, whose features are described below [12]. *Frame:* It is the main structure in which all other parts are integrated. Usually made of lightweight and durable materials, the frame contains other components such as rotors, battery, cards and camera. *Motors:* The motors used to control the height of the drone, usually rotate clockwise and anti-clockwise, providing spatial movements of the drone. *Propellers:* The propellers, which provide the movement of the drone by taking the power from the motors, depend on factors such as the shape, size and number of propellers for the speed and lifting capacity of the drone. *Electronic Speed Control (ESC):* ESC is used to connect the battery to the electric motor. It controls the engine speed and adjusts during flight. It converts the signal from the flight control unit into engine revolutions. *Flight Controller:* It is a computer processor that manages balance and telecommunication controls using different transmitters. It is a control unit that provides the stability and steering capabilities of the drone. It is equipped with an accelerometer, barometer, magnetometer, gyrometer, GPS and other sensors. *Battery:* It represents the drone's power source and lithium polymer (LiPo) batteries are generally preferred. *Transmitter and Receiver:* These are devices that allow the user to control the drone remotely.

Drones are equipped with various types of cameras and sensors for different types of missions. These sensors include the following [11]: *RGB sensors* are commonly used in visual sensing, providing imaging in standard colors. *Near infrared sensors* collect information in the light band range to which the human eye is less sensitive, used in plant health and agricultural applications. *Multispectral sensors* are used in agriculture and environmental monitoring applications by measuring the light of vegetation at different wavelengths. *Hyper spectral* sensors are sensors that determine the spectral characteristics of objects in detail and measure a wide range of the electromagnetic spectrum. *Thermal sensors* create heat maps by showing the temperature differences of objects and are used in areas such as search and rescue, security and monitoring of energy facilities. *LIDAR (Light Detection and Ranging) sensors* create environmental maps using laser beams and are used in 3D mapping and distance measurements. *Synthetic Aperture Radar* (SAR) sensors use radar waves to create high-resolution maps of obstacles to visibility. Furthermore, sensors integrated into drones include atmospheric sensors (temperature, pressure, wind, humidity), chemical sensors, geolocation sensors (GPS), audio sensors (microphone) and many more. This wide range of sensors allows customization of drones for agriculture, mapping, security, search and rescue and many other applications.

3. Drone Technology in Animal Health and Management

Today, rapidly developing technology brings various innovations in the field of veterinary medicine. One of these innovations is the use of drone technology in veterinary applications. Drones offer a wide range of new possibilities by making animal health and management more effective and efficient. From animal counting to monitoring and emergency response, from zoonotic disease monitoring to habitat improvement, the integration of drones allows veterinarians to take important steps in faster diagnosis, more effective treatment and farm management. This emerging technology is playing an important role in the future of veterinary medicine by taking both animal health and farm operations to a higher level.

The use of UAVs in wildlife research plays an important role in data collection processes. However, there is a situation highlighted by Duporge et al. [13] that the use of this technology is prohibited in the national parks of many countries due to concerns of disturbing wildlife. Christie et al. [14] stated that the use of UAVs in wildlife research is limited by flight range, regulatory frameworks and lack of verification. In this case, it is suggested that more studies and regulations are needed for the effective use of UAVs. Also, Christie et al. [14] stated that regulatory laws and technological infrastructure have not kept pace with the rapid increase in the use of UAVs. However, it was suggested that increasing demand could make UAVs more accessible and effective analytical tools. Despite their potential advantages, the use of UAVs in wildlife research involves regulatory and ethical challenges. On the other hand, Ezat et al. [15], in a study conducted to determine the Nile crocodile population in South Africa, stated that UAVs are an alternative to the problems of high cost and observer bias. The research shows that data obtained using UAVs has the potential to identify crocodile populations compared to traditional ground surveys. This finding suggests that UAVs can be used effectively in wildlife surveys and that this technology can improve management actions. Similarly, a study by Zabel et al. [16] evaluated the accuracy of UAVs and thermal infrared cameras in counting red deer populations. The study revealed that factors such as season, flight altitude and temperature affect the accuracy of the UAV. These results suggest that UAVs have the potential to provide accurate population counts, but it is important to consider various factors. The concerns raised by Duporge et al. [13] emphasize the ethical use of UAV technology. However, research by Ezat et al. [15] and Zabel et al. [16] shows that UAVs have potential for accurate population counts and more effective monitoring of wildlife. Therefore, harmonization of regulatory frameworks and ethical guidelines for the use of UAVs in the future may lead to more widespread use of this technology in wildlife research.

Some errors may occur in inventory studies conducted with UAVs. These errors can arise from four main sources: availability of animals, poor detection, difficulties in recognition and double counting [17]. In addition, a problem such as overcounting may arise due to misidentification of species [18]. One of the most important disadvantages of wildlife inventory studies with UAVs is that they are prone to undercounting [19]. Undercounting can be caused by factors such as light conditions, animal movements, size and color. In addition, factors such as detectability, vehicle height and search flight speed can also affect [20].

UAVs require the use of sensor technologies such as electro-optical and thermal infrared (TIR) imaging due to their lack of onboard observers and flight cameras. In particular, the use of sensor technologies such as electro-optical and thermal infrared imaging is important to improve animal detectability [21, 22]. However, the quality of TIR images should be carefully assessed as it can be influenced by various factors.

Recently, UAVs have become an important tool for conservation management due to their potential to wildlife monitoring techniques [23, 24, 25]. So, UAVs have been used effectively in applications such as monitoring the surface of certain habitats and conducting animal population counts, as well as in anti-poaching programs [26, 27].

UAVs offer a new opportunity in wildlife research with their advantages such as low cost, safe flight capabilities and usefulness for surveying sensitive species. However, disadvantages such as flight time limitations, weather conditions, potential impacts on animal behavior and social concerns should also be considered [24, 28, 29]. The use of this technology allows the development of more effective and sustainable strategies for conservation management.

However, sensor technologies and various factors need to be carefully considered to obtain accurate and reliable data. UAVs will continue to be an important inventory and monitoring tool in future research for wildlife conservation and sustainable management.

Rietz et al. [30] evaluated the potential of infrared technology for the detection of animal carcasses. In their study on African swine fever, they used drone-based thermal cameras to locate 42 carcasses in different stages of decomposition. They concluded that the thermal camera accurately measured carcass temperature and that environmental factors influenced the probability of detection. They concluded that the use of thermal cameras was particularly effective in open habitats with temperature conditions favorable to maggot development and that this technology could be used as a potential tool for the detection of wild boar carcasses. These findings point to the potential for developing a new and effective tool for the control of animal carcasses and prevention of disease spread.

UAVs are playing an increasingly important role in the agriculture and livestock sectors. As reported by Kuru et al. [31], UAV-supported smart agriculture applications contribute to the effective management of large farms. The high mobility, autonomy, sensor technologies and artificial intelligence integration of UAVs offer the advantages of providing instant information to farmers and reducing costs.

Cattle counting in large livestock areas is a challenging process, time-consuming and stressful for farm workers. UAVs, in combination with the proposed approach, improve herd assessments and farm management by automating cattle counting. The study by De Lima Weber et al. [32], using Convolutional Neural Networks and YOLOv4, YOLOv5 models resulted in high accuracy in cattle counting and suggested the use of larger data sets by considering various factors.

High resolution imagery acquired by UAVs has the potential to be used in the development of computerized vision systems for the effective management of cattle herds. These technological advances enable individual identification of animals on farms, enabling better monitoring of the health status and behavior of herds.

The EU-funded SPADE project aims to create a Smart Ecosystem using UAVs to provide sustainable digital services to various end-users in sectors such as agriculture, forestry and livestock farming [33]. Studies such as the M100 UAV platform designed by Andrew et al. [34], emphasize the use of UAVs for the development of sustainable digital services and automated monitoring of livestock in various sectors. Furthermore, the use of UAVs in animal grazing processes is highlighted by studies such as the smart grazing ecosystem designed by Cao et al. [35] and Mufford et al. [36] using UAVs to measure spatial proximity. These applications show that UAVs can be used effectively to direct herds to desired locations and monitor the behavior of individual animals.

As also reported by Kuru et al. [31], shows that UAVs can play a key role in the future of agriculture and this technology can provide great advantages to farmers in farm management and animal tracking. The instant information provided by UAVs can increase productivity and support the sustainability of farms. However, more work needs to be done in future research, such as using larger data sets, considering various weather conditions, and evaluating various animal species.

As stated in Qureshi et al. [37], the use of drones has significant advantages in the healthcare sector. In particular, the potential of drones to shorten travel time in diagnosis and treatment processes emerges as an important force to improve healthcare services in hard-to-reach areas. This technology offers an effective alternative in critical areas such as the rapid transport of emergency medical supplies and the transport of medical samples from hard-to-reach areas to laboratories. In addition, medical drones can also play an important role in emergency response for the rapid transport of medicines used, which can prevent losses in situations where timely intervention is vital. Therefore, medical drones have significant transformational potential by increasing accessibility and reducing travel times in healthcare.

Poljak and Šterbenc's [38], study addresses the potential of drones in healthcare by reviewing the literature in the field of infectious diseases and microbiology. Based on data from PubMed and reliable online sources, the study reveals that drones can be successfully used in healthcare services such as sample transport, drug delivery and surveillance of infectious diseases and have great potential in this field. However, they face some challenges such as national airspace regulations, legal barriers and social acceptance.

Fornace et al. [39] demonstrated the use of drones to characterize changing patterns of terrain and deforestation affecting the zoonotic spread of malaria parasites in Malaysia. In another case study, Barasona et al. [40] used drones to monitor the spatial distribution of large mammals carrying tuberculosis in southern Spain. Recently, researchers have used drones with nucleic acid analysis modules to detect Staphylococcus aureus and Ebola virus [41].

The study by Griffith et al. [42] investigated the potential for drones to deliver RVF vaccines in Rwanda, in a context where livestock vaccination to combat Rift Valley Fever (RVF) has become ineffective due to constraints in the vaccine supply chain. The research assessed the potential advantages of drones in the delivery of RVF vaccines, concluding that the use of drones could improve RVF vaccination. Participants indicated that the use of drones has potential benefits such as reduced transport time, improved cold chain maintenance and cost savings. These findings suggest that drones could be an effective tool for vaccine delivery and address constraints in the vaccine supply chain.

The study by Flemons et al. [43], highlighted the potential of remotely controlled aircraft systems, or drones, to eliminate geographical barriers, increase timely delivery and improve access to health supplies, equipment and remote care. Assessing the suitability of drones for the delivery of supplies, medical equipment and treatment, the study successfully tested in various scenarios and demonstrated that drone-based medical delivery models offer an innovative solution to issues related to healthcare access and equity.

In a study focusing on the potential uses of UAVs for the control of zoonotic diseases, it was noted that serious public health problems such as echinococcosis could be controlled by UAVs. For example, a pilot trial in the Qinghai-Tibetan Plateau targeting wild animals by distributing praziquantel-containing baits via UAVs was concluded to be a cost-effective and efficient approach [44].

The foot and mouth disease (FMD) outbreak in 2001 had a devastating impact on the agricultural industry and animal welfare in the UK. The outbreak led to the spread of FMD, which is considered an exotic disease in the country, and was contained by the slaughter of millions of animals. Researchers trying to quickly detect diseases with innovative methods such as drones and thermal imaging technology. These technologies can potentially be used to reduce disease-related costs by providing early warnings by determining the health status of animals. Machine learning and thermal imaging techniques can be effective tools for monitoring animal health and detecting potential diseases. Applications of these technologies in agriculture and animal health can play an important role in disease control and improving animal welfare [45].

In recent years, the use of drones in search and rescue operations has increased. Drones have been used effectively in the detection of missing persons in steep terrains and high altitudes. In addition, drone technology combined with deep learning and image processing techniques have made search and rescue operations more effective. However, there are also challenges such as legal restrictions and weather conditions. However, continuously developed technologies enable drones to be used more effectively in search and rescue operations [46].

4. Conclusion

In conclusion, drone technology is emerging as an effective tool in animal health and management. It offers a wide range of new possibilities in veterinary practice, from animal health management to emergency response. From animal census to monitoring and emergency response, from zoonotic disease monitoring to habitat improvement, the integration of drones enables veterinarians to make significant strides in faster diagnosis, more effective treatment and farm management. This new technology will play an important role in veterinary medicine in the future, taking both animal health and farm operations to higher levels.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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