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Eye of the farmer in the sky: Drones

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ABSTRACT

Mankind develops new technics and technologies constantly to have a better life. In this way, powerful machines and robotic systems replace human and animal labour in agriculture. Animal husbandry, which is a part of agricultural activity in our country, is mostly carried out in rural areas due to its nature. Goat breeding, in particular, is carried out in highlands, scrub and forest lands and under extensive conditions. Qualified shepherd employment is an important handicap in sheep and goat breeding. Agricultural enterprises are also faced with a manpower deficit due to the decrease in the rural population. Remote sensing systems have been developed and used for about 100 years to support and enhance agricultural activities. In this study, the importance of unmanned aerial vehicles in terms of animal husbandry is mentioned and it is emphasized that they should be taken into consideration in future agricultural projections.

Çiftçinin Gökteki Gözü: Drone

Anahtar Kelimeler
Hassas tarım,
Tarım 5.0,
İnsansız hava aracı,
Çiftlik yönetimi.

ÖZ

İnsanoğlu, daha iyi bir yaşama sahip olmak için sürekli olarak yeni teknikler ve teknolojiler geliştirmektedir. Böylelikle güçlü makineler ve robotik sistemler, tarımda insan ve hayvan işgücünün yerini almaktadır. Ülkemizde tarımsal faaliyetin bir parçası olan hayvancılık, doğası gereği daha çok kırsal kesimde yapılmaktadır. Küçükbaş hayvan yetiştiriciliği özellikle yaylalarda, maki ve ormanlık alanlarda ve geniş koşullarda yapılmaktadır. Koyun ve keçi yetiştiriciliğinde nitelikli çoban istihdamı önemli bir sorundur. Tarımsal işletmelerde kırsal nüfusun azalması nedeniyle insan gücü açığı ile karşı karşıyadır. Uzaktan algılama sistemleri, tarımsal faaliyetleri desteklemek ve iyileştirmek için 1930'lardan beri geliştirilmiş ve kullanılmaktadır. Bu çalışmada insansız hava araçlarının hayvancılık açısından öneminden bahsedilmiş ve gelecekteki tarımsal projeksiyonlarda dikkate alınması hususu vurgulanmıştır.

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1. INTRODUCTION

Satellites have been scanning fields since 1930s, collecting data such as spectral reflection and temperature, and reporting to farmers. Crop health and water consumption of the plant can be understood through this information (Kulbacki et al., 2018).

Unmanned aerial vehicles (UAV) have been used in many areas in recent years. UAV is an aircraft that uses aerodynamic forces to hold a non-pilot vehicle in the air and is flown by an external pilot, either pre-programmed or by ground command (Xiang & Tian, 2011; Albani et al., 2017; Gonzalez-de Santos et al., 2017; de Castro et al., 2018).

Drones, which were previously invented and developed for hobby purposes, have become effective in many areas via the equipment such as cameras and sensors they carry, today. These vehicles are also used for gathering information and locating, have become indispensable for the defence industry. The use of drones was not limited to these areas, but also managed to enter other areas of life. The use of drones in agriculture is on the rise in disaster risk reduction (Luo et al., 2019), early warning systems (Ju et al., 2018; Hunt, 2014), crop production (Reinecke and Prinsloo, 2017, Söffker, 2019), fishing (Harris et al., 2019), forestry and wildlife protection (Chrétien and 2015; Aydemir, 2019). Drone technology provides a hi-tech transformation to the agricultural industry via real-time data collection such as soil and field analysis (Kulbacki, 2018), planting (Malamiri, 2021), crop spraying (Gonzalez-de-Santos, 2017), crop monitoring (Lottes, 2017), irrigation (Abbas et al., 2019), yield estimation and planning (Banhazi et al., 2009), and strategy based on processing (Alsalam et al., 2017).

These remote-controlled vehicles are among the tools preferred by ecologists for the analysis, evaluation and preparation of reports of the situation in the ecosystem. Although environmental activities are carried out with experts, they are one step ahead with the advantage of making fewer mistakes and being faster (Van Henten et al., 2002, Slaughter et al., 2008, Xiang & Tian, 2011; Xue et al., 2017, Alsalam et al., 2017, Albani et al., 2017; Lottes et al., 2017; Gonzalez-de Santos et al., 2017, de Castro et al., 2018).

Unmanned aerial vehicles came into use for agricultural purposes under the leadership of Japan in the 80s. Many countries including the USA, UK, China and New Zealand has adapted this technology afterwards, particularly in precision farming and herd management practices (Hunt et al., 2014; Tripicchio et al., 2015; Beloev, 2016; Hogan et al., 2017; Zhang et al., 2019). During these periods, drones and tractors were optimized by the integration of a GPS navigation system and obtained data for product management strategies (Wathes et al., 2008; Bramley, 2009).

Precision livestock management could be defined as an activity that uses engineering principles and technologies more effectively in animal farming (Frost et al., 1997; Wathes et al., 2008; Berckmans, 2008; Banhazi & Black, 2009). The systems used in this technology enables monitoring individual and group behaviours, the emergence of diseases, reproductive activities in the herd and measuring variations between individuals and animal groups over time.

UAVs, equipped with advanced sensors, can capture high resolution spatial and temporal images with the Internet of Things (IoT) based detection systems. Various types of sensors are available for UAVs, depending on product parameters (Lagkas et al., 2018). Sensors can be diversified according to the payload and requirements of the drone. The main criteria here are weight, energy consumption and size.

2. DRONES

Four main UAV types, according to the classification for wing and propeller structures, are fixed-wing, single rotor, multiple rotor and hybrid. Evaluations for cost, power source, and base material could carry out for each class. However, vertical landing and take-off, durability and payload capacities are also important for animal husbandry purposes. Therefore, here is drone technology has been taken into consideration.

2.1. Drone Technology

2.1.1. Hardware

A drone consists of a support structure, body, battery, rotors, sensors and a control board.

Communication can be established between the animal and the UAV with an RFID or a sensor box placed on the animal. The sensor box mostly contains a GPS module, sensor (e.g. 9-axis sensor), memory card (e.g. microSD), microchip and a communication protocol (e.g. SPI) and a battery (Krajnik et al., 2011).

2.1.2. Software

Drone software not only provides communication but also helps the pilot to perform manoeuvres (Krajnik et al., 2011).

2.2. Pros of UAVs

Limited restrictions: An unmanned aircraft can move independently of physical constraints such as roads, paths or obstacles.

Shorter travel distance: The shortest distance between two points is a line. Similarly, UAVs can move linearly between two points. This movement pattern of course depends on the wing/rotor type of the drone.

Use in the dark: Compared to vehicles controlled by humans, autonomous UAVs can fly at default routes, even at near-zero visibility, such as in pitch darkness or thick fog.

Saving on time and labour: All activities such as counting, monitoring and gathering animals require extra labour and time.

Cost: Costs also decrease as a result of the reduced labour.

Aerial photography: Farmers will be able to get a bird's eye view of the desired area using drones.

2.3. Cons And Proposed Solutions

Weather dependency: Environmental factors such as strong winds, fog and rain can affect the use of drones. Moreover, raptors, trees, power lines are other obstacles that adversely affect or even block the flight of drones. A drone totters in the wind, cannot get a clear image. Simple measures can help to eliminate these obstacles. Otherwise, if a dropped drone becomes unusable or cannot be found in dense bushes, it will result in financial losses.

Battery: Battery technology limits the flight time of the drone. However, battery charging may not be available in the field. This will create a serious problem in day-long observations and herd management. One of the first measures to be taken in these cases is to have a spare battery. In addition, an appropriate solar panel with battery charger or solar panels placed on the drone can help overcome this problem.

Pilot errors: Using drones requires some skill and expertise. Moreover, knowledge of hardware is also required.

Legal permit and authorization for flight: In Turkey, a drone license is issued by the General Directorate of Civil Aviation and these activities are carried out under legal instructions like other countries (Tsiamis et al., 2019). However, no legal instructions and legislations are available for the use of drones in rural areas for animal husbandry. Legal regulations on this subject should be prepared as soon as possible.

Drone prices: The prices of drones are at a level that can bring serious costs to small businesses. Particularly high-quality sensors and cameras and additional equipment increase the costs even more. For high-income businesses, it is a profitable investment with a high initial cost. Including regions within the scope of investment and making them attractive with grants or other supports will solve the problem so that businesses at every level can benefit.

Spare part and Service: Service facilities in many agricultural tools and equipment are available on a regional basis. Drone spare parts and service networks, which are a new technology and are becoming widespread, will also expand depending on the need. Customer services can help to solve basic problems in the first place.

Flight distance: Flight time and distance of a drone are limited due to the battery and low signalling characteristics. These problems will hopefully be prevented shortly with the developing battery technology. Moreover, drones will be able to fly in wider areas with satellite connection. In this way, the farmer will be able to fly more comfortably and safely from high ground.

Ethics and privacy: Although animal husbandry is commonly carried out in rural areas, people may feel uncomfortable with a drone flying over. However, as flight safety can be violated by jammers, such devices are also open to pirate attacks.

Payload: Depending on the rotor type, a drone's payload can vary and the amount of that payload directly affects the battery life and therefore the flight distance. The payload capacity also depends on the sensors and processing technologies mounted on the drone.

Farmer's bias: Technology bias will appear as an obstacle to the integration of drones into agricultural activities.

Connectivity: Goat breeding is common in areas where wi-fi connection is weak or even not available at all. This situation also increases costs for the farmer.

Data processing efficiency: The software is of great importance in terms of data processing efficiency at all stages from planning the flight route to photo processing. Since UAV technology is a newly developing technology, efficient technologies in terms of data collection and processing should be developed.

2.4. Sensors to be attached to UAS

2.4.1. Cameras

Visible Light Sensors (RGB): These are the most popular sensors used in agricultural practices. RGB sensors generate real colour using the base components (red, green and blue) of the spectrum (Barbedo & Koenigkan 2018; Maddikunta et al. 2020).

Thermal: It is a type of camera that detects changes in temperature using a long-wavelength infrared band and have much lower spatial resolution than other sensor types. Their general purpose is to locate living things as they have a higher temperature than their environment. Therefore, advantage of thermal cameras is that they can be used especially at night to detect farm animals or wild animals (Chabot et al., 2015; Linchant et al., 2015; Longmore et al., 2017; Miller et al., 2017; Witczuk et al., 2018).

Multispectral: These sensors capture images as bands at specific wavelengths in the infrared region (mostly vegetation) along with RGB bands and even thermal band (animals) and could be optimized with NDVI (Normalized Difference Vegetation Index) so it will be possible to identify and count animals. (Terletzky et al., 2012). This type of sensors has lower spatial resolution than RGB ones (Chabot & Bird 2015).

Hyperspectral: Hyperspectral sensors capture images at a higher spectral resolution than multispectral sensors, at a certain wavelength range. This type of sensors enables the determination of diseases, animal counting and identification of breeds (Barbedo & Koenigkan 2018; Maddikunta et al. 2020).

Video cameras: These type of sensors, which are easy to use, provide a single output file and more suitable for movement detection and tracking individuals. Counting animals requires the use of high-resolution sensors (Chabot & Bird, 2015; Fang et al., 2016).

LiDAR: This type of sensors can be defined as a combination of light and radar technologies and provides information about the surface structure and distance through the laser beams it sends on the object (van der Merwe et al., 2020).

Broadband colour-infrared: It is a modification of RGB sensors. This type of sensors isolate near-infrared light in a single channel and capture visible light in the two remaining channels (Van der Merwe et al., 2020).

3. UAS

Typically, a UAS consists of UAV for take-off with propulsion systems, GPS systems and hardware, and sensors and cameras.

3.1. Use of sensors and cameras in agriculture

Drones have served various purposes since the day they into our lives. Drones used for military purposes during the First World War also performed tasks such as tracking, espial and mapping. (Yeşilay & Macit, 2020). Depending on the developing technology, it serves in many areas of life today. With the increasing environmental awareness, studies in recent years focus on the protection of natural life (İsrail, 2011; Franke et al., 2012; Vermeulen et al., 2013; Mulero-Pa'zma´ny et al., 2014; Chabot & Bird, 2015; Lhoest et al., 2015; Linchant et al., 2015; Chre´tien et al., 2015-2016; Christie et al., 2016; Gonzalez et al., 2016; Witczuk et al., 2018). Aydemir (2019), stated that the sound of the drone induce hiding individuals to come visible and so make it easier to determine herd inventory. The researcher detected the safe approach distance with the drone as 30m and thermal cameras make it easier to locate wild goats. Therefore, accurate detection of population sizes will make it possible to plan sustainable wildlife hunting. Schroeder et al. (2020), reported that drones are more effective than humans in the behaviour and counting of Llamas. Brisson-Curadeau et al. (2017), stated that drones are more effective in the counting of sea birds. Bhusal et al. (2019), reported a 70-90% better classification rate for counting and identification of bird species. Hodgson et al. (2017), stated that drones are better than human in tracking natural life.

3.2. Use of Drones in Plant Production

Drones and robotic systems are used extensively for various purposes in agriculture in many countries of the world (Cortes et al., 2004, Hussein & Stipanovic, 2007; Pimenta et al., 2008, Cheng & Savkin, 2009; Schwager et al., 2009, Cheng & Savkin, 2011, Savkin et al., 2015, Ju & Son, 2018). Various reports on crop harvesting and detection of disease by using sensors mounted on drones and robots are available (Mohanty et al., 2016). Some researches are as follows;

Afonso et al. (2019), detected dickeya and pectobacterium pathogens on potatoes at a rate of 95% using a combination of an algorithm they built and an image processing technique.

Tripicchio et al. (2015) reported a way to determine soil layers and properties by an image processing algorithm they built. Majeed et al. (2019) found that the algorithm they developed on the image processing technique to solve the problems in green twig pruning in vineyards is faster and more effective than the work done by humans. Polder et al. (2019) reported that the video image processing technique they developed to detect the Tulip Break virus that damages tulips is more effective than humans. Abbas et al. (2019) found that the problems can be solved easily with the algorithm and image processing technique developed to detect the problems in irrigation channels. Mitsuashi et al. (2019), planned to use an algorithm developed in lettuce harvesting. As a result of the study, researchers reported a better detection of harvesting size in lettuce than human. Xie et al. (2019) determined the success of grading and classification according to the colour scale in carrots with the image processing technique as 96.67%. The image processing technique developed for the harvesting of products that have reached the appropriate size and colour in various plants can be safely used (Zapetony-Andersen & Lehnet 2019, Kennedy et al., 2019, Zhang et al., 2019). Söffker et al. (2019) determined that the image-processing model they developed to monitor vegetative growth and determine the water requirement in the corn plant can be applied safely.

All these researches prove that in almost every field of plant production, the cultivation and harvesting processes can be monitored or performed with camera and sensor systems mounted on drones or robots.

3.3. Use of drones in livestock production

New paradigms have been developed on drones to ensure sustainability, reduce labour force, increase farm productivity and quality, and make future predictions in modern enterprises, where more sensitive agriculture is practised. Producers can monitor their facilities digitally and evaluate the data they obtain more objectively using this technology. Drones can display and process terrain data with their geolocation features and high-resolution cameras. (Gnip et al., 2008; Reinecke & Prinsloo, 2017; O'Mahony et al., 2019; Malamari et al., 2021).

Various studies on the use of drones in animal husbandry such as counting, detection and management (Chamoso et al., 2014; Longmore et al., 2017; Jung & Ariyur, 2017), health control (Webb et al., 2017), grazing behaviour (Nyamuryekunge et al., 2016) are available. Beyond this, patents of this technology have been received (Horton & Vorpahl, 2017a, 2017b; Trumbull & Myrtle, 2017).

Qiao et al. (2019) conducted an identification study in cattle based on the face identification system. They reported that with the model developed as a result of this study, the cattle were successfully identified at a rate of 88-91%. Andrew et al. (2019) stated that with the software they developed, cattle grazing on the pasture could be identified biometrically. Barbedo & LV (2018), Barbedo et al. (2019 and 2020) and Rivos et al. (2019) reported that tracking and localization of the herd and individuals can be performed easily with cameras mounted on drones. Li & Xing (2019) stated that herd management can be performed with aid of cameras mounted on drones and artificial neural networks and image processing technologies. Jung & Ariyur (2017) rounded up a herd using noising devices mounted on drones.

Livestock farming is one of the most promising emerging markets for the drone industry. Regardless of the herd size or the geographical condition of the pasture, the mobility of the livestock can be safely monitored with drones, particularly in highlands. The daily activities of each animal can be followed through the sensors and RFID tags, attached to the animals. For example, this will enable early diagnosis of findings such as critical deviations from the animal's activity of the previous day, temperature change in the body, detection of sick or injured animals, and the possibility of a health problem in the animal.

Unmanned aerial vehicles not only save time but also increase property awareness. Although every farmer knows to produce in one way or another, they also continue traditional farming methods. Farmers generally do not do the economic analysis of the business and they may not have sufficient information about diseases. However, drone technology will enable precision agriculture and enable producers to access a large data pool that they can plan by analysing the factors that directly affect the business, such as economy, disease and weather. The investment cost of this technology may be high at first, but feedback would be much more profitable.

Agriculture is a sustainable resource. As a branch of agriculture, livestock breeding aims at the proper care and feeding of animals. The pasture animals go; herbs they eat, health protection, prevention of diseases, precautionary actions, processing and marketing of the products obtained are among the main functions of animal husbandry. However, shepherd's crises and rising costs can create problems in finding labour. In such cases, these problems will be avoided by using robots and drones. Considering that animals spend a long time in the fields, pastures, forest edges and rough terrain, it takes time and effort to track herds. Conventional monitoring methods are performed by humans based on the identification of animals with their natural characteristics. In addition, bushy and rough terrain may limit the shepherd's range of movement and observation. Such situations can cause an increase in labour with the risk of lost animals. Drones will be able to identify individuals geographically with tags attached to animals and so prevent damages. This observation of animals in the pasture using drones could be performed by different methods. If the herd is travelling to a point far from the shelter, the drone is carried by the shepherd and the observation may be done from high ground. If the herd is close to the shelter, an autonomous drone can track the herd throughout the day. Drones can detect the condition of pastures as well as tracking animals. Alternating grazing in large pastures may be possible in this way. In addition, it is possible to take herds to places where pastures are strong.

Drones' flight times and hardware technology are constantly being studied. Flight times and camera properties have been improved especially utilizing the recent successes in the defence industry. Programming drones will result in significant savings in labour and time on farms. Drones can fly and collect images within a specified route for this purpose. The location of each animal can be determined with the tags attached to the animals. Animal losses will be prevented in this way. Drones will be able to observe not only in pastures but also in paddocks. Drones can monitor the most common oestrous behaviours in cattle. This system can also be used to monitor chickens in free-range egg production and to eliminate external dangers.

3.4. Farm Security

Herd management can be performed with shepherd dogs, who are the assistant and guardian of the shepherd on a farm. In herds with a large number of animals, the number of dogs should also be higher. Although it is not an important issue, the housing of the shepherd dogs come with expenses. By detecting the unusual movements of animals in the pasture, drones can control external attacks and direct the herd by making noise. It can warn against security threats by making routine patrol flights over the farm. A consistent flow of information can be achieved with wide-angle views of the farm environment. Drones can also be used to detect trespassing predators and illegal activities. By identifying creatures around the farm, drones can help to investigate potential disturbances, shorten the response time and keep farm personnel safer.

4. RESULTS

Scientists, industrialists, technology experts and developers make serious investments and take steps to make people's lives easier. Robotic systems equipped with advanced technology are still being used in many branches of agriculture, which are the basis of human life. It will be possible/essential soon to expand this technology, which is built on certain frameworks, and to use it in all areas of agriculture in an integrated manner. Along with the increase in living standards, the ageing of the population engaged in agriculture and the difficulties in the labour, the use of drones in the field of animal husbandry, especially in rural areas, is important in terms of food, health protection and security measures. Drone technologies need to become more effective depending on the breeding system. Scientific studies should be carried out for the optimization of existing technology. While ensuring that the breeders receive the necessary training, courses such as smart agriculture, drone use and maintenance should be added to the curriculum at the institutions, faculties and colleges that provide agricultural education, and sufficient training should be made compulsory.

Author contributions

All authors contributed equally to the study.

Conflicts of interest

The author declare no conflicts of interest.

Statement of Research and Publication Ethics

The author declare that this study complies with Research and Publication Ethics

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