SCIENTIFIC REVIEW

PROPOSAL OF IT SOLUTION, LEGAL AND MANAGEMENT REGULATIONS FOR AGRICULTURE DRONES IMAGE PROCESSING

SPALEVIĆ Žaklina[1], MILANOVIĆ Bratislav[2], ILIĆ Miloš[3]

[1] Singidunum University, Danijelova 32, Belgrade (SERBIA)
[2] Faculty of Law, University of Pristina in Kosovska Mitrovica, Lole Ribara 29 (SERBIA)
[3]Faculty of Technical Sciences, University of Pristina in Kosovska Mitrovica, Kneza Milosa 7 (SERBIA)

E-mails: zspalevic@singidunum.ac.rs; bratislav.milanovic@pr.ac.rs; milos.ilic@pr.ac.rs

ABSTRACT

Traditional agriculture production needs to be improved in order to provide better results, better and healthier products. In the area of information and communication technologies different approaches, techniques, hardware and software tools could be implemented in agriculture production. UAV's aircrafts called drones are very popular these days. Their use can greatly contribute to the improvement of agricultural production. One of the main uses is to collect data by flying over agricultural land. In this way, the condition of crops on large areas can be recorded in a short time. The main task of the research was processing of images collected using drones over agriculture field. Drone usage, and recording of the land is regulated by regulations that are prescribed by civil aviation authorities. The use of drones can lead to unwanted legal consequences if people or objects whose filming is prohibited are found on the footage. Considering the importance of legal regulations in the field of civil aviation, a special place in this paper is dedicated to the legal regulations regulating the use of drones.

Keywords: *Agriculture images, Drones, Dehazing, Legal regulations, NDVI, Prediction, Video recording*

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INTRODUCTION

The widespread use of technology in both personal and professional settings has resulted in the integration of information and communication technologies and smart devices into almost every aspect of modern life. This includes the field of agriculture, which has seen an increase in hardware devices and software solutions used in daily operations. The implementation of technology in agriculture has given rise to precision agriculture, which is based on the collection and analysis of data to inform decision-making processes. With the use of software solutions, precision agriculture enables the prediction of optimal conditions for specific agricultural practices and facilitates the management of agricultural machinery. As a result, the agricultural production process has become more automated and precise [1].

The availability and use of small drones outside of the military industry has led to their commercial use in various areas of life and work, including agriculture. Drones could be used to capture footage over agricultural areas. Footages created on this way could be used by many different people. Observing these footages could provide information about physical condition of the agriculture crops. If the user wants to collect more precise information it will need to apply some of the image processing tools or algorithms. For this purpose, specialized software could be used. In the same time on of the limiting factors is the quality of the captured images or recorded video. Operators of such drones must adhere to legal regulations to avoid privacy violations and potential punishment [2].

The paper is organized as follows. The second chapter of the paper represents overview of the similar researches. Third chapter of the paper gives the overview of the currently used techniques for image processing that could be applied on images collected with the use of drones. The fourth chapter provides the list of main legal norms that are in use when we are toking about drone usage over agriculture land. In the conclusion part some of the main conclusions and ideas for future research are highlighted.

LITERATURE REVIEW

One research study focused on the use of drones and sensor technologies in agriculture as a key objective. In this paper, the authors emphasized the development of drones. They have specially processed drones designed for use in agriculture. The conducted studies aimed to highlight both the advantages and disadvantages of using drones and sensor-based technology in the agricultural production process [3]. Since it is necessary to process the obtained data from the images, the authors also presented different algorithms for pre-processing. According to the authors, the biggest challenge is to ensure the reliability of the data collected through this kind of processing [4]. The authors identified potential problems associated with using remote access sensor technologies and drones. The study found that the performance and capabilities of drones in agriculture have improved over the years, while their prices have decreased. Drones are particularly useful for obtaining data from difficult terrains. Combining sensor technologies with image processing from drones offers a new dimension to precision agriculture.

One of the studies observed aimed to conduct a comparison of various types of agricultural drones. In this research, the authors presented a list of different drones, providing details about their specific characteristics and potential applications for monitoring agricultural production. The study thoroughly analyzed the strengths and weaknesses of each drone, focusing on their technical specifications to assess their suitability for agricultural purposes. According to the authors' conclusion in [5], the utilization of drones in agricultural production can lead to easier agricultural management and enhanced crop quality. In another study, the authors explored the application of drones in gathering essential data for agricultural production. They initially traced the historical development of drones, starting from their military applications for espionage and warfare, to their present-day widespread adoption in various fields, including agriculture. The authors highlighted the advantages of using drones in agriculture, including soil analysis, crop monitoring, sowing process monitoring, chemical protection, irrigation, and drainage. Furthermore, the authors highlighted that drones have versatile applications in various industries such as healthcare, transportation, and local governments [6]. However, they acknowledged that the data collected by drones in agricultural contexts can be intricate and memory-intensive, necessitating the use of specialized algorithms to present the information in a comprehensible manner for farmers. To handle the high-resolution images and sensor data obtained from drones, the authors suggested the possibility of using cloud storage. Additionally, specialized software can be employed to process the data, enabling tasks like

generating terrain maps and identifying specific areas where agro-technical measures need to be implemented. The authors highlighted that these generated maps have practical applications in agricultural equipment and machinery, allowing for targeted pesticide application and other precision farming practices. In this context, GPS technology plays a pivotal role by connecting drones to satellites for accurate location tracking. The most common areas where drones find applications in agriculture are field crops such as wheat, legumes, and sugar beet. The authors underlined that the benefits of utilizing drones in agriculture include the ability for real-time monitoring of crops and the capability for quick response times in implementing appropriate agricultural measures [7].

One study presented a new method to determine the location of soil samples using high-resolution images from drones. The approach relies on creating land maps based on the images captured by the drones. The researchers found it interesting that the maps are generated using drone images. In their experiment, they used drones to take pictures of agricultural areas right after plowing, which allowed them to create maps based on variations in the land's structure. The study was conducted in southern Finland, and the results indicated that drones can successfully be used to create soil structure maps [8]. Crop monitoring using drones has the potential to generate sufficient data for analyzing the presence of plant diseases and pests on cultivated crops [9].

PROCESSING OF AGRICULTURE IMAGES COLLECTED WITH THE USE OF DRONES

Collecting data with the use of image processing is a challenge in the manner of accuracy. The use of drones to record agricultural areas also adds to the complexity of image processing due to weather and atmospheric conditions that can affect the visibility of the images. To address this, a software solution based on a set of methods has been proposed to obtain accurate information from the images [10].

To evaluate the proposed solution, agricultural areas were surveyed and the obtained images were processed for the development of a system to recognize and predict the occurrence of diseases and pests and the appropriate time for agrotechnical and chemical measures. The first set of methods involves removing fog, shadows, and other noise from the images, which is necessary to obtain a significant number of high-resolution images for the task [11]. After noise removal, the images are compressed to reduce memory space usage without losing relevant information. Finally, image processing is performed to extract relevant information for agricultural production.

DEHAZE REDUCING

Dehazing methods play a crucial role in enhancing image quality by eliminating the presence of haze. These techniques find widespread application in image processing and computer vision tasks. In scenarios where atmospheric conditions like fog, gloomy weather, or light reflections deteriorate image quality, the haze model can be employed to generate clearer images. The haze model operates on the principle of altering the positions of pixels in the image through a linear transformation. Particles in the atmosphere, ranging from 1 to 10μm in size, have a significant impact on image quality. Haze is caused by a combination of external light and direct attenuation, leading to decreased visibility. Dehazing methods can vary in their application, depending on whether they are applied to a single image or multiple images simultaneously. These methods serve as valuable tools to combat the adverse effects of atmospheric conditions and improve the visual clarity of images. Overall, dehasing methods play an important role in improving the quality of images affected by atmospheric conditions [12]. Different dehasing methods are shown on Fig. 1.

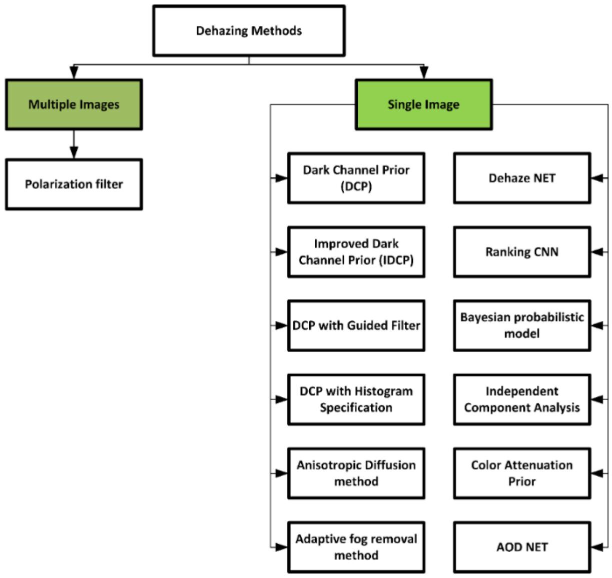

Figure 1. *Different dehazing methods*

Polarization filtering is a technique employed to eliminate haze from images, but it necessitates multiple input images of the same scene captured during distinct weather conditions. The scattered light resulting from atmospheric particles that align with the direct light reaching the camera is referred to as airlight. However, relying solely on polarization filtering cannot entirely eliminate the presence of airlight. The input image in this approach comprises two unknown components: the scene radiance in the absence of fog and the airlight.

By leveraging polarization filtering and appropriately adjusting the orientation of the polarization filter, the contrast of a single input image can be enhanced. This process aids in reducing the impact of haze, leading to an improvement in the visual quality of the image. However, it's important to note that complete removal of airlight may require additional techniques or information beyond polarization filtering alone. The polarization filter is able to determine the haze content of the image, which can then be eliminated to obtain a clearer image. One advantage of this method is that it can be applied at any time, regardless of weather conditions. However, it still requires multiple input images, which can be a limitation in certain situations. As can be seen from Figure 1, the number of single-image dehazing methods is bigger than dehazing methods that are implemented in order to work with multiple images on the input. The list of different dehazing methods shown on the Figure is not final. If we observe and compare the methods that can be used on images obtained by recording agricultural areas, the following methods stand out.

The DCP method is a popular single image dehazing technique and is particularly effective in improving the quality of images of agricultural land obtained from drones. This method incorporates the concept of dark channels, which refers to pixels in an image with low intensities in at least one of the color channels. The Dark Channel Prior (DCP) technique involves four key steps: atmospheric light estimation, transmission map estimation, transmission map refinement, and image reconstruction. In the first step, the method estimates the amount of atmospheric light present in the hazy image. Atmospheric light refers to the light that is directly scattered by atmospheric particles and reaches the camera without being affected by the scene radiance. Accurate estimation of atmospheric light is essential for further dehazing the image effectively. The second step involves estimating the transmission map, which represents the proportion of light that is transmitted through the atmosphere. The third step refines the transmission map by considering edge information in the image. Finally, in the fourth step, the image is reconstructed using the refined transmission map to obtain a clear image. Overall, the DCP method is an effective approach for enhancing the quality of images obtained from drones in agricultural applications [13].

The Dark Channel Prior (DCP) method relies on identifying so-called "black pixels" in an image, which are characterized by having very low values in at least one-color channel. However, an exception to this rule exists when observing an image of an outdoor environment, particularly in regions where the sky is present. The image processing using the DCP technique involves four sequential steps that each image must undergo. The first step entails estimating the amount of atmospheric light present in the hazy image. The second step focuses on assessing the transmission map, which describes the degree of haze in different

parts of the image. The third step involves refining the created transmission map to improve its accuracy. Finally, the fourth step is the image reconstruction, which yields the dehazed output image. Representing the mentioned four steps mathematically, starting from the equation of the initial image, can be done as follows [13]:

$$R^{dark} = R^c)$$
$$\hat{T} = 1 - \omega(I^c/L^c)$$
$$R^{dark} \to (R^c(y))$$
$$\hat{T} = 1 - \omega(\frac{I^c(y)}{L^c}))$$
$$R = \frac{I - L}{max\ (T, t_0)}$$

R - scene radiance of the image; R^{dark} – dark channel; c- colour channels; T - quantity of light; Ω – patch size; T– Transmission map; I – Input image; L^c - Channel-wise atmospheric light;

Before using the DCP method, it is essential to ensure that the image to be processed does not include any bright and white objects. In case there are any such objects in the image, the effectiveness of the DCP method may be compromised, leading to suboptimal results. The drawback associated with using the DCP method on such images is that it may generate undesired artifacts. [14]. Based on the above statement, it can be inferred that the DCP method heavily relies on external lighting conditions, and thus an improved prior could result in better outcomes. In the domain of image processing and transmission map creation, two key parameters are of significant importance: structural and statistical features. Neural networks, specifically those based on artificial intelligence, can be utilized to acquire knowledge from the data extracted from the images. Among these networks, Convolutional Neural Networks (CNN) have demonstrated considerable success in evaluating structural features in images. Structural features refer to the spatial arrangement and patterns present in the image, such as edges, corners, and shapes. CNNs are adept at learning and detecting such structural characteristics, making them effective for tasks like object recognition and image segmentation. On the other hand, statistical features encompass pixel-level statistics, color distributions, and texture patterns in an image. Capturing and understanding statistical features is crucial for tasks like image denoising, deblurring, and dehazing. However, CNNs have shown limitations in handling statistical features, as they primarily rely on convolutional layers that excel in learning local and hierarchical structural features.

To address this limitation and leverage the power of neural networks in capturing both structural and statistical features, researchers have explored the use of hybrid architectures. These architectures combine traditional CNNs with additional modules, such as recurrent neural networks (RNNs) or attention mechanisms, to better capture global contextual information and long-range dependencies in images. Such hybrid models aim to enhance the network's ability to handle statistical features and, in turn, improve performance in various image processing tasks that require a comprehensive understanding of both types of features. To account for both types of features, a method called ranking layer is often used in CNN image processing. This method allows for the integration of both structural and statistical features in the creation of the CNN. The ranking layer works by taking map features into consideration during processing and can produce maps of certain sizes and clarity. In input data processing, the ranking layer replaces the order in the input folder. Comparing the calculation of statistical features between CNN and ranking layer, CNN requires more convolutional filters, while only one is needed with the ranking layer. This is why the ranking layer has been added to CNN, allowing for pixel-based estimates. To increase performance in the system, a random forest generator can be utilized [15].

SINGULAR VALUE DECOMPOSITION (SVD)

Singular Value Decomposition (SVD) is a useful tool for various digital image processing problems, particularly in the area of compressing images of agricultural areas. Images captured from both aerial and ground sources tend to have high resolutions, which require a lot of memory to store. Storing a large number of such images over time to create a database can become quite challenging. Image compression reduces the amount of memory required and simplifies the processing and use of these images. To do this,

each selected image can be represented as a matrix of pixel values, which is a mathematical approach. In grayscale images, each pixel has a gray scale number between black and white, while color images have three numbers. Image compression aims to decrease the data needed to represent a digital image effectively. SVD (Singular Value Decomposition) is utilized to transform the image data, but it doesn't directly compress the image itself. Instead, SVD arranges the data in a way that the most crucial image information is captured in the first singular value. Consequently, only a small subset of singular values is required to represent the image with minimal deviations from the original version.

Decomposition of matrix A to the $U\Sigma V^T$ product represents an approximation of the matrix A using much smaller values compared to the original matrix.

$$A=\sigma_1 u_1 v_1^T+\sigma_2 u_2 v_2^T+...+\sigma_r u_r v_r^T+0u_{r+1}v_{r+1}^T+...$$

Since singular values are always positive, adding elements that are dependent and have singular values of zero does not change the image. Ultimately, we end up with an equation that includes these elements:

$$A=\sigma_1 u_1 v_1^T+\sigma_2 u_2 v_2^T+...+\sigma_r u_r v_r^T$$

Additionally, the matrix that is obtained can be simplified by removing the singular members of matrix A. Since the singular values are arranged in descending order, the final members have less impact on the resulting image. This process helps in reducing the memory space required to store the newly created image. The most similar matrix of rank k can be obtained by truncating those sums after the first k terms:

$$A=\sigma_1 u_1 v_1^T+\sigma_2 u_2 v_2^T+...+\sigma_k u_k v_k^T$$

If we observe the compression ratio, it can be calculated as in:

$$R=\frac{nk+k+mk}{nm}*100$$

The compression percentage is denoted by R, and k represents the chosen rank for truncation. The number of rows and columns in the image are denoted by m and n, respectively. To illustrate the calculation of the compression coefficient and the size of the compressed image, a representative image taken with a drone over a field is used. The original image has a resolution of 3840 x 2160, which amounts to 8294400 pixels in the uncompressed image. The value of k is set to 20, which can be interpreted as the number of iterations. The resulting equation would be similar to the following:

$$A=\sigma_1 u_1 v_1^T+\sigma_2 u_2 v_2^T+...+\sigma_{20} u_{20} v_{20}^T$$

Using the value of k = 20, the number of singular values used in the SVD transformation, we can calculate the number of components in each vector ui and vi. Each ui contains 648 components, each vi contains 480 components, and each σi represents 1 component. If we denote the compressed image with NK, the number of pixels of the compressed image can be calculated as follows:

$$N_k=20*(3840+2160+1)=120020$$

The compression ratio of image can be calculated as follows:

$$R=\frac{2160*20+20+3840*20}{2160*3840}*100=1.45\%$$

In conclusion, the experiment showed that after 20 iterations, the compressed image size was reduced to 1.45% while maintaining a reasonable image quality. However, for better visual quality, 150 iterations were used, resulting in a compressed image that took up 10.85% of the original size. Compared to the compressed image obtained with 20 iterations, the one with 150 iterations looked much better with more sharpness and details while still taking up a small storage space [17]. The original image required 5.43MB of storage space, while the compressed images required only 888KB to 1.35MB, depending on the number of singular values used in the compression.

NDVI

In the next phase after the pre-processing, specific information about crops on agricultural land can be obtained. This can be achieved using Normalized Difference Vegetation Index (NDVI) maps [15]. NDVI maps are based on the NDVI index, which calculates the difference between the intensities of reflected light at two different frequencies.

$$NDVI = \frac{(NIR - VIS)}{NIR + VIS}$$

The two frequencies used in the NDVI index are the visible part of the spectrum (400-700 nm) and the infrared part (700-1300 nm). In the process of photosynthesis, healthy plants absorb most of the visible spectrum while reflecting a large amount of the infrared spectrum. Vegetation in weaker condition and scattered areas reflect more of the visible spectrum and less of the infrared. The NDVI index values for each pixel range from -1 to +1, indicating the level of vegetation present [16].

This means that the NDVI index values are close to zero if there are no green leaves on the surface, while values close to +1 (0.8-0.9) indicate a high presence of green leaves in plants. To account for different natural factors that can affect the NDVI index value, the index can be calibrated using various factors such as SAVI and EVI [15]. Calibration can provide more accurate analysis of different vegetation-biophysical parameters using remote sensing data obtained from a drone [17]. To increase the accuracy and reliability of the NDVI index, it is becoming common practice to correct it with several factors such as the NNI index, which requires knowledge of the actual and critical concentration of oxygen in plants, and the RI index, which involves feeding the NDVI calibration tape with recommended doses of nutrients based on basic chemical analysis of the land [18].

LEGAL REGULATIONS FOR THE USE OF AGRICULTURE DRONES

Aviation regulations can pose a constraint on the usage of unmanned aerial vehicles, including drones, in various fields, such as agriculture. These regulations are often not very stringent in many countries, such as Germany, where drones weighing less than 5kg and flying within 1.5 km of the take-off location or outside inhabited areas do not require special permission [20]. However, in the United States, special approval is needed for each take-off, and the operator must hold a pilot license for certain types of drones. Canada has similar regulations, with oral approval required from air traffic control in the flight area, and operators needing to undergo training for each flight. Insurance coverage for accidents is also required as part of the permit to operate drones [21]. These regulations often impose restrictions, such as maintaining line of sight with the operator and a maximum flight altitude of 120m in Canada, despite the minimal flight altitude for drones being 640m according to their technical specifications [22].

In the Republic of Serbia, "according to Article 8 of the Convention on International Civil Aviation (Chicago Convention), any unmanned aircraft capable of flight without a pilot must obtain special approval before crossing the territory of the Republic of Serbia, or vice versa". However, drones may be used for economic, scientific, educational, sports, and other purposes as long as they do not pose a threat to air traffic safety [23]. The person who operates a drone is responsible for any potential damages that may result from its use. The Rules regarding unmanned aerial vehicles state: "that only drones with an operating mass of less than 0.5 kg, a speed below 20 m/s, and a maximum flight length of 15 m and height of 10 m can operate on the territory of the Republic of Serbia without any permits. Drones that exceed these limitations are classified into four categories based on their technical characteristics, and each category has its own set of approvals and permits that the person operating the drone must obtain in order to manage it" [24].

In the Republic of Serbia, according to the Rules about unmanned aerial vehicles, the use of drones without a permit is only allowed for aircraft with an operating mass less than 0.5 kg, a maximum flight length of 15 m, maximum height of 10 m, and a speed not exceeding 20 m/s. Other drones are divided into four categories and require specific approvals and permits for operation. Drones in all categories can only be operated during the day and must be in sight at all times of the person operating them. The maximum height of flight is limited to 100 m above the ground, and the maximum horizontal distance from the operator is 500 m. Drones with an operating mass exceeding 150 kg and those whose flight is controlled entirely by a computer located in the aircraft are not allowed to be operated without approval from the Civil Aviation Directorate. Article 12 of the ordinance states that only medically fit adults who have passed

the subject knowledge test on aviation regulations can operate drones used for economic purposes, as well as category 2, 3, and 4 drones. The person responsible for any damage resulting from the use of a drone is the operator of the drone. [25]. According to Article 15 of the Rulebook, the person operating a drone aircraft must have the manufacturer's instructions for using the drone and a certified copy of the approval from the Directorate for that specific aircraft, as well as the act of acceptance of the statement on qualification and a certificate of passing the knowledge test. In order to maintain accurate records of drone aircraft in the Republic of Serbia, all unmanned aircraft used for commercial purposes, as well as unmanned aircraft of categories 2, 3, and 4 used for non-commercial purposes, must be registered in the Aircraft Register. [26].

The process of collecting data through aerial recording of agricultural production areas for the purpose of assessing crop condition and making decisions on agro-technical measures may involve capturing footage of public and private facilities, public figures, and other individuals. [27]. It is important to note that laws and regulations related to photography and filming can vary depending on the jurisdiction and specific circumstances. In general, however, it is considered a violation of privacy to make unauthorized recordings of individuals in situations where they have a reasonable expectation of privacy, such as in their own homes or in private facilities. On the other hand, if individuals are in a public place or performing a public function, such as in the case of public figures or officials, they may have a reduced expectation of privacy. It is always advisable to consult the relevant laws and regulations and obtain any necessary permissions or consent before engaging in any photography or filming activities. “The act of making an unauthorized recording of a person through photography, film, video, or other means, which significantly invades their personal life, can result in a fine or imprisonment for up to one year, as stated in Article 144 of the Criminal Code of Serbia. It is worth noting that this law only pertains to the invasion of privacy of natural persons and does not include public buildings and areas. The Decree of the Government of the Republic of Serbia on determining security protection of certain persons and facilities ("Official Gazette of RS", No. 72/2010) partially addresses this issue and primarily deals with security protection and which institutions and services are responsible for its implementation”.

Regarding this matter, it is possible for a particular service to require the implementation of a measure or action to prevent the protection of a protected object, based on this regulation. If necessary, the competent public utility service, in relation to photography, may put up signs indicating that photography or recording is prohibited. Only then can a security officer enforce the ban and act according to the security plan and their authorized powers [28]. Another important aspect of this topic is the lack of clarity regarding the potential sanctions for such actions. There is no specific penalty mentioned for this particular act, leaving it unclear how to handle it. As a result, it can be concluded that it may not be considered a misdemeanor or a criminal offense, but rather a basis for further investigation and potential actions [29]. Several authors have suggested that individuals who record and capture footage of facilities or individuals in addition to agricultural production areas could face legal consequences under Article 143 of the Criminal Code which pertains to unauthorized wiretapping and recording, and Article 145 of the Criminal Code of the Republic of Serbia which pertains to the unauthorized publication and display of another person's image or recording. The obtained recordings may be further processed and distributed by multiple parties, hence warranting legal implications. “The act of wiretapping and audio recording (143 Kz) violates an individual's right to privacy and protection of that right. A person who records or eavesdrops on a conversation without the knowledge or consent of the person being recorded or eavesdropped on commits this offense and may be subject to a fine or imprisonment for a term of 3 months to 3 years. Paragraph 2 of the same article allows the person whose conversation was recorded without authorization to gain access to such recording” [29]. The legal practice demonstrates that the most effective approach to dealing with the recorded materials is to process them by removing any identifiable faces or objects that may cause legal issues for the person who recorded them. [30]. When making recordings, the main goal is not to capture people's faces or objects, but it's possible to accidentally record them. To avoid legal consequences, it's advisable to remove those parts of the recording. However, if there's a sign prohibiting filming or if someone in charge of a facility warns against recording, filming should be halted. In such cases, a permit should be obtained for surveying the agricultural area, ensuring that acquired facilities are not included in the survey [31].

CONCLUSION

The incorporation of new technologies in agriculture, particularly information and communication technologies (ICT), has significantly enhanced agricultural production. One of the primary contributions of these technologies is the ability to monitor agricultural areas and the crops cultivated within them. This monitoring aspect plays a crucial role in optimizing agricultural practices, improving resource management, and maximizing crop yields. The data collected through ICT solutions enables farmers and agricultural stakeholders to make informed decisions, implement precision farming techniques, and address challenges such as pests, diseases, and resource constraints more effectively. Overall, the integration of new technologies in agriculture has revolutionized the way farming is conducted, leading to increased efficiency, sustainability, and productivity. Data collection is the first step in the monitoring process and is used to draw conclusions about further agro-technical measures that need to be taken. Drones are a popular tool used to collect data by capturing images of production areas that can be processed to obtain the necessary information. Indeed, images captured by drones over agricultural areas can be affected by various factors such as adverse weather conditions, light reflections, and other atmospheric interferences. These issues often lead to blurry or degraded image quality. However, researchers and engineers have proposed and developed effective methods of image processing to address these challenges and improve the quality of drone-captured images. Post-processing techniques, such as image dehazing, denoising, and image enhancement algorithms, have been applied to rectify the captured images. These methods help to remove haze, reduce noise, and enhance image details, resulting in clearer and more visually appealing images. By utilizing advanced image processing algorithms, the agricultural community can benefit from higher-quality drone-captured images. This, in turn, enables better monitoring and analysis of crops, soil health, and other vital agricultural parameters. The improved image quality enhances the accuracy and reliability of data obtained from drone surveys, contributing to more informed decision-making and more effective agricultural management practices. However, the use of drones in agriculture may be limited by legislation, especially in areas near public or restricted facilities. Violations of privacy and distribution of recordings to third parties are specifically sanctioned by the law, so recordings must be processed to eliminate disputed areas or objects before being used.

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