IMAGE PROCESSING COMING FROM AGRICULTURAL DRONES – IT SOLUTIONS, LEGAL OBSTACLES

Žaklina Spalević[1],
Aleksandra Stojnev Ilić[2],
Miloš Ilić[3]*,
Petar Spalević[4]

[1]Singidunum Univesity,
Belgrade, Serba

[2]Faculty of Electronic engineering,
Niš, Serbia

[3]Academy of Professional studies
South Serbia,
Department of Agricultural and
Food Studies Prokuplje,
Prokuplje, Serbia

[4]Faculty of Technical sciences,
University of Priština,
Kosovska Mitrovica, Serbia

Abstract:

The problem we tried to solve is related to directing agricultural production towards the active use of information and communication technologies. Specific research is based on the use of small drones in order to record agricultural plantations. Observed from the point of view of the application of information and communication technologies in agriculture, drones can serve as a good tool for collecting information on the condition of agricultural areas or the condition of crops in them, all without leaving the traditional tour of the observed areas. This solution brings benefits in reducing costs and benefits in terms of reducing the time required to tour large agricultural areas. When surveying agricultural land, both public buildings and buildings of national importance are often photographed, which can lead to legal problems. The aim of this paper is to focus on two areas of research. The first area refers to methods of processing images and video material obtained from drones, while the second area refers to legal regulations that must be followed and legal regulations that may be a limiting factor in the use of such devices.

Keywords:

Agricultural Drones, Image Processing, Video Processing, Legal acts.

INTRODUCTION

The application of information and communication technologies in agriculture has become increasingly important in recent years and has led to something known as controlled production or precision agriculture. Different definitions for precision agriculture can very often be found in the literature. The basic principles of precision agriculture are reflected in the creation of a set of data that will be used in the later processing process to create examples for predictive models. The application of information and communication technologies in precision agriculture aims to facilitate and make the process of agricultural production more precise [1]. This domain includes systems for collecting data from the field, creation of soil maps, decision making based on data collected from different sources, and at the end the automation of as much as possible agricultural production processes [1].

Correspondence:
Miloš Ilić

e-mail:
milos.ilic@pr.ac.rs

DOI: 10.15308/Sinteza-2022-191-198

Many companies around the world use drones extensively to survey agricultural land in order to gather information on crop status. Footage obtained by flying over agricultural areas can at least be used to obtain general information on the condition of agricultural land or the condition of crops sown or planted in a given area. Such information can be obtained by simply viewing videos by experts in agricultural production. Far more precise information on the condition of crops can be obtained by software processing of videos and digital photos obtained from drones. The process of processing video material and digital photos includes pre-processing and post-processing of the materials obtained in this way.

The ultimate goal is to create a set of data that will be sufficient to train machine learning algorithms in order to create a system capable of prediction and independent decision making. Basing agricultural production on such systems is becoming more common in countries around the world. The first steps in the application of such systems were within the institutes and research systems, while they are further developed towards agricultural producers. The basic application of drones in agricultural production is reflected in the collection of the necessary information from the field.

Depending on the type of drone in use and its equipment, the area it can capture in one flight will differ, and the quality of video material and digital photos. Depending on all the above, the further processing of the obtained materials will depend.

Due to the fact that the survey of production areas is most often performed according to a predefined pattern, it is not uncommon for drones to record more than the area in which the sown agricultural crops are located. In addition, in a significant number of cases, agricultural land is bordered by public or private land and facilities. It is for these reasons only filming or photographing can be considered a violation of privacy. In this regard, filming may be prohibited or even in the event that agricultural areas border the facilities where filming is punishable, persons that operate drones may be punished. In order for the entire process of using drones for the purpose of data collection to be legally legal, a set of legal norms has been defined, which regulates the use of such aircraft.

The goal of this paper is to present the two main tasks of conducted research. The first task is reflected in the possibility of processing the digital materials obtained from drones, all in order to process them and use the information obtained in order to improve agricultural production. The second task was to revise the legal norms that regulate the use of drones in general. In addition, the research also included legal norms related to offenses committed by surveying areas for which a ban on filming is prescribed.

The work is organized as follows. The second chapter provides an overview of relevant literature in the field of drone applications in agriculture, processing of digital video and photographic material, and literature related to legal regulations and legal practice of drone use. The third part of the paper presents the possibilities of using different dehazing algorithms, tools and image processing systems in order to process images obtained from unmanned aerial vehicles. The fourth part of the paper defines the legal norms that regulate the use of drones both in the world and in the Republic of Serbia and neighbouring countries.

2. LITERATURE REVIEW

In one of the researches, the authors set the application of drones and sensor technologies in agriculture as key goals. Namely, they gave an overview of the development of drones that can be used in agriculture. Emphasis is placed on drones that can provide adequate and reliable data that can be used in various applications intended for agriculture. They especially pointed out the advantages and disadvantages of using the observed drones, as well as sensor technologies. As a proposal for overcoming the problem, they mentioned various methods for data pre-processing. [2].

A similar study on a hybrid approach that combines sensor technology and drones is described in [3]. In this research, the authors relied on the definition of potential problems when using remote access sensor technologies and drones. Research has shown that over the years, the performance and capabilities offered by drones in agriculture have increased, while on the other hand, the price of these devices has fallen. The authors also concluded that drones are especially useful when it is necessary to obtain data from bad terrain. The application of sensor technologies in combination with the processing of the image obtained from drones offers a completely new dimension in precision agriculture. The authors cite the legal norms that define the management of unmanned aerial vehicles as a limiting factor for the general use of drones in agriculture.

The key goal of one of the observed studies is to compare different types of agricultural drones. The authors first listed different drones, their characteristics and possibilities of application for the needs of agricultural production monitoring. The advantages and disadvantages of each of these drones are given on the basis of technical specifications. The basic conclusion of the author is that the use of drones in agricultural production should enable easier agricultural production as well as better crop quality [4].

In one of the researches, the authors dealt with the use of drones in the process of collecting data needed in agricultural production. The authors first point out the path of development of drones from the military industry and the use the need for espionage and warfare to today's comprehensive use. In addition, to use in areas such as industry, health care system, use by local governments as well as in the process of transport control, the authors emphasize the special advantages of use in agricultural production. Areas of application of drones in agricultural production highlighted by the authors include soil analysis, monitoring the condition of crops in agricultural fields, monitoring the sowing process, chemical protection, irrigation, drainage, etc. The authors point out that the use of drones in agricultural production is possible from the moment of sowing until the harvest of crops from plantations. Data sets from drones can be very memory-intensive and complex, so special algorithms are used to present them to farmers in an understandable way [5]. As one of the ways of storing high-resolution images obtained from drones as well as data collected by sensors, the authors cite cloud storage, while for the processing process, they cite the use of specialized or other mechanisms by agricultural experts or farmers. These specialized software offer possibilities such as creating terrain maps, as well as displaying places where a specific agro-technical measure needs to be performed. As a special possibility, the authors state that once created, maps can be further inserted into agricultural equipment and machinery in order to, for example, apply a pestle on the part of the surface where it is needed. Connecting drones to satellites using GPS has a special role in this process. As some of the most common areas of application of drones in agriculture, the authors point out field crops such as wheat, legumes, sugar beet, etc. The main advantages of the use of drones in agriculture are reflected in the lack of monitoring and speed of response in the field of application of appropriate measures.

In one of the published researches, the authors presented a proposed approach that would determine the location of soil samples on the basis of high-resolution images obtained from drones. Determining the location is based on creating land maps. Also interesting is the fact that land maps are created based on images obtained from drones. Practically, the drone was used to record agricultural areas immediately after ploughing, which ensured that maps were created based on differences in the structure of the land. The entire research was practically realized in southern Finland. The results of the research show the successful application of drones in the process of creating soil structure maps [6].

Crop recording using drones can provide adequate data that can be used in the process of analyzing the existence of plant diseases and pests on sown crops. One of the researches is based on the use of drones in the process of determining the moment of occurrence of sugar beet disease. The research was practically realized in the fields of Tokat province. The observed disease was sugar beet leaf spot. The authors used different image processing algorithms in the research process. Practically, algorithms have been used to determine if there are changes to the list by comparing images of healthy leaves and images obtained from the field that could potentially be infected. In addition to the application of algorithms, and especially in the training process, the same confirmations were obtained from agricultural experts who performed traditional comparisons. The study included twelve images of different stages in the development of the disease. The mentioned images were obtained by painting the production surfaces at different moments. Also, the effect of natural light was different with almost every shot. Subsequent image processing was performed using MATLAB software. Research has shown that the use of images obtained from drones and their processing provides much more accurate information than is the case with traditional methods. [7].

Drones can be actively used in agricultural production to determine the presence and number of plant species on an area. In one of the studies, the key goal was to determine the presence of weed species within arable land. As in previous research, the results were obtained by combining high-resolution images obtained from drones and algorithms with which the subject images were further processed. Within this research, data processing was used to obtain data that were later used to train machine learning models. The authors gave an overview of the system for precise monitoring and control of weed species.

The processed systems were based on available sensors. The author's conclusion is that serious efforts are needed when it comes to the application of such systems in everyday agricultural production. Their conclusion is based on the great similarity of the weed community with cultivated plants [8].

The use of drones in the world is one of perhaps the most current topics of today, both starting with military use and for much more humane purposes. It is for these reasons that the area of use of drones must be regulated by law. A lot of research exists on this topic. One of the studies provides a review of the relevant literature describing the legal regulations for the use of drones in sub-Saharan Africa. The authors collected the results by conducting interviews with lawmakers. The aim of this research was to properly set the basic frameworks that need to be used in the process of enacting legislation for the use of drones in agriculture. The challenges facing regulators are very great. The research showed that the legal regulations for the use of drones in agriculture largely rely on the already adopted laws of civil aviation, especially in the use of remote-controlled aircraft. Respondents also pointed out that the creation of legal regulations in this region is inherent in the region or country for which it is made, as well as that it requires respect for ethical and other principles [9].

Another study deals with the analysis of legal regulations and legal practice regarding the use of drones. In the research, the authors tried to define the similarities and differences of the legal regulations that regulate the use of drones by applying the method of comparing the legal regulations of the national laws of developed countries. Also, one of the goals of the research is reflected in the proposed solution for the improvement of these legal regulations as well as their harmonization. The legal regulations governing the use of drones differ depending on whether they were created gradually with the advent of drones and the beginnings of their use or were created in a hurry to keep pace with other countries. The authors placed special emphasis on the differences in legal norms for the use of drones in the countries of the European Union. The authors also defined a proposed framework that could be used when creating legislation to regulate the use of drones. The proposed solution defines the diversity of regulations depending on the user, which further results in the advantages and limitations of use [10].

3. DIFFERENT APPROACHES FOR PROCESSING DRONE IMAGES

Image processing in order to collect data is a challenge in relation to the correction of images in order to adjust them. Particularly challenging are images obtained from a great distance and the images from which it is necessary to obtain as precise details as possible. Images obtained by recording the production of agricultural areas with the help of unmanned aerial vehicles require a special degree of processing. Due to weather conditions and atmospheric conditions, it is very often necessary to pre-process images obtained from drones before processing them in order to obtain the necessary information. Some of the methods for removing noise or fog in the figure are described later in this chapter.

3.1. DEHAZING METHODS FOR AGRICULTURE DRONE IMAGES PROCESSING

It is generally known that when photographing the external environment, images of poor quality are very often obtained due to external influences. Images with poor visibility or images that have been discolored or contrasted must be processed to correct the defects. The most common shortcomings that occur under the influence of haze. Dehasing methods have been successfully applied to eliminate the presence of haze. These methods are used in image processing techniques as well as computer vision. The expected results of the applied methods are reflected in the fact that a higher quality image is obtained at the output of the system. This image can be subjected to further processing. The haze model is very often used in order to create an image in the external environment. More precisely, this model can be used if the atmospheric conditions are very bad when creating the image, which includes fog, gloomy weather, light reflections, etc. As particles coming from the atmosphere affect the quality of the image, it is necessary to use methods to eliminate the shortcomings that they carry. Although sizes between 1-10μm, these particles can greatly affect image quality. As the haze model is a linear model, the application of this model changes the position of the pixels [11]. It is known, for example, that fog occurs as a combination of external light and direct attenuation, and thus reduced visibility occurs precisely because of these two phenomena. Depending on the method of application and depending on whether it is applied to one or more images, different dehasing methods may differ. The classification of these methods is shown in Figure 1.

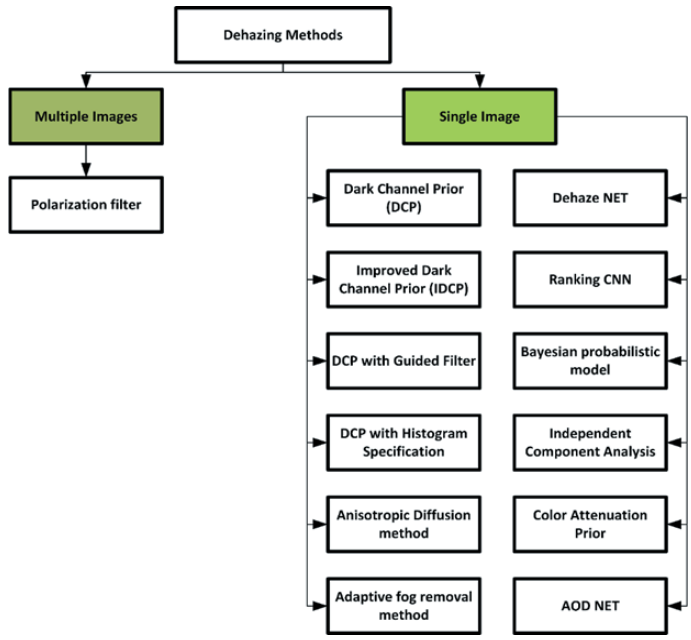

Figure 1 – Classification of dehazing methods

Polarization filter is one of the methods that take multiple input images of the same scene that has been taken during different bad weather conditions. The amount of light scattered due to atmospheric particles in the same direction of direct light arriving in the camera is termed as airlight. In general, the airlight will not be completely polarized. Thus, the polarizing filter, on its own, cannot remove the airlight. The polarization filter alone cannot remove the fog from images. In this method, input image is combination of two unknown components. The first one is the scene radiance in the absence of the fog and the other one is airlight. This method doesn't need the weather conditions to change and it can be applied at any time. The polarization filtering and the orientation of the polarization filter improved the contrast of the single input image. In order to resolve this issue of haziness, polarization filtering is used to determine the haze content of an image and then this haze contents are eliminated from the image to get a clear image.

As can be seen from Figure 1, the single image dehazing method has significantly more than is the case with multiple image dehazing methods. It should be emphasized that the list of methods shown in Figure 1 is not exhaustive. Depending on the quality of the input image and the specific application, each method has some advantages and disadvantages. The following are some of the methods that give the best performance when working with images of agricultural land obtained from drones.

The Dark Channel Prior (DCP) method is based on so-called black pixels. These pixels are characterized by the fact that their presence is very large in at least one color channel. The exception to this rule if you look at an image obtained from the outside environment is the region in the image where the sky is located. The process of image processing using the DCP technique consists of four steps that each of the images must go through. The first step is to estimate the amount of atmospheric light. the second step is transmission map assessment. The third step refers to the refinement of the created transmission map. The last fourth step is the reconstruction of the image, which gives the output. [12].

Starting from the equation of the initial image, the mentioned four steps can be represented as in the following equations:

$$R^{dark} = \min_{c\in(R,G,B)}\left(\min_{y\in\Omega} R^{c}\right) \quad (1)$$

$$\widehat{T} = 1 - \omega \min_{c}\left(\min_{y\in\Omega} I^{c} / L^{c}\right) \quad (2)$$

$$R^{dark} \rightarrow \min_{c\in(R,G,B)}\left(\min_{y\in\Omega} R^{c}(y)\right) \quad (3)$$

$$\widehat{T} = 1 - \omega \min_{c}\left(\min_{y\in\Omega}\left(\frac{I^{c}(y)}{L^{c}}\right)\right) \quad (4)$$

$$R = \frac{I - L}{max(T, t_{0})} \quad (5)$$

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

As a prerequisite for applying the DCP method, it is necessary that the image on which this method will be applied does not contain any white and lighter objects. If there are white objects in the picture, the mentioned method can give worse results. The disadvantage in terms of the results obtained by applying the DCP method over such images is that DCP creates artifacts. [13]. It follows that DCP is largely dependent on light in the external environment, and therefore improved prior could give better results. From the point of view of image processing and creating a transmission map, there are two basic parameters that every image must have and which play a key role in this process. One of them is structural and the other is statistical. Artificial intelligence based on neural networks can be used in the process of generating knowledge based on the data obtained from the image. Some of the Convolutional Neural Networks (CNN) have proven successful when it comes to their application in the process of evaluating structural features. On the other hand, when it comes to statistical features within the image, CNN do not show significant results. In order to take into account both features when processing the image using CNN, a method known as ranking layer is very often used. By applying this method, both mentioned features can be used in the process of creating CNN. The principle of application of the Leveling level is reflected in the fact that it takes map features when investing, while maps of a certain size and clarity can be expected at the exposure of this method. In the process of processing input data, this level replaces the order in the input folder. If we compare the calculation of the statistical feature at the level of CNN and Ranking level, we can see that for the calculation using CNN it is necessary to apply more convolutional filters, while with Ranking level it is necessary to apply only one. It is for this reason that the Ranking level has been added to CNN to allow estimates to be made based on each individual pixel. A Random forest generator can be used to increase performance within the rest of the system [13].

4. LEGAL REGULATIONS

Aerial recording of agricultural production areas for data collection that will be used later in the process of assessing crop condition and making decisions on the next agro-technical measures that need to be implemented can often include public and private facilities, and public figures and others. Namely, very often agricultural production areas are bordered by private property, public facilities, acquired facilities, military facilities. During the recording process, and in order to record the entire surface, due to the fact that the recording is very often done on a predefined path, the objects that border the production areas are recorded. Natural persons, public figures, and acquired persons can also be found on the recordings during the filming. Precisely for these reasons, it is necessary to know the legal regulations that regulate the field of shooting and photography. According to Article 144 of the Criminal Code of Serbia, unauthorized photography can be considered if someone makes an unauthorized photographic, film, video or other recording of a person and thus significantly intrudes on his personal life or who hands over or shows such a recording to a third party or otherwise allows him to meet him. The prescribed punishment for such an act may be a fine or imprisonment for a term of one year. It can be seen here that it does not mention or imply photographing public buildings and surfaces, and that it only states and thinks of invading the privacy of a natural person, but not some public performance of that person's business, but only his personal and private life. In addition to this, it can be said that this issue is partly touched upon by 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) and it primarily regulates security protection, such as and which services and institutions are responsible for their implementation.

In this regard, it can be said, for example, that a specific service may, in its assessment, under this Regulation, order the application of a measure or action in order to prevent the protection of a protected object, and as far as possible a specific service or in this case (in connection with photography) the competent public utility service for placing signs, puts the sign "prohibited photography" or "recording". Only then does the security officer have the right to warn about this ban and continue to act according to the study, that is. security plan and its powers. The second question of this extremely important topic is what is the envisaged sanction, because we

did not find the threatened sanction for that specific act, and it remains unclear - how to sanction such an "act". This imposes the conclusion that this is not a misdemeanor or a criminal offense, but only a justified basis for the operational processing of the person who is such a recording, i.e. the photograph also provided a sufficient basis for further undertaking certain measures and actions. According to a number of authors, persons who would record and thus record other facilities or persons in addition to production areas could face legal consequences prescribed by Article 143 of the Criminal Code relating to unauthorized wiretapping and recording, and Article 145 of the Criminal Code of the Republic of Serbia. Relating to the unauthorized publication and display of another's file, portrait or recording, due to the fact that the obtained recordings are further processed and may be processed by several persons. Sanctioning of wiretapping and audio recording (143 Kz) is the right of citizens to secrecy, more precisely the protection of that right. Anyone who records or eavesdrops on a conversation without the knowledge or consent of the person whose conversation is being eavesdropped on or recorded commits this offense and may be fined or imprisoned for 3 months to 3 years. Also, paragraph 2 of the same enables the other to get acquainted with a conversation, statement or statement that has been intercepted or audio recorded without authorization. Legal practice shows that it is most practical to process the obtained recordings in order to remove from them the parts in which faces can be seen, or objects due to which the cameraman may bear legal consequences. As the recording of faces and objects is not the primary task, but they can potentially be recorded by mistake, removing parts of the material provides legal protection. On the other hand, if there is a sign that filming is strictly prohibited, for example in the case of military facilities, and if the person in charge of guarding such a facility warns of a recording ban, filming must be stopped. In such cases, a permit for the survey of the productive agricultural area must be sought, with guarantees that the acquired facilities will not be covered by the survey.

5. CONCLUSION

The use of modern information and communication technologies in agriculture improves agricultural production. The main contribution of the use of new technologies in agricultural production is reflected in the monitoring of agricultural areas and crops sown in those areas. The monitoring process begins with the collection of data on the basis of which later in the process of processing them, conclusions will be made about further agro-technical measures that need to be done. One of the ways to collect data is definitely the use of drones. Using these raspberry drones, shots of production areas can be made in order to achieve the required results on the basis of shots in the post-processing phase. Images obtained by shooting outdoors are often blurred due to weather conditions and light reflection, so they must first be processed to obtain images of adequate quality. The proposed methods of image processing have shown good results in application to images obtained by recording agricultural areas from the air. Research has shown that legislation can be a limiting factor in the use of drones in agriculture. This is especially true in the field of surveying areas that border public and acquired facilities. In this regard, the drone operator and the company performing the recording may face legal consequences if objects and people whose recording is prohibited reach the recording. The legislation specifically sanctions the violation of privacy and distribution of recordings to third parties, so in such cases, the processing of recordings must first be aimed at eliminating parts of the recordings where the disputed people or objects appear.

6. REFERENCES

[1] M. Ilic, S. Zaklina, M. Veinovic and A. Stojnev, "Informaticko pravna karakterizaija upotrebe dronova u poljoprivredi," in *YUINFO,* Kopaonik, 217.

[2] D. Merwe, D. Burchfield, T. Witt, K. Price and A. Sharda, "Chapter One - Drones in agriculture," *Advances in Agronomy*, pp. 1-30, 2020.

[3] M. Kulbacki, J. Segen, W. Kniec, R. Klempous, K. Kluwak, J. Nikodem, J. Kulbacka and A. Serester, "Survey of Drones for Agriculture Automation from Planting to Harvest," in *IEEE 22nd International Conference on Intelligent Engineering Systems (INES)*, Las Palmas de Gran Canaria, Spain, 2018.

[4] V. Puri, A. Nayyar and L. Raja, "Agriculture drones: A modern breakthrough in precision agriculture," *Journal of Statistics and Management Systems*, vol. 20, no. 4, pp. 507-518, 2017.

[5] S. Muraru, P. Cardei, V. Muraru, R. Sfiru and P. Condruz, "Researches regarding the use of drones in agriculture," in *International Multidisciplinary Scientific GeoConference : SGEM*, Sofia, 2019.

[6] J. Huuskonen and T. Oksanen, "Soil sampling with drones and augmented reality in precision agriculture," *Computers and Electronics in Agriculture*, vol. 154, pp. 25-35, 2018.

[7] Z. Altas, M. M. Ozguven and Y. Yanar, "Determination of Sugar Beet Leaf Spot Disease Level (Cercospora Beticola Sacc.) with Image Processing Technique by Using Drone," *Current Investigations in Agriculture and Current Research*, vol. 5, no. 3, pp. 621-631, 2018.

[8] M. Esposito, M. Crimaldi, V. Cirillo, F. Sarghini and A. Maggio, "Drone and sensor technology for sustainable weed management: a review," *Chemical and Biological Technologies in Agriculture*, vol. 8, no. 18, 2021.

[9] M. Ayamga, B. Tekinerdogan and A. Kassahun, "Exploring the Challenges Posed by Regulations for the Use of Drones in Agriculture in the African Context," *Digital Agriculture for Sustainable Food Systems: Implications for Land-Resource Use and Management*, vol. 10, no. 2, pp. 1-13, 2021.

[10] N. Tsiamis, L. Efthymiou and K. Tsagarakis, "A Comparative Analysis of the Legislation Evolution for Drone Use in OECD Countries," *Drones,* vol. 3, no. 4, p. 75, 2019.

[11] S. Patel and M. Nakrani, "A Review on Methods of Image Dehazing," *International Journal of Computer Applications*, vol. 133, no. 12, pp. 44-49, 2016.

[12] L. Sungmin, Y. Seokmin, N. Jun-Hun, W. Chee Sun and J. Seugn-Won, "A review on dark channel prior based image dehazing algorithms," *EURASIP Journal on Image and Video Processing*, vol. 4, pp. 1-23, 2016.

[13] A. Parihar, Y. Gupta, Y. Singodia, V. Singh and K. Singh, "A Comparative Study of Image Dehazing Algorithms," in *e Fifth International Conference on Communication and Electronics Systems (ICCES 2020)*, 2020.