Review Article

A Systematic Review of Drone Development and Innovation Helps Handling during a Pandemic and its Challenges for Health Technology

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ABSTRACT

This technological advancement makes researchers around the world develop many new things to support the harmony of life. Humans think a lot, including in terms of technology for the advancement of the times and to sustain life, and there are still many challenges in handling outbreaks, especially the unprecedented coronavirus that spread at the end of 2019, referred to as COVID-19 by the World Health Organization (WHO), and has put the whole world in a precarious position. The impact of the COVID-19 outbreak has become a matter of great concern for almost every country around the world, overburdened healthcare systems have forced most countries around the world into partial or complete lockdowns. Even in the post-pandemic period, humans are learning and increasingly developing research with many open new challenges. Researchers have begun developing studies in various fields to help control the virus and aid the world of health. Technology is also forced to adapt and develop faster to deal with the existing situation. In response to this action, with this review paper, we use trusted sources to present a detailed review of specific aspects related to technological developments during the COVID-19 pandemic, especially UAV or drone technology. In this study we explore the use of technologies such as Unmanned Aerial Vehicles (UAVs) or drones that are modified for handling pandemic situations, and how these technologies are also combined with other trending technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and 5G, among others, to help reduce their impact from the COVID-19 outbreak and the challenges for the post COVID-19 period. Where UAV technology can be modified and developed according to the needs of the pandemic and development for the post-pandemic and endemic period.

INTRODUCTION

The epidemic coronavirus (COVID-19) is a highly contagious virus caused by SARS-CoV-2. COVID-19 has caused global health problems (Hamid et al., 2020). The World Health Organization (WHO) has officially declared COVID-19 or coronavirus infection a pandemic. Most people infected with the COVID-19 virus will experience mild to moderate respiratory illness. Older people, and those with underlying medical problems such as cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illnesses. The COVID-19 virus is spread mainly through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. (World Health Organization, 2019).

Each state government anticipates this by taking various ways and actions that the public must comply with to reduce the number of spreads because this pandemic has greatly affected many sectors such as mental health, people's habits, education, and economy. The survey result held by Young Minds shows 83% of 2111 lower than 25 age participants said that pandemics make it worse for people who have mental illness (Lee, 2020) Indonesia has the fourth largest population in the world which is of course a very big risk in the spread of the COVID-19 pandemic. The Indonesian government has taken the fastest action by utilizing existing technology, but not all of them are ready. Indeed, the effective way to stop the spread of the COVID-

19 virus is to stay at home and avoid (physical) contact. As well as isolating people under surveillance (ODP), patients under surveillance (PDP), and those who are positively infected (Badan Nasional Penanggulangan Bencana, 2020).

Lockdown and social distancing are some of the things implemented during the pandemic to prevent the spread of the virus. This can be a solution to minimize the spread of the virus during the pandemic and to support the program using technology like drones that can be equipped with speakers and displays to broadcast public health messages and educate the public about endemic diseases, preventative measures, and treatment options. (Somaldo et al., 2020). To overcome this, healthcare is needed that can help people affected by the COVID-19 virus or other dangerous diseases in terms of information, assistance services, and tracking.

Technology is one of the most feasible approaches as a means of community surveillance to reduce the spread of this pandemic (Kapoor et al., 2020). One form of utilization of information technology is carried out in many countries, one of which is China in the form of mass surveillance. China requires all citizens to scan the QR Code for residents who want to move out of town assisted by the use of drones (Lu, 2020). Technology development during COVID-19 is adjusted to circumstances to help handle outbreaks is widely tried to be implemented in various countries. In this review, we will explain research grouping the use of drones to help deal with the COVID-19 pandemic.

Some research on the use of drone technology has begun to be widely tested as explained above, but whether the technology can really be used and still has further challenges is the purpose of the author to make this review. The systematic focus of this review paper also groups researchers who use technology drones for health and during the COVID-19 pandemic situation. With this review paper, it is hoped that you will get answers regarding the use of drones to help handle the COVID-19 pandemic and also the recommendations and challenges for health technology.

RELATED WORKS

Several literature reviews were found to discuss the potential use of drones and also the acceptance of drones in the community, in this literature the author emphasizes more about the review of the use of drones developing during the pandemic and the future potential for health technology. Related working studies for this systematic review have been conducted using data search methods

using queries to obtain specific references using two databases, IEEE Xplore and Science Direct. Several literature reviews were found to discuss the potential use of drones and also the acceptance of drones in the community, in this literature the author emphasizes more about the review of the use of drones developing during the pandemic and the future potential for health technology. Systematic search is carried out by identifying research information articles from the database, identifying based on queries provided in existing literature databases. The search on the database is based on the query that has been created. Selected databases have a background in science and engineering. There is an IEEE Xplore digital library (https://ieeexplore.ieee.org/Xplore/home.jsp) and Science Direct (https://www.sciencedirect.com/).

Systematic Review
A systematic review is carried out using systematic review and Meta-Analysis (PRISMA) to Create a systematic literature review with flowchart examples and systematic explanations of reviews. Systematic literature review is a research method to identify, evaluate, and interpret all relevant research results related to certain research questions, certain topics, or phenomena of concern. Individual study is a form of primary study, while systematic review is a secondary study. Assess and interpret all available research evidence to provide answers to specific research questions. The function of the Systematic Literature Review data analysis technique is to synthesize as well as deepen various relevant research results (Reyvan Maulid, 2022).
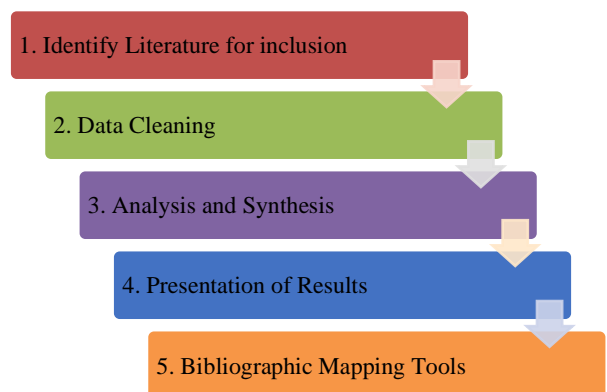

Figure 1. Collection Methods for Systematic Literature Review

Search Strategy
The query was inputted to an advanced search engine with order ((drone OR UAV) AND (COVID-19 OR COVID 19 OR COVID)). In all databases, authors complete a search method by entering the string "drone" or "UAV" with the following keyword "COVID-19" or "COVID 19" or "COVID" to further clarify the scope. The article publication year is from 2020 to 2021 because COVID-19

appeared and was declared a pandemic at the beginning of 2020, which are the article was published in the English language.

Based on a search with an advanced model on September 20, 2021, the number of searches for 152 papers on IEEE Xplore related to the keywords used above. After reviewing the title, there are 58 papers related to the use of drones, or UAV for COVID-19. Of the 58 articles regarding the use of drones or UAV, 21 papers discuss the use of drones in handling COVID-19 in the title, there are research papers related to drones for handling COVID-19 in the database. In other databases such as Science Direct, 93 papers found related to the keywords Drone and COVID-19 were entered.

The search is focused on conducting a review of related studies that have previously existed on the use of drones and unmanned aircraft technology to overcome the worldwide pandemic. The trend of using drone technology through this review will be detailed, only for the use of drones that are used for problem-solving and helping during the pandemic. There are 6 papers related to COVID-19 and the use of technology. Of the 6 papers, there are specific papers that explain the use of drones for handling COVID-19 in detail. The search strategy of the review paper that has been done is described in the following table and diagram:

Table 1. Search Strategy Query Setting

DIGITAL LIBRARY	IEEE Xplore	ScienceDirect
LANGUAGES	English	English
RUN ON	Full Text	Full Text
TYPE	Paper, Journal	Paper, Journal

Eligibility Criteria

Only studies that mention UAV or drones that are used during and for the prevention of COVID-19 are selected for the investigation. The studies on UAV collected from the two databases were mapped. Various studies on drones that are used to help handle countermeasures during a pandemic, and also articles about drones using the combination of technology like IoT and Artificial Intelligence for the methods are similar. Studies selected focus on drone technology that can be used to support the COVID-19 era. The eligibility criteria choose articles in the English language published in less than two years and in the pandemic period starting from 2020, when COVID-19 began to spread rapidly and became a worldwide pandemic. Duplicate articles were not considered, and authors removed all the articles that did not fulfill the eligibility criteria.

Identification of Studies

The selection process for this study is done by taking data from both databases, the first thing that needs to be done is to choose a title, eliminate unrelated research or article results, and filter duplicate articles. This process is called the process of data preparation. Then, choose an abstract and read it carefully to find relevance to the topic for further reading.

The references review is concerned with the different uses discussed in the references by the questions, do drones have a realistic place during the pandemic time or UAVs in different sectors by looking for research studies using drones that were developed and devoted to the COVID-19 pandemic use for private, military, health, etc.

In this review paper, we will identify the latest research related to the use of drones during a pandemic. So it is hoped that with this study research on drones can be further developed and become an inspiration for other researchers, and can find out whether technology such as drones can help in handling a pandemic, what kind of drone handling is, and what methods the author uses in this review. Although some of the studies had similar areas, however, these articles focused on differences in purpose, and from two databases focused on the use of drones for COVID-19 27 studies met the selected criteria.

A diagram, in Figure 2, illustrates the diagram flow of the article selection process in three databases. The review has been carried out to look for studies that can be developed for the pandemic period and the use of drones in the field of technology for health. Some literature reviews are found and excluded because after a review the title and abstract are not found to be in accordance with the search query set as a limitation of the study. The content of the paper is also not in accordance with conducting a review related to research on drone technology implemented during the pandemic or related to post-pandemic health technology.
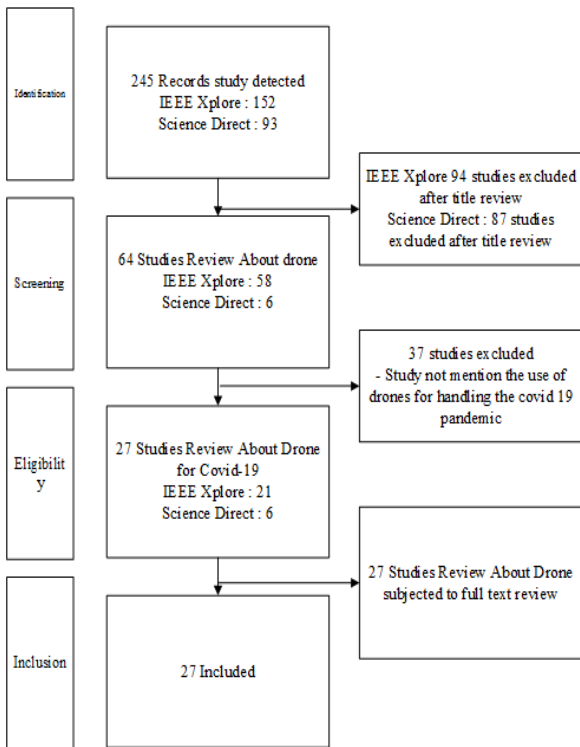
Figure 2. Flow Diagram Of Research Literature and Selection Process

RESULT AND DISCUSSION

The studies that have been collected through a systematic method will then be summarized and analyzed. Research and reviews on drone technology used during the previous pandemic have also been carried out such as Refs (EUCHI, 2021), where they collected various sources about drones and used two methods to classify reference reviews divided into two parts (1) the first part concerning the different uses discussed and (2) the second part of the references looks more at the resolution approach, namely by using exact, heuristic, metaheuristic, or hybrid methods. Methods inspired by various related disciplines, and in this study they do not discuss more in-depth control systems from drones for COVID-19. In other publications such as Refs (Chamola et al., 2020) from existing studies, we can observe the modification of several forms of drone applications that are tried to be used in various sectors.

Figure 3. Drone Used During COVID-19 Pandemic (Google, 2021)

The observe a growing number of researchers trying to develop drone technology with a variety of methodical and algorithmic solutions that can solve specific problems to help during a pandemic. During times of health emergency, lockdown during a pandemic, COVID-19, UAV drones, can have many advantages. They can ensure that human interaction should be minimized, and can also be used to reach inaccessible areas. China, the first country to face the COVID-19 situation, and several other countries and organizations (Sierra Leone, Rwanda, United States, Spain, Italy, France, United Kingdom, India, and others) worldwide have deployed drones to oversee the public space by getting a better situation awareness, and enforce quarantine by sending messages through loudspeakers and track down non-compliant citizens. They have utilized drone technology and combined it with other technologies to fight the COVID-19 outbreak (Unicef, 2021).

Table 2. Application Sector Of Drone Technology Implementation During COVID-19 Pandemic

WRITER	APPLICATION SECTOR	DRONE TOOLS
Adarsh Kumar, Kriti Sharma, Harvinder Singh, Sagar Gupta Naugriya, Sukhpal (Kumar et al., 2021)	Remote and highly congested pandemic areas where either the wireless or Internet connectivity is a major issue or chances of COVID-19 spreading are high.	Six rotors (Hexa-copter)
Fahad Saeed, Amjad Mehmood, Muhammad Faran Majeed, Carsten Maple, Khalid Saeed, Muhammad Kashif Khattak, Huihui Wange, Gregory Epiphaniou (Saeed et al., 2021)	Self-swab test results and tools delivery, using a drone	DJI Phantom 4

Jalel Euchi (Euchi, 2021)	Pharmaceutical sector	DJI Mavic, DJI Phantom 4, Trimble UX5, DJI Mavic Air 2
Nitin Koshta, Yashoda Devi, Sabyasachi Patra (Koshta et al., 2021)	Supply chains	Aerial bots or Drones are unmanned aerial vehicles (UAVs)
Ahmed Barnawi, Prateek Chhikara, Rajkumar Tekchandani, Neeraj Kumar, Bander Alzahrani (Barnawi et al., 2021)	COVID-19 detector	IoT applications of UAVs (IoT UAV)
M. Joe Thomas, Vishnu Lal, Ajith Kurian Baby, M Rabeeh VP, Alosh James, Arun K. Raj (Thomas et al., 2021)	Technology used for COVID-19 pandemic	Drone for screening, and monitoring in travel sectors, healthcare, disinfection, and logistics.

From Table 2, we can observe the modification of several forms of drone applications that are tried to be used in various sectors. Here we observe a growing number of researchers trying to develop drone technology with a variety.

Table 3. Objectives and Finding Research for Drone Technology Implementation During COVID-19 Pandemic

PAPER	OBJECTIVE	FINDING
(Kumar et al., 2021)	The main objectives of this work are: • To propose an artificial intelligence-based system that collects the data through drones, analyze and provide the necessary security measures. • To implement a real-time drone-based system for sanitization, monitoring, vigilance, face recognition, thermal scanning etc. in COVID-19 hotspots.	In an implementation, it is observed that a large distance can be covered within a short period and the proposed drone-based healthcare system is effective for COVID-19 operations. In the simulation, the proposed approach is tested for indoor and outdoor activities. Results show that a distance of 1200 kilometers can be covered in 2293 to 18 900 min with a variation of 3–30 drones. In an indoor activity, thermal image-based patient identification is found to be very effective during COVID-19 pandemic.
(Saeed et al., 2021)	The authors developed a mechanism so that the public can safely carry out the test and that swab samples can be collected at home. Introducing drones to deal with emergencies can bring great benefits to mankind.	Drones can be quite efficient in collecting samples and delivering emergency kits.
(EUCHI, 2021)	The authors conducted a synthesis literature review devoted to the use of UAVs in healthcare with their different aspects. A total of different research made are given to describe the role of UAV in Home healthcare with the presence of SARS-COV-2.	The authors conclude that the drones will be able to optimize the way of eliminating contamination by a very high percentage (through the reduction of human contact) with the increase of the flexibility of the flight (reaching the less accessible regions every hour of the day).
(Koshta et al., 2021)	This article not only highlights the applications of drones in various supply chains during the COVID-19 outbreak but also inspires future research in this direction.	Drone for humanities. Specifically, the focus is on food, administrative, and healthcare supply chains that are the core to combat the pandemic.
(Barnawi et al., 2021)	This paper aims to devise an IoT-based UAV system using a Thermal Corona Combat Drone (TCCD) to automatically detect COVID-19 from thermal images.	The thermal image captured from a drone for COVID-19
(Thomas et al., 2021)	The study discusses the benefits of these digital technologies in curtailing the pandemic and 'how' the different sectors adapted to these in a shorter period. Social media and television's role in ensuring global connectivity and serving as a common platform to share authentic information among the general public were summarized.	This review conclusively showed that the nations that flattened the COVID-19 outbreak (in terms of active cases and mortality rate) had adopted wide use of digital technologies such as drones.

The studies that have been collected through a systematic method will then be summarized and analyzed. Research and reviews on drone technology used during the previous pandemic have also been carried out such as Refs (Kumar et al., 2021), where they collected various sources about drones and used two methods to classify reference reviews divided into two parts: the first concerning the different uses discussed in the second part of the references looks more at the resolution approach, namely by using exact, heuristic, metaheuristic, or hybrid methods. Methods inspired by various related disciplines, and in this study they do not discuss more in-depth control systems from drones for COVID-19. In other publications such as Refs (Lee, 2020), from existing studies, we can observe the modification of several forms of drone applications that are tried to be used in various sectors. Here we observe a growing number of researchers trying to develop drone technology with a variety of methodical and algorithmic solutions that can solve specific problems to help during a pandemic.

Drones have been shown to play a role in various aspects, including monitoring public spaces for social distancing compliance, delivering medical supplies to remote or quarantined areas, and even facilitating the transport of COVID-19 test samples. Research studies, such as the work of (Mohsan et al., 2022) highlight the efficiency and speed of drone-enabled medical delivery during the pandemic, reducing the risk of person-to-person transmission. Drones equipped with cameras and sensors have been used for real-time data collection, assisting authorities in monitoring crowd density and ensuring compliance with health protocols.

The integration of drone technology into pandemic response strategies not only increases the effectiveness of public health initiatives but also minimizes human exposure to the virus, showcasing the potential of drones as an important tool in future public health emergencies.

Discussion and Challenges
From the references that have been obtained and reviewed, drones are a form of innovation in the use of technology in the pandemic era, and can continue to be developed in the endemic era.

Figure 4. Expandable for Drone Components That Can Be Developed as A Means of Transportation or Monitoring

The challenges of developing drone technology can also remain interesting and have a lot of potential for research and development. The potential in developing drones can be increased in terms of flexibility, material quality, material strength, flight endurance, battery, flight distance, and ability to carry loads. So that research on drones can continue to be developed and can help in learning the use of health technology.

Drones for Transporting Goods and Emergency Kits
During a pandemic, it is necessary to maintain distance and interaction, so during that time the delivery of goods involving human beings that directly interact should be limited, In this case, the use of robots can be developed and become an alternative (Yoo et al., 2018). The use of drones can be tested as a carrier of goods such as medical equipment and medicines. It can even be used to transport groceries for self-isolation patients. Drones are also used to transport disinfectants so that they can help spread spraying anti-virus cleaning fluids in an environment by air, even those that are difficult for land vehicles to pass through. Drones can transport medical supplies, including life-saving medications, blood, vaccines, and medical equipment, to remote or hard-to-reach areas.

This is important and valuable for delivering supplies during emergencies, accidents, natural disasters, or in rural regions with limited access to healthcare facilities. During infectious disease outbreaks like the COVID-19 pandemic and the possibility that other viral pandemics may occur in the future, drones can be used to deliver medical supplies and collect samples from patients without the need for

direct human contact. This can minimize the risk of disease transmission (Yaprak et al., 2021).

The use of drones to be developed with delivery technology requires further and strict regulations and is still a challenge for both governments and researchers because drone-related technology for delivery also requires further education of users and recipients of goods sent by drone (Sedig et al., 2020). In addition, arranging drones for delivery, be it for medical materials or other industries requires multi-discipline Collaboration between the government, public and private sectors, where The private sector will proactively demonstrate how they will use drones to support government efforts to improve access to health, and unaffordable access to escorts.

Drones for Monitoring and Surveillance

Drones can be used to monitor public spaces and enforce lockdowns or social distancing measures. They could identify gatherings, check compliance, and provide real-time data to authorities (Merkert & Bushell, 2020). It also can be used to monitor quarantine zones and ensure individuals were complying with isolation orders during pandemic (Angurala et al., 2020). After the end of the pandemic drones also can be used for remote sensing for environmental data, drones can collect environmental data, such as temperature, humidity, and vegetation patterns.

This information is critical for understanding the ecological factors that influence the prevalence of endemic diseases like malaria or dengue. Drone monitoring also can be developed for monitoring air quality. After the pandemic period ends and the endemic is declared, other problems may also arise. Previously, during the lockdown period, the environment and air quality in the world improved due to activity restrictions, after the endemic, activity increased again and caused problems with air quality which became worse due to air pollution and smoke. Drones with sensors can be used to monitor areas to recommend policies regarding air quality. Assembling drones in combination with other sensor arrays can make development and challenges will continue to exist in research on this topic.

Figure 5. Example of Assembled Drones For Quadcopters Can Be Used For Monitoring

Many manufacturers have issued and sold their drones commercially that are commonly used for shooting pictures or content, but commercial types of drones are often difficult to develop open source, there are also types of assembled drones that can be assembled from scratch and combined with other sensors for monitoring, such as sensors for temperature monitoring, Thermal cameras, or combined with air pollution detection sensors and even heat sensors to detect potential fires. Drones with this type of assembly will be easier to combine with other open-source hardware.

Challenges on Technology

- Battery life is the most important challenge in research for drones, the length of flight time is determined by the large battery capacity, while large batteries often have a large weight that affects the payload weight of the drone. How to make the power in the battery have a higher level of life and may be able to utilize ambient energy sources such as solar and wind energy as support is also a challenge in this field.
- The challenge of creating large carrying capacities is of interest to this area of research. The material for the frame, the effect of the weight of the battery, and how to find the right balance between the payload capacity and the size of the drone are very important.
- Challenges in the reliability of systems, sensors, hardware, and software used for drones also require the best level of accuracy and the best percentage of error to be used as a means of transportation or monitoring, for medical material transportation equipment also needs more detailed trials because it can carry medical equipment and even very important organs.
- The specifications of the drone also need to be improved by allowing it to carry a storage box that can have temperature control to regulate temperature conditions for the package carried, very supportive

for drones for medical purposes that can transport organs or blood.

- Other challenges can also be developed in drone technology by adding Internet of Things (IoT) modules so that drones can be developed into sensor nodes that are flown in the air by having more than one drone, making a drone network connected to the internet and can be a tool for data retrieval. The development potential of the Internet of Drone Things still needs to be developed and implemented. Especially in the field of monitoring.
- Drone for data collection and analysis. Drones can be used as platforms and means for data collection, assisting in the collection of environmental and geographic data that can inform healthcare decisions. Monitoring when disease outbreaks occur, tracking environmental factors that impact health, monitoring areas or places that cannot be directly reached by humans assessing the needs of health care infrastructure and much more can all be facilitated through the use of drones. A data-driven approach to healthcare enables proactive public health management and leads to more informed, targeted, and effective public health interventions.
- Challenges in dealing with weather. Many studies on drones say that weather can be one of the big causes of concern for important drone services. The technical design of UAVs should take into account environmental factors for the wider application of drone operations in healthcare daily.

Challenges to Social and Regulations

- Challenges in operating professionally and education for drone operations are still challenges in learning, the need for human resources who can master the operation and maintenance of drones is very important
- Another challenge in studies that have been done is privacy. Drone flights are feared to interfere with the privacy of one or a group of individuals, so regulations for drone flights are also very important to socialize.
- Challenges in terms of cost are also still much debated. Drone technology is still considered an expensive technology for society. The cost of assembling, operating, training, and maintaining a drone can be a bottleneck. So there is also a need for a comprehensive study of components that have a low price for drones.
- Challenges in data security remain a hot topic, for drones that are used as data collection tools, or drones connected to the internet network can increase the potential and gaps in data security problems and system hacking, especially for autonomous systems

and the Internet of Things that can run alone and be connected to the internet network.

- The noise generated by drone propellers can contribute to noise pollution and can impact the well-being of individuals in areas with frequent drone activity. In addition, concerns have been raised about the potential health effects of prolonged exposure to electromagnetic fields emitted by drone systems that could be further investigated. The use of drones for medical delivery, while promising, also raises questions about the safety and sterility of medical supplies transported. In addition, the rapid proliferation of drones in urban environments can cause psychological distress due to the constant surveillance that occurs or can also cause concern to the public if more drones fly in an area that can trigger negative thoughts about their use.
- Drone flight regulations. Drone flight regulation has become a challenge and the most important aspect of the development and mobilization of modern aviation. Various countries have implemented strict guidelines and rules to ensure the safe operation of drones. These regulations typically cover aspects such as registration requirements, height restrictions, no-fly zones, and licensing for commercial drone operators. The government aims to strike a balance between promoting the growth of drone technology for useful purposes such as aerial photography, surveillance, and delivery services, while also maintaining public safety and privacy. Regulatory agencies are working continuously to adapt to the evolving drone landscape, addressing emerging challenges such as drone integration into controlled airspace and the development of technology to prevent collisions with manned aircraft.

CONCLUSION

UAV technology, with drones, can offer many advantages. During the pandemic, post-pandemic and endemic. Global challenges posed worldwide by the COVID-19 pandemic have driven innovative solutions with drone technology emerging as a valuable tool in pandemic response efforts. Drones have proven to play a role in various aspects, including monitoring public spaces for social distancing compliance, delivering medical supplies to remote or quarantined areas, and even facilitating the transport of COVID-19 test samples. Applications and practical implementation of drone use still face certain limitations. Common factors that limit drone capabilities and can pose development challenges include payload capacity, flight endurance, battery, weather challenges, and autonomy. Drones can only be used to serve a limited area with limited size and weight packages. Material development and flight

power can continue to be developed. The use of drones for monitoring can also be further utilized, especially to support facilities and health. There are many challenges to face the latest technology research for the future, the a need for further and in-depth research into various factors of drone technology development. Both in the improvement of its technology, as well as research related to regulations and public response to the presence of drone technology that can continue to be developed.

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