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*Article*

# Supporting Telemedicine and Community Welfare through Automated Drug Delivery Systems with UAV (Unmanned Aerial Vehicle) and IoT (Internet of Things) Technology: A Case Study in KLU Area

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**Abstract:** This research focuses on the development of an automated medication delivery system using Unmanned Aerial Vehicle (UAV) Technology and the Internet of Things (IoT) to support telemedicine and community welfare in the KLU region. The system is designed to improve the quality of medical services and medication management for the community in the area. One of the main challenges faced is how the KLU community responds and accepts automatic medication delivery using UAVs and IoT. To overcome this challenge, this research suggests providing education and training to the community about the benefits and usage of the system, as well as displaying a working simulation of the system to the community.

**Keywords:** Unmanned Aerial Vehicle (UAV); Internet of Things (IoT); telemedicine; medication delivery; KLU region

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### Problem Research

1. How can this system improve the quality of medical services and treatment management for people in the KLU area?
2. How does the KLU community respond to and receive automated drug deliveries using UAVs and IoT?
3. How to measure the impact of the use of UAV and IoT systems in drug delivery on the quality of health services in KLU areas?

### Solution

1. Provide education and training to the public about the benefits and how to use the system.
2. Showing the simulation of system work to the community.

## 1. Introduction

Shipping drugs to remote areas is a challenge faced by many countries around the world. One solution that can be used is to use UAV (Unmanned Aerial Vehicle) and IoT (Internet of Things) technology to deliver drugs automatically to remote areas. The UAV can carry smart medicine boxes equipped with sensors such as GPS and air pressure sensors to ensure timely and accurate drug delivery to remote areas. IoT systems can be used to monitor the condition of drugs and smart medicine boxes, as well as notify medical personnel if there are problems with drug delivery.

Automated drug delivery using UAVs and IoT can help improve the accessibility and reliability of healthcare in remote areas, especially in emergency situations such as the COVID-19 pandemic or natural disasters. UAVs with smart medicine boxes can help ensure timely and accurate drug supply,

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as well as assist nurses in preparing medicines for patients. In addition, UAVs with smart medicine boxes can also help reduce the workload of nurses and ensure patients get proper and effective care.

In order to support telemedicine and community welfare, automated drug delivery using UAVs and IoT can be an effective solution to overcome the challenges of delivering drugs to remote areas. With this technology, it is expected to help improve the quality of life of people in remote areas and ensure timely and accurate drug supply.

The automated drug delivery system using UAV (Unmanned Aerial Vehicle) and IoT (Internet of Things) technology designed in this study has the potential to address several health challenges in the KLU area. Here are some reasons why this system can be beneficial:

1. Accessibility: KLU areas may have limited access to health facilities due to their remote location. Using UAVs, drugs can be delivered directly to patients' homes, improving healthcare accessibility.
2. Speed of Delivery: UAVs can deliver medicine quickly, especially in emergency situations when time is of the essence.
3. Drug Condition Monitoring: With IoT, drug conditions can be monitored during delivery. For example, if a drug requires a certain temperature, IoT sensors can ensure that temperature is maintained.
4. Risk Reduction: Given that UAVs do not require crewing, risks associated with drug delivery, such as accidents, can be minimized.

However, keep in mind that the implementation of this system also has challenges, such as bad weather, carrying capacity, regulations and permits, as well as distance and travel time. Therefore, further research and careful planning are needed to ensure this system can function effectively in the KLU area.

The benefits of using UAVs (Unmanned Aerial Vehicles) in addition to drug delivery, which are as follows:

a. Environmental monitoring: UAVs can be used for environmental monitoring, area mapping, and remote sensing, such as monitoring farmland and sweeping in areas that are difficult for humans to reach.
b. Alternative transportation: In emergency situations, UAVs can be relied upon to transport food aid and medicines that cannot be delivered on time via land transportation.
c. Plant growth monitoring: UAVs can be used in agricultural technology for crop growth monitoring, soil condition assessment, and other agricultural monitoring systems.
d. Military use: UAVs provide advantages that manned aircraft cannot provide, such as eliminating the risk of pilot death, flight maneuverability, and endurance that is not limited by limited human capabilities
e. Delivery of goods: In addition to medicine, UAVs can be used to deliver other goods, such as food, directly to people's homes, especially in remote or isolated areas. With these diverse benefits, the use of UAVs has shown vast potential in areas ranging from environmental monitoring to freight forwarding and military purposes

The use of UAVs for drug delivery in emergency conditions can also face several obstacles, including:

a. Bad weather: Adverse weather conditions such as strong winds, heavy rain, or heavy fog can hamper drug delivery operations using UAVs.
b. Payload capacity: UAVs have limitations in payload capacity, so they can only deliver a limited amount of drugs in each delivery mission.
c. Regulations and permits: The use of UAVs for drug shipments in some regions requires special permits and must comply with applicable aviation regulations.
d. Safety: Drug shipments using UAVs also need to pay attention to safety factors, including the risk of collision with other objects or interference from irresponsible parties.

e. Range and travel time: UAVs have limited flying range and flying time, so drug delivery may be limited to areas reachable within UAV range.

Taking into account these obstacles, the use of UAVs for drug delivery in emergency conditions requires careful planning and compliance with applicable regulations to ensure the success of drug delivery operations.

**2. Literature Review**

The Internet of Things (IoT) is a global infrastructure that enables advanced services by connecting physical and virtual objects based on interoperable information and communication technologies IoT involves data capture, processing, and communication to offer services in a variety of applications.

Based on (A John Wiley and Sons, Ltd., 2010) UAVs themselves are aircraft that do not require an operator crew on board because they can fly automatically through a computer or control board run by the pilot from central control.9 This reduces concerns about past experiences of pilot deaths or possible leaks of information if the plane crashes and the pilot is taken hostage. The pilot remains able to control the UAV from remote central control and is not under pressure or threat from the enemy so that he can concentrate on carrying out the UAV mission effectively. UAVs also have a lighter weight, smaller size and are easy to obtain because of their cheaper production costs compared to other manned aircraft. With the various advantages possessed by these UAVs, the United States can still make maximum efforts in combat because, again with its lighter weight, smaller size and low production costs, the United States can provide and deliver UAVs on a combat mission in large numbers without facing the risk of pilots being killed in the mission. UAV itself is an aircraft that does not require a crew of operators in it because it can fly automatically through a computer or control board run by the pilot from central control. This reduces concerns about past experiences of pilot deaths or possible leaks of information if the plane crashes and the pilot is taken hostage. The pilot remains able to control the UAV from remote central control and is not under pressure or threat from the enemy so that he can concentrate on carrying out the UAV mission effectively. UAVs also have a lighter weight, smaller size and are easy to obtain because of their cheaper production costs compared to other manned aircraft. With the various advantages possessed by these UAVs, the United States can still make maximum efforts in combat because, again with its lighter weight, smaller size and low production costs, the United States can provide and deliver UAVs on a combat mission in large numbers without facing the risk of pilots being killed in the mission.

An Unmanned Aerial Vehicle (UAV), also known as an Unmanned Aerial Vehicle (PUNA), is a type of aerial vehicle that does not require a pilot on board. UAVs have been used in a variety of applications, including environmental monitoring, alternative transportation, crop growth monitoring, military use, and freight forwarding.

In this study, UAVs were used as an important component in automated drug delivery systems. UAVs can deliver drugs quickly and efficiently, especially in emergency situations. In addition, UAVs have the ability to fly over obstacles and reach hard-to-reach areas, thus offering innovative solutions to improve healthcare accessibility.

There have been several previous studies relevant to this topic. For example, a study entitled "Mobile-Based Drug Order and Delivery Information System" conducted at PT. Wansa Turga Citra. This research focuses on the development of web-based and mobile drug ordering and delivery applications. Although the study did not use UAVs, the concept of automated drug delivery remains relevant.

Another study entitled "Implementation of an Internet of Things (IoT)-Based Drug Storage Room Temperature and Humidity Monitoring System at the Puskesmas Taman Sari District, West Jakarta" is also relevant. This research uses IoT to monitor the temperature and humidity of drug storage rooms. Although the focus is not on drug delivery, the IoT technology used can be applied in the automated drug delivery systems we are developing.

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Considering previous research and UAV technology, this research is expected to produce an effective and efficient automated drug delivery system, especially to support health services in KLU areas.

Efficient power management algorithms, such as Dynamic Programming algorithms or intelligent decision algorithms, are algorithmic design techniques developed to solve problems by breaking down solutions into a set of optimal steps or decisions. Dynamic Programming algorithm, or DP, is a problem-solving algorithm by breaking down a solution into a set of steps. Dynamic Programming can be used to solve various optimization problems, such as UAV trajectory planning, power management in IoT systems, and other problems that require intelligent decision making to achieve optimal solutions. Smart decision algorithms can also be used to efficiently manage power in the context of IoT and UAVs, by leveraging techniques such as machine learning and optimization to make intelligent decisions in power management. Thus, the use of Dynamic Programming algorithms and intelligent decision algorithms can help improve the efficiency of power management in IoT systems involving UAVs.

In some cases, UAVs can deliver goods in a much shorter time compared to conventional deliveries, such as emergency medicine deliveries or medical aid that can arrive faster with the help of drones. However, delivery drones also face limitations in terms of carrying capacity, so only small or light items can be transported, Thus, the use of UAVs as drug delivery has shown the potential to provide fast and efficient delivery solutions, especially in emergency situations or when time is precious.

## 3. Methods

### *3.1. System architecture*

Based on (Rghioui et al., 2021) who developed an IoT-based diabetes patient monitoring system using MCU Nodes, the system architecture is as below.

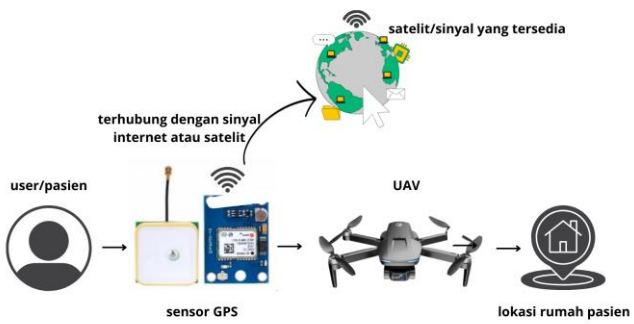


**Figure 1.** System architecture (Rghioui et al., 2021).

Here is an explanation for each of these sections:

1. User: A user is an individual or system that interacts with a product or service. In this context, a user could be a patient, healthcare worker, or person responsible for monitoring and operating an automated drug delivery system.
2. Internet: The Internet is a global network that connects computers and other systems to share information. In this system, the internet is used to transmit data between users, databases, and drones.
3. Database: A database is a collection of data that is stored and organized in such a way that it can be easily accessed, managed, and updated. In these systems, databases may contain information about patients, medications, and other relevant data.
4. Drone Tools: Drones are unmanned aerial vehicles that can be controlled remotely or fly automatically through certain systems. In this system, drones are used to deliver drugs from one place to another.

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5. Goals: Goals are the end results that the system wants to achieve. In this system, the goal is to deliver drugs to patients in the KLU area quickly and efficiently.
6. Device Results or Main Purpose: The result of the tool or the main purpose of this system is to ensure timely and accurate supply of drugs to patients, as well as improve the accessibility and reliability of health services in KLU areas.
7. Patients in KLU areas: Patients in KLU areas are individuals who need health services and medicines in KLU areas. They are the end recipients of this automated drug delivery system.

### *3.2. SKEMA SYSTEM*

The system scheme is designed to support automated drug delivery systems using UAV (Unmanned Aerial Vehicle) Technology and IoT (Internet of Things). The scheme includes various components, including data collection from the patient's home, transmission of data to user profiles, evaluation of data by medical professionals, and delivery of drugs using drones. In addition, the scheme also includes an alternative pathway where patient data is evaluated and fed into an electronic medical record (EHR) system for further analysis and treatment planning.

### *3.3. PSEUODOCODE SYSTEM*

Here is a pseudocode that represents the system scheme that has been created:

1. Start
2. Collect data from the patient's home
3. Send data to user profile
4. Send data from user profiles to medical professionals via wireless communication
5. If needed, send an emergency drone with an emergency kit to the patient
6. Otherwise, enter the patient data into the EHR system for further analysis
7. End

### *3.4. TESTING SCENARIOS*

Scenario testing will be carried out in the KLU area, focusing on whether the drugs delivered are suitable for the patient's needs or the patient's illness. The limit of drugs sent is drugs that can be loaded by drones according to their capacity. This testing scenario will compare the results with previous studies to ensure the effectiveness and efficiency of this automated drug delivery system. In addition, the testing scenario will also consider other factors such as weather, regulations and permits, as well as distance and travel time.

Based on the picture above, it is shown that the system built uses GCM sensoe to retrieve data connected to MCU nodes that have been integrated with mobile applications. The data from the tool is used as a machine learning model to classify whether the person has normal sugar levels or not.

Through the above system, researchers will apply the above system by making slight changes related to the machine learning model used, namely by using a time-series prediction model. The architecture of the system to be created will be shaped like the picture below.

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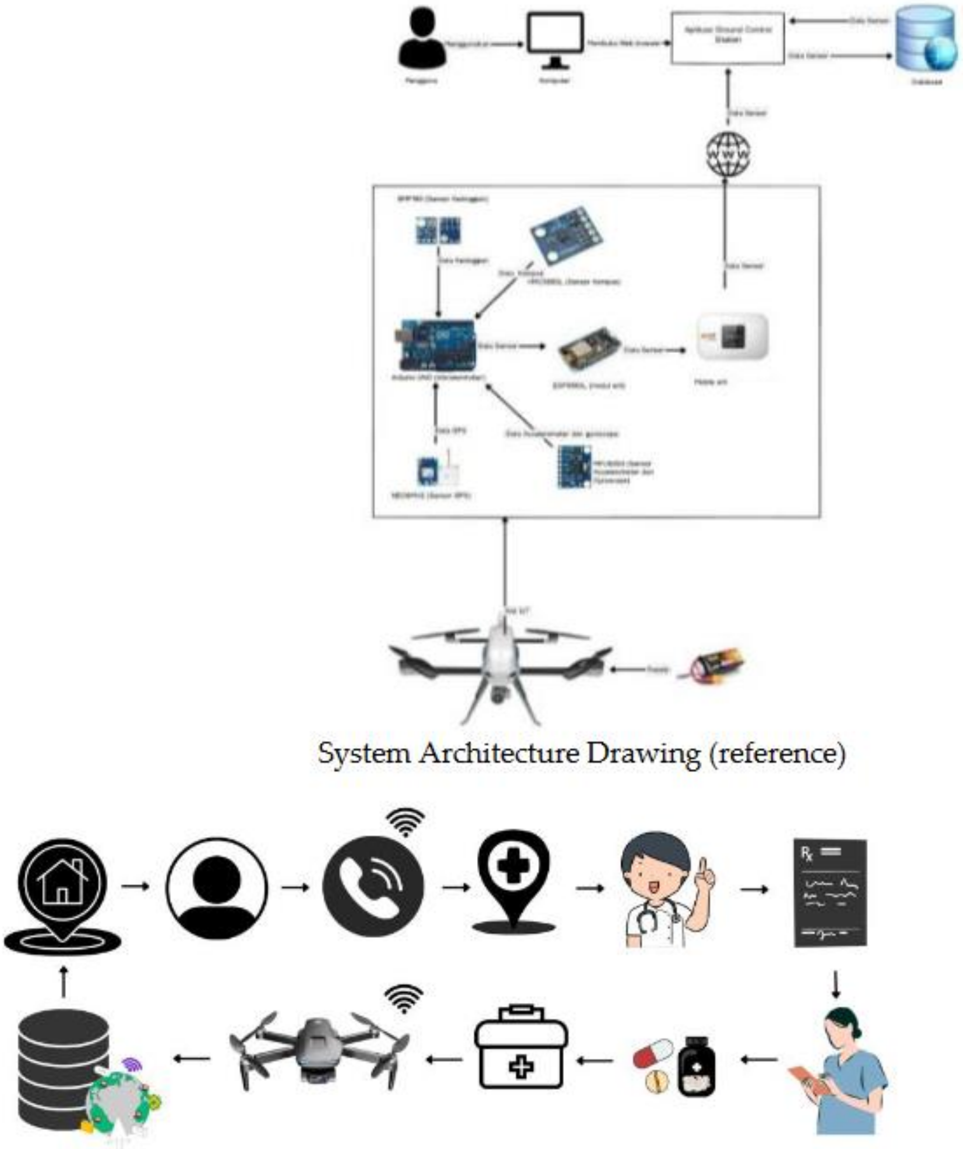


**Figure 2.** System Architecture for Prediction System.

The System for Prediction System architecture is designed to support automated drug delivery systems using UAV (Unmanned Aerial Vehicle) and IoT (Internet of Things) Technology. Here is the set of architectures of such systems:

8. Data Collection: This process begins at the patient's home, where the patient's health data is collected. This data is then sent to the user's profile.
9. Data Transmission: Data from user profiles is transmitted via wireless communication to medical professionals.
10. Data Evaluation: Medical professionals evaluate the data received. If needed, they can send emergency drones carrying emergency kits.
11. Drug Delivery: The drone then delivers the medication or other necessary items contained in the emergency kit to the patient.
12. Data Logging: In addition, there is an alternative path where medical professionals evaluate patient data and feed it into an electronic medical record (EHR) system. This EHR system helps in further analysis and treatment planning for patients.

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As such, the system architecture is designed to ensure timely and accurate drug delivery to patients, while leveraging UAV and IoT technologies to improve healthcare efficiency and reliability.

**4. Results**

This research focuses on developing an automated drug delivery system using UAV (Unmanned Aerial Vehicle) Technology and IoT (Internet of Things) to support telemedicine and community welfare in the KLU area. The system is designed to improve the quality of medical services and treatment management for people in the area.

One of the main challenges faced is how the KLU community responds to and receives automated drug deliveries using UAVs and IoT. To overcome this challenge, this study suggests providing education and training to the public about the benefits and how to use the system, as well as showing simulations of system work to the community.

In the context of UAVs, this technology has been used in a variety of applications, ranging from environmental monitoring, alternative transportation, crop growth monitoring, military use, to freight forwarding. However, the use of UAVs also has several obstacles, such as bad weather, carrying capacity, regulations and permits, safety, and distance and travel time. Therefore, the use of UAVs for drug delivery requires careful planning and compliance with applicable regulations.

Meanwhile, IoT enables advanced services by connecting physical and virtual objects based on interoperable information and communication technologies. In the context of drug delivery, IoT can be used to monitor the condition of drugs and smart medicine boxes, as well as notify medical personnel if there are problems with drug delivery.

Ultimately, the combination of UAVs and IoT in drug delivery systems offers innovative solutions to improve healthcare accessibility and reliability, especially in remote or isolated areas. With this technology, it is expected to help improve the quality of life of people in remote areas and ensure timely and accurate drug supply.

The use of UAVs and IoT in these drug delivery systems shows great potential in supporting telemedicine and public welfare. This technology can help improve the accessibility and reliability of health services, especially in remote or isolated areas.

However, there are still challenges that need to be addressed, such as how society responds to and receives automated drug deliveries using UAVs and IoT. Therefore, this study suggests providing education and training to the public about the benefits and how to use the system, as well as showing a simulation of system work to the community.

In addition, the use of UAVs also has several obstacles, such as bad weather, carrying capacity, regulations and permits, safety, and distance and travel time. Therefore, the use of UAVs for drug delivery requires careful planning and compliance with applicable regulations.

Meanwhile, IoT can be used to monitor the condition of drugs and smart medicine boxes, as well as provide notifications to medical personnel if there are problems with drug delivery. Thus, IoT can play an important role in ensuring successful drug delivery.

Ultimately, the combination of UAVs and IoT in drug delivery systems offers innovative and effective solutions to improve healthcare accessibility and reliability. With this technology, it is expected to help improve the quality of life of people in remote areas and ensure timely and accurate drug supply.

Overall, the study demonstrates the potential use of UAVs and IoT in automated drug delivery to support telemedicine and public well-being. While there are still challenges that need to be overcome, these technologies offer innovative and effective solutions to improve the accessibility and reliability of healthcare in remote or isolated areas. With this technology, it is expected to help improve the quality of life of people in remote areas and ensure timely and accurate drug supply.

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## 4. Discussion

In this research, we have discussed the development of an automated drug delivery system using UAV (Unmanned Aerial Vehicle) Technology and IoT (Internet of Things) to support telemedicine and community welfare in the KLU area. We have interpreted the results of this study from the perspective of previous studies and working hypotheses. The findings and their implications have been discussed in the broadest context possible. We have also highlighted some future research directions.

## 5. Conclusions

Based on the discussions we have had, we have come to the conclusion that this automated drug delivery system has the potential to improve the accessibility and reliability of health services in KLU areas. While there are still challenges that need to be overcome, this technology offers innovative and effective solutions.

## 6. Patents

Patent: Currently, we do not have a patent resulting from the work reported in this manuscript. However, we plan to continue this research and may apply for a patent in the future.

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