Design and Build A Logistics Delivery Drone to the Patients' Quarantine Room Using ROS Technology Without GPS: An Initial Study

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Abstract:
Drones are small unmanned aircraft that usually use GPS (Global Positioning System) technology to identify areas they pass through. However, its use is limited to open areas (outdoors) where the GPS sensor can connect to satellites without obstacles that can weaken the signal. An updated idea emerged about an indoor logistics delivery drone to the patient quarantine room automatically using ROS (Robot Operating System) technology without the GPS. This drone uses the main components of a Raspberry Pi, a PX4 flight controller, and an Intel Realsense T265 camera sensor. The Intel Realsense T265 camera sensor gets the current position and the drone's movement; then, the data is processed on the Raspberry Pi. The drone goes to the place commanded by the program on the Raspberry Pi. It automatically places the logistics according to the desired location when it reaches the specified position. Even without GPS, it is hoped that drones can make it easier for medical personnel to deliver logistics on target and minimize virus transmission because they are not close to patients. Based on three times testing, the progress obtained is quite good. The drone can fly stably. Although some accidents were in the trial, they can be handled well.

Keywords:
Autonomous · Camera · Delivery · Drone · Logistic · Raspberry Pi · ROS

1. Introduction

This research chooses a leading theme that aligns with the latest problems, namely mitigating the effects of the Covid-19 pandemic, and in line with the agenda for Sustainable Development Goals (SDGs) number 3, namely good health and wellbeing. SGDs were established by the United Nations (UN) in 2015 as a global development agreement to be a solution to social problems in the world [1]. The problems in the community that will be resolved from this research based on the featured theme above are about logistics delivery, especially food, beverage, medicine, vitamins, and clothing aid

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packages for patients in quarantine rooms. Usually, the quarantine area for patients is very dangerous if medical personnel or other interested people enter, even though they are wearing PPE (Personal Protective Equipment). So, tools are also needed to distribute logistics to these patients safely so as not to transmit disease viruses to medical personnel and others [2]–[6].

Over the past ten years, the advantages of unmanned aerial vehicles (UAVs) or drones in daily life have been more apparent; hence new developments in these technologies are required [7]–[9]. The novelty of this automated logistics delivery drone is that it uses ROS (Robot Operating System) technology without GPS and is quiet [10], [11]. The drone can use ROS technology to identify the region to be passed as a guide and to read the area in front of it to avoid any potential hazards, stay safe, and travel to a predetermined location. Drones that are often encountered still use GPS technology which is very less effective and cannot work indoors. Drones are designed and instructed to walk to the desired location without questioning GPS and satellite mapping to minimize obstacles to GPS. In addition, it can help human work, especially in delivering logistics materials to the indoor area at the quarantine area for Covid-19 patients. Drones are equipped with indoor sterilization boxes before and after carrying out logistics delivery tasks so that drones do not become a means of spreading the dangerous disease virus because health workers do not need to touch or interact directly with Covid-19 patients. Sterilization using ultraviolet (UV) light effectively reduces the number of airborne germs [12].

Drones are commonly employed in news coverage, creating videos that capture disasters, traffic congestion, and celebratory events. The entertainment industry and civil society also utilize drones to capture aerial photos and videos, which are often considered superior in quality. The utilization of drone technology is experiencing rapid growth, with its applications increasingly assisting human endeavors across various domains, including agriculture, plantations, expeditions, and healthcare. However, many drones still heavily depend on GPS technology for positioning and navigation [13], [14]. Among the various types of unmanned aircraft, the Quadcopter stands out with its four propellers and four brushless motors acting as actuators. Quadcopters exhibit reduced stability when used indoors due to their reliance solely on GPS sensors for positioning. Consequently, their ability to receive GPS signals is weakened, making it challenging to determine precise coordinates accurately [15][16]. It's worth noting that the use of GPS technology significantly impacts the efficiency of drone operations, as errors and other issues commonly arise within GPS technology [17]–[19].

The ROS platform, a framework that includes libraries, drivers, and tools to ease the building of sophisticated programmes on many robot platforms, can be used to process digital images from camera captures on drones. How it works refers to processing digital images via a computer. Previous research has implemented digital image processing on drones to be able to detect ARTag and make landings autonomously using digital image processing or computer vision and the ROS platform [7], [10], [20], [21]. ARTag is a fiducial marker system to support augmented reality using digital coding theory. ARTag markers are bitonal planar patterns (black and white only) that contain an ID (Identification) number. Before the detection process and landing mission are carried out, the most important thing is to create an object in the form of an ARTag. Making this ARTag uses a modification of the Hamming code principle. ARTag is used as an AR Drone runway object with black outer rectangles as borders [21]. At the same time, computer vision is the science of computer programming to process to understand images and videos so that computers can see [11]. The ROS library can be installed as a drone system controller on the Ubuntu operating system version 20.04. ROS functions as a liaison for transferring image data and control signals, controlling drone motion, displaying navigation data while the drone is on a mission, and as a digital image processing media in the form of video. The ROS library is first downloaded and installed on a PC (Personal Computer) or Raspberry Pi. Several typical use cases for developing robotics software are handled by ROS [22]. Furthermore, a project workspace was created that contained a digital image processing program and drone motion control to carry out landing missions [23], for example, in the patients' quarantine area.

COVID-19 has become a pandemic in almost all countries [24], [25], as evidenced by March 11, 2020, WHO (World Health Organization) declared it a pandemic. The SARS-CoV-2 coronavirus has affected 125,048 confirmed people as of March 12, 2020, with a 3.7% higher mortality rate compared to the influenza mortality rate of less than 1% [26]. The rapid spread of the coronavirus has caused many positive cases of COVID-19 patients in various regions of the world. Several technologies have been created to make it easier for medical personnel to deal with COVID-19 problems, including a model to distinguish COVID-19 from four other chest diseases (H1N1, H5N1, SARS, and Hantavirus) through Internet of Things (IoT) technology that can assist medical staff in monitoring the spread of COVID-19 [25]. In the health sector, this logistics delivery drone is expected to minimize the spread of the virus when there is a pandemic, especially among medical.

2. Materials and Methods

The drone is a type X drone design because it has four propellers/propellers in the shape of an X or a cross and a brushless motor acting as the power source, as illustrated in Figure 1.

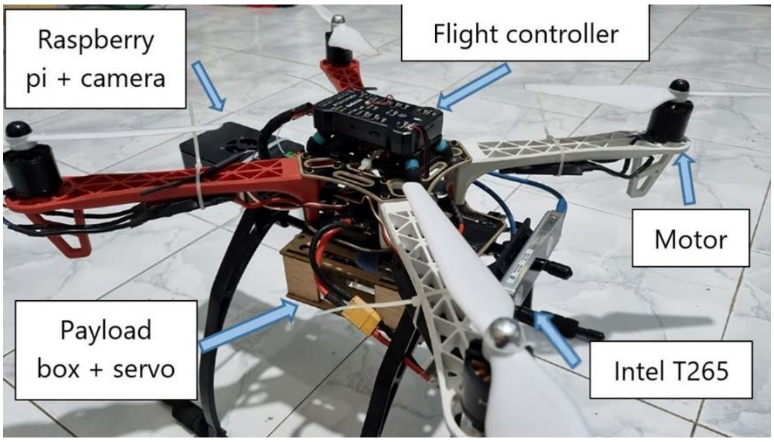


Figure 1: The physical design of the drone in general

The components of this drone in Figure 1 are:

1. Raspberry Pi / Raspi or a single-board computer the size of a credit card to run programs, process, and execute commands from connected sensors.
2. Flight controllers adjust the flying performance of the drone, for example, to adjust the altitude, direction, and speed.
3. Intel T265 sensor is able to capture image data of the area.
4. A brushless motor uses to generate lifting force as a propeller drive on the drone, which receives electricity from the battery via the ESC.
5. The servo motor is connected to the Raspberry Pi to open and close the payload box so that the logistics in it can be placed automatically.
6. Payload boxes are located under the drone, which can carry logistics.

In this initial study, the main operating system uses ROS combined with Raspberry Pi as the main support. Systematics, in general, can be seen from the chart in Figure 2.

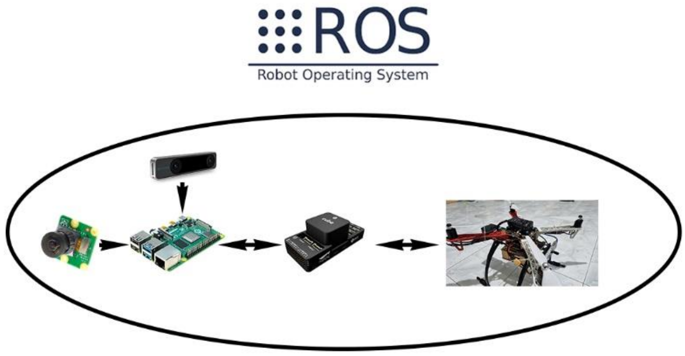


Figure 2. The working scheme of the drone

The schematic in Figure 2 shows the working sequence and the circuit on the drone that has been used in this study. The main source of the drone is a 2200 mAh 4S battery, which supplies power to all electronic components in the drone, from the battery to the Flight controller. This component functions as a drone driver controlled by a remote or as a flight controller, which later is combined with the autonomous program method. After the flight controller is powered, it is connected to the Raspberry Pi, which is the main component to support the operating system's operation and the autonomous system of the drone's work. The system used is ROS, which is the initial idea of making a drone to deliver goods or logistics to the hospital room autonomously without using GPS. In the ROS operating system, several sensors or components have been embedded in the installation of the Raspberry Pi. Furthermore, a camera connected to the Raspberry Pi was later operated with the ROS operating system. The camera used is an Intel RealSense T265 camera. This camera can see the object in front by depicting in 3D or in real what is recorded in front of it. So, able to move according to the program to be run in the ROS.

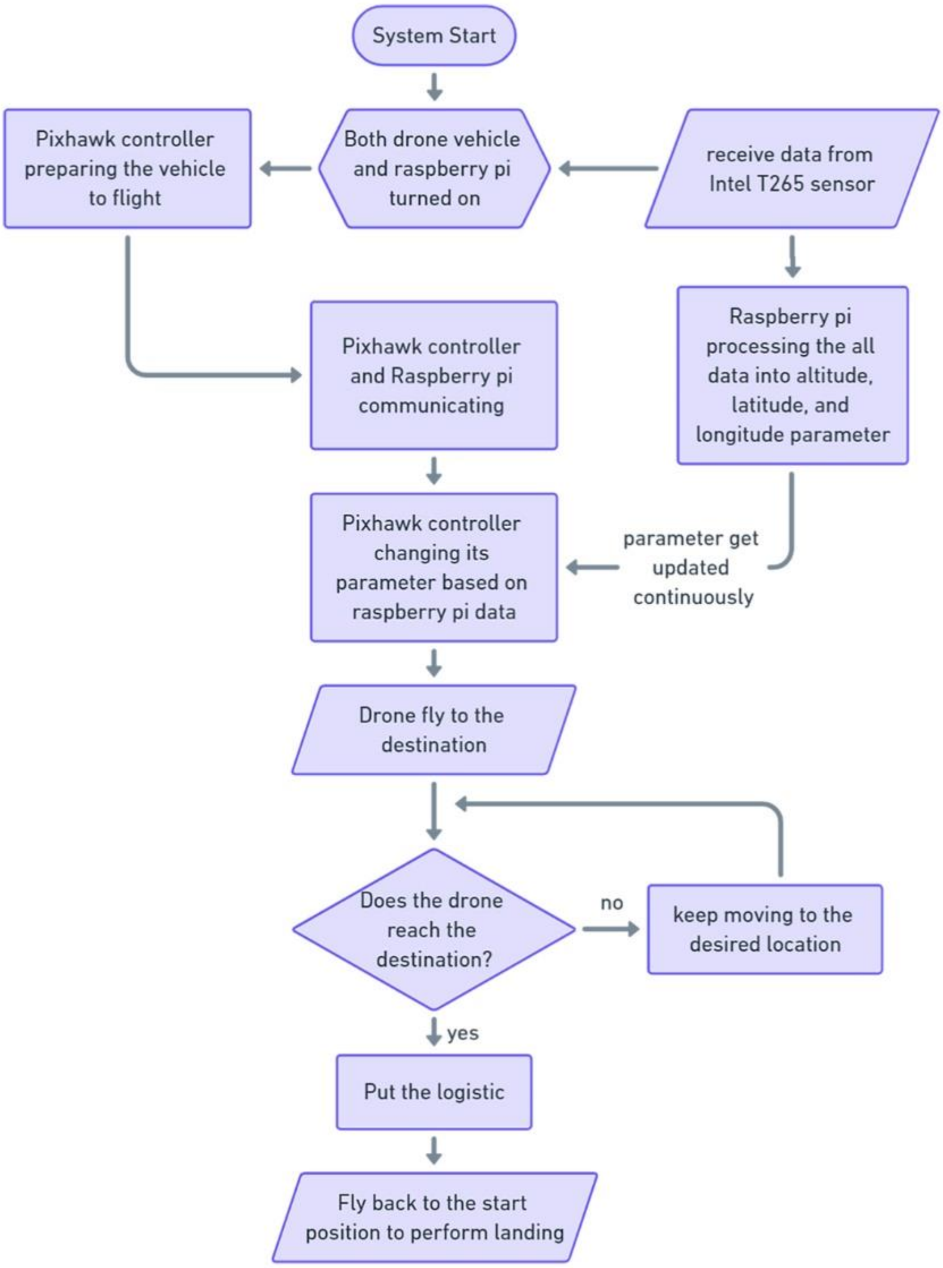


Figure 3: System flowchart

Based on Figure 3 displays how the system work. When the system starts, all of the electronic components are turned on and begin to do their job. The flight controller checks and prepares all of the drone's necessary parameters, including battery life, electrical supply, and communication setup. On the other hand, the Raspberry Pi processes data from the Intel T265 sensor and converts the data into altitude, latitude, and longitude. With the provided data from Raspberry Pi, the Flight controller can now fly to the desired location with a positioning system based on its initial position. When flying, the drone checks whether it's reached the target location or not by using a camera system to detect specific parameters such as QR codes or signs placed outside the room. If the parameter detected is correct, Raspberry Pi commands the payload box to put its payload in that place. After the payload is delivered, the drone automatically returns to the initial start position and performs landing, then finishes before repeating tasks and the sterilization process in the UV room.

3. Results and Discussion

In this study, the main test was conducted in an indoor environment. An outdoor environment test is only conducted to ensure all the sensors work properly. The place that used to be the outdoor environment was a football field. By conducting the drone system on an open area with a soft surface, the damage received by the drone components when drone crashes can be minimized. After the testing in the outdoor environment success, the drone was tested in the indoor environment for data collection. The place that used to be the indoor environment was inside the building room. By conducting the drone system inside the room, the drone is expected to operate accordingly to the actual mission.

3.1 Results

Based on Figures 4, 5, and 6, while the drone flies and hovers without any instruction to move, the drone tends to maintain its position.

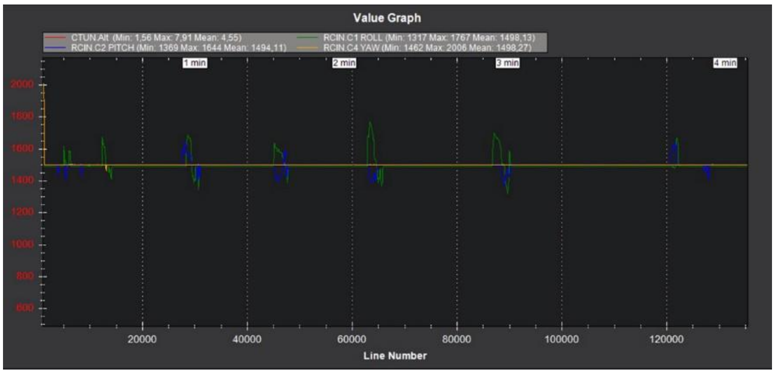


Figure 4: Control input

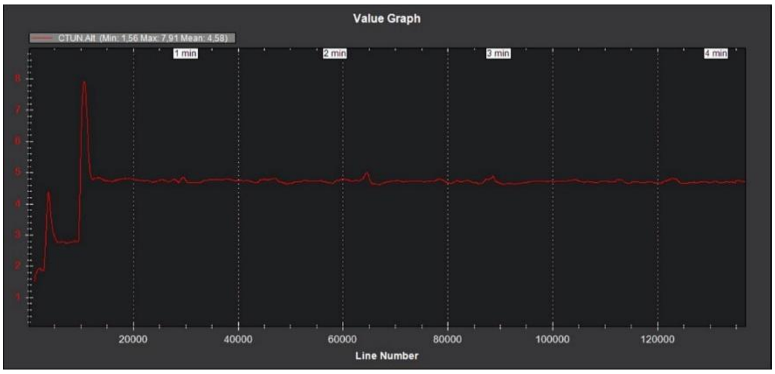


Figure 5: Altitude of the drone

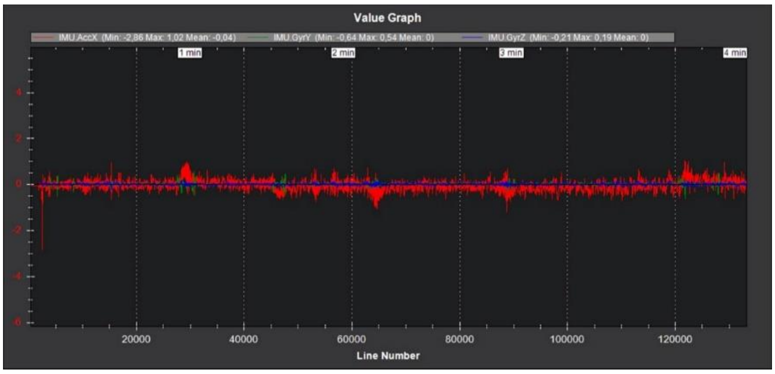


Figure 6: Position of the drone

Figure 4 shows that almost no control instructions to move were given to the drone. In this situation, the positioning system of the drone can be observed. Figure 5 shows that without the control instruction to move, the drone tends to maintain its height at the current level. Figure 6 shows that without the control instruction to move, the drone still sometimes moves its position a little bit to fix the position.

Figure 7: The track of the moving drone

Figure 7 shows the track of the drone with the control instruction that was given. The instruction was "move right 60cm - move left 120 cm - move right 60cm - move forward 60 cm - move backward 60 cm - move forward 60cm - landing." The figure shows that the drone moved in the same direction as the instruction. Still, at the side of the movement (right side, left side, front side, back side) from the initial position, the track shows the drone moved too far from the target location, but the drone automatically fixed its position.

Based on Table 1, the drone system can be appropriately operated in an indoor environment. The parameter on the table shows that with the control instruction given to move the drone, the drone moves in the same direction as the instruction. The drone moved to the right side and held its position with a range of approximately 0.6218 meters after receiving orders to move right 60 cm.

Table 1: Displacement of moving drone

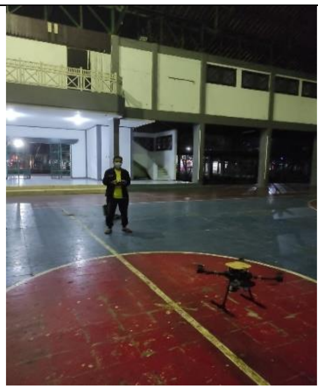
Instruction	Drone Position Based on Initial Position	Displacement in meters		
		X	Y	Z
Move right	Right side	0.6218	0.0065	0.0285
Move left	Left side	-0.5982	-0.0115	-0.0411
Move right then Move forward	Front side	0.0447	-0.0164	-0.6353
Move backward	Back side	-0.0140	0.0106	0.6711

Then, with instruction to move left 120 cm, the drone moves to the right left and holds its position with a range of about 0.5982 meters from the initial position. The drone moved to the front side and held its place with a range of approximately 0.6353 meters from the starting location after being instructed to travel to the right 60 cm and then forward 60 cm. Next, with instruction to move backward 60 cm, the drone moves to the back side and holds its position with a range of about 0.6711 meters from the initial position.

Figure 8: QR code reading process.

QR code in this test used to be a sign for the system to check whether the drone reached the target location by using a camera sensor. After the drone reaches the desired location, the drone starts to scan below the drone using a camera. Because a QR code matches the system, the drone decreases its height and opens its payload box to drop the logistics inside. When the logistics dropped, the drone increased its height and returned to the initial position to perform the landing.

Table 2: Trial results

No.	Experiment	Time and place	Photos	Test Results	Next Plan
1.	First flight test	Wednesday, June 23, 2021. Outdoor in the field of Psikologi UMS.	 **Figure 9: Checking the rides before flying outdoor**	The drone flies pretty stably, but due to windy weather conditions, the drone overturned, and the propeller broke.	Improve the propeller by replacing it and maximizing the ability of the battery during the flight.
2.	Second flight test	Saturday, July 3, 2021. Indoor at GOR (sport center) Campus 2 UMS.	 **Figure 10: Test of battery capability indoor**	Using a 2200 mAh battery, the drone can fly for 4.12 minutes.	The next plan will still try to fly the drone manually with the same battery but in an outdoor location to see its ability and stability in the face of windy weather.

3.	Third flight test	Wednesday, June 23, 2021 Outdoor at UMS Psychology field	 **Figure 11: Outdoor flight test**	The drone could fly stably in an outdoor test flight using a 2200 mAh battery. However, due to a landing error, the drone caused the ESC to be damaged.	The faulty ESC will be replaced with a spare ESC. When it is finished, a flight test will be carried out again.
4.	Fourth flight test	Tuesday, July 19, 2022. Indoor at GOR (sport center) Campus 2 UMS.	 **Figure 12: Stability test**	In an indoor flight using a 2200mAh battery, the drone could fly stably and now hold its position.	Instruct the drone to move to the desired location using.
5.	Fifth flight test	Saturday, July 30, 2022. Indoor at GOR (sport center) Campus 2 UMS.	 **Figure 13: Fly to target location test I**	The drone crashed in an indoor flight using a 2200mAh battery because it hit the wall, but no fatal damage was received.	Try to do the mission in the wider area.
6.	Sixth flight test	Monday, October 10, 2022. Indoor at GOR (sport center) Campus 2 UMS.	 **Figure 14: Fly to target location test II**	The drone could fly stably in an indoor flight using a 2200mAh battery and reach the desired location.	Try to make the drone drop the logistic.
7.	Seventh flight test	Tuesday, November 1, 2022. Indoor at GOR (sport center)	 **Figure 15: Dropping payload test I**	In an indoor flight using a 2200mAh battery, the drone could read the QR code properly due to the vibration.	Adding the damper to the camera mounting so that the vibration can be reduced.

		Campus 2 UMS.			
8.	Eighth flight test	Saturday, November 5, 2022. Indoor at GOR (sport centre) Campus 2 UMS.	 **Figure 16: Dropping payload test II**	In an indoor flight using a 2200mAh battery, the drone reached the desired location, dropped the logistic, and landed safely.	-

Based on the temporary test results in Table 2, it can be seen that the drone is able to complete its mission but under certain conditions. This drone system could track its position but could not detect obstacles such as wall, person, and object around it. On the other hand, the vibrating issue from the motor affected the camera sensor. So, a good dampening for the camera mounting is required.

3.2 Discussions

After all testing, currently, the drones we make can include:

1. Fly stably in indoor conditions;
2. Changing the position towards a certain point in meters;
3. Read the QR code and open the payload box based on the scanned QR code;
4. Fly back to the starting point and land.

However, drones cannot yet:

1. Avoid surrounding objects;
2. Recognize the location and analyze the environmental conditions.

4. Conclusion

Some of the problems, either hardware or software, faced in this study was resolved. However, there are some other problems that are still unable to be resolved, such as the capability to avoid the obstacle around the drone. This drone system suits indoor missions with large and wide areas but is highly not recommended for indoor tasks with small and narrow areas due to its incapability to avoid obstacles. With the capability to detect the object around the drone and map the surrounding wall, this drone system can deliver the logistics even to a small and narrow place.

In this initial study, the drone was not sterilized because it was focused first on flight stability testing. Further research will strengthen the ability to fly drones to achieve the main goal of safely delivering logistics to the patient's quarantine rooms.

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