MeDrone- A Smart Drone to Distribute Drugs to Avoid Human Intervention and Social Distancing to Defeat COVID-19 Pandemic for Indian Hospital

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Abstract: Many healthcare centres generally have a centralized unit-dose drug distribution system (CUDD). The in-patient’s drugs are warehoused in a centralized location such as hospital pharmacy. The required or prescribed drugs available in the pharmacy will be distributed to the patient by either the nurse or attendant. The attendant often collects the medicine from the pharmacy. This process is quite time-consuming and in this COVID’19 pandemic should maintain social distancing by the attendant in the pharmacy. In a field where time is of great importance and can save lives and also, a human intervention which in turn need to maintain social distancing, we can use MeDrones that will dispense medicines to the designated patient(s) location which will avoid human intervention and social distancing to defeat COVID-19 pandemic which is the need of the hour. The drone will be designed to deliver payload (tablets/saline) within/across the hospital premises. Apart from delivering medicines to the respective patients, the drone will be equipped to decide the optimal path to reach patients and prioritize attending to critical patients based on the hospital’s central database. The drones can be customized to return the unused medicines from the patient’s location to the pharmacy. Lightweight secured drugs container kit with authentication enabled will be designed for carrying the medicines to distribute to the respective destination inside the healthcare centre. The drone regulations result from increasing demand in UAV that must be devised to permit adaptation extensively as a logistics solution, to escalate efficacy in the healthcare domain.

Keywords: Drone, Pharmacy, Drugs, Social Distancing, Remote Sensing, Surveillance

1. Introduction
Despite the growth of modern technology, some things remain constant. Although some tasks must not change with technology, certain daily-activities must evolve with time and technology. These improvements will help us to save time and efforts. One such important, yet basic service is drug distribution to patients within the hospital. In the case of an elderly attendant with the patient, he/she has to come to the pharmacy which may be located far away from their patient room/bed to collect their prescribed medicines [1].

1.1. Drones Generations
The evolution of drone technology migrates from one generation to other generation; the brief description of the same was presented in this section.
**First Generation:** The first generation drone has been designed for all aircraft forms with basic features with remote controlling features.

**Second Generation:** Drones designed in the second generation also hold the manual piloting control with a static design featuring a fixed camera mounted on it to capture still images and video recording [2].

**Third Generation:** The static drones were designed with two-axis gimbals supporting High Definition (HD) video facilities with basic model system pertaining to safety measures and aided piloting.

**Fourth Generation:** A refined transformative design based drones have been proposed in the fourth generation. These drones support three-axis gimbals and 1080P HD video [3] capability ancillary higher-value equipment extending enhanced safety and autopilot modes.

**Fifth Generation:** Similar to fourth generation drones, fifth-generation drones pertain to Transformative designs associating 360° gimbals topping 4K video capabilities with higher-value equipment supporting intelligent piloting modes.

**Sixth Generation:** The drones were designed with commercial suitability following all safety protocols and regulatory standards. It was featured with platform and payload adaptability along with automated safety modes [4]. As for fifth-generation drones, this sixth-generation drone is coined with intelligent piloting models extending full autonomy and the airspace awareness system.

**Seventh Generation:** The drones competing, complete commercial suitability, promoting fully compliant safety protocols and regulatory standard-based design. These drones are also compatible with platform and payload interchangeability with automated safety modes. They have ensured improved models with intelligent piloting and full autonomy. These drones are customized with full airspace consciousness in all possible automatic actions like flight takeoff period, during flight mission execution time and landing period as well [5].

1.2. **Background and Problem with Existing Art**

Every second matters in a life or death situation, and hence time is of high importance in medicine. Instead of going to the pharmacy directly to collect the medicines, the complete process of collecting the medicines can be automated [6]. UAV (Unmanned Aerial Vehicle) can get deployed in many commercial applications like Aerial photography, Shipping and delivery of goods, Geographic mapping, Disaster management, Weather forecast, Wildlife monitoring, etc. [7]. In addition to the existing applications, this work aims to deliver the medicines as payload in the health care centres through drones. Zipline [8] Drones are used to distribute the drugs to the specific location using parachute over open space area without landing at the delivery site, which fails to authenticate the person who receives the drugs [9]. The existing system does not distribute medicines inside the healthcare centres. Also, there is no support feature of returning the unused medicines from the patient's room/bed to the pharmacy. Increasing demand in UAV results in drone regulations that have to be devised to permit its adaptation extensively as a logistics solution to escalating efficacy in the healthcare domain [10].

1.3. **Objective**

The proposed work aims to develop a user-friendly smart MeDrone that can deliver medicines to and from the patient(s) location to avoid human intervention and social distancing during Covid’19. Also, develop a drone that can navigate/inside the building and open spaces to reach the desired location with the help of a predetermined shortest path. Furthermore, to design and develop a lightweight secured drugs container with authentication enabled. Thus the proposed work focused on developing a user-friendly smart MeDrone that can deliver medicines to and from the patient(s) location to avoid human intervention and social distancing during Covid’19 [11]. It also aims to train the drone to navigate/inside the building and open spaces to reach the desired location with a predetermined
shortest path. The proposed work is also intended to design and develop a lightweight secured drugs container with authentication enabled.

2. Proposed System
The proposed system's methodology can be achieved by designing an autonomous flight drone and developing relevant application software for MeDrone such as developing interactive user interface (UI) and creating and integrating the associated database with UI [12]. It also ensures security and authentication by generating OTP / RFID authentication to guarantee drug delivery's correctness. Through the MeDrone App, the doctor's prescription is sent to the attendant /patient's mobile phone as a message used for verifying the medicines delivered. MeDrone also helps in returning the unused medicine from the patient's room/bed to pharmacy. This drone can navigate across/inside the building and open spaces to reach the desired location. The work targets designing a drugs container kit using lightweight materials like CRFC (Carbon fibre-reinforced composites) and other thermoplastic materials like nylon, polyester, and aluminum polystyrene, etc., for holding the medicines providing appropriate security for the medicine container. After dispatching the medicines, the drone will return to the ground station. The drone analyses the path/obstacles through image processing techniques and identifies the shortest route for dispatching the medicines inside/across the hospital premises. The drone's current position could be tracked/monitored by the attendant/professional certified operator through a GPS tracking system. The drone and the drug container must be sanitized if it returns to the pharmacy after delivering the medicines to the respective COVID 19 affected destination area. Drone fly area shall be allotted for the hospitals under construction like newly proposed AIMS hospital in Madurai, which simplifies the deployment of MeDrone for drugs distribution. For existing hospitals, the drone needs to be trained to find the shortest route and the same could be used as a predetermined path for drugs distribution to reach its destination.

2.1 Design and Working Principle
Recently a research firm predicted the revenue outcome by drone/UAV in the global market is anticipated to stretch $11.2 billion by the end of the year 2020. Due to the increased demand of the commercial drones in the market, there is an increasing convergence of the customer leading with an endless array of application [13]. One of such main applications is the delivery of payload. Figure 1 shows the architectural view of MeDrone. Initially, details of patient, locations, prescriptions, doctors will be sent to the drone operator through application software. The pharmacy operator will feed the patient ID, room details (such as room number and floor), and the prescribed medicines to MeDrone for dispatch. The medicines will be placed in the sliding compartments that are attached at the bottom of MeDrone. The drone will deliver the medicines from the pharmacy to the designated patient(s) location via staircase/open space in the hospital premises. The operator will constantly monitor the status of the battery charge. In case of low battery, the operator switches the drone to power-saving mode. Devices with tracking app installed will be placed in the wards so that the patients can track the drone's location [14].

2.1.1 Design Features:
Battery Status: The operator will be intimated about the battery status as soon as it reaches its threshold value even when MeDrone is mid-air. The various options to intimate the operator regarding the battery status are:

- **Full Charge:** The operator will be intimated when the drone is charged with a full battery, and this is to prevent overcharging of the battery, as it may affect the battery's life in the long run.
- **Recharge Soon:** The battery is functioning normally but holds roughly half its battery capacity. The drone may be used for a few more round trips; however, it may need to recharge very soon.
- **Recharge Now:** The battery is functioning normally, but it has reached its threshold value. The operator will be intimated about the battery's status, and it could be docked for recharging.
- **Dock**: The drone will head over to the nearest dock for charging, upon instruction from the operator.

![Architectural design of MeDrone](image)

**Image Processing**: The camera in the drone will be continuously sent images of its journey to the operator. These 2D images will be converted into 3D versions, which will help calculate estimated depth for traversing through staircases and take diversions from the obstacle.

**Door Lock Intimation**: When the MeDrone encounters the assigned room location is closed, the drone will make an alarm sound and wait for few seconds, and then the status of the room will be intimated to the operator to take necessary actions.

**Authentication**: Before delivering the medicines to the patient, the drone will ask the attendant to authenticate the OTP process [15] (One Time Password).

**Path Optimization**: During the drone's first trial run, its route can be optimized using the shortest flight path algorithm. The MeDrone will be customized to follow this optimized route for further medicine distribution.

**RFID for identification**: Every room and floor will have an RFID tag. This tag will help determine the designated patient(s) location and the path that drone will have to take.

### 2.1.2 Component Descriptions:

The various components required for the design of MeDrone along with its purpose and functionalities is tabulated in Table 1.
| Name of the Component | Purpose/Function |
|-----------------------|-----------------|
| Propellers            | These are the front propellers of the drones; they carry the drone through the air. The props help the quadcopters in flying as the helicopter props help the helicopter to take off. Some props are made up of plastics, while others of good quality are made up of carbon fibre (tough yet lighter in weight). |
| Pusher Propellers     | These are present at the back of the drone, as the name suggests, they mainly push the drone forward. The contra rotation of these props cancels out the motor torques during stationary flights. These are commonly made from plastic, but carbon fibre is also used to manufacture them for good quality. |
| Brushless Motors      | Due to its efficiency, reliability and low sound, the brushless motors are used in almost all the advanced drones. Because of its efficiency and design, it provides more flight time and consumes less battery power. |
| Motor Mount           | The motor mount in quadcopters may be constructed with the amalgamation fittings of struts (landing) or the UAV frame fragment. |
| ESCs                  | An electric circuit to monitor the motor's speed, direction for driving brushless motors. The Direct Current (DC) battery power is converted into Three Phase Alternate Current (AC) by ESC. ESC is an important component of all the modern drones, which ensures high-power, high-resolution and high-frequency three-phase AC power to the motors in a compressed minuscule suite. |
| Flight Controller     | The inclusion of flight controller enables to receive and interpret the signals received from the receiver device, GPS module, battery monitor, IMU and other integrated sensors. It also controls the motor speed through ESCs, provides steering and triggering the camera and other payloads, regulates autopilot, follow me, waypoints, failsafe and other advanced and autonomous functionality units, and holds the central position in controlling the drone. |
| GPS Module            | It mostly combines the GPS receiver and magnetometer to afford its parameters such as longitude, latitude, and elevation plus the compass retrieved from a single device. It is a premium requisite for numerous autonomous functionality of drones, including the waypoint navigation. |
| Antenna               | The antenna is considered a loose wire whip, or sometimes it might be in helical type, depending on the type of receiver. These are easy to upgrade with a circularly polarized cloverleaf antenna that provides long video signals with improved video stability. The antennas which stop the issues of multi-path effect and blind angle are considered good ones. |
| Battery               | Lithium Polymer (LiPo) batteries are most often used in drones. These provide the best combination of power density and lifetime. |
| Battery Monitor       | It displays the power level of the battery to the pilot. It is necessary to be aware of one's drone's battery and its flight time. |
| Gimbal                | The pivotal mount rotates around x, y, and z-axis to point the camera and other sensors. It prevents the drone from moving in multiple directions to point the camera on anything; instead, the gimbal does it with ease, and drone remains still. |
| Camera                | Numerous drones come with built-in cameras and gimbal; these cameras are especially designed for aerial filming and photography. Real-time streaming |
| Sensors               | Drones are being used in land mapping, agriculture, delivery, 3D mapping, to create a 3D map, for all these applications to be triggered, a camera with GPS needs to be fixed at the top of the drone. |
2.2 MeDrone Flowchart diagram

The flow diagram for finding shortest route, OTP generation for attendant and drug distribution or returning of unused drugs is explained in Figure 2. The architecture diagram of MeDrone is depicted in Figure 3.

**Figure 2:** Flowchart for MeDrone: A smart Drone to distribute drugs

**Figure 3:** The Architecture diagram of MeDrone

Unmanned Aided Vehicle  Unmanned Guided Vehicle
Figure 4: Flow diagram of Unmanned Aided vs Guided Vehicle

Figure 5: Flow diagram of obstacle Avoidance
Figure 4 depicts the navigation between an UAV functioning in a GNSS-challenged location with a (UGV) Unmanned Ground Vehicle. It also emphasizes the design of the optimum motion of the UGV to finest aid the UAV's navigation solution.

Through the usage of cooperative UGV's peer-to-peer radio ranging, this proposed method lessens the uncertainty of a UAV's navigation solution. Thus for the UAV, the position is deliberated to improve positioning geometry [16]. Over 3D mapping and obstacle avoidance planning; thus, the UAV always pays visual-inertial navigation. To implement path planning grounded on a traversability analysis, this UGV utilises the map and produces an elevation map.

Figure 5 depicts the parameters such as orientation and geometry of satellite navigation systems are the precious data used for observation processing retrieved from the Regional Navigation Satellite Systems. These are meticulously helped for applications in precise point positioning and orbit determination. The entire process is recurrent till the UAV system finishes the intact flight travelling mission. In-case where there is no evidence of ground obstacles on its track, the UAV system immediately neglects the avoidance procedure of ground obstacle and continues its regular flight mission. The accuracy of the projected system will be supervised and tested appropriately. With low-cost GNSS sensor, appropriate measurements will be carried out through the investigation outcomes attained from tools, such as the software-in-the-Loop (SITL) simulation tool and real UAV flights.

![Interface diagram of MeDrone system](image)

Figure 6: Interface diagram of MeDrone system

Figure 6 describes the drone's flow function process and working structure in a bi-directional mode. The drone's complete relevant info and the processed data using the autopilot unit and microcontroller is collected by the sensors, and based on the received data, the ground control station can monitor and control the vehicle. The human operator can command the vehicle's direction, orientation concerning the received data.
3. Result and Discussions

3.1 Drone Design Parameters:
The parameters that need to be considered for the drones' design and its dimensions are length×width×height, both in folded and unfolded type. The other related parameters are Takeoff Weight, Max Flight Time, Max Speed, Photography, Obstacle Sensing (forward, backward, upward, downward, sideward). Concerning aircraft, its Maximum Takeoff Altitude, Operating Temperature Range Transmission Control, GNSS, GPS/Vision Positioning. The positioning of the gimbal in pan, tilt, roll with Mechanical and controllable Range and its stabilisation are also need to be considered.

The Operating Environment of Sensing System in all possible direction such as forward, backward, upward, downward, sideward seems to play a vital role in its design. The other necessary components required for the design are relevant sensors, camera for capturing high resolution still images and video recording, Remote controller and its appropriate battery and charger manipulated with its input and output power supply. The various APPs it needed are Video Transmission System, Live View Quality, Max Live Video Bitrate, Latency.

3.2. Drone Specifications:
- Proposed Drone Vehicle Weight: 2.75 Kg.
- Proposed Drugs Container Kit Weight: 500 gms.
- Drone max. travel time: 25 minutes

3.3. Cost-benefit Analysis:
There is no existing system which distributes the drugs inside the healthcare centre. So, when we deploy it in a real-time environment on a larger scale, the cost may drop about 1.5 Lakhs.

3.4. Development and deployment insights:
These work will be accomplished in many levels of phases, such as:

**Phase 1:** Autonomous Flight
a) Drone Flight
   i. Setting the Drone path for Flight
   ii. Medical Complex/Block Surveillance
   iii. Sending live Images to the controller
b) Designing an Automatic Flight Subsystem

**Phase 2:** Medical Building Image Processing to path-detection
a) Building Image conversion (bi-level transformation)
b) Analysing the obstacles along the path
c) Shortest flight path findings to reach the destination
d) Implementing appropriate techniques to identify the floor/room number.

**Phase 3:** Development of MeDrone application software
a) Development of Interactive User Interface
b) Creating and integrating Database with UI

**Phase 4:** Design of Storage Box
a) Design of secured medicine container
b) Delivery of medicines through the storage box
c) Drone returning to Ground station

Thus Figure 7 depicts the complete insight of the MeDrone.
3.5 Applications of MeDrone
Table 2 signifies the various areas of applications where the designed MeDrone could be deployed and benefited at the maximum.

| Healthcare/Pandemic Situation                               |
|-------------------------------------------------------------|
| Medicine delivery                                           |
| Hospital area Surveillance                                   |
| Emergency Medical kit delivery Remote area                   |
| Chemical spraying                                           |
| Safety Awareness announcement                                |
| Road Traffic Management                                     |
| Medical- Blood samples Transportation                        |
| Medical waste disposal                                      |
| Emergency Transportation (organs)                           |
| Urban community area health service                         |

4 Conclusion
Thus a MeDrone is with Secured Lightweight Drugs container for drugs distribution by navigating inside the healthcare centre. The MeDrone proposed here is designed to deliver payload (tablets/saline) within/across the hospital premises. Apart from delivering medicines to the respective patients, the drone is equipped to decide the optimal path to reach patients and prioritize attending critical patients based on the hospital's central database. The drones can be customized to return the unused medicines from the patient's location to the pharmacy. Lightweight secured drugs container kit with authentication enabled will be designed for carrying the medicines to distribute to the respective destination inside the healthcare centre.
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