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Extending drone's capabilities for autonomous flight approach combined with indoor pod delivery mechanism

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Abstract

Drone technology is being tested and used in various fields today. Using drones to deliver items is one of the most promising aspects of the technology which is being developed by many companies around the world. It is very challenging to develop algorithms to decide flight paths and maneuver drones autonomously in the real world. Making an autonomous flying vehicle requires interdisciplinary approach. An array of various sensors working together and sharing data combined with machine learning models to analyze and act on that data is paramount for executing the level of autonomy required to achieve this feat. The drone needs to have intuitive understanding of routes. Removing discrepancies in the flight path requires well-constructed algorithms to assess the real life situations and make decisions to tackle problems which might occur due to accidents, collisions, onboard control issues etc. The technology should be optimal enough to handle practical constraints such as battery life, distance of travel, weather proofing etc. This paper focuses on the tools and algorithms available today and how they can be extended and modified to make a delivery system by combining delivery drones and a network of indoor tubes to deliver the item directly to one's home without them having to collect it outside.

Keywords--- *Delivery, Autonomous, Drones, Tubes, Pods.*

I. Introduction:

Drones are unmanned aerial vehicles (UAV) which can fly autonomously or can be controlled remotely. Using drones to deliver items is one of the most promising aspect of the technology as they can maneuverer in remote areas without roads or traffic congestion. Many start-ups and big multinational corporations like Amazon are trying their hand at this technology to deliver goods to the customers. Current technologies require the customers to collect their package outside their home as the drones cannot deliver it directly inside or at the doors. This is not an easy feat to achieve though, problems such as limited battery capacity, spatial awareness, location tracking, optimal route calculation etc. are to be solved or handled in order to make an efficient delivery mechanism. After handling the problems related to drone flight, a suitable delivery mechanism is to be developed which should be capable of delivering the items directly in the consumer's home. This mechanism will have a problem set of its own for example, identifying the target drop zone, shape and size detection, variable payload handling etc. To deliver the items inside, an internal mapping platform is necessary for the pods to deliver the item to its target location. This paper combines techniques of flight, delivery and an indoor delivery mechanism to achieve an autonomous delivery system.

II. Methodology:

First issue is tackling the vehicle routing with drone problem (VRDP). The problem is to find the most energy efficient paths for the whole round trip from the depot to the delivery location it is known as energy minimizing vehicle routing problem or (EMVRP). A web based visualization tool can be used to find the most energy efficient routing path [1]. Spatial awareness can be achieved by using on-board sensors to

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detect location and direction in real time. This is combined with an obstacle detection system to avoid collisions.

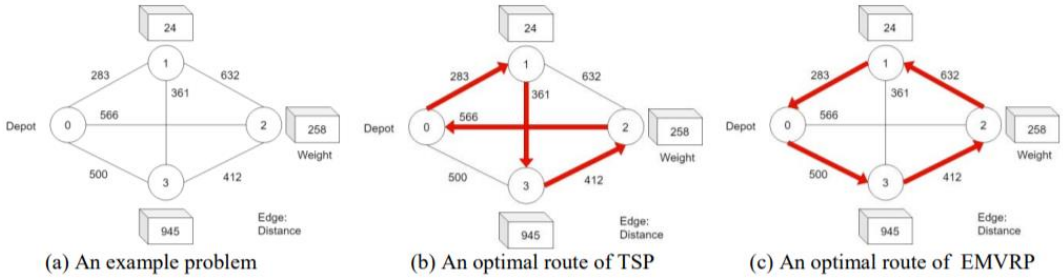

Fig 1. *Drone routing* [1]

Drones are used to minimize the time required for the delivery of the goods. This time is the total delivery time which is the duration between the order placed and after delivering the order the time of round trip. Algorithms are used to calculate the Total Time by factoring in environmental variables, average distance, ration of Euclidian distance to network distance [2 9].

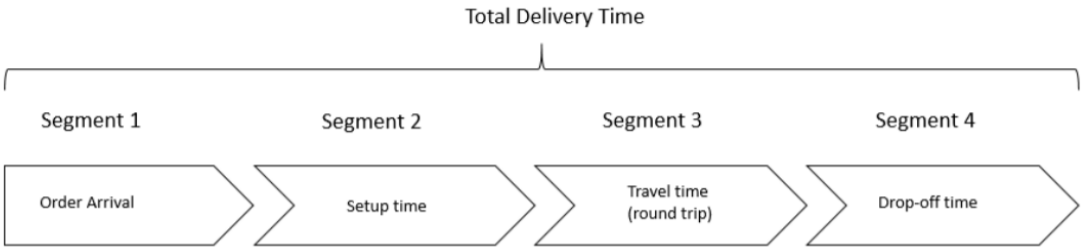

Fig 2. *Total Delivery Time* [2]

Drones are less reliable as they cannot take off during storms, they can breakdown or malfunction. These problems need to be factored in to make the system efficient as losses can pile up if the goods are not delivered properly or gets lost. The "uncertainty" factor of the delivery should be calculated. A method is to used combined ground and aerial vehicle combined delivery system known as ground and aerial delivery service optimization and planning (GADOP) [3 8].

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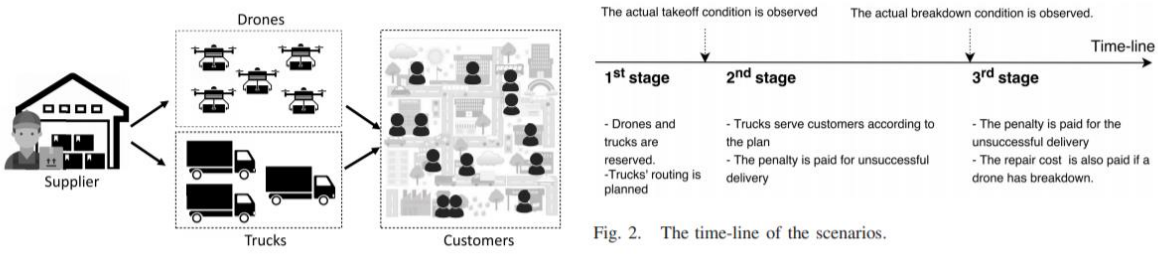

Fig. 2. The time-line of the scenarios.

Fig 3. *GADOP Framework* [3]

There are two types of obstacles avoidance, known or fixed obstacles or unknown obstacles (Fig 2). Dimensions of the known obstacles can be pre-programmed to avoid them entirely but the dimensions of unknown obstacles cannot be pre-programmed and for an autonomous drone, it is not possible to pre-program every existing object's dimensions [4]. A method is to use ultrasonic transduces to measure distance around the object. If the distance is high, it can move forward else repeat the steps with slight shifts.

Fig 4. *Ultrasonic Transducer*

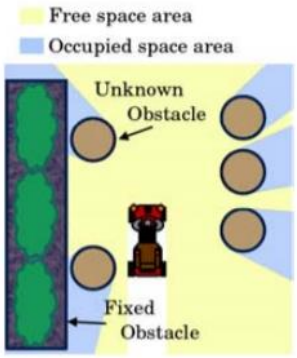

Fig 5. *Obstacle type* [4]

Indoor small scale environment navigation is an important area of exploration when it comes to drone delivery systems. In broad terms, the problem of "last-mile" affects many aspects of delivery. Various methods have been proposed to handle this problem one of which is to combine an IMU sensor with existing ORB-SLAM algorithms for more accurate small scale navigation delivery. (Oriented FAST and Rotated BRIEF) SLAM algorithms ensures high precision flight capabilities [5].

The payload capabilities of the drone determine how much load or weight it can carry and for how long. More payload weight will drain more battery as the motors will have to spin faster to generate more thrust. By changing the positioning of the components, and rotation movements the effective payload capacity can be increased [6].

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Hospitals use pneumatic tube delivery systems to delivery small items through a distributed network of tubes [7]. A similar mechanism is required for the indoor home delivery system.

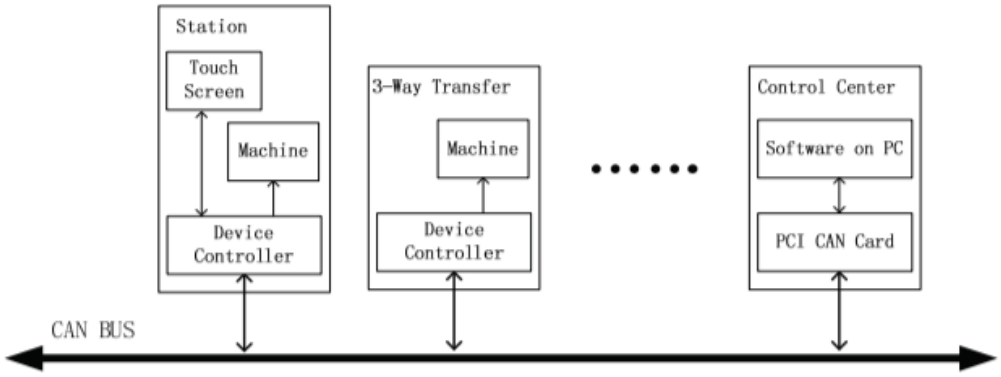

Fig 6. *Pneumatic system architecture* [7]

Fig 7. *Pneumatic Tube System in hospitals.*

III. Proposed Architecture:

The proposed architecture here is to use the techniques available to create an efficient delivery system combined with an indoor delivery mechanism. Drones will use QR markers to identify the target where they have to drop the item or the payload. These markers will be assigned to the buildings at the time of indoor mechanism installation. Each customer will have a unique IDMarker which will identify their home so that the pods can deliver the item directly in their home. Customer will be able to order and collect the items such as food, medicine, clothes etc. using a kiosk installed on their home which will be connected to the

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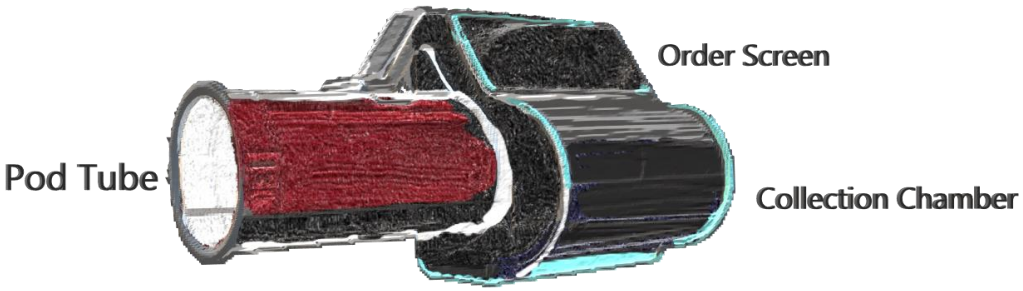
delivery tube. The drones will drop the items at a defined position on a building or home where the pods will carry it to the customer's kiosk. The IDMarker will be fed through an online system to the pods so that they can deliver the items to the customer's home kiosk.

Fig 8. *Indoor Pod delivery kiosk*

V. Results and Conclusion:



From the techniques mentioned above to develop an efficient way autonomous flight and combining them with the proposed indoor delivery mechanism, we can develop a delivery system which will be capable of delivering items directly inside the customer's home quickly and efficiently. Such a system will require handling of logistical problems related to autonomous flight and indoor delivery. Drones will have to be equipped with intelligent on-board systems combining image processing, spatial awareness and other essential components of unmanned autonomous flight.

VI. Future Scope:

In future this system will be pre-installed during the construction of the buildings. Retailers have to sign-up with the delivery company so their items can be uploaded to the kiosk database and can be ordered. Many retail shops can sign-up to deliver their goods using this system. The kiosk will have the list of available vendors and option to check out and pay for the selected items.

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