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Assignment-8

Summary on Drones in Smart Cities: Overcoming Barriers Through Air Traffic Control Research

In this paper the author focus on self-flying planes (drones) also known as Unmanned Aerial Systems(UAS), operated in densely populated cities to deliver goods and information by providing a solution to air traffic control and management services that has been replaced by other transportation vehicles. This is done on the cloud based system for safety and collision avoidance by combining the new system which is been described. These drones are operated in low altitude (500ft or below 150cm), followed by FAA NPRM with low cost air traffic control services for safety reasons. The author presents three technical products, two of which are built with a focus on cities and other one with low cost air traffic control services.

To Consumerize air traffic control the engineers present *three pieces of work* as follows:

Community drone platform**:** It is established on cloud platform to be used by citizens and cities to design low altitude airspace. *The first platform* is community drone where the urban Unmanned aerial commerce needs systematic airspace with precisely detailed airways from the landowner like building height, landing areas, flight restrictions and safe approach path to do package delivery. The landowner is encouraged to update information by using web browser about the parcel to lessen the risk to insurance companies. *The second platform* is based on trespass restrictions about the air parcel, privacy and environmental concerns to protect unwanted photography, reserve airspace for safe, low noise drones and other characteristics. *The third platform* function is flight planning services for drone operators by using vehicle routing problem which computes a flight path from origin to destination by abstracting the campus road network and running Dijkstra's algorithm on it which is done by google maps that helps to compute the air routes in three dimensions.

Co-ordination functions for drone and city infrastructure:

(i) *The unique identifier allocation problem*: Here the legal person needs a unique identifier which includes aircraft tail numbers to trace the license plate that contains SIM card or IP addresses. The author proposes in which each drone carries a flight integrity unit(FIU) that is essentially a flying cellphone record's flight data including GPS waypoints and speed configured with model number to provide safety to citizens.

(ii) *The non-real time identification and flight analysis problem*: Here the author focuses on the problem enabling drone operators to fly as good citizens in compliance with local laws for the payment of taxes or fees established by cities for commercial operations.

(iii) *The Real-time drone identification problem*: To know the identification of a drone in real time the FAA's Air traffic control solves this problem by using secondary surveillance radar called as ADS-B which provides unique identifier of the aircraft based on cellular data communications and LED's.

- *Identification by LED*: The LED requires an FIU on the drone which enables the police officer to read the license plate with the help of camera that has special attachable 12x zoom lens that captures the image with the help of OpenCV library app to detect colors, and identify the UAS. The FIU cellphone which is attached to the drone blinks a color pattern (red, green, cyan, yellow and pink) encodes the number of the SIM card that is connected to a RGB LED array, in turn which operate as an autopilot.

- *Identification by cellular data communication*: The FIU will transmit aircraft position and velocity under good cellular coverage with current GPS positions that helps the officer to identify the drone.

Drone Based control functions*: Since the drones fly in low altitude there is a collision between drones and helicopters with the manned aircraft* (below 500ft or 150 meters). *The manned helicopter* ambulance could be flying to pick up the patient, while *unmanned aircraft* will be delivering packages. The author concerned about the distance a helicopter will be flying that cause a drone to eliminate collision avoidance specified as worst case minimum maneuver distance(WCMMD).

The article debates *on cooperative and non-cooperative solutions*. The *Non-cooperative* focuses to avoid collision avoidance by using ADS-B. The ADS-B out performs aircraft GPS position and velocity data at 1hz which will be accepted by the nearby aircraft with ADS-B in to avoid collision.

An expression is derived to accomplish a single vehicle optimal maneuver which allows the vehicles get close as possible before it produce an avoidance maneuver. The following scenario is addressed: a small quadrotor, implemented with ADS-B in and out. The basic configuration is shown below:

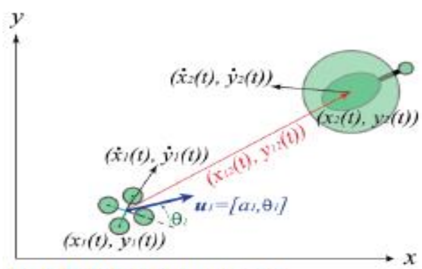

Fig. 4. The collision avoidance scenario.

In the figure 4. The vehicles 1 and 2 are quadrotor and helicopter subsequently, the positions and velocities are (x_k, y_k). The pair $U_1 = [a, \theta_1]^T$ is expression for avoidance maneuver where u_1 is the acceleration vector with magnitude a_1 and direction θ_1

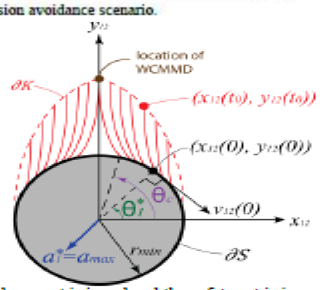

Fig. 5. The avoidance set is in red and the safety set is in gray.

From the figure 5. It highlights some position trajectories in solid red lines under optimal control. $(x_{12}(t), y_2(t))$ is heading toward the quadrotor. Where $t = t_0$ in the past and t = 0 advances to the present time with initial position $(x_{12}(t_0), y_{12}(t_0))$ and final position $(x_{12}(0), y_{12}(0))$. The acceleration vector stays constant. The set $(x_{12}(t_0), y_{12}(t_0))$ generates the boundary of the avoid set Ək which is been indicated by the *dashed red curve.* The *solid gray circle* with radius Rmin around the quadrotor is defined as *safety set S*. The set $(x_{12}(0), y_{12}(0))$lies on the boundary set Əs. The worst case (WCMMD) is defined as $\|x_{12}(t_0)Y_{12}(t_0)\|x_{12(t_0)} = 0$ which is the largest distance to start optimal maneuver.

There are two goals to be accomplished first we need to minimize $\|x_{12}(t_0)Y_{12}(t_0)\|2$ equation to derive the optimal acceleration vector, second we should graph WCMMD to function several parameters.

$$\theta_1^* = \tan^{-1}\left(\frac{y_{12}(0)}{x_{12}(0)}\right) + \pi$$

This equation is derived to decrease the relative component along the safety set S at time t=0.

$$x_{12}(t_0) = \left(r_{min} - \frac{v_{12}(t_0)\sin^2\theta_1^*}{2a_{max}}\right)\cos\theta_1^*$$

$$y_{12}(t_0) = \left(r_{min} + \frac{v_{12}(t_0)}{2a_{max}}(1+\cos^2\theta_1^*)\right)\sin\theta_1^* \qquad \theta_c = \sin^{-1}\frac{\sqrt{2a_{max}r_{min}}}{v_{12}}, \quad 2a_{max}r_{min} < v_{12}^2$$

The above two equations are used to compare the vehicle to vehicle position and speed to avoid collision and to provide safe interactions without human interaction.

***Conclusion*:**

This paper proposes solution for widespread UAS flight at low altitudes through community platform and on vehicle-city coordination to ensure safety to the citizens and avoid collisions.