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Parallel Navigation of Multi-Drones using City Information for Search and Rescue Operations

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Abstract: The ongoing global warming causes an increased number of disasters around the globe and is going to have a severe impact on our society in the years to come. Thanks to the rapid development of technology, drones have emerged, and the Search and Rescue operation become effective and efficient. In this paper, we propose the assessment of multi-drones for Search and Rescue (SAR) operations. The proposed SAR uses an appropriate city model with a diverse population density where the multi-drones can be dispatched based on the city's geographic information for the Search and rescue operation during a disaster.

Keywords: Drone; Search and Rescue; Disaster; Operations

I. INTRODUCTION

The emergence of drones with their capabilities of a remote-controlled have made Search and Rescue (SAR) operations more efficient and effective. Eliminating the risks of a search and rescue team in a dangerous area. They are already saving thousands of lives through their involvement in various public emergencies, safety operations, missing persons in a forest, and locating victims through their integrated high-resolution video camera and sensors under bricks debris when it comes to earthquakes. Drones also are making an impact in our daily life by being present in almost every area such as in media, agriculture, fishery, and even war frontlines. For example, the media uses drones for TV documentary picture shooting or TV program preparation. Filmmakers also are getting the advantages of drones [1]

Search and Rescue operations are not only difficult but also unpredictable. These two factors play an important role in the outcome of Search and Rescue (SAR) operations. The following are the elements that can determine the effectiveness and efficiency of the SAR. Time, terrain, weather conditions, and awareness of the mission area. Due to the flexibility of drones to adapt very quickly to any situation involving SAR, many private companies have joined universities to develop SAR drone applications.

[3] Proposes an Agent-Based system for maritime search and rescue operations where multiple detection stations equipped with Radio Direction Finders (RDF) have been used simultaneously to acquire the direction of the distress radio request by estimating the source of a signal by triangulation. Their platform also includes visualization features by which drone operators are provided a geographical Information System (GIS) Interface. [4] Introduces a Camera-Based Target Detection and positioning UAV system for Search and Rescue which is capable of both target and post-target identification. In this paper we propose an assessment of multiple drones' interaction for Search and Rescue (SAR) operations in a disaster based on city map information (CMI) where drones are dispatched into each area with more population to save life as quickly as possible.

II. BACKGROUND

Japan is one of the countries in the world that is suffering all kinds of natural disasters each year in spite of its high technology level. Recently the research on Search and Rescue (SAR) has become an urgent subject to deal with among research institutions and universities so that lives can be saved and eventually reduce the damage in human lost during a disaster

When a disaster occurs in Japan, the first operation team that is dispatched to the disaster site in order to protect lives and property is the Japanese Ground Self-

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defense Force (JGSDF). The JGSDF is dispatched by the order of the Minister of Defense, or an individual designated by the Minister, upon the request of the Prefectural Government or other related official. The JGSDF performs a variety of activities including Search and Rescue, accident victims' recovery, assistance to ships flood control, and water supply to the disaster victim. These activities are done in many cases manually due to a lack of equipment integrated with technology (Fig.1).

Fig.1 JGDSF operations activities example

The second problem encountered by the JDSDF is that most of them are called from different parts of Japan and therefore they are not familiar with the disaster site, so the outcome of their SAR is not as expected depending on the type of disaster.

The third difficulty of the JGSDF SAR operations is the weather condition. Which does not allow SAR operations due to unpredictable risks for the SAR team. In the case of a situation, the SAR operations mission is simply sopped causing sometimes lives lost.

The last and fourth difficulty of the JGDSF is the disaster site risk for their life. Even if their duty is to aid victims, save lives, and protect property, they are human and also have family to feed including their own life that is matter. So, when the SAR site condition can cause risk to their life the dispatched order is called off. When this happens the disaster victims are left on their own without hope. In order to bring our contribution to the SAR operations, we addressed the above — mentioned four JGSDF difficulties with one technology response, which is the use of city map geographical information. To do so, we proceed as follows:

III. METHODOLOGY

A. Search and Rescue Development Procedure

We first use Google Maps to locate the city's geographical map information. From this information, we list each area with its population number from less populated areas to more populated areas. This population density shown in the Google map is a density area in squares. Although the density population in the Google map has detailed information but not sufficient for SAR Operations so, we use the Regional Statistic Database, which is a system of social and demographic statistics called e-stat. The system provides us with the following data to help us acquire the information needed for the task. Total area population, population pyramid, and regional radar chart. From this population information, we can divide the SAR area based on the available drones for SAR operations. For this assessment, we have presently seven drones. Two DJI Phantom 4 RTK Se Combo + D-RTK 2 mobile station Combo and five Tello TLW004 Fig.2 and Fig.3 are the available SAR drones

Fig.2 Search and Rescue Phantom 4 RTK drone

Fig.3 Search and Rescue Tello TLW004 drone

The Vision Positioning System helps the aircraft maintain its current position. With the help of the Vision Positioning System, drones can hover in place more precisely and fly indoors or outdoors in windless conditions. The main components of the Vision Positioning System are a camera and a 3D infrared module located on the underside of the aircraft. Table 1. shows Tello drones' specifications.

Table I. Tello drone specifications

Aircraft (Model: TLW004)	
Weight (including Propeller Guards)	87 g
Max Speed	17.8 mph (28.8 kph)
Max Flight Time	13 minutes (0 wind at a consistent 9mph (15 kph))
Operating Temperature Range	32° to 104° F (0° to 40° C)
Operating Frequency Range	2.4 to 2.4835 GHz
Transmitter (EIRP)	20 dBm (FCC) 19 dBm (CE) 19 dBm (SRRC)
Camera	
Max Image Size	2592×1936
Video Recording Modes	HD: 1280×720 30p
Video Format	MP4
Flight Battery	
Capacity	1100 mAh
Voltage	3.8 V
Battery Type	LiPo
Energy	4.18 Wh
Net Weight	25±2 g
Charging Temperature Range	41° to 113° F (5° to 45° C)
Max Charging Power	10 W

In traditional SAR, the operation can be conducted on a large scale by contrast. So, we first select one area with more population of 500 meters and divide it by 5 to reduce the SAR travel distance to 100 meters for each drone. Which means each drone will only scan its allocated distance. Here each drone will have 100 meters to scan so that all areas can be covered. We set the speed for the departure of each drone to be the same to estimate each drone's SAR time. In SAR operations the most important factor is the impact of wind drone flight. This factor will affect the speed and SAR time and eventually the SAR outcome. This is what we will focus on to make the SAR system more efficient. Our projection is to have the distance between each drone will be about 50 meters for a better result.

IV. RESULT

When a disaster occurs and the SAR operations teams arrived at the disaster site the first, thing they have to do is to dispatch five drones based on the population information provided by both the google map and the regional demographic statistic. Each drone has a specific search trajectory to follow in order to find any disaster victim. All drones do not interfere with each other search trajectory. The search area for this assessment is about 100 meters square for each drone (Fig.3).

Fig.3 dispatch drone.

Victims are required to make a SAR sign and place them in a visible location for the drone to detect easily. They are not any predefined SAR sign in advance that is instructed to all those waiting for the rescue. Any person can make any rescue sign using any available items around them. When a victim is found, the drone is supposed to sound a Beep three times in order to get off the Search and Rescue Team operations while at the same time sending all the necessary information to the SAR team on the ground. Information such as distance from the SAR Team to the location of the victim has been located and an estimated arrival time is calculated

V. CONCLUSION

In this paper, we propose a solution for multi-drones for Search and Rescue (SAR) operations. The proposed SAR uses an appropriate city model with a diverse population density where the multi-drones can be dispatched based on the city geographic information for the Search and rescue operation during a disaster. The search area for each assessment is about 100 meters square for each drone. The proposed work will be tested in the coming month to assess its efficiency and effectiveness.

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