Summary of pre-disaster literature review

1. Pre-disaster:  Path planning – with cameras/ LiDAR's

In consideration of our proposed solution to the pre-disaster section of the usage of drones in civilian evacuation, we researched important relating topics like path planning and obstacle detection with cameras, algorithmic pathfinding, and LiDAR sensor usage. We looked at several papers relating to these topics.

Before discussing literature, a background of the usage of these drones is necessary. We plan to use these drones in the role of aiding first responders during a civilian evacuation. Evacuations are always chaotic and difficult to control, and any help offered to first responders and organizers will be crucial to evacuating and saving lives. First responder organizations like the police departments, fire battalions, paramedics, and dedicated evacuation response staff often have resources stretched thin and are inadequate when dealing with the sheer scale and unpredictability of disasters. Drones could serve in a variety of capacities to aid these first responders and our research intends to formulate new applications of drones in the field of evacuation response. One application that drones could serve in areas is communication drones or signal drones where they relay signals from organizers to evacuees in ways that normal signals cannot reach. The main application will be as pathfinders for evacuees and organizers. Drones can be used to search for safe evacuation paths before and during a disaster as UAVs, unmanned aerial vehicles, can get to and image places that humans cannot access.

Diagram

Description automatically generated

Some of the papers that we reviewed were concerned with the algorithm that the drones would deploy to do exactly that, search through an area for the best escape route. Obstacles can be pre-programmed or simulated for the drones and the drone must then identify a path considering all the simulated debris. This path can then be marked for later use if an actual disaster were to happen. During a disaster, drones can serve the same purpose. They can search through actual debris fields and disaster ruins and search for safe and easy paths that evacuees could use to escape an area and get to safety. Several algorithms were mentioned in these papers, including PSO (Particle Swarm Operation), WOA (Whale Optimization Algorithm). One paper was specifically about the testing of different algorithms and their computing cost and quality in deciding a safe path through a field of obstacles. This experiment tests these searching algorithms, with different path-finding scenarios. Some include a few large obstacles while others include several smaller obstacles. It also runs scenarios where the path is clearly defined to a human but not as well defined to a machine. Each algorithm is used to find multiple paths and decide which path is the best based upon its travel cost and obstacle value. The algorithms are graded upon how good of a path it finds and how much computing power it needs to find that path. Through several such tests on all the algorithms across multiple different scenarios, the DGBCO (Dynamic Group Based Cooperative Optimization) algorithm proved to be the best searching algorithm because of its unique dynamic grouping capabilities.

Chart, bubble chart

Description automatically generated

Drone’s path finding experimentation with varied obstacle distributions

Another paper discusses the usage of big data resources to plan and analyze vehicle routes during an evacuation scenario. This paper's focus is wildfires, but the concepts can be transferable to other disasters as well. It writes that there are two primary streams of traffic when a disaster occurs. One stream involves the evacuees, and the other stream involves the first responders. This is a common occurrence in all sorts of evacuations, from buildings on fire to entire city-wide evacuations. The paper also writes that this application was tested in a wildfire in British Columbia.

One paper dealt with a specific testing scenario as well as different applications for the usage of drones. This paper discusses the pre-disaster 3-D mapping of cities, specifically over the city of Victoria, British Columbia. This was the first mapping mission over an urban area approved by the Canadian aviation authority. The images were captured through sense Fly eBee Plus fixed-wing drone with real-time kinematic/post-processed functionality, with the goal being to assess the quality of pre-disaster data about geospatial accuracy of buildings and landmarks.

Aerial view of a city

Description automatically generated with medium confidence

Landscape (left) is scanned by a drone, creating an outline of objects (right)

These papers are all useful in deciding how a pre-disaster planning and path-finding system would work. Through our literature review, we have found that a combination of the DGBCO algorithm and a network of connected drones will be effective in tracking the movements of a group of evacuees, deciding what paths they can take to escape the situation, and how best to distribute the resources that first responders and evacuation staff have available.

When planning for disasters, redirecting citizens to safer areas away from natural disasters is essential in mitigating potential loss of life. Our first article discusses the need for drones and UAV integration to maximize the effectiveness of evacuations among all disasters. The paper points out the importance of using drones and UAV systems together to achieve improved reconnaissance in evacuation scenarios, allowing for improved tracking of people from the disaster. The data collected from tracking the movement of people can help drones direct citizens towards more practical evacuation routes while helping national guards in planning and allocating resources, among many other uses. The second article highlights the need for specialized networks for drones to deal with many different problems, ones which can be used for predicting the disaster by structural and environmental monitoring, information analysis for forecasting, and early warning systems. When citizens do not have enough time to evacuate from a city, they need to be directed towards safer areas in a city. The previously mentioned “specialized networks” solve this problem, allowing drones to receive signals from their central controller with ease, therefore making them relays between the emergency services and evacuation organizers and the evacuees and first responders.

We also investigated literature that is specifically related to specialized topics like LiDAR, path planning, and infrared camera use on drones. The first paper that we found related to how autonomous drones would conduct path planning operations in a safe manner. The paper’s researchers focused on several possible situations where the drone was to calculate the reaction to the situation before the situation began. They stated that their experimental data proved that their system of autonomous drones could appropriately react to situations where an escape path needed to be calculated and executed.

Another article specified the wide range of lidar sensors that could potentially be used for both civilian and military applications. Regarding its civilian uses, lidar is particularly useful in capturing high-resolution 3-D data from reasonable distances. The paper focused on the practical uses of lidar in capturing information in bleaker weather, such as natural disasters, as a way of collecting data on the direction, power, and potential duration of the natural disaster. It also discussed new developments in radar that could enable cameras to identify singular people moving on the ground, opening potential uses of lidar beyond capturing 3-D data of large objects. This is relevant to our research as it enables further accuracy in both our plans to track the movements of people pre-disaster and to analyze the storms, hurricanes, and tornadoes using our high resolution, 3-D lidar scanning system.

<https://ieeexplore.ieee.org/document/9333111>

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