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Drones in Human Aid and Disaster Relief using Thermal Imaging Technology

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Abstract

Disaster Rescue is a very dangerous job to carry out the process without risking more lives in the process as the environment plays a major role. To find the people, requires the system to identify the movement and recognize the human by using the Thermal imaging system in the place of low-temperature areas such as forests, flood areas, Dark places, and so on. Not just thermal but also RGB cameras, stereo cameras and Infrared cameras are used to gain the surrounding situational inference, and by using the intelligent system to identify humans by their body shape from a distance and using the CV pipeline the movement can be identified and confirmed for victims condition in the disaster area. By mounting the optical systems in the Drone, the process makes it safe for the people, and a quick rescue response can be implemented. Using the heavy payload carrying Drone to supply emergency kit and food supplies to the Victims on time. It as well can also act as an emergency communication Network establishment with the GPS to gain the location of a specific point of Disaster regions.

Keywords: *Thermal Imaging, CV Pipelines, GPS, Stereo Camera, Communication Network and Payload Capability.*

1. Introduction

The Drone system with the ground station control system makes it possible to handle the search process to be more efficiently by using the system process of controlling the drone from a long distance with the safe control features, reducing the risk of the rescue workers to the direct interaction with the danger in the disaster-prone areas. As it handles the delivery of emergency rations and first aid by the payload capacity it has and the capability to find the movement of the humans by using the thermal imaging and motion detection by CV pipelines. The field of disaster management is rapidly evolving with the integration of drones, as technological progress consistently broadens their capabilities and uses. Their ability to gather data, enhance situational awareness, and improve the efficiency and effectiveness of disaster response efforts represents a significant step forward in how societies manage and recover from catastrophic events.

2. Purpose

The project aims to utilize inspection drones to revolutionize disaster response efforts by enhancing situational awareness, minimizing risks to responders, optimizing resource allocation, and fostering innovation in disaster management practices. Through the rapid assessment and surveillance capabilities of inspection drones, responders can gain invaluable real-time data on disaster-affected areas, enabling informed decision-making and swift allocation of resources to areas in need. By reducing the exposure of human responders to hazardous environments, drones mitigate risks and enhance overall safety during response operations to find the victims with

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the help of optical technologies and techniques.

3. Motivation

The project's motivation lies in leveraging inspection drones to enhance disaster response by providing rapid, detailed assessments, improving situational awareness, minimizing risks to responders, achieving cost-efficiency, and driving technological innovation. These drones offer a safer, more cost-effective alternative to traditional methods, with the potential for further advancements through integration with AI and other cutting-edge technologies [12]. Ultimately, the project aims to improve disaster management strategies and mitigate the impact of disasters on communities.

4. Methodology

A Thermal Imaging system is used to read an object's heat signature to identify human presence by their body shape and movement by CV pipelines [10]. RGB camera readings are taken that are processed with Yolo and data pipeline to find the movements of people in disaster areas with high radiation or heat disturbances [13]. The stereo camera [14] is used to analyze the depth or distance to get a full reading of the surroundings and the victims [1]. By mounting these optical technologies on the drone creates it very efficient to observe and work with the rescue operations [2]. The tracking system works by GPS location marking with faster communication systems to map the location in the database for better rescue and prompt response. It also uses a targeted detachable physical marking device to make it possible to find the location with better accuracy, and the drone creates an emergency communication network [8]. Delivery system [11] of the drone to send in supplies to the disaster locations and provide immediate medical supplies and first aid kit to the victims in the case of emergency search response. It works by a detachable cargo load to drop off the supplies with multiple compartments.

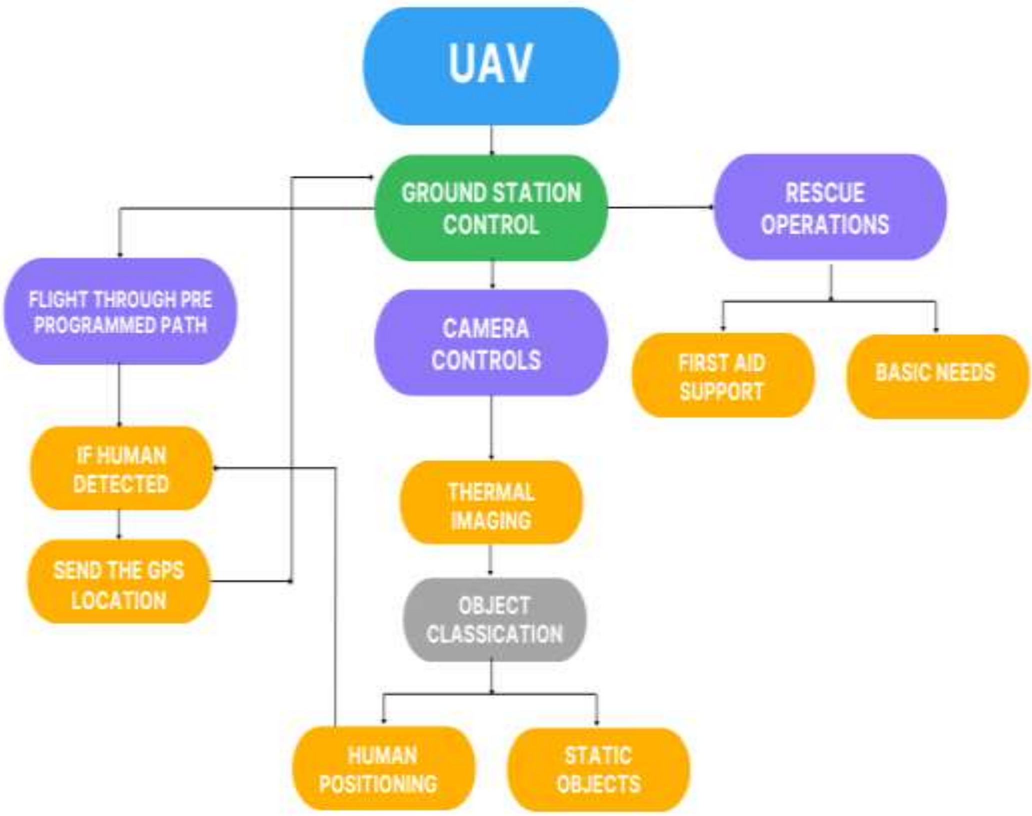

Figure 1 Data Flow Diagram

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5. Proposed System

The drone undertakes an inspection mission to manage and mitigate the impacts of these disasters. It captures thermal data through its onboard camera, initiating the first step in the data acquisition process. The onboard computing unit then engages in preliminary processing, combining thermal data with navigation and sensor inputs to find the victims' location and provide real-time insights and immediate response, as shown in Figure 1.

6. Working Process

The process starts with the Drone moving into the disaster area. With the employed ground stations, it creates a communication network through which the drone is instructed to follow the mapped path. Until it completes the marked area, the location of the identified victims is marked for the rescue [7]. The camera mounted gets situational awareness and uses the thermal, RGB and infrared cameras to identify the victims by processing the visual data. This identifies the human by their body shape with the CV pipeline makes it possible to confirm their presence and their situation based on their movements [7]. The data is sent to the ground station for decision making and the process of emergency supplies is delivered to the place where it is difficult to carry out the rescue process on the run. So the path to move in and out with the supplies will be easy to plan as the supplies can be dropped in the place needed and the path to move can be calculated for executing the rescue operations safely [3]. With the stereo camera [15], we can find the distance of the victims from the point of inference to move up and ahead and the possible risks can be reduced while increasing the chance of an effective rescue process [10]. The drone movement will need to be stable and the systems should be able to move in without delay by obstacles so it uses a depth perception of objects and move to the nearest path change or to move up and carry forward by programming the system with path following till the identification of the Victims once the identification is confirmed the Decision will be taken and instructed by Ground station controller [10]. This process is carried out till all the marked areas are covered, and all the civilians are rescued for safety, as shown in Figure 2 & 3.

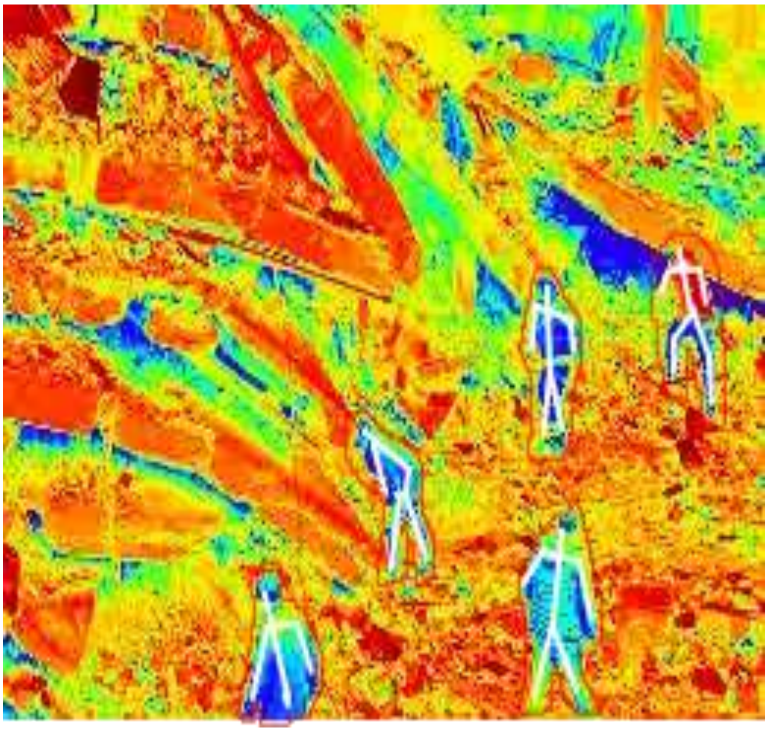

Figure 2 **CV Media Pipeline to Estimate the Movement**

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Figure 3 People Identification by their Body Shape

7. Hardware Components

The major components are Drone parts, communication and optical devices like stereo cameras, thermal cameras, etc...

- **Drone Parts**
  It requires a number of components to make it able to fly in the sky, they are motors that create torque with the propellers it makes an upward drift to move up in the air, the speed of the motor is controlled with an ESC and Its signals are transmitted by a flight controller with a receiver the instructions from the transmitter to follow the control instructions and with the GPS device[8] to program a path following system and telemetric device to maneuver through the air without hitting any obstacles.
- **Stereo Cameras**
  It is a camera with two or more lenses and an image sensor. It is used to simulate human binocular vision and gives the ability to get three-dimensional image perception. The two image points capture a different point with non-uniformity and by the disparity between the two images create a depth perception effect through which the distance can be measured.
- **Thermal Camera**
  Unlike regular cameras that capture images using visible light, it uses infrared radiation to capture the heat signature forming the image. It operates in a long wavelength spectrum up to 14000 nanometers. The sensor array consists of thousands of tiny thermopiles. When exposed to heat, they generate a small electrical signal that are processed to generate an image [1, 10].

8. Software Components

The software technologies comprise of Yolo v5, CV Media pipeline, Mission planner, HMID, etc...

8.1. YOLO v5

Yolo v5[5] is a very famous object detection and Image segmentation model for its effective ability to identity items with balanced state of accuracy and speed.

$$A = 1/(1+exp*(-A)) Softmax(A_i) = exp(A_i)/(sum(exp(A_j)) for all j) Sum squared expression, L = (x-x)^2 + (y-y)^2 + (sqrt(w) - sqrt(w))^2 + (sqrt(h)) - sqrt(h))^2.$$

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Compared to all the other previous versions, v5 is more famous for its lightweight architecture with variants that can be selected to suit the model or application we execute the model for. These variants are small, medium, large, and extra-large from the point of difference between the accuracy and speed of the data processing. Generates feature pyramids, aiding the model in handling objects of varying scales it employees Path Aggregation Network. Cross Stage Partial Networks serve as the backbone. This cutting-edge technology applies anchor boxes to features, providing you with output vectors that contain class probabilities, object scores, and bounding boxes. It uses sigmoid activation function f(x)=1/(1+e^(-x)).

8.2. CV Media Pipeline

Google has developed MediaPipe, an open-source platform that enables the creation of pipelines for machine learning, specifically designed to analyze and process data over time. It works by creating a skeletal structure of the human from the recognition of points know as region of interest where these points intersect and It uses two components they are Detector and Tracker. Detector is used to find that ROI point there 33 points are used to segregate the human structure and Tracker follows these points and link them up to create a skeletal structure that provides the movement form of human by using a ML model to train on the already existing movements to see the similarities and compare. MediaPipe is lightweight and optimized for on-device execution, so it can be processed at the point of real-time use [9]. Detecting key points Euclidean distance between two key points (x1, y1) and (x2, y2). Normalization and scaling are carried out on these points [6].

8.3. Mission planner

Mission Planner is a comprehensive, open-source software application used for planning, executing, and analyzing missions for remote-controlled (RC) drones. It's particularly popular with drones running the ArduPilot firmware [4], serves as both a configuration utility and a dynamic control supplement for autonomous vehicles. It Creates waypoints, defines flight paths, and plans autonomous missions to carry out missions with little human intervention and is safer to work on as loss of signal will not affect the mission. It also has an application to Set up your vehicle parameters, calibrate sensors, and fine-tune settings. Receive real-time data from your vehicle during the flight and its conditions can be analysed it works a ground station control system for the Drone [4].

8.4. HMID

Human body Model-based Identification is used by acquiring the possible shape of body limbs so as to train the model that trains for shape, pose, and biometric identification features to extract certain characteristics that are utilized to discerner the possible ways in which it can be present in the comparison of the similarity measure. Human Mesh Recovery network [13] is used to find the 3D structure from 2D trained model. This model is generally developed in the Neural Network models so as to meet the variation in all the possible data to be encountered. In the case of using the data to be set with Thermal data [1] it is trained with shapes as well as all the possible temperature readings that can be seen in humans.

9. Results and Discussion

The resultant image integrates thermal and stereo cameras for enhanced visibility in disaster zones. The picture we get from the drone puts together thermal and stereo cameras to see better in places hit by disasters. YOLOv5 helps us spot people even when there's a lot of stuff around, like debris. Mission Planner helps plan out search and rescue missions and keeps track of everything as it happens. MediaPipe makes it easier to tell if someone needs help by spotting their poses quickly. ArduPilot helps the drone fly by itself and change its path when needed, especially in dangerous areas. With all these tools working together, we can respond faster and save more lives during disasters, as in Figure 4, 5, 6.

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Figure 4 CV Pipeline and HMID detection

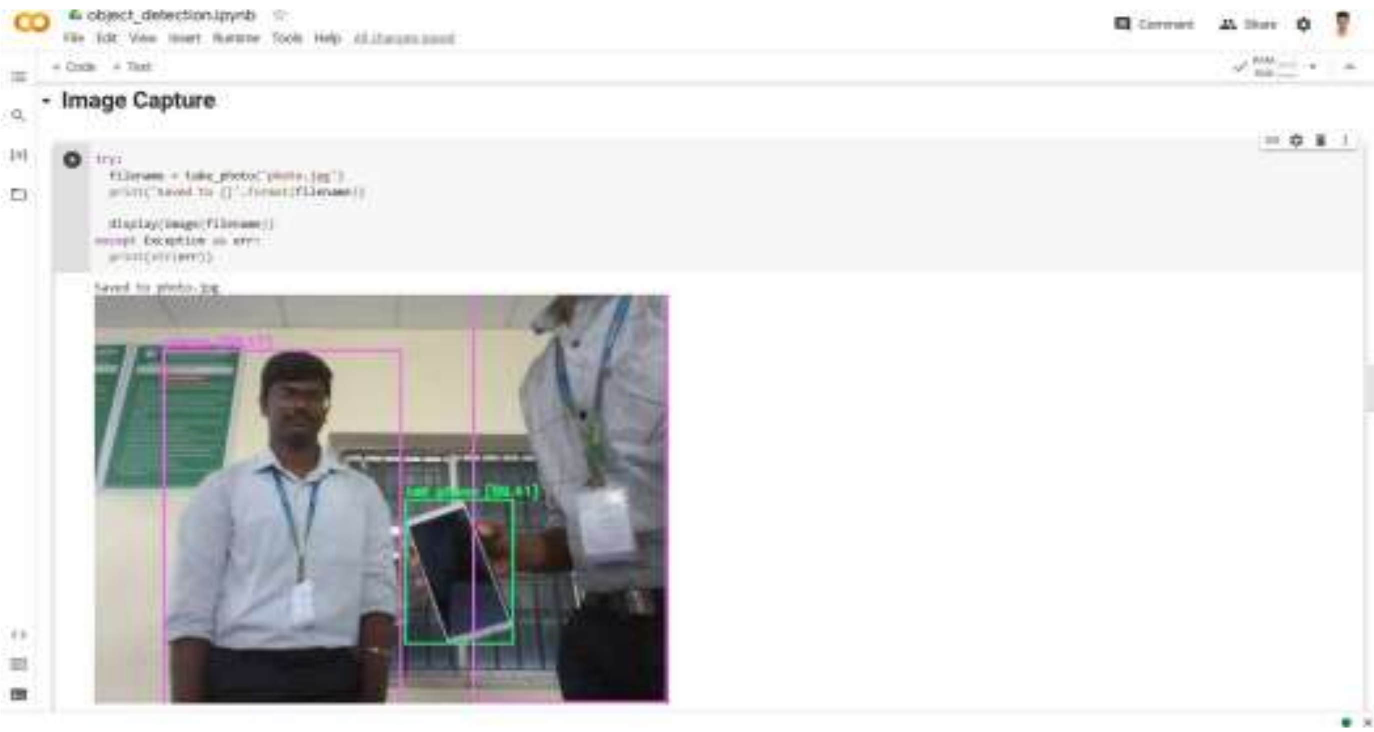

Figure 5 Image Segmentation using YOLOv5

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Figure 6 **Mission Planner Interface**

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Conclusion

The utilization of inspection drones in disaster management represents a significant advancement in response capabilities, offering unparalleled opportunities to enhance situational awareness, minimize risks to responders, optimize resource allocation, and drive innovation in disaster management practices. By harnessing the rapid assessment and surveillance capabilities of drones, responders can make informed decisions in real-time, facilitating swift and targeted interventions in disaster-affected areas. Additionally, incorporating cutting-edge technologies like artificial intelligence and machine learning offers potential to significantly enhance the efficiency and impact of disaster response operations. As innovation and refinement progress in this domain, it becomes clear that inspection drones will become pivotal in boosting the resilience of communities against

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natural or human-made disasters. This advancement will not only save lives but also lessen the effects of disasters on impacted communities.

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