Project Notes:

Project Title: Path Planning for an Autonomous Search and Rescue Drone
Name: Vikhaash Kanagavel Chithra

Note Well: There are NO SHORT-cuts to reading journal articles and taking notes from them. Comprehension is paramount. You will most likely need to read it several times, so set aside enough time in your schedule.

Contents:

Knowledge Gaps:

This list provides a brief overview of the major knowledge gaps for this project, how they were resolved and where to find the information.

Knowledge Gap	Resolved By	Information is located	Date resolved
Search patterns	Internet search	https://owaysonline.com/iamsar-search-patterns/	11/19
Python turtle	Reading documentation	https://docs.python.org/3/library/turtle.html	11/23
	Youtube tutorial	https://www.youtube.com/watch?v=pxKu2pQ7ILo	11/25
	Web tutorial	https://realpython.com/beginners-guide-python-turtle/	11/25

	Example code	https://github.com/topics/python-turtle-graphics	11/26
	Talking to a cs major	Conversation	11/28

Literature Search Parameters:

These searches were performed between (Start Date of reading) and XX/XX/2019.
List of keywords and databases used during this project.

Database/search engine	Keywords	Summary of search
Google scholar	"Autonomous drone control"	Autonomous drone control system for object tracking
Google scholar	Path planning mathematical models	Drone to Obstacle Distance Estimation Using YOLO V3 Network and Mathematical Principles
Google scholar		Unmanned Aerial Vehicle with Human Detection and People Counter Using YOLO v5 and Thermal Camera for Search Operations
Google scholar		Combining stigmergic and flocking behaviors to coordinate swarms of drones performing target search
Google scholar		Optimum Path Finding Framework for Drone Assisted Boat Rescue Missions
Google scholar		Multi-UAV Coverage Path Planning Based on Hexagonal Grid Decomposition in Maritime Search and Rescue
Google scholar		Ant colony optimization for path planning in search and rescue operations
Google scholar		Energy-Efficient Drone Coverage Path Planning using Genetic Algorithm
Google scholar	Drone human identification	Drone-based Autonomous Human Identification for Search and Rescue Missions in

		Real-time
Google scholar		Successful Search and Rescue in Simulated Disaster Areas
Google scholar		A UAV Search and Rescue Scenario with Human Body Detection and Geolocalization
Google scholar		Faster R-CNN Deep Learning Model for Pedestrian Detection from Drone Images
Google scholar		
Google scholar		
Google scholar		
Google scholar		
Google scholar		

Tags:

Tag Name	
Intro/Problem	Past
Innovation	Solution?

Template

KEEP THIS BLANK AND USE AS A TEMPLATE

Source Title	
Source citation (APA Format)	
Original URL	
Source type	
Keywords	
#Tags	
Summary of key points + notes (include methodology)	
Research Question/Problem/ Need	
Important Figures	
VOCAB: (w/definition)	

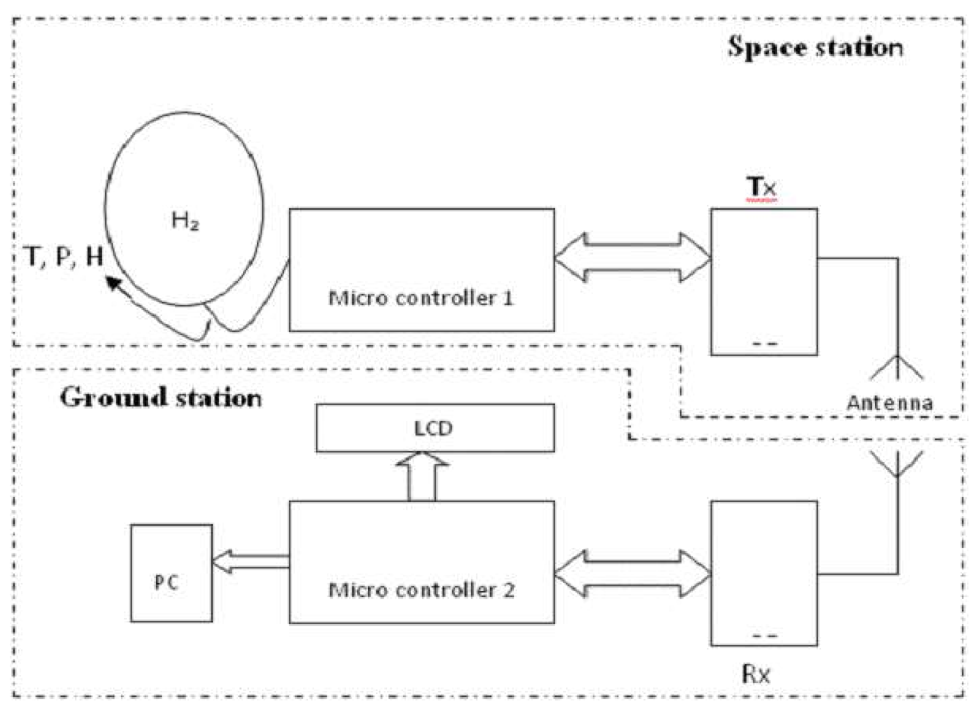
Cited references to follow up on	
Follow up Questions	

Article #1 Notes: Embedded System for Monitoring Atmospheric Weather Conditions Using Weather Balloon

Article notes should be on separate sheets

Source Title	Embedded System for Monitoring Atmospheric Weather Conditions Using Weather Balloon
Source citation (APA Format)	Sankar, P., & Norman, Suresh. R. (2009). Embedded system for monitoring atmospheric weather conditions using weather balloon. *Communication and Energy Conservation 2009 International Conference on Control, Automation*, 1–4.
Original URL	https://ieeexplore.ieee.org/document/5204416
Source type	Conference Paper
Keywords	Weather Balloon, Atmosphere measurement, Payload, Sensors
#Tags	#atmosphere monitoring, #sensors, #payload
Summary of key points + notes (include methodology)	The paper by Dr. Norman presents an embedded system designed for monitoring atmospheric weather conditions using a weather balloon. The system incorporates various sensors, microcontrollers, and communication modules to collect accurate and real-time data on temperature, humidity, air pressure, wind speed, and wind direction. Through successful test flights,the system demonstrates its capability to acquire reliable meteorological data at different altitudes.The developed embedded system holds promise in enhancing weather forecasting accuracy and advancing our understanding of atmospheric dynamics, making valuable contributions to meteorological research and applications. Key points: - Utilizes a 10-bit ADC for converting analog signals from humidity, temperature, and pressure sensors to digital values - Temperature Sensor (NTH5G10 Thermistor): - Thermistor is used as a temperature sensor due to its accuracy, stability, and fast thermal response.

	- Resistance is inversely proportional to temperature.
	- Pressure Sensor (Fujikura Atmospheric Pressure Sensor):
	  - Measures atmospheric pressure and is typically normalized to sea level.
	- Humidity Sensor (EPA-600 Humidity Sensor):
	  - Measures humidity as a fraction of the maximum amount of water air can absorb at a specific temperature.
	- Microcontroller (ATmega48):
	  - Used for measuring and controlling weather monitoring, featuring high performance and low power consumption.
	-

Research Question/Problem/ Need	Weather balloons sent every 4 hours by the government are expensive. This paper suggests a low cost instrumentation build.
Important Figures	 This image is important as it outlines livetime radio communication from the sensor. The sensor data is fused in Micro controller 1 which is then converted to digital signal using the ADC.
VOCAB: (w/definition)	Capacitor: A device that stores energy in the form of an electrical field

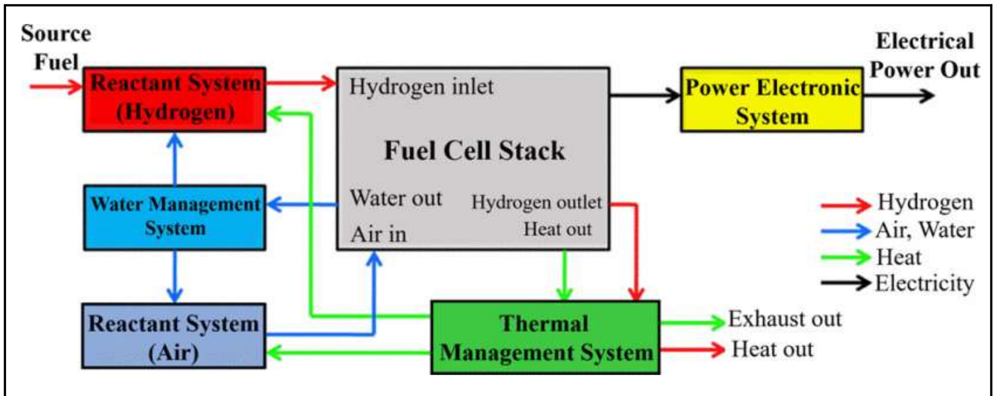
Cited references to follow up on	Patrizia Basili, Stefania Bonafoni, Piero Ciotti, Filvio Mar-zano, "Retrieving Atmospheric Temperature Profiles by Microwave Radiometry Using a Priori Information on Atmospheric Spatial-Temporal Evolution," IEEE Transactions On Geoscience And Remote Sensing, Vol. 39, No. 9, September 2001, pp. 1896 to 1905.
Follow up Questions	- How feasible is it to retrieve these instruments so they can be reused? - How much more accurate is it than normal weather monitoring systems? - How could this embedded system payload be retrieved easily? - What is the range of communication of this embedded system and how could you better it?

Article #2 Notes: Power Supply Architectures for Drones

Article notes should be on separate sheets

Source Title	Power Supply Architectures for Drones
Source citation (APA Format)	Boukoberine, M. N., Zhou, Z., & Benbouzid, M. (2019). Power Supply Architectures for Drones—A Review. *IECON 2019 - 45th Annual Conference of the IEEE Industrial Electronics Society*, *1*, 5826–5831. https://doi.org/10.1109/IECON.2019.8927702
Original URL	https://ieeexplore.ieee.org/document/8927702
Source type	Conference Paper
Keywords	Hybrid power supply, endurance
#Tags	#power supply, #hybrid

Summary of key points + notes (include methodology)	"Power Supply Architectures for Drones - A Review" provides an overview of different power supply systems designed for drones. It discusses various architectures and technologies used to efficiently manage power requirements in drone applications. The review covers topics such as battery technologies, energy harvesting methods, power distribution systems, and the challenges associated with optimizing power supply for drones. The article aims to present insights into the advancements in power supply solutions for drones, enabling longer flight times, improved reliability, and enhanced overall performance of these unmanned aerial vehicles.
	Key points:
	Battery based drones: DRAWBACK- Limited range of operation
	- One way to charge the drone is through swapping
	    - In swapping, the drone charges its depleted battery by resting on a dock station and continue flying when it fully charges
	- Laser Beam in-flight charging:
	    - A Laserbeam is generated from a laser generator which is then converted to electricity and used to charge the battery on the drone
	Hybrid powered drone:
	Combines advantages of a fuel cell and battery powering

	Battery powered during take off and climbing but the fuel cell will be responsible during time of cruise
Research Question/Problem/ Need	How to optimize power supply for longer flight times?
Important Figures	 This is an important figure because it outlines the energy management system of a fuel cell. A lot of this has to be scaled down to avoid overloading the drone. It is also important to note that a lot of energy could be lost
VOCAB: (w/definition)	Internal Combustion Engine (ICE): A type of engine that combusts fuel internally to generate power. Proton Exchange Membrane (PEM): A type of fuel cell where protons move through a membrane to produce electricity. Energy Management System (EMS): A system that manages the distribution and usage of energy in a device or machine to optimize performance and efficiency. Maximum Power Point Tracking (MPPT): A technique used in solar power systems to optimize the power output of solar panels. Perturb and Observe (P&O) Method: A method used in Maximum Power Point Tracking for photovoltaic systems. A priori: Based on knowledge or predictions before actual experience or data

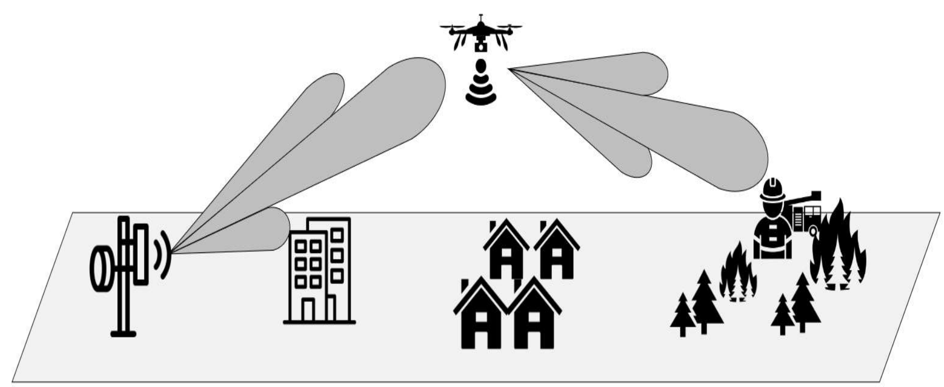
	collection.
Cited references to follow up on	N. Lapena-Rey, J. Blanco, E. Ferreyra, J. Lemus, S. Pereira, and ˜ E. Serrot, “A fuel cell powered unmanned aerial vehicle for low altitude surveillance missions,” International Journal of Hydrogen Energy, vol. 42, no. 10, pp. 6926–6940, Mar. 2017.
Follow up Questions	How do varying environmental conditions, such as extreme temperatures or adverse weather, impact the efficiency and effectiveness of laser-beam inflight recharging for drones, and what are the current strategies to mitigate these effects?

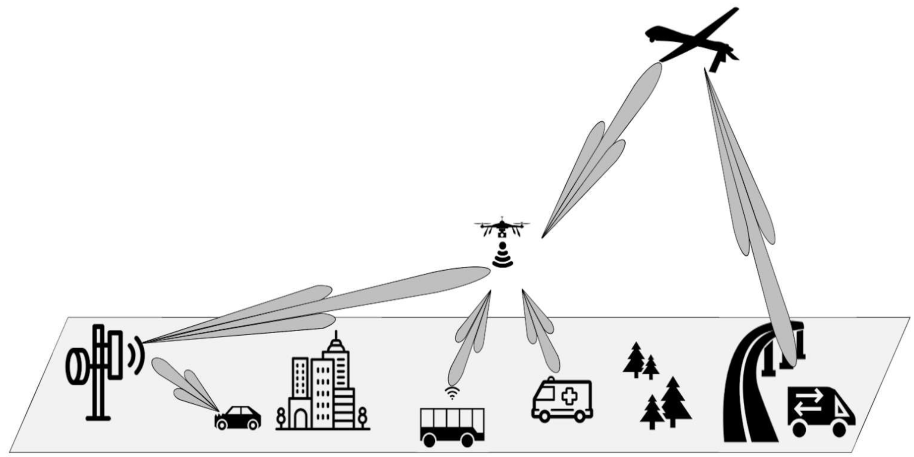
Article #3 Notes: Drones in B5G/6G Networks as Flying Base Stations

Article notes should be on separate sheets

Source Title	Drones in B5G/6G Networks as Flying Base Stations
Source citation (APA Format)	Amponis, G., Lagkas, T., Zevgara, M., Katsikas, G., Xirofotos, T., Moscholios, I., & Sarigiannidis, P. (2022). Drones in B5G/6G Networks as Flying Base Stations. *Drones*, *6*(2), Article 2. https://doi.org/10.3390/drones6020039
Original URL	https://www.mdpi.com/2504-446X/6/2/39/html
Source type	Journal Article
Keywords	Relay, Base Station, WiFi Drone
#Tags	#altidea
Summary of key points + notes (include methodology)	The paper "Drones in B5G/6G Networks as Flying Base Stations" delves into the innovative concept of utilizing drones as dynamic flying base stations within the framework of beyond 5G (B5G) and 6G networks. This approach aims to address coverage limitations and capacity demands by strategically deploying drones to provide enhanced connectivity in areas with network deficiencies, emergencies, or events. The paper delves into the intricate challenges of implementing this technology, including optimizing drone mobility, trajectory planning, interference mitigation, and energy efficiency. Additionally, it underscores the significance of regulatory cooperation and safety considerations in navigating the operational landscape of drone-based communication networks. With the potential to reduce latency, improve data rates, and redefine network infrastructure, the paper positions drone-integrated networks as a pivotal step in advancing wireless communication beyond 5G and setting the stage for the evolution of 6G networks. Key points: - Individual UAVs can work as aerial base stations using WSN - Drone base stations(BS) can serve as communication relays for autonomous vehicle or ground traffic - cellular-enabled drones function as service providers; aerial nodes functioning as cellular base stations can provide pivotal improvements to

	ultra-dense small cell networks
	- Given their mobility and LOS-establishing capabilities, UAVs can support mobile ad hoc networks (MANETs) on the terrestrial plane, and more specifically vehicular ad hoc networks (VANETs)
	- Aerial BSs can also enhance the reliability of device-to-device and inter-vehicular links
	- The energy expenditure of UAVs is mainly associated with:
	    - Energy consumed for the purpose of flying and hovering above a desired location
	    - Energy consumed for communication and on-board processing

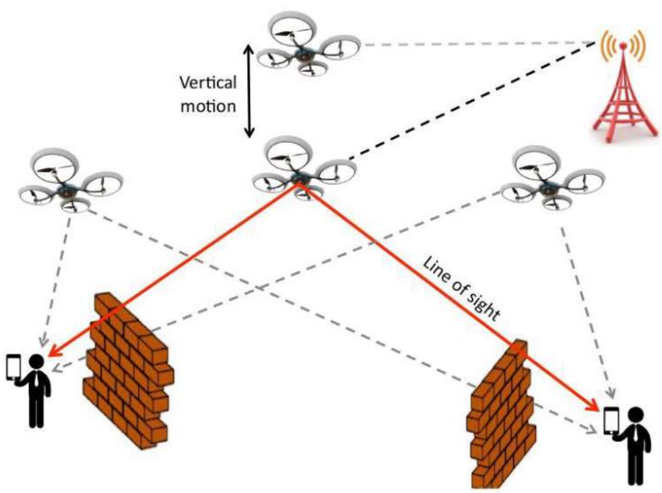
Research Question/Problem/ Need	Extend B5G/6G to remote locations or for temporary need using drones
Important Figures	 Figure 3. Terrestrial network coverage enhancement: a drone BS-supported firefighting scenario. This is an important figure as it illustrates the solution proposed by the authors of this paper. They suggest using autonomous drones as base stations for extending networks.

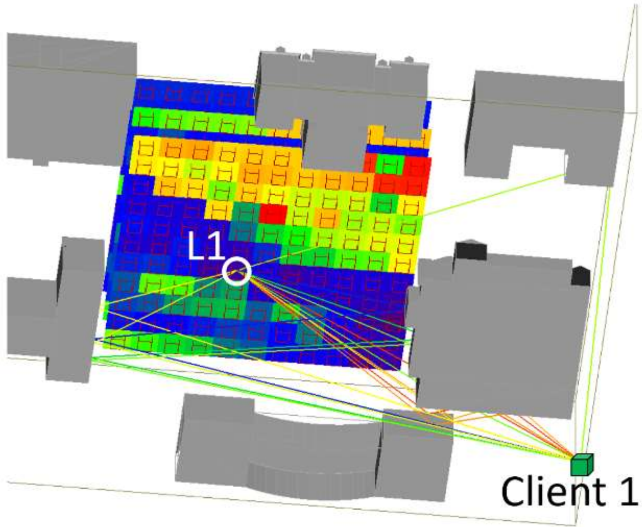
	 **Figure 4.** Drone-BS-assisted vehicular communications scenario. This is an important figure as it shows another application for drone base stations. The base stations could be used for intervehicular communications which sometimes would be blocked by structures. For example, consider the car on the left of the image. The car couldn't communicate with the ambulance and the bus as it was blocked by the building but it was able to circumvent it by using the drone as a base station and communicating via it.
VOCAB: (w/definition)	WSN(wireless sensor network)- networks of spatially dispersed and dedicated sensors that monitor and record the physical conditions of the environment and forward the collected data to a central location NS(Network slicing)- Network slicing is a virtual network architecture that creates multiple virtual networks on top of a single, shared physical network, allowing for greater network flexibility.
Cited references to follow up on	Kaur, S.; Randhawa, S. Google LOON: Balloon-powered internet for everyone. AIP Conf. Proc. 2018, 2034, 020006. [CrossRef] Mozaffari, M.; Saad, W.; Bennis, M.; Nam, Y.H.; Debbah, M. A Tutorial on UAVs for Wireless Networks: Applications, Challenges, and Open Problems. IEEE Commun. Surv. Tutorials 2019, 21, 2334–2360. [CrossRef]
Follow up Questions	- How could the battery system be made more efficient? - What is the payload weight of the equipment needed for network relay? - What software was used in finding optimal position and performing network slicing? - How was this drone made autonomous? - What was the communication protocol used to communicate network status to the drones flight controller?

Article #4 Notes: Extending Cell Tower Coverage through Drones

Article notes should be on separate sheets

Source Title	Extending Cell Tower Coverage through Drones
Source citation (APA Format)	Dhekne, A., Gowda, M., & Choudhury, R. R. (2017). Extending Cell Tower Coverage through Drones. *Proceedings of the 18th International Workshop on Mobile Computing Systems and Applications*, 7–12. https://doi.org/10.1145/3032970.3032984
Original URL	https://dl.acm.org/doi/pdf/10.1145/3032970.3032984
Source type	Conference Paper
Keywords	Drones, WiFi, Range extension, Moving Tower
#Tags	#towerbases #uav #data extender #disaster aid
Summary of key points + notes (include methodology)	The paper explores using a drone as an optimally placed wifi device whose location depends on the client's location and any signal obstacles. This was accomplished by constructing an SNR heatmap using the 3D environment which was then used to calculate the optimal flying location and height of the drone. The data showed a throughput gain in this paper, however, the paper had certain limitations that would hinder its real-world application. Key points: The authors of this paper wanted to address the low connectivity in cities because of wireless shadows. They noted that the SNR variation does not really decrease with a decrease in height. This means that a connectivity drone doesn't have to adjust its height based on the client's position. A ray tracing simulation is conducted on a 3D model from google earth. Using this, an SNR heatmap is generated. The drone should be placed at an ideal location
Research Question/Problem/ Need	Could drones be used as cell tower extenders and how effective are they?

Important Figures	 **Figure 1: Drone locations present tradeoffs: Closer to the ground aggravates multipath and blocks line of sight (LOS) to the cell tower, while vertically higher placement increases distance to clients. Lateral movements can achieve LOS to some clients but get blocked from others.** This is an important figure as it showcases the logic used in determining the optimal position of the drone for extending cellular networks.

	 Figure 6: 3D SNR heatmap The sound to noise ratio was measured to determine the ideal position of the drone. The place with the least SNR was determined to be the ideal position for extending cellular network
VOCAB: (w/definition)	SNR-(noun)(abbrv.) sound to noise ratio. Usually for signals to measure dispersion
Cited references to follow up on	V. Namboodiri and L. Gao, “Prediction-based routing for vehicular ad hoc networks,” IEEE Transactions on Vehicular Technology, 2007.
Follow up Questions	This paper used google maps 3D data pre-flight to optimize flight location but how would that work for unknown sites or destroyed sites? Is it possible for the drone to perform these computations onboard? How could lidar technology be applied?

Article #5 Notes: Autonomous monitoring, analysis, and countering of air pollution using environmental drones

Article notes should be on separate sheets

Source Title	Autonomous monitoring, analysis, and countering of air pollution using environmental drones
Source citation (APA Format)	Rohi, G., Ejofodomi, O., & Ofualagba, G. (2020). Autonomous monitoring, analysis, and countering of air pollution using environmental drones. *Heliyon*, *6*(1), e03252. https://doi.org/10.1016/j.heliyon.2020.e03252
Original URL	https://www.cell.com/heliyon/pdf/S2405-8440(20)30097-9.pdf
Source type	Journal Article
Keywords	Air pollution, Sensor drones
#Tags	#environmental drone #purpose #introduction
Summary of key points + notes (include methodology)	The paper explores the engineering of an air quality monitoring drone. Using various air pollutant detectors, the drone collected aerial pollution data which was then used to determine the amount of abatement solution to use. While this paper only combatted NO3, the drone was successful in dropping the NO3 levels. Key points: - programmed autonomous drones can be used for pollution monitoring, detection, and abatement at altitudes above ground level in a specific geographic region - The E-drone has a base station at the location where environmental data is to be acquired. The base station consists of a compact solar panel with power connections running down the side to provide continuous power supply to the drone in between weather data acquisition - total weight of the system was approximately 1.5 kg - the design of the E-drone system allows for the drone to be able to carry 500 m l of abatement solution
Research Question/Problem/ Need	Could an air quality monitoring drone improve air quality by abating?

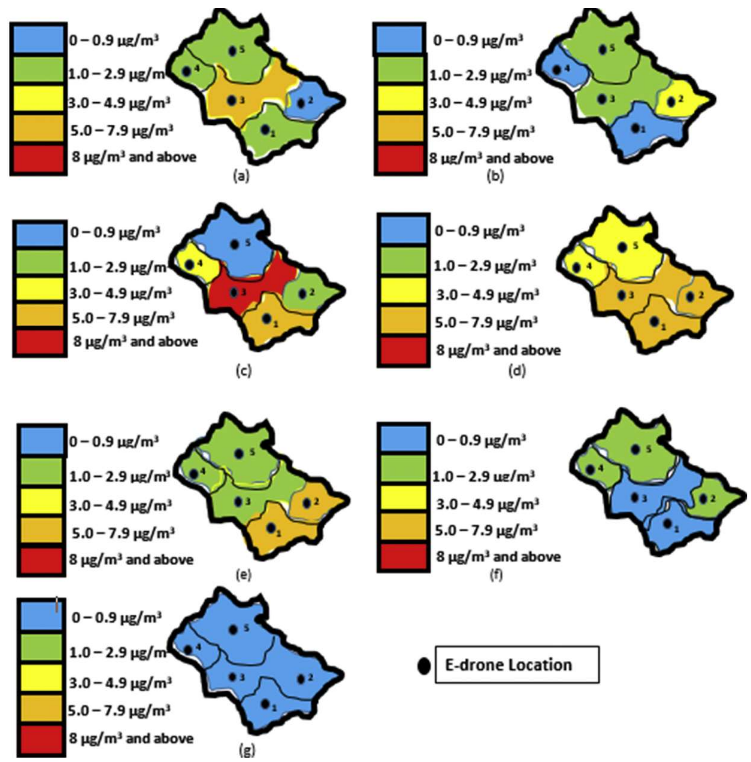
<table>
<tr><td>Important Figures</td><td>


Figure 6. AQHI maps by E-drones in Ontario, New Brunswick at 11:05 p.m. April 30, 2017. (a) AQHI O_3. (b) AQHI PM. (c) AQHI NO_2. (d) AQHI CO_2. (e) AQHI SO_2. (f) AQHI CO. (g) AQHI NH_3.

This is an important figure as it shows the applications of the said drone. The drone was able to measure air pollution by common pollutants and create an AQI(air quality index) map.
</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>Abatement- (noun) the lessening of something</td></tr>
<tr><td>Cited references to follow up on</td><td>Malaver, A., Motta, N., Corke, P., & Gonzalez, F. (2015). Development and Integration of a Solar Powered Unmanned Aerial Vehicle and a Wireless Sensor Network to Monitor Greenhouse Gases. Sensors, 15(2), 4072–4096. MDPI AG. Retrieved from http://dx.doi.org/10.3390/s150204072</td></tr>
<tr><td>Follow up Questions</td><td>How could swarm technology be implemented to further reduce air pollution using your said methods?
Would it be possible for the software to visualize these air conditions which would update in real-time?
Could the pollutants in the air power the drone somehow?</td></tr>
</table>

	How can the pollutant maps from each of the individual sensors combined to make an overall AQI map? How can you weigh the higher dangers of some pollutants over others?

Article #6 Notes: Autonomous drone control system for object tracking: Flexible system design with implementation example

Article notes should be on separate sheets

Source Title	Autonomous drone control system for object tracking: Flexible system design with implementation example
Source citation (APA Format)	Smyczyński, P., Starzec, Ł., & Granosik, G. (2017). Autonomous drone control system for object tracking: Flexible system design with implementation example. *2017 22nd International Conference on Methods and Models in Automation and Robotics (MMAR)*, 734–738. https://doi.org/10.1109/MMAR.2017.8046919
Original URL	https://ieeexplore.ieee.org/abstract/document/8046919/
Source type	Conference Paper
Keywords	Tracking, autonomous, computer vision, onboard processing
#Tags	Solution?
Summary of key points + notes (include methodology)	The paper introduces a flexible control system for autonomous UAVs, focusing on object tracking. It emphasizes modular architecture and hardware-software integration for ease of adaptation to diverse equipment. The system utilizes ROS for effective data exchange and presents an example using Raspberry Pi 3 and Pixhawk flight controller. The approach is aimed at participation in robotic challenges, showcasing effective algorithms for vision-based landing and tracking. Future plans involve upgrading the onboard computer for enhanced performance and refining control laws for optimal results. Key points: - was equipped with Pixhawk flight controller and Raspberry Pi 3 as an onboard computer. Set of sensors providing data about drone position was connected directly to Pixhawk; data from those sensors were tunneled to Raspberry Pi through MAVROS - contour detection on grayscale image with Canny edge detection

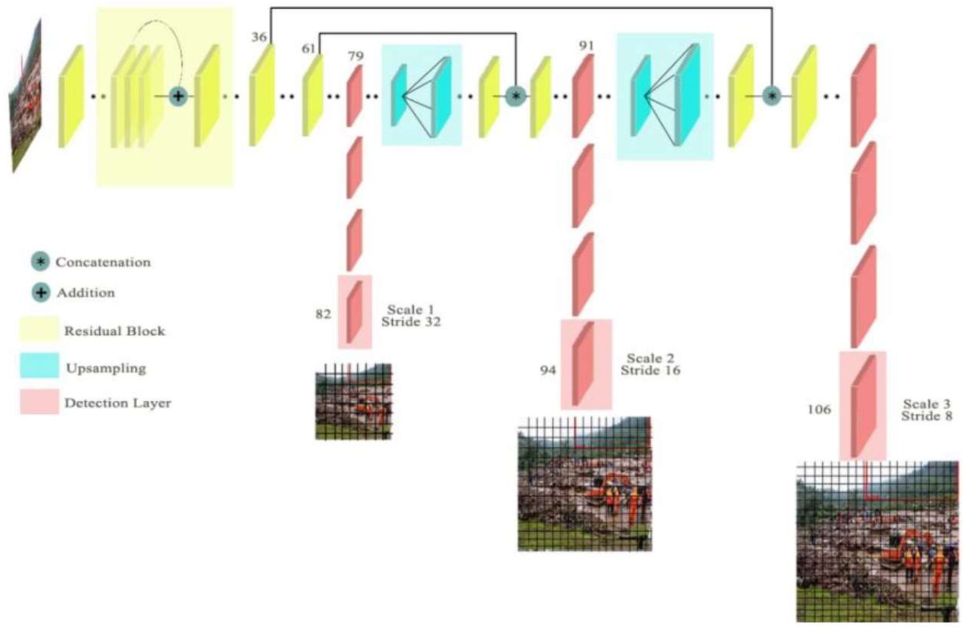
	algorithm was used to detect the landing pattern - Instead of actively searching for the landing pattern the drone waited in an ideal position and waited for the pattern to appear in its current frames.
Research Question/Problem/ Need	Designing a drone capable of onboard tracking and automated landing
Important Figures	 Fig. 2. Hardware platform designed for competition Overall design of the hexacopter
VOCAB: (w/definition)	Modular Architecture: Design approach that divides a system into smaller, independently functional modules, making it easier to manage, maintain, and update the system. PID Controller (Proportional-Integral-Derivative Controller): A control loop feedback mechanism used in control systems to calculate and apply a correction based on the proportional, integral, and derivative terms, helping stabilize and improve the control of a system.
Cited references to follow up on	N. Suzuki and Y. Yamazaki, "Basic research on the driving performance of an autonomous rescue robot with obstacles", in *2015 IEEE International Conference on Robotics and Biomimetics (ROBIO)*, pp. 982–987, 2015.
Follow up Questions	1. How does the concept of a modular architecture enhance the design and adaptability of the autonomous drone control system? 2. Could you explain how ROS (Robot Operating System) facilitates communication and collaboration between various software modules in

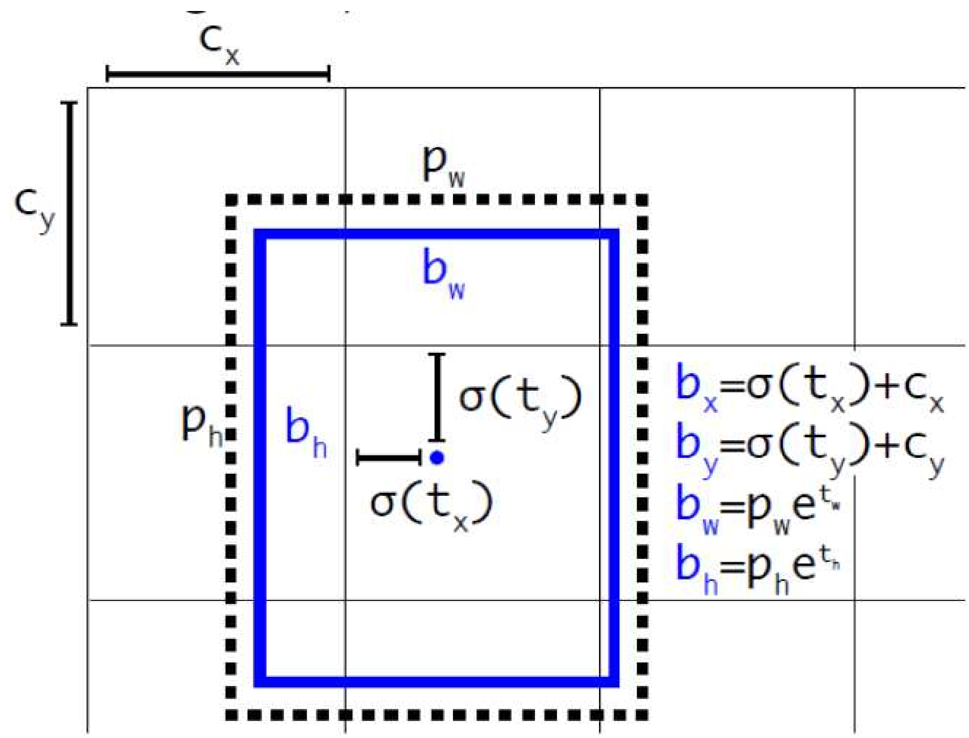
	the system? 3. In what scenarios or applications outside the described competition could the presented autonomous drone control system be most beneficial?

Article #7 Notes: Drone to Obstacle Distance Estimation Using YOLO V3 Network and Mathematical Principles

Article notes should be on separate sheets

Source Title	Drone to Obstacle Distance Estimation Using YOLO V3 Network and Mathematical Principles
Source citation (APA Format)	Aswini, N., Uma, S. V., & Akhilesh, V. (2022). *Drone to Obstacle Distance Estimation Using YOLO V3 Network and Mathematical Principles*. *2161*(1). Scopus. https://doi.org/10.1088/1742-6596/2161/1/012022
Original URL	https://doi.org/10.1088/1742-6596/2161/1/012022
Source type	Conference paper
Keywords	YOLOv3, object localization in image frames, mathematical modeling of drone and images
#Tags	Solution?
Summary of key points + notes (include methodology)	Long Summary The paper delves into the applications of drones equipped with monocular cameras, ranging from search and rescue operations to traffic monitoring, infrastructure inspection, and construction site management. To enhance the capabilities of drones in obstacle detection, the authors propose an innovative onboard obstacle detection model. This model integrates deep learning techniques with a mathematical approach to calculate the distance between the detected obstacle and the drone. **AI GENERATED** The central question revolves around improving obstacle detection capabilities in drones without adding extra hardware components, thereby reducing complexity and cost. The results highlight the efficacy of the proposed model, demonstrating its potential to enhance the autonomy and safety of drones in various operational scenarios. The methodology involves the development and integration of the obstacle detection model using deep learning techniques and mathematical calculations, showcasing its viability and effectiveness in real-world applications.

Research Question/Problem/ Need	The researchers wanted to add obstacle detection capabilities without adding extra hardware components
Important Figures	 **Figure 2**: YOLO V3 Architecture This is an important figure as it shows the architecture of the deep learning model used by the researchers.

	 **Figure 3**: Bounding Box This image is important as it shows the localization of an object in a bounding box and their coordinate relative to the drone
VOCAB: (w/definition)	Monocular (adjective): Relating to or involving one eye. Ubiquitous (adjective): Present, appearing, or found everywhere.
Cited references to follow up on	Redmon J., Divvala S., Girshick R. and Farhadi A. 2016 You only look once: Unified, real-time object detection *Proceedings of the IEEE conference on computer vision and pattern recognition* 779-788/
Follow up Questions	How does the proposed obstacle detection model using deep learning compare to traditional obstacle detection methods? Are there any limitations or challenges associated with relying solely on vision sensors for obstacle detection in drones? Could the mathematical approach for calculating distances between the drone and obstacles be further improved or optimized?

Article #8 Notes: Unmanned Aerial Vehicle with Human Detection and People Counter Using YOLO v5 and Thermal Camera for Search Operations

Source Title	Unmanned Aerial Vehicle with Human Detection and People Counter Using YOLO v5 and Thermal Camera for Search Operations
Source citation (APA Format)	Lagman, J. K. D., Evangelista, A. B., & Paglinawan, C. C. (2022). Unmanned Aerial Vehicle with Human Detection and People Counter Using YOLO v5 and Thermal Camera for Search Operations. *2022 IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS)*, 113–118. https://doi.org/10.1109/I2CACIS54679.2022.9815490
Original URL	https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9815490
Source type	Conference Paper
Keywords	Thermal imagery, YOLOv5 algorithm, Crowd detection
#Tags	
Summary of key points + notes (include methodology)	This study focuses on developing an unmanned aerial vehicle (UAV) with human detection and people counting capabilities for search and rescue operations during disasters. The primary motivation is to enhance rescue efforts and protect the lives of both victims and rescuers by utilizing UAVs with advanced technology. The research proposes a prototype that employs YOLOv5, an object detection algorithm, and thermal imaging to detect and count humans in disaster-stricken areas. The study successfully designs a UAV-based system that can aid search and rescue operations by efficiently detecting and counting humans using advanced technologies. The prototype demonstrates promising results in different conditions, showcasing its potential for real-world application in disaster response

	scenarios. scription of the steps involved in the UAV detecting system, including attaching a thermal camera to the drone, data gathering, human detection using Deep CNN and YOLOv5, and people counting. materials used in the study, such as the Tello Drone, FLIR Lepton 2.5, Raspberry Pi 3 Model B, laptop, and other components Description of the GUI developed for controlling and displaying real-time views from the drone camera and the thermal camera. Training process using the CoCo Dataset for training the pre-trained model and fine-tuning the system for accurate human detection.
Research Question/Problem/ Need	When disasters or accidents occur, conducting search operations, especially in risky locations, is unsafe for human rescuers due to limited equipment and dangerous scenarios. There is a need for a safer and more efficient approach to search and rescue operations, which can be addressed by utilizing UAVs with advanced technologies to detect and count humans in disaster-affected areas. This technology can provide real-time information to rescuers, aiding in a more effective response to emergency situations.

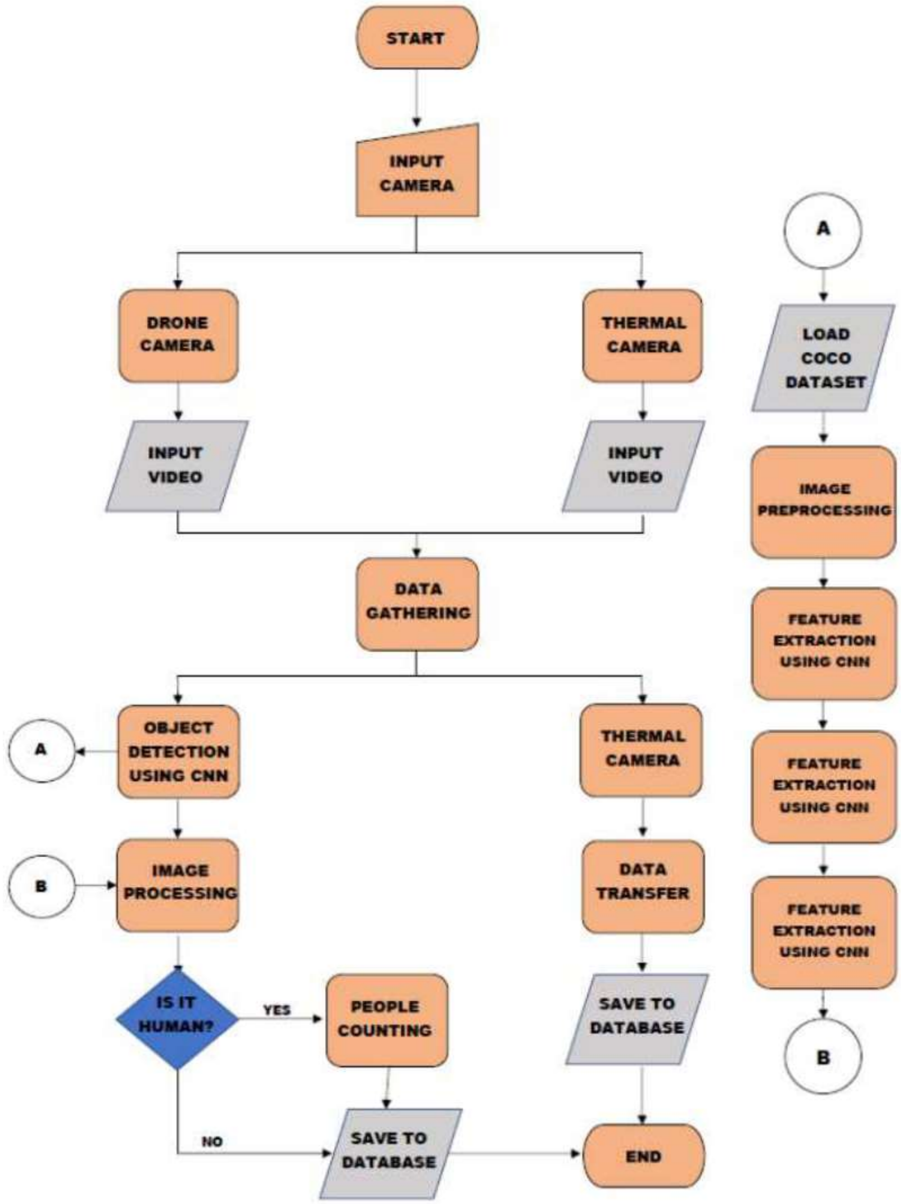
Important Figures	 This is an important figure as it shows the algorithm and flow used for this research

TABLE I. NUMBER OF HUMANS DETECTED IN DIFFERENT HEIGHTS

Distance Height	Number of Actual Counts of Human							
	1		2		3		4	
	Number of Detected Human	% Error	Number of Detected Human	% Error	Number of Detected Human	% Error	Number of Detected Human	% Error
500cm	1	0%	2	0%	3	0%	4	0%
1000cm	1	0%	2	0%	3	0%	4	0%
1500cm	1	0%	2	0%	3	0%	4	0%
2000cm	1	0%	2	0%	3	0%	4	0%
2500cm	1	0%	2	0%	2	33%	3	25%
Average Percentage Error: 2.9%								

This is an important figure as it shows the error rates for the human counter at different distances identified as flying heights

VOCAB: (w/definition)

GUI (Graphical User Interface): A GUI is a visual interface that allows users to interact with software

FLIR Lepton: FLIR Lepton is a type of microbolometer-based thermal imaging sensor developed by FLIR Systems

Cited references to follow up on

S. Sambolek and M. Ivasic-Kos, "Automatic Person Detection in Search and Rescue Operations Using Deep CNN Detectors," in IEEE Access, vol. 9, pp. 37905-37922, 2021, doi: 10.1109/ACCESS.2021.3063681.

Follow up Questions

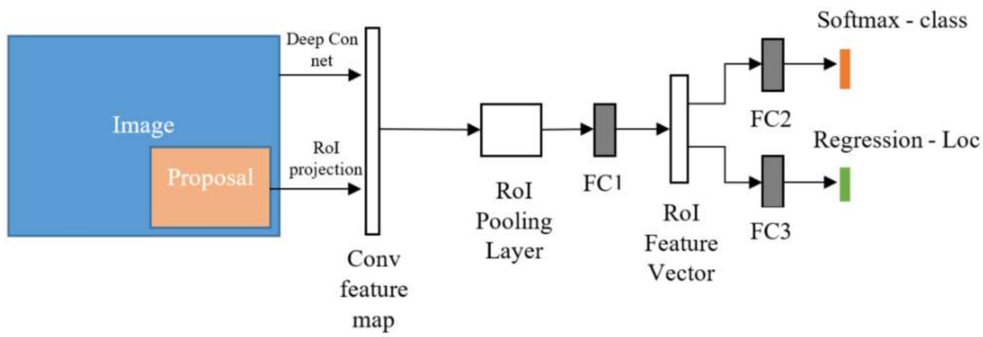
How might the integration of thermal cameras enhance the accuracy and effectiveness of human detection in disaster-stricken areas compared to traditional cameras?

Are there any limitations or challenges mentioned in the study regarding the use of Unmanned Aerial Vehicles (UAVs) for search and rescue operations? How were these addressed in the proposed system?

Can you elaborate on how the YOLOv5 algorithm works and why it was chosen specifically for object detection in this study?

Article #9 Notes: Drone-based Autonomous Human Identification for Search and Rescue Missions in Real-time

Source Title	Drone-based Autonomous Human Identification for Search and Rescue Missions in Real-time
Source citation (APA Format)	Jayalath, K., & Munasinghe, S. R. (2021). Drone-based Autonomous Human Identification for Search and Rescue Missions in Real-time. *2021 10th International Conference on Information and Automation for Sustainability (ICIAfS)*, 518–523. https://doi.org/10.1109/ICIAfS52090.2021.9606048
Original URL	https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9606048
Source type	Conference Paper
Keywords	Search and rescue, Deep learning model, customly trained neural network
#Tags	Solution?
Summary of key points + notes (include methodology)	The paper presents a drone-based human identification system to enhance search and rescue missions. Drones, due to their aerial imaging capabilities, can aid ground teams in finding missing individuals or assisting law enforcement in crowd control. However, observers often struggle to effectively identify humans in the video feed from the drone. The proposed system autonomously detects signs of human presence in real-time aerial videos and navigates towards suspicious locations for verification. It utilizes a custom-trained neural network for object detection and a single-board computer for real-time image processing and autonomous navigation. The system aims to make drones fully autonomous with operator override as an option. The research evaluates different object detection platforms and methodologies, choosing TensorFlow for on-board processing due to its deployability. The system is simulated using Software in the Loop (SITL) to verify its functionalities, and real-flight tests demonstrate its expected performance. The study explores

	resolving GPS coordinates of detected human objects, considering different flight angles for accurate localization. Overall, the system achieves a detection success rate of 84.1% true positives with 18.7% false positives and 16.5% false negatives. Future work may extend the system to incorporate thermal imaging and optimize for different operational parameters to improve its autonomy and effectiveness in search and rescue missions.
Research Question/Problem/ Need	To enhance search and rescue missions by developing a drone-based human identification system.
Important Figures	 Fig. 1: Deep Neural Network Architecture This is the architecture of the customly trained ML model

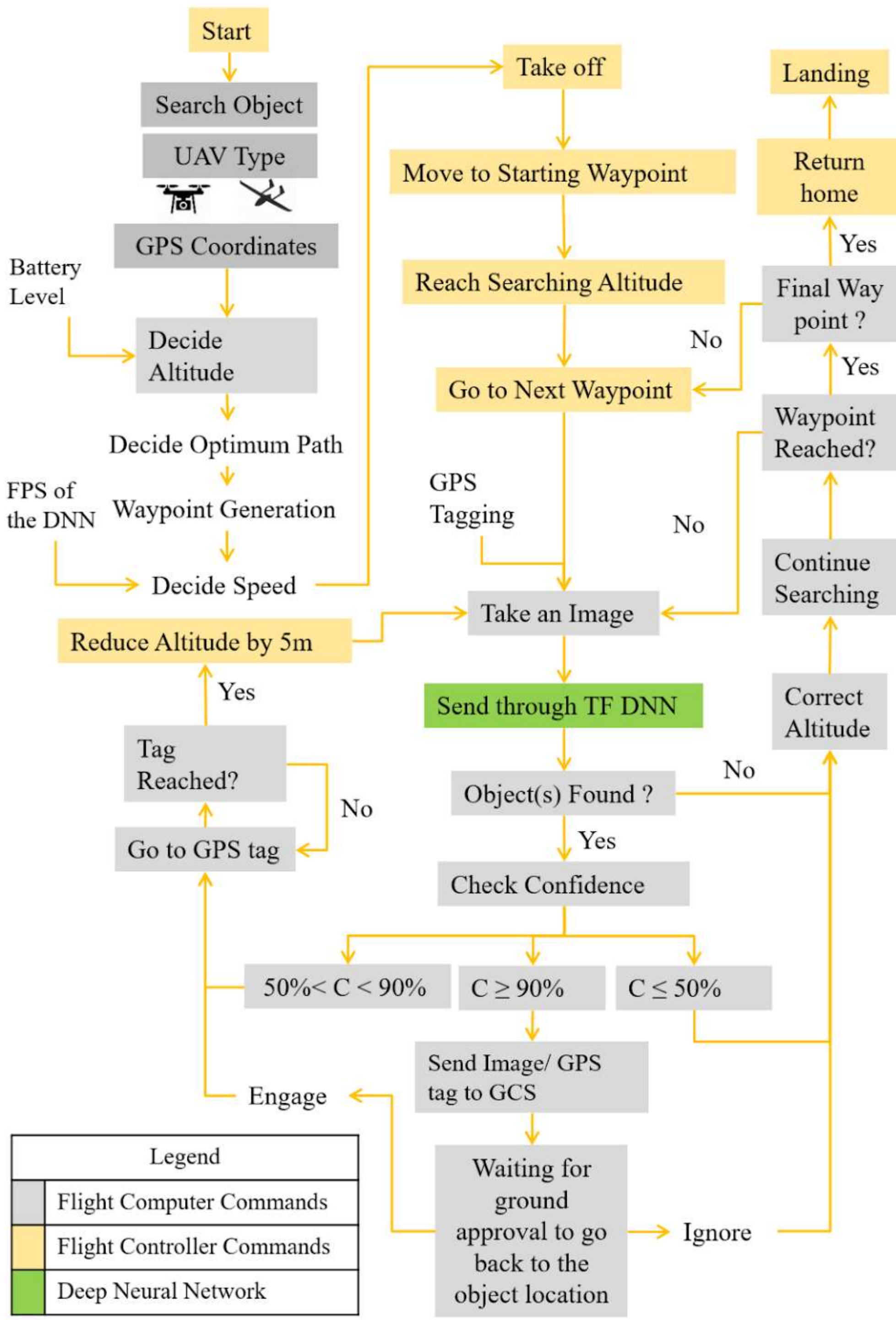


Fig. 2: Program flow diagram of the flight controller and computer

This is the algorithm flowchart of the designed drone

VOCAB: (w/definition)	SITL (Software in the Loop): A simulation technique that allows testing and debugging of software in a simulated environment before deploying it on real hardware HOG (Histogram of Oriented Gradients): A feature descriptor used in object detection that calculates the distribution of intensity gradients in an image. Edge Device: A device that performs data processing and computation locally rather than relying on a centralized server or cloud.
Cited references to follow up on	Jacinto C.Nascimento,Jorge S. Marques, ”Performance Evaluation of Object Detection Algorithms for Video Surveillance”,Instituto Superior Tecnico (IST), Lisbon,Portugal,Aug.15-20, 2019 Huang J, Rathod V, Sun C, Zhu M, Korattikara A, Fathi A, Fischer I, Wojna Z,Song Y, Guadarrama S, ”Speed/accuracy trade-offs for modern convolutional object detectors”, Murphy K, CVPR 2017
Follow up Questions	How does the autonomous human identification system for drones presented in the paper improve the effectiveness of search and rescue missions? Could you explain in more detail how the custom-built Tensorflow neural network is used as the object detector in the drone-based human identification system? What are the key challenges or limitations mentioned in the paper regarding the manual identification of humans in aerial video feeds, and how does the proposed system address these challenges?

Article #10 Notes: Combining stigmergic and flocking behaviors to coordinate swarms of drones performing target search

Source Title	Combining stigmergic and flocking behaviors to coordinate swarms of drones performing target search
Source citation (APA Format)	Cimino, M. G. C. A., Lazzeri, A., & Vaglini, G. (2015). Combining stigmergic and flocking behaviors to coordinate swarms of drones performing target search. *2015 6th International Conference on Information, Intelligence, Systems and Applications (IISA)*, 1–6. https://doi.org/10.1109/IISA.2015.7387990
Original URL	https://ieeexplore.ieee.org/document/7387990
Source type	Conference Paper
Keywords	Stigmergy, swarm control
#Tags	Innovation
Summary of key points + notes (include methodology)	- Pheromones and stigmergy serve as a communication medium influencing robot actions and enabling emergent behaviors. Using the physical environment for communication offers advantages such as scalability, information storage, and reduced communication overhead. The proposed algorithm utilizes stigmergic markers for inter-robot communication, achieving efficient exploration through a divide-and-conquer approach. The study presents a pheromone-based algorithm for coordinating multiple robots to explore unknown environments. Algorithm incorporates stigmergic markers, random movements, wall avoidance, and forward bias for exploration efficiency. Simulation experiments are conducted, comparing the proposed algorithm with related ones like Probabilistic Ants (PAnts) and Node Counting (NODEC). Different map sizes and numbers of robots are used to evaluate the algorithm's

	scalability and efficiency in exploration. The proposed algorithm demonstrates superior exploration efficiency compared to PAnts and NODEC algorithms across varying map sizes and robot numbers. The algorithm achieves a "divide-and-conquer" approach, efficiently exploring the environment and reducing exploration time. The scalability tests show better-than-linear speedup with an increasing number of robots, highlighting the algorithm's effectiveness in utilizing multiple robots for exploration.
Research Question/Problem/ Need	How can a group of robots efficiently explore and navigate through unknown environments using minimal communication?

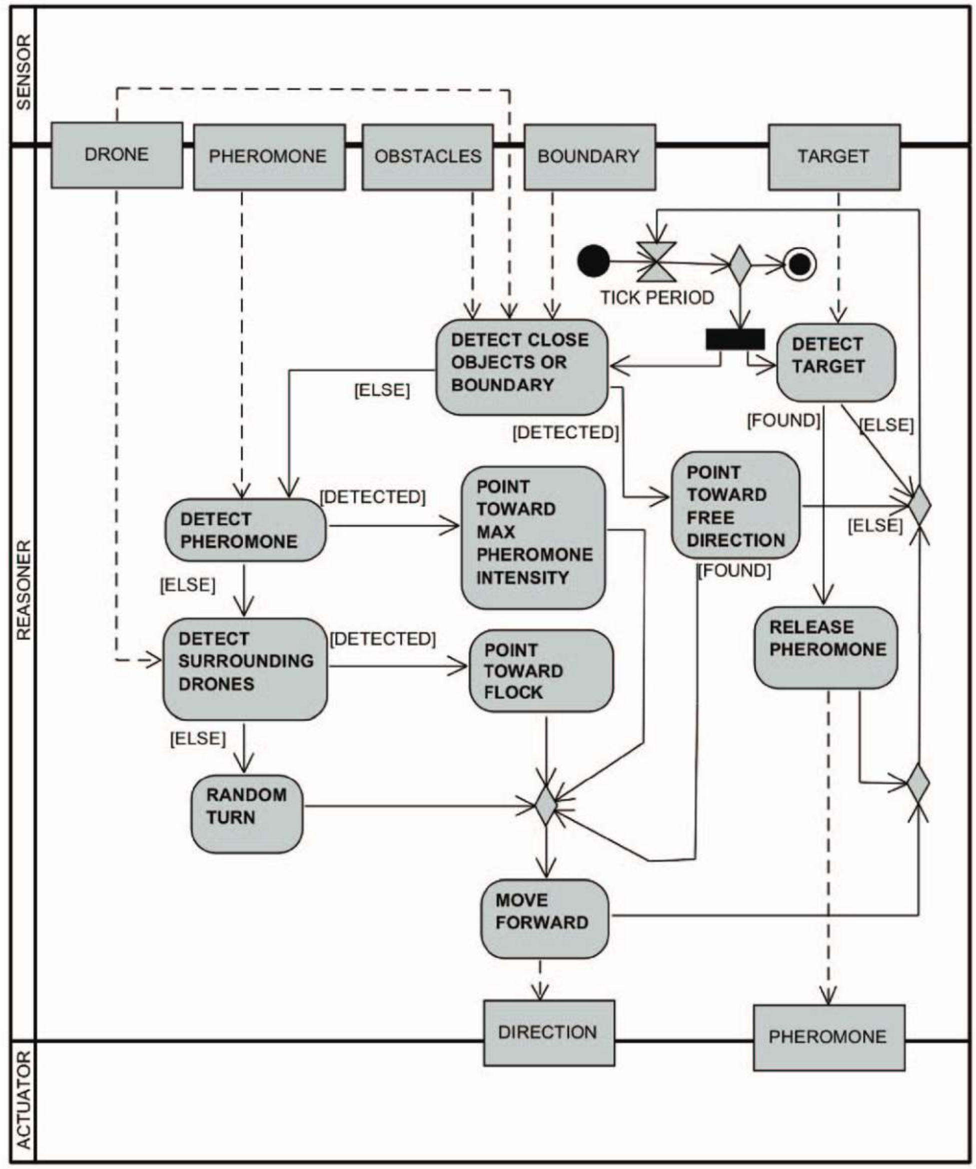
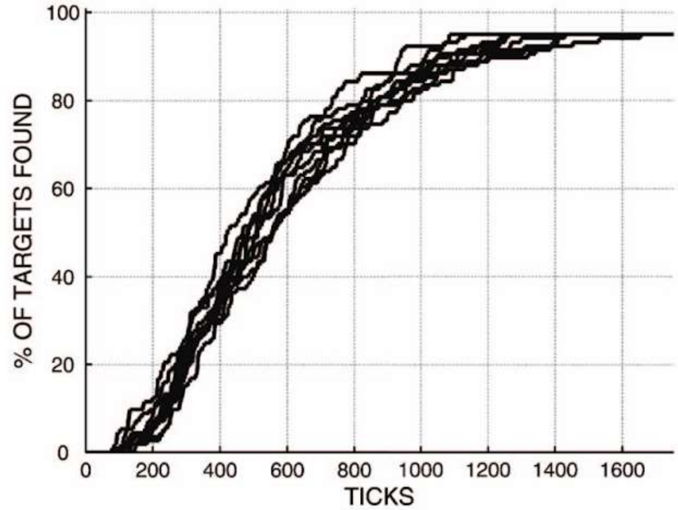
Important Figures	 Fig. 2. Overall representation of the drone behavior. Algorithm chart of the drone

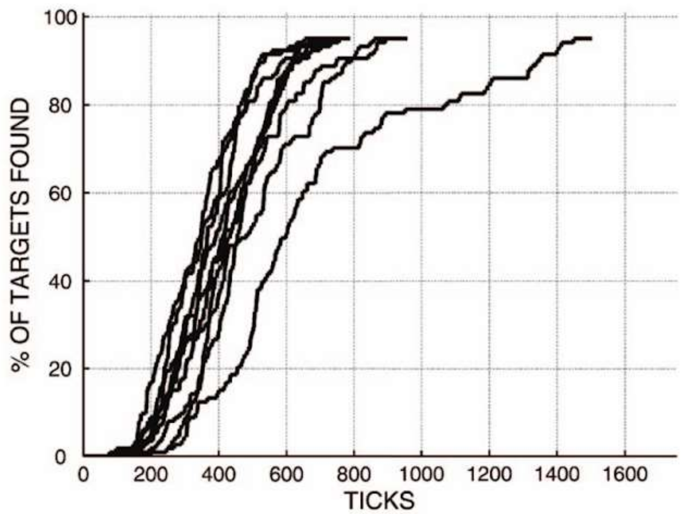
TABLE II. NUMERICAL RESULTS

Scenario	*N° of targets / clusters*	*Type / n° of obstacles*	*Drones*	*Completion time (ticks)*	
Field	50 / 5	Trees: 0 Build: 0	80	R	1756 ± 178
				S	802 ± 160
				S+F	689 ± 142
Forest	20 / 1	Trees: 400 Building: 0	80	R	2378 ± 512
				S	744 ± 194
				S+F	677 ± 68
Urban	110 / 2	Tree: 0 Building: 7	40	R	1448 ± 106
				S	861 ± 148
				S+F	800 ± 73
Rural Mines	28 / 28	Tree: 281 Building: 3	200	R	724 ± 83
				S	694 ± 88
				S+F	666 ± 68
Urban Mines	40 / 40	Trees: 54 Building: 28	25	R	354 ± 25
				S	455 ± 60
				S+F	415 ± 44

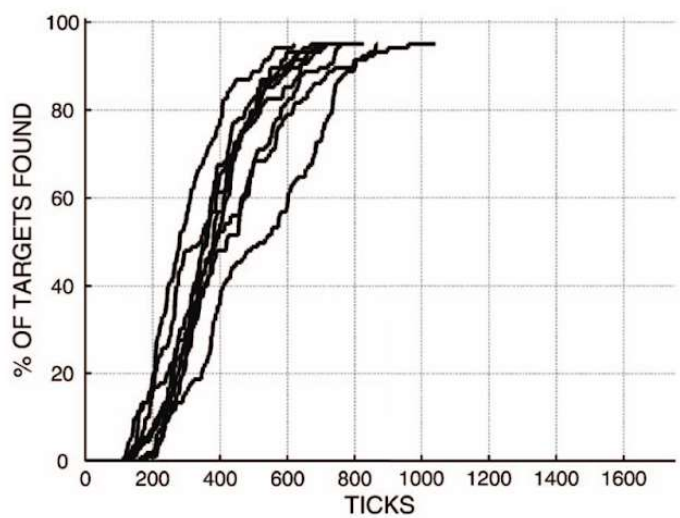
Differing efficiencies of the 3 methods in the simulations



(a)



(b)



(c)

Fig. 6. Completion rate against time for the Urban scenario: (a) Random Fly; (b) Stigmergy; (c) Stigmergy + Flocking.

	Differing time consumptions among the 3 different methods
VOCAB: (w/definition)	Stigmergic: Self-organization through environment-based communication. Pheromones: Chemical signals influencing behavior in organisms. Aggregation: Grouping or coming together
Cited references to follow up on	R. McCune, R. Purta, M. Dobski, A. Jaworski, G. Madey, Y. Wei, et al., "Investigations of DDDAS for command and control of uav swarms with agent-based modeling", Proceedings of the 2013 Winter Simulation Conference: Simulation: Making Decisions in a Complex World, pp. 1467-1478, 2013
Follow up Questions	Are there any real-world examples where pheromone-based communication is used by living organisms for complex tasks? Can you explain more about the practical applications of this algorithm in real-life scenarios, beyond simulation?

Article #11 Notes: Optimum Path Finding Framework for Drone Assisted Boat Rescue Missions

Source Title	Optimum Path Finding Framework for Drone Assisted Boat Rescue Missions
Source citation (APA Format)	Kilic, K. I., & Mostarda, L. (2021). Optimum Path Finding Framework for Drone Assisted Boat Rescue Missions. In L. Barolli, I. Woungang, & T. Enokido (Eds.), *Advanced Information Networking and Applications* (pp. 219–231). Springer International Publishing. https://doi.org/10.1007/978-3-030-75078-7_23
Original URL	https://link.springer.com/content/pdf/10.1007/978-3-030-75078-7_23.pdf
Source type	Conference paper
Keywords	Drone, Boat rescue, Offshore, Communication station (CS), Optimization, Red-gray path, Heuristic
#Tags	Innovation
Summary of key points + notes (include methodology)	The text addresses the challenge of optimizing drone-assisted boat rescue missions in offshore areas. The primary problem is to design a framework for these missions, taking into account the static configuration of communication stations (CSs) and the limited range of drones. The goal is to find an efficient way for a drone to reach boats in need of rescue, considering multiple objectives, such as minimizing energy consumption for drones and reducing waiting time for boats. Notes ● Article discusses optimizing drone-assisted boat rescue missions. ● Emphasizes efficient communication station (CS) deployment and drone range limitations. ● Introduces the "red-gray path" heuristic for path optimization. ● Multi-objective optimization balances goals for drones and boats. ● Probability analysis justifies the heuristic's importance.

	● Compares the effectiveness of different CS grid configurations. ● Results and specific numerical data are expected in future discussions. Methods used to address problem ● CS Deployment Configuration ● Red-Gray Path Heuristic ● Multi-Objective Optimization ● CS Grid Deployment Strategies ● Probability Analysis Optimum Tour Finding Algorithm based on hard disk scheduling algorithms
Research Question/Problem/ Need	The text addresses the challenge of optimizing drone-assisted boat rescue missions in offshore areas. The primary problem is to design a framework for these missions, taking into account the static configuration of communication stations (CSs) and the limited range of drones. The goal is to find an efficient way for a drone to reach boats in need of rescue, considering multiple objectives, such as minimizing energy consumption for drones and reducing waiting time for boats.

Important Figures

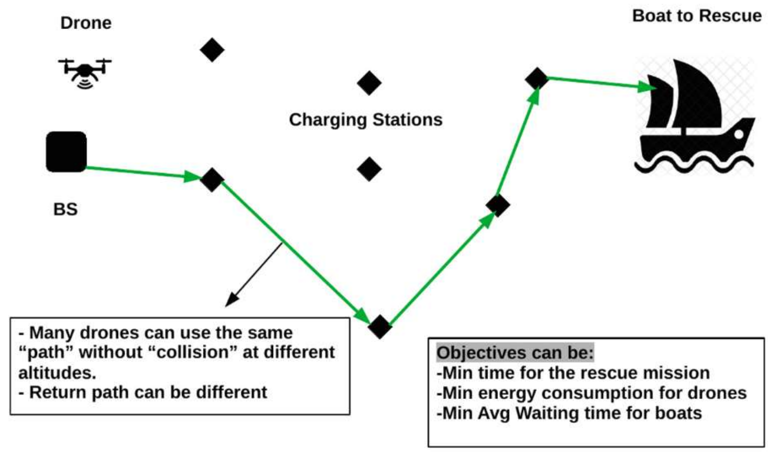


Fig. 1. Boat rescue operation with drones.

This figure illustrates the problem statement of this article

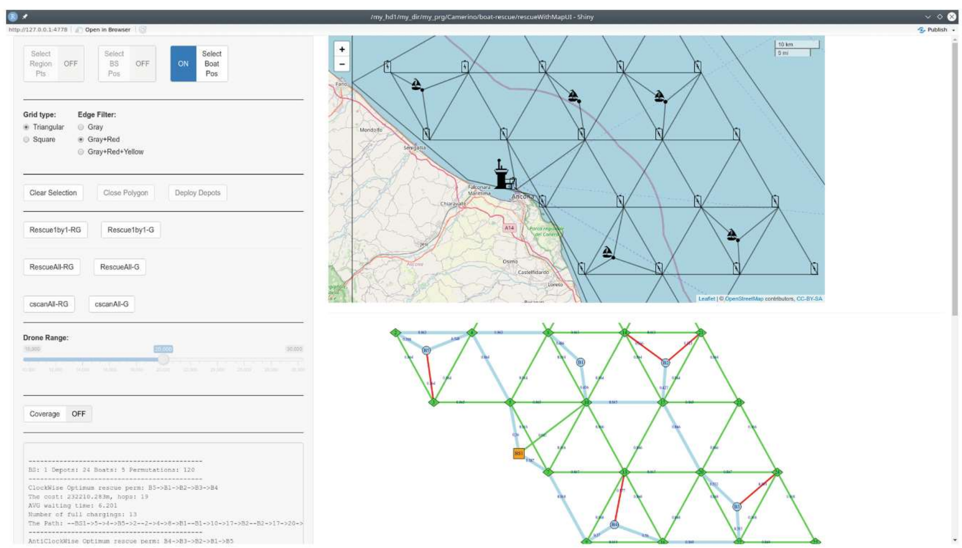
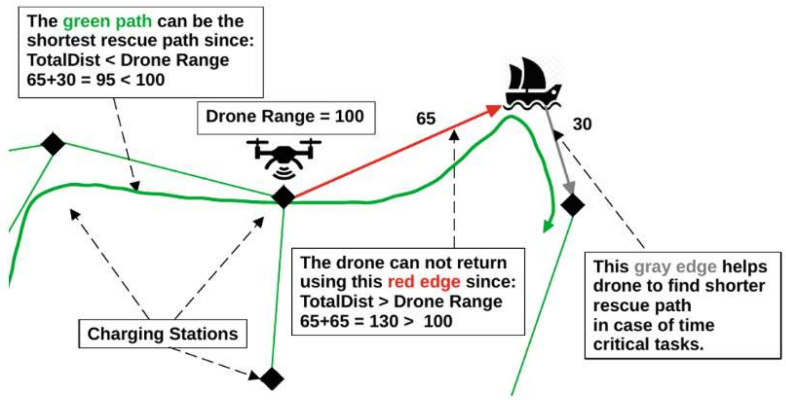


Fig. 2. Prototype UI developed for the rescue system.

This figure shows the UI developed by the researchers to visualize their proposed framework.

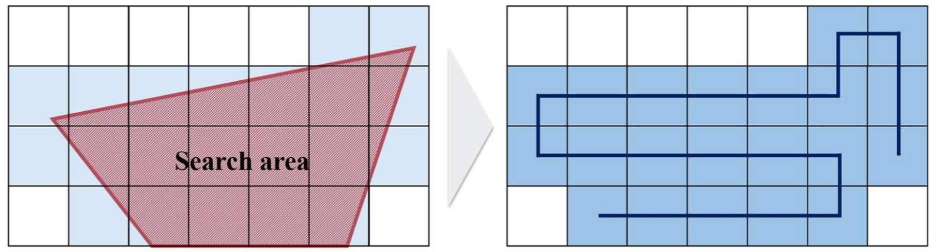
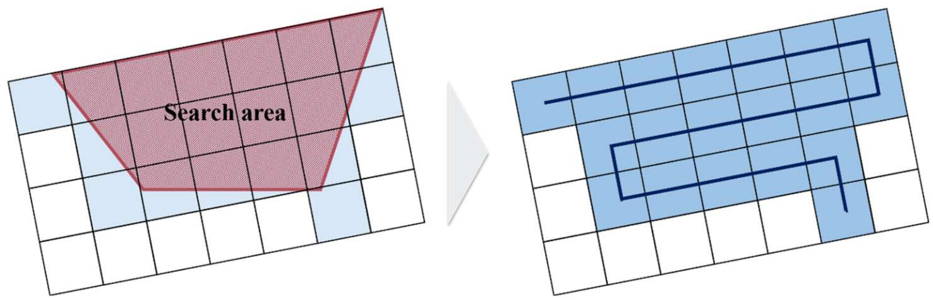
	 **Fig. 4.** The good red-gray path making the rescue possible. An example of the red-gray heuristic path planning
VOCAB: (w/definition)	Communication Station (CS): A designated location equipped with technology for communication, often used as waypoints for drone missions. Heuristic: A problem-solving approach or technique that uses a practical and intuitive method, typically providing a solution that is not guaranteed to be optimal but is efficient. NP-Hard Problems: A class of computational problems that are considered among the most challenging in computer science, as finding exact solutions is believed to be infeasible in polynomial time. TSP (Traveling Salesman Problem): A classic optimization problem where the goal is to find the shortest possible route that visits a set of locations and returns to the starting point
Cited references to follow up on	Fenton, A.: The bees algorithm for the vehicle routing problem. Master's thesis, Department of Computer Science, University of Auckland (2016). http://arxiv. org/abs/1605.05448
Follow up Questions	How significant is the role of communication stations (CSs) in facilitating efficient drone-assisted boat rescue missions? what potential benefits could the "red-gray path" heuristic bring to the optimization of drone rescue paths, and how might it impact real-world

	operations?

Article #12 Notes: Coverage path planning for multiple unmanned aerial vehicles in maritime search and rescue operations

Source Title	Coverage path planning for multiple unmanned aerial vehicles in maritime search and rescue operations
Source citation (APA Format)	Cho, S. W., Park, H. J., Lee, H., Shim, D. H., & Kim, S.-Y. (2021). Coverage path planning for multiple unmanned aerial vehicles in maritime search and rescue operations. *Computers & Industrial Engineering*, *161*, 107612. https://doi.org/10.1016/j.cie.2021.107612
Original URL	https://www.sciencedirect.com/science/article/abs/pii/S0360835221005167
Source type	Journal article
Keywords	maritime, search and rescue, unmanned aerial vehicles, coverage path planning
#Tags	Solution?
Summary of key points + notes (include methodology)	This article is about coverage path planning for multiple unmanned aerial vehicles (UAVs) in maritime search and rescue (SAR) operations. Maritime SAR is a challenging task due to the large and dynamic search areas, as well as the harsh environmental conditions. UAVs have the potential to improve the efficiency of maritime SAR operations by providing a wide range of capabilities, such as long-endurance surveillance, high-resolution imaging, and rapid deployment. The authors of the article propose a two-phase method for solving the coverage path planning problem. In the first phase, the search area is decomposed into a grid and each grid cell is assigned to a UAV. This is done to minimize the total area that each UAV needs to cover. In the second phase, an integer linear programming (MILP) model is used to find the optimal coverage path for each UAV. The MILP model takes into account the distance between the grid cells, the speed of the UAVs, and the time it takes to search each grid cell. The authors evaluate their proposed method using numerical experiments and

	show that it outperforms previous approaches in terms of both the coverage rate and the total search time. Overall, the article presents a novel and effective method for coverage path planning of multiple UAVs in maritime SAR operations. The proposed method is able to generate high-quality solutions in a timely manner, even for large-scale instances. The methodology of the paper is as follows: ● Decompose the search area into a grid. This is done to simplify the problem and to make it more efficient to solve. ● Assign each grid cell to a UAV. This is done to minimize the total area that each UAV needs to cover. ● Formulate a mathematical model to find the optimal path for each UAV to cover its assigned grid cells. This model takes into account the distance between the grid cells, the speed of the UAVs, and the time it takes to search each grid cell. ● Develop a heuristic algorithm to solve the mathematical model for large-scale instances. This algorithm is faster than the commercial solver that they tested it against, and it produces solutions of similar quality.
Research Question/Problem/ Need	Coordinating the movements of multiple UAVs to ensure that the entire search area is covered is a complex problem. Coverage path planning algorithms can help to solve this problem by generating efficient flight paths for the UAVs

Important Figures	 (a) Case 1: The search area decomposed into a square grid cell and a coverage path  (b) Case 2: The search area decomposed into a square grid cell and a coverage path **Fig. 1.** Illustration of grid-based area decomposition. This image shows the base of the approach used by the authors of this paper. They segmented the search area into grids and squares before designing an optimization problem for it.

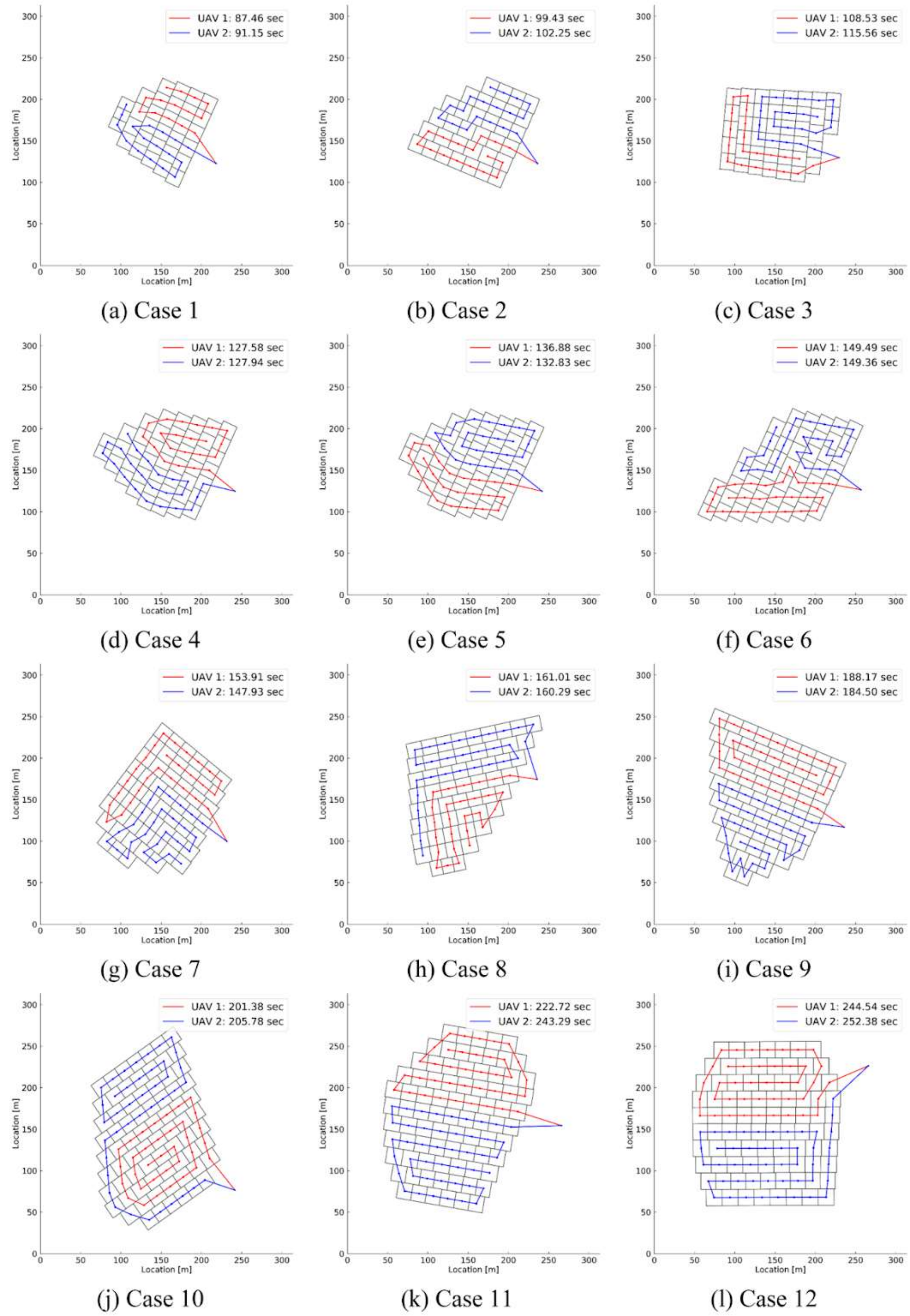
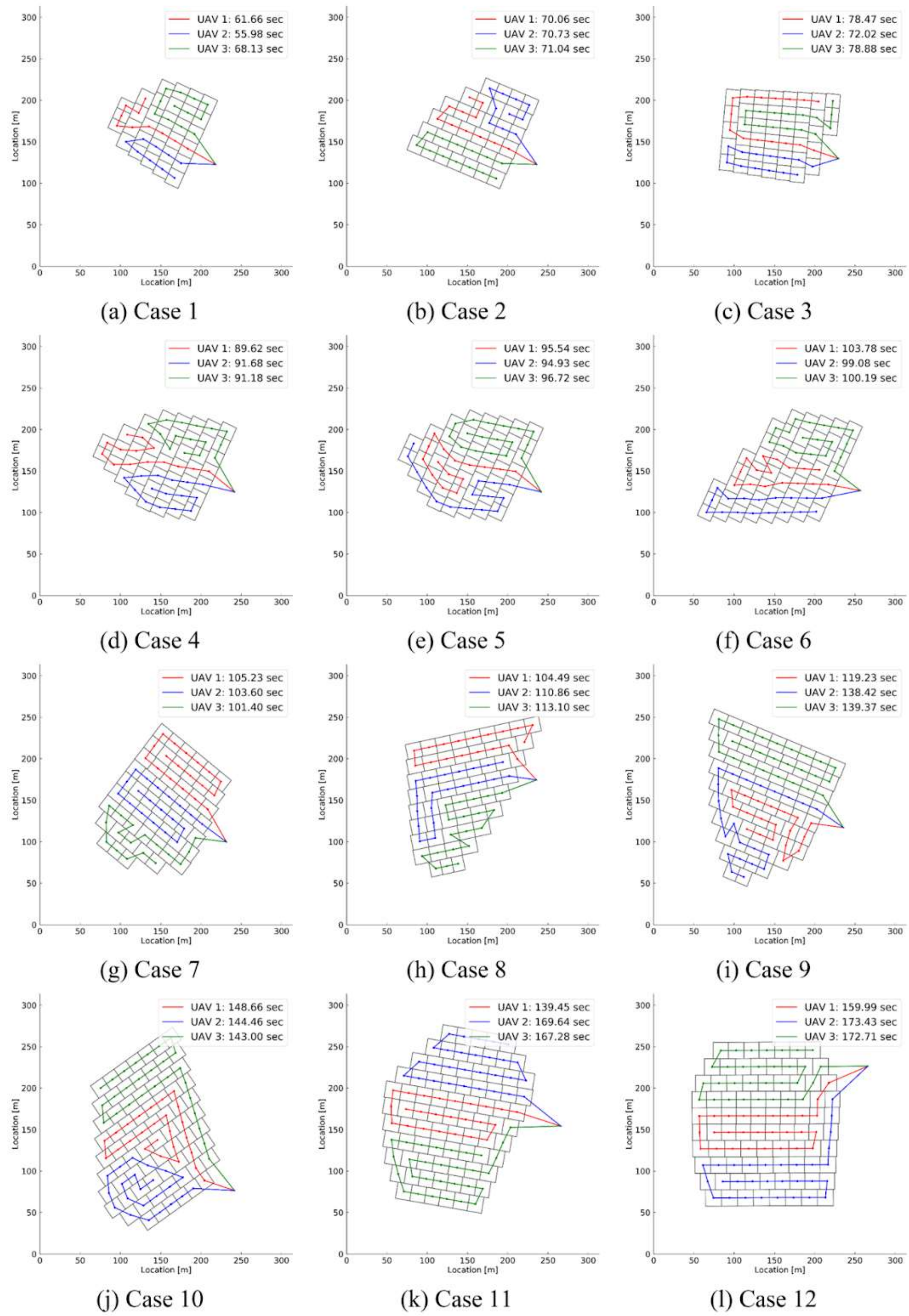


Fig. 10. Solutions of the test cases.

	 **Fig. 11.** Solutions with three served UAVs of the test cases. Both of these images show UAVs using their path planning algorithm and measure the total time spent. The first one is for 2 UAVs while the second one is for 3 UAVs
VOCAB: (w/definition)	Coverage path planning (CPP): A problem of finding a path for a robot to cover a given area. Grid-based area decomposition: A method of dividing an area into smaller grids. Mixed-integer linear programming (MILP): A type of mathematical programming

	that uses both integer and continuous variables. Randomized search heuristic (RSH): A type of algorithm that uses randomness to find solutions to problems.
Cited references to follow up on	Araujo, J. F., Sujit, P. B., & Sousa, J. B. (2013). Multiple UAV area decomposition and coverage. In 2013 IEEE symposium on computational intelligence for security and defense applications (CISDA) (pp. 30–37). IEEE.
Follow up Questions	What are the main challenges of coverage path planning for multiple UAVs in maritime search and rescue operations? What are the advantages of the proposed two-phase method over other existing methods? How does the proposed grid-based area decomposition method minimize the decomposed search area? How does the proposed randomized search heuristic (RSH) algorithm solve the MILP model for large-scale instances?

Article #13 Notes: Energy-Efficient Drone Coverage Path Planning using Genetic Algorithm

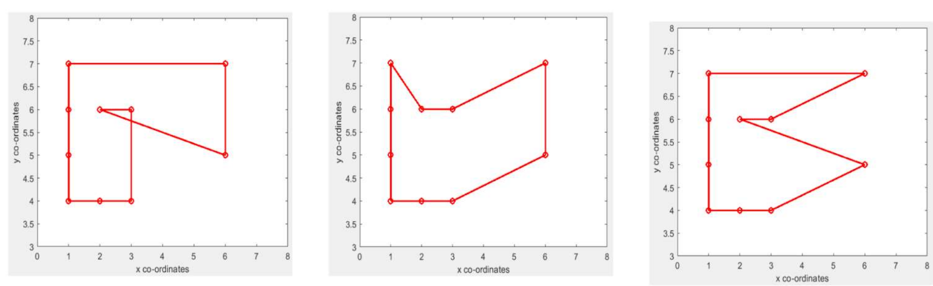
Source Title	Energy-Efficient Drone Coverage Path Planning using Genetic Algorithm
Source citation (APA Format)	Shivgan, R., & Dong, Z. (2020). Energy-Efficient Drone Coverage Path Planning using Genetic Algorithm. *2020 IEEE 21st International Conference on High Performance Switching and Routing (HPSR)*, 1–6. https://doi.org/10.1109/HPSR48589.2020.9098989
Original URL	https://ieeexplore.ieee.org/document/9098989
Source type	Conference paper
Keywords	Unmanned Aerial Vehicles, UAVs, environmental sensing, surveying, coverage path planning, battery capacity, energy optimization, genetic algorithm, greedy algorithm
#Tags	
Summary of key points + notes (include methodology)	● The paper discusses the use of Unmanned Aerial Vehicles (UAVs) in environmental sensing and surveying applications. It introduces the problem of coverage path planning for UAVs with limited battery capacity. The authors propose a genetic algorithm to optimize UAV energy consumption and reduce the number of turns, comparing it to a greedy algorithm with different numbers of waypoints. ● ● The genetic algorithm significantly reduces energy consumption, by 2-5 times compared to the greedy algorithm, while covering all waypoints. The paper presents an energy consumption model for UAVs, formulates the path planning problem as a Traveling Salesman Problem, and implements the genetic algorithm to find optimized energy-efficient paths. ● ● Overall, the research demonstrates the effectiveness of the proposed genetic algorithm in minimizing energy consumption for UAVs during surveying tasks, especially in scenarios with a large number of waypoints. ● ● Formulated the UAV path planning problem as a Traveling Salesman Problem (TSP).

- Developed an energy consumption model for the UAV, accounting for acceleration, deceleration, turning, and straight flight.
- Implemented a genetic algorithm to optimize the energy consumption and path planning.
- Compared the energy consumption of the genetic algorithm with the greedy algorithm.
- Conducted experiments and simulations with varying numbers of waypoints.
- Evaluated and compared the results for energy consumption and path planning efficiency.
- Analyzed the impact of reducing the number of turns on energy consumption

Research Question/Problem/ Need

The research problem or need in this article is to optimize the energy consumption of Unmanned Aerial Vehicles (UAVs) during environmental surveying tasks. UAVs are commonly used in surveying and data collection, but their limited battery capacity restricts their flight time. The study aims to address this limitation by formulating the path planning problem as a Traveling Salesman Problem and developing an energy-efficient path planning solution to minimize energy consumption

Important Figures



(a) Genetic algorithm with energy optimization. (b) Genetic algorithm with distance optimization. (c) Greedy algorithm with energy optimization.

This image shows the 3 algorithms and their proposed path covering the 10 vertices that the researchers tested

TABLE II: Average energy consumption with genetic algorithms and greedy algorithm for 10 waypoints.

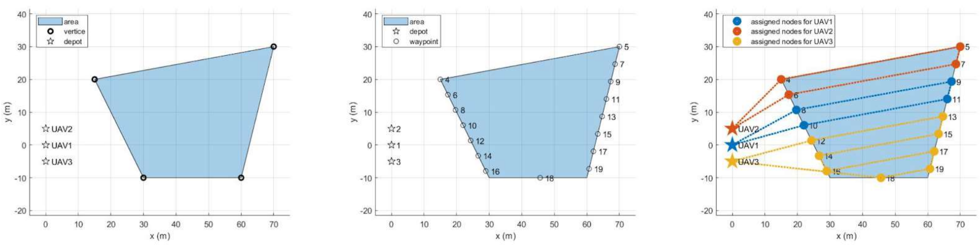
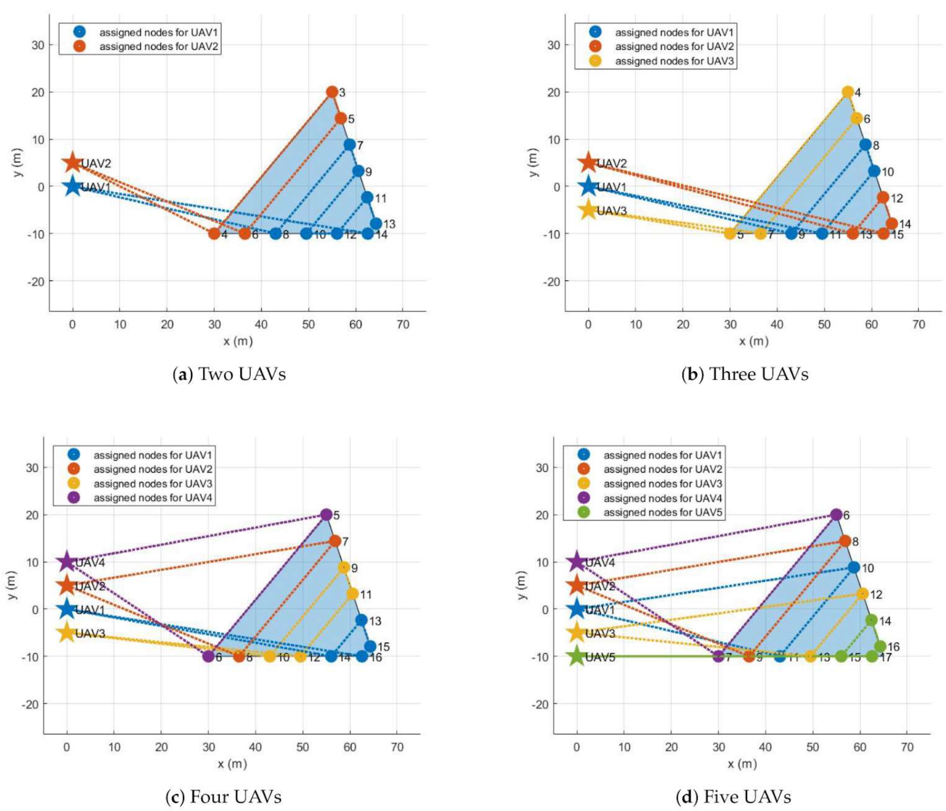
Algorithm	GA (Energy optimization)	GA (Distance optimization)	Greedy (Energy optimization)
Energy consumption (kJ)	1.8766	2.2019	2.076
Distance traveled (m)	19.1231	15.7388	20.3983
Computation time (sec)	13	14	4

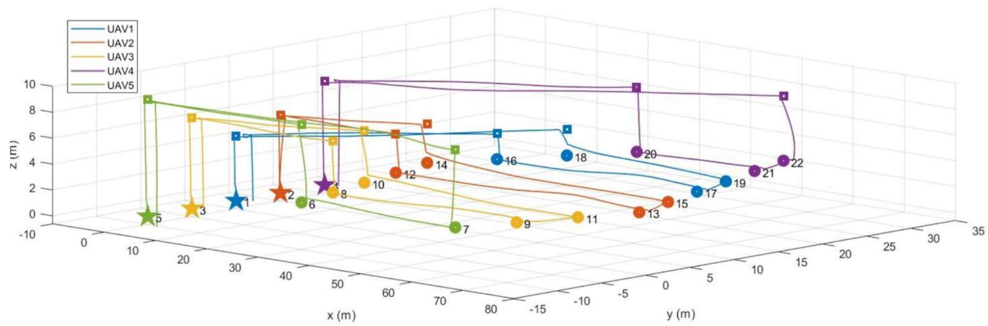
This image connects to the image above and shows the different measurements for the 3 different algorithms

VOCAB: (w/definition)	Traveling Salesman Problem (TSP): TSP is a well-known combinatorial optimization problem in which the goal is to find the shortest possible route that visits a set of cities and returns to the starting city. In this article, the UAV path planning problem is formulated as a TSP. Genetic Algorithm: Genetic algorithms are a type of heuristic algorithm inspired by the process of natural selection Energy Consumption Model: This is a mathematical model that describes how energy is consumed by the UAV during different phases of its flight, including acceleration, deceleration, turning, and straight-line flight.
Cited references to follow up on	M. Erdelj, E. Natalizio, K. R. Chowdhury and I. F. Akyildiz, "Help from the sky: Leveraging uavs for disaster management", *IEEE Pervasive Computing*, vol. 16, no. 1, pp. 24-32, 2017.
Follow up Questions	What specific environmental sensing and surveying applications are commonly performed using UAVs, and how do these applications benefit from optimized energy consumption? How does the energy consumption model presented in the article account for factors such as acceleration, deceleration, turning, and straight-line flight when optimizing UAV energy usage?

Article #14 Notes: Autonomous Mission of Multi-UAV for Optimal Area Coverage

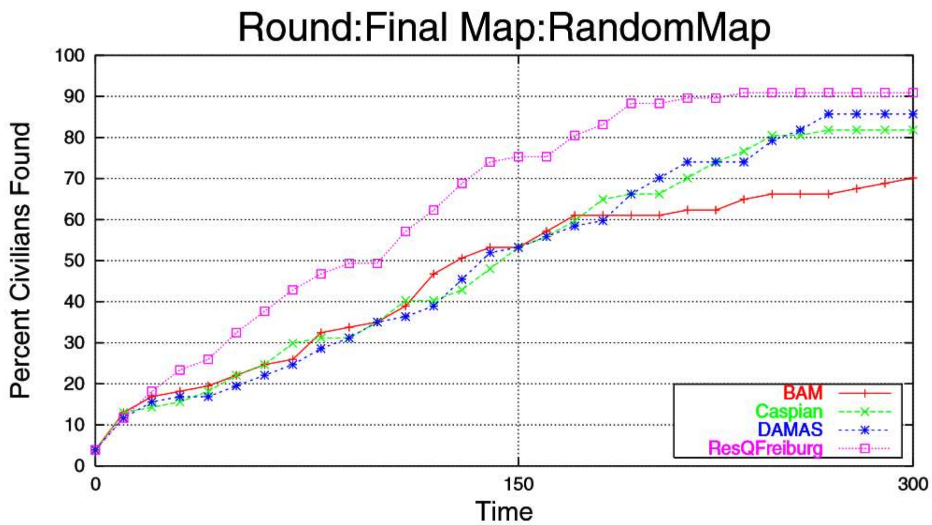
Source Title	Autonomous Mission of Multi-UAV for Optimal Area Coverage
Source citation (APA Format)	Hong, Y., Jung, S., Kim, S., & Cha, J. (2021). Autonomous Mission of Multi-UAV for Optimal Area Coverage. *Sensors*, *21*(7), Article 7. https://doi.org/10.3390/s21072482
Original URL	https://www.mdpi.com/1424-8220/21/7/2482
Source type	Journal Article
Keywords	autonomous mission, unmanned aerial vehicles, area coverage, optimization problem, waypoints, decision-making autonomy, experienced operators, efficiency, allocation problem, coverage path planning, UAV trajectory planning, path planning for multiple UAVs
#Tags	Solution?
Summary of key points + notes (include methodology)	This article is about the autonomous mission of multi-UAV for optimal area coverage. It discusses the task assignment problem and the need for an efficient and autonomous solution. The article proposes a new optimization problem that allocates waypoints created to cover the area. The article also discusses the need for a method to spatially separate each UAV. The final output of the area coverage mission will be 3D maps or 3D models. The goal is to assign tasks in a way that is efficient and maximizes the coverage of the area. Traditional methods for solving the task assignment problem are often inefficient and require human intervention. The authors propose a new method that is both efficient and autonomous. The authors propose a new optimization problem that allocates waypoints to the drones. The goal of the optimization problem is to minimize the total distance traveled by the drones. A method for spatially separating each UAV: The authors discuss the need for a method to separate each UAV to avoid collisions between the UAVs.

	The final output of the area coverage mission will be 3D maps or 3D models. These maps and models can be used for path planning for various missions. The proposed system is able to make decisions autonomously, without the need for human intervention. This makes it more efficient and reliable than traditional systems.
Research Question/Problem/ Need	The problem they are addressing is the need for an efficient and effective way to cover a large area with multiple unmanned aerial vehicles
Important Figures	 (**a**) Initial configuration (**b**) Nodes (**c**) Assignment results Example of ideal task assignment minimizing distance traveled by each drone.  (**a**) Two UAVs (**b**) Three UAVs (**c**) Four UAVs (**d**) Five UAVs Multiple UAVs planning for a triangle shaped search area while minimizing

	distance traveled by each drone.  **Figure 10.** MATLAB and gazebo cosimulation results. Example of the output produced by the optimization algorithm
VOCAB: (w/definition)	ground control station (GCS): The central computer that controls the UAVs waypoints: A set of points that a UAV must visit in order to complete its mission task assignment subsystem: The subsystem that allocates waypoints to UAVs
Cited references to follow up on	Avellar, G.S.; Pereira, G.A.; Pimenta, L.C.; Iscold, P. Multi-UAV routing for area coverage and remote sensing with minimum time. Sensors 2015, 15, 27783–27803.
Follow up Questions	How does the proposed method compare to existing methods for task assignment in multi-UAV systems? What are the limitations of the proposed method? Under what conditions is the proposed method most effective?

Article #15 Notes: Successful Search and Rescue in Simulated Disaster Areas

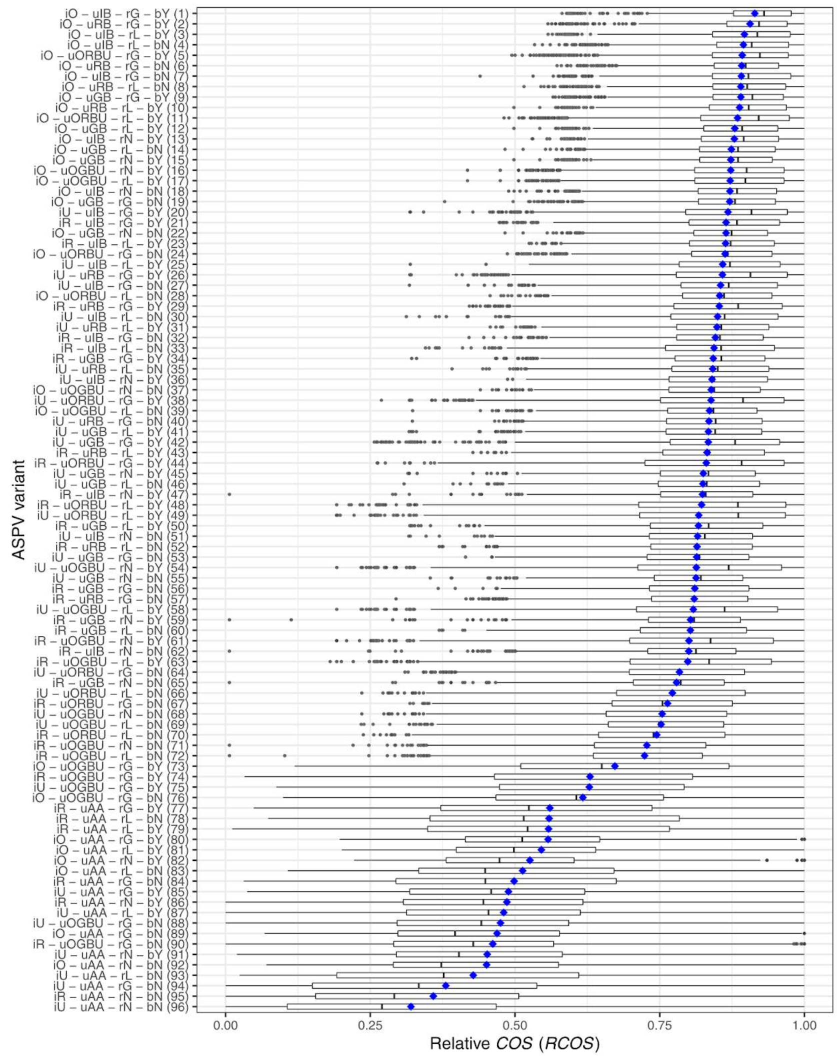
Source Title	Successful Search and Rescue in Simulated Disaster Areas
Source citation (APA Format)	Kleiner, A., Brenner, M., Bräuer, T., Dornhege, C., Göbelbecker, M., Luber, M., Prediger, J., Stückler, J., & Nebel, B. (2006). Successful Search and Rescue in Simulated Disaster Areas. In A. Bredenfeld, A. Jacoff, I. Noda, & Y. Takahashi (Eds.), *RoboCup 2005: Robot Soccer World Cup IX* (pp. 323–334). Springer. https://doi.org/10.1007/11780519_29
Original URL	https://link.springer.com/content/pdf/10.1007/11780519_29.pdf
Source type	Conference Paper
Keywords	Rescue sequence optimization, C4.5 algorithm, Genetic Algorithm
#Tags	
Summary of key points + notes (include methodology)	ResQ Freiburg excelled in the RoboCupRescue simulation competition by strategically focusing on exploration and rescue sequence optimization during the 2004 event. ● The team's success was measured through the percentage of clean roads, saved buildings, explored buildings, found civilians, and the number of saved civilians. ● Their approach prioritized early identification of civilian locations and efficient exploration strategies, outperforming other teams in critical aspects of disaster response simulation. ● Data collection involved using an autorun tool to simultaneously initiate the simulation and agents, generating datasets with health and damage values for civilians at each time step. ● Simulations were conducted within 400 time steps, excluding rescue operations and fires, to minimize noise in the data. ● Machine learning techniques were used using the WEKA tool. ● Genetic Algorithm (GA) optimization was used for rescue sequence improvement, considering factors such as ambulance team dispatch and external factors. ● Efficient path planning, crucial for reaching target positions, utilized a ResQ

	path planner based on a road graph's structure and considered various factors like blockades and other agents' trajectories.
Research Question/Problem/ Need	The research problem addressed in the article is the effective simulation and optimization of search and rescue operations in disaster-stricken
Important Figures	 This graph shows the number of civilians found in the simulation by the algorithm designs by the authors of this article
VOCAB: (w/definition)	Utility Function: A function that measures the desirability or preference of a particular outcome. In the context of the article, it quantifies the expected number of civilians that are predicted to survive based on a given rescue sequence. Regression Trees: A type of decision tree used in regression analysis, predicting numerical values. In the article, it is applied to predict the simulation time of civilians. Confidence Values: Measures indicating the reliability or certainty of predictions, particularly in relation to the accuracy of predicting a civilian's time of death. Blockades: Obstacles or barriers on roads that impede movement. In the context of the simulation, police agents aim to remove blockades to enable smoother rescue operations. Floyd-Warshall Matrix: A dynamic programming algorithm used for finding the shortest paths in a weighted graph. In the article, it is mentioned as a calculation method for exact travel costs, but is considered less efficient

Cited references to follow up on	J. L. Bentley. Multidimensional binary search trees used for associative searching. Communications of the ACM, 18(9):509–517, 1975.
Follow up Questions	How does the ResQ Freiburg team handle dynamic changes in information about civilians during each round? What mechanisms are in place to control fluctuations in the rescue sequence caused by information updates from exploration or surveillance?

Article #16 Notes: Ant colony optimization for path planning in search and rescue operations

Source Title	Ant colony optimization for path planning in search and rescue operations
Source citation (APA Format)	Morin, M., Abi-Zeid, I., & Quimper, C.-G. (2023). Ant colony optimization for path planning in search and rescue operations. *European Journal of Operational Research*, *305*(1), 53–63. https://doi.org/10.1016/j.ejor.2022.06.019
Original URL	https://www.sciencedirect.com/science/article/pii/S0377221722004945
Source type	Journal Article
Keywords	Evolutionary computationsSearch and rescueOptimal search path planningAnt colony optimizationHumanitarian operations
#Tags	
Summary of key points + notes (include methodology)	This paper discusses the use of Ant Colony Optimization (ACO) algorithms for optimizing search paths in search and rescue operations. The focus is on the NP-hard optimal search path problem with visibility. The proposed Ant Search Path with Visibility (ASPV) algorithm is evaluated through extensive experiments, comparing 96 algorithmic variants. The study demonstrates that ACO algorithms, especially ASPV variants, outperform a standard greedy heuristic and a state-of-the-art mixed-integer linear program solver in terms of efficiency and success probability.
Research Question/Problem/ Need	Are ACO algorithms better than other commonly used search path algorithms?

Important Figures	 This figure compares the success rates of different variants of the algorithms that's being studied in this paper
VOCAB: (w/definition)	Markovian: Related to the Markov model, which is a statistical model describing a sequence of events where the probability of each event depends only on the state attained in the previous event. Pheromone: Chemical substances that are secreted or excreted by an organism and can influence the behavior of other members of the same species. Metaheuristic: A higher-level procedure or heuristic designed to guide the exploration of a solution space to efficiently find good solutions. Intensification: The process by which ants converge to better solutions in the context of ant colony optimization or ACO algorithms.

Cited references to follow up on	Abi-Zeid, I., Morin, M. and Nilo, O. (2019). **Decision Support for Planning Maritime Search and Rescue Operations in Canada**. In *Proceedings of the 21st International Conference on Enterprise Information Systems - Volume 1: ICEIS*; ISBN 978-989-758-372-8; ISSN 2184-4984, SciTePress, pages 328-339
Follow up Questions	In the text, there's a mention of the "Exponential Detection Law." Could you explain how this law is applied in the context of detecting objects, and what advantages it offers in probabilistic models? The text discusses both intensification and diversification in the context of optimization. How do these two processes work together, and why is it important to balance them in algorithms like ant colony optimization?

Article #17 Notes: Search Strategies for Multiple UAV Search and Destroy Missions

Source Title	Search Strategies for Multiple UAV Search and Destroy Missions
Source citation (APA Format)	George, J., P. B., S., & Sousa, J. B. (2011). Search Strategies for Multiple UAV Search and Destroy Missions. *Journal of Intelligent & Robotic Systems*, *61*(1), 355–367. https://doi.org/10.1007/s10846-010-9486-8
Original URL	https://link.springer.com/article/10.1007/s10846-010-9486-8
Source type	Journal Article
Keywords	UAV Coalition formation Task allocation Search
#Tags	
Summary of key points + notes (include methodology)	unmanned Aerial Vehicles (UAVs) undertake a mission to search for and destroy targets in a predefined region. The UAVs, each uniquely identified, possess different capabilities and capacities for carrying various resources. Coalition formation plays a crucial role, where the UAV detecting a target becomes the coalition leader responsible for forming effective coalitions with other agents. The search strategies employed include random search, lanes-based search, and grid-based search. Random search involves agents moving randomly until a target is detected, potentially leading to high repeated coverage. Lanes-based search divides the region into lanes to minimize repeated coverage. Grid-based search discretizes the area into cells, allowing efficient exploration. Monte-Carlo simulations are conducted to evaluate mission performance, considering variations in the number of UAVs, targets, and resources. Results show that grid-based search outperforms others, followed by lanes-based search, while random search performs the least efficiently. The effectiveness of each strategy depends on factors such as communication costs, agent density, and information sharing overhead. Methodology:

	Agent Characteristics: ● UAVs with different velocities and capacities. ● Unique token numbers and resource-carrying capabilities. Coalition Formation: ● Leader-agent detection of targets. ● Formation of coalitions meeting resource requirements. Search Strategies: ● Random Search: ○ Agents move randomly until target detection. ○ Simple implementation with potential repeated coverage. ● Lanes-Based Search: ○ Region divided into lanes for efficient exploration. ○ Minimization of repeated coverage. ● Grid-Based Search: ○ Area discretized into cells. Agents explore unexplored cells efficiently. Mission Performance Evaluation: Monte-Carlo simulations for varied UAVs, targets, and resources. Comparison of mission completion times for each search strategy. Comparison of Search Strategies: Grid-based search performs the best. Lanes-based search follows closely. Random search exhibits the least efficiency.
Research Question/Problem/ Need	How can UAVs efficiently form coalitions to engage detected targets while considering diverse capabilities and resource constraints?

Important Figures	

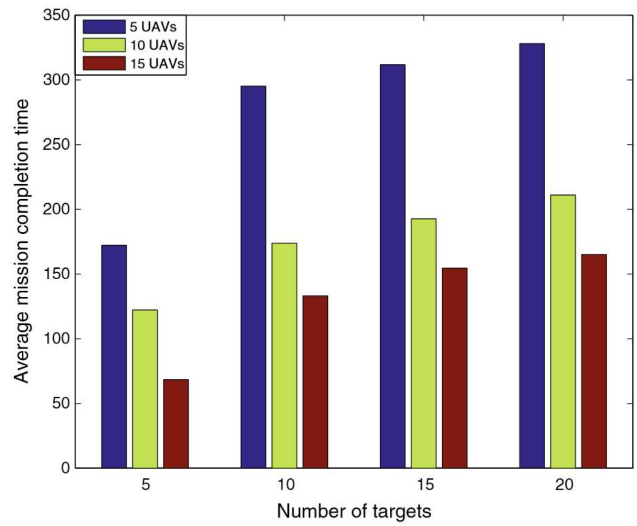


Fig. 5 Average mission performance with varying number of agents and targets when the agents use random search

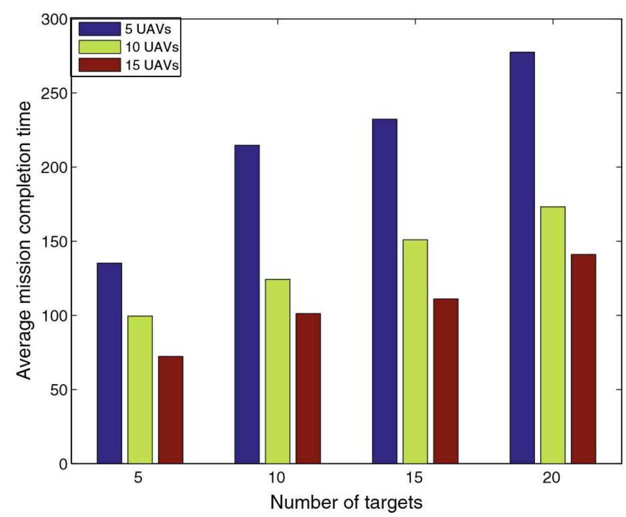


Fig. 6 Average mission performance with varying number of agents and targets when the agents use lanes based search

Fig. 7 Average mission performance with varying number of agents and targets when the agents use grid based search

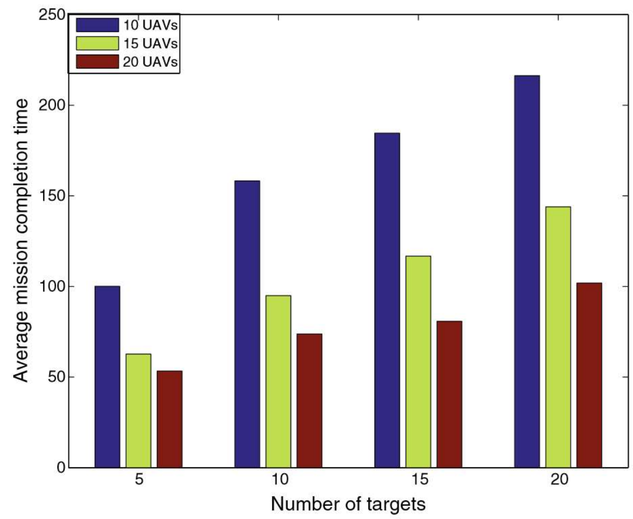
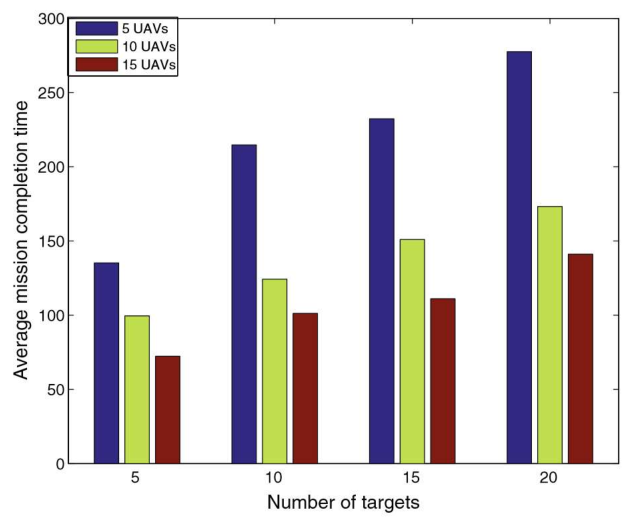


Fig. 6 Average mission performance with varying number of agents and targets when the agents use lanes based search



VOCAB: (w/definition)

Coalition Formation:

Definition: The process by which multiple agents or entities come together to collaborate and achieve a common objective.

Kinematic Constraints:

Definition: Restrictions imposed on the motion of UAVs, typically defined by parameters like velocity and heading rate.

Monte-Carlo Simulations:

Definition: Computational techniques that use random sampling to model and analyze complex systems, often involving multiple sources of uncertainty.

Cited references to follow up on	Nygard, K.E., Chandler, P.R., Pachter, M.: Dynamic network flow optimization models for air vehicle resource allocation. In: Proc. of the the American Control Conference, pp. 1853–1858. Arlington, Texas (2001)
Follow up Questions	What factors influence the selection of a coalition leader among UAVs? How are resource constraints managed during the coalition formation process?

Article #18 Notes: A UAV Search and Rescue Scenario with Human Body Detection and Geolocalization

Source Title	A UAV Search and Rescue Scenario with Human Body Detection and Geolocalization
Source citation (APA Format)	Doherty, P., & Rudol, P. (2007). A UAV Search and Rescue Scenario with Human Body Detection and Geolocalization. In M. A. Orgun & J. Thornton (Eds.), *AI 2007: Advances in Artificial Intelligence* (pp. 1–13). Springer. https://doi.org/10.1007/978-3-540-76928-6_1
Original URL	https://link.springer.com/content/pdf/10.1007/978-3-540-76928-6_1.pdf
Source type	Conference paper
Keywords	Unmanned Aerial Vehicle Rescue Scenario Plan Executor Task Planner Execution Monitor
#Tags	Innovation
Summary of key points + notes (include methodology)	The methodology described in the text revolves around utilizing autonomous unmanned helicopter systems in an emergency service scenario, specifically addressing the challenges posed by a devastating earthquake and tsunami. The scenario involves two legs: the first focuses on cooperative scanning by UAV platforms to identify injured persons and generate a saliency map, while the second aims at using this map to plan and execute the delivery of relief supplies to the identified individuals. The hardware platform used is the UAVTech UAV, a modified Yamaha RMAX helicopter equipped with an on-board camera system and multiple embedded computers for flight control and image processing. The Image Processing module employs a classifier to detect human bodies in thermal and color images. Experimental results indicate successful body identification and

	geolocation accuracy. The planning and execution involve a task planner (TALplanner) and an execution monitor to ensure robust, safe, and dependable operation. The integrated system is implemented on UAVs, demonstrating the potential for combining high-level deliberative capabilities with lower-level reactive functionalities in complex, real-world scenarios. Leg I: Body Identification ● Cooperative scanning by UAV platforms to identify injured persons. ● Saliency map generation based on thermal and color images. ● Geolocation of identified bodies using GPS and image processing. ● Experimental results show successful body identification and geolocation. ● UAVTech UAV, a modified Yamaha RMAX helicopter. ● On-board camera system with thermal and color cameras. ● PC104 embedded computers for flight control and image processing. ● Deliberative/reactive system (DRC) for high-end autonomous functionalities ● Thermal image analysis for human body-sized silhouettes. ● Color image analysis using a human body classifier. ● Geolocation of identified bodies using GPS and image processing. Mission Leg II: Package Delivery Planning, execution, and monitoring for delivering relief supplies. Use of task planner (TALplanner) and execution monitor for robust operation. Integration of high-level deliberative capabilities with lower-level reactive functionalities. Implementation on UAVs with a focus on logistics and package delivery.
Research Question/Problem/ Need	How can autonomous unmanned helicopter systems be optimally utilized to address the challenges of search and rescue operations, including body identification, logistics planning, and supply delivery, in the aftermath of a catastrophic event such as an earthquake and tsunami?

Important Figures

Fig. 5. Flight path and geolocated body positions

Fig. 6. Images of classified bodies. Corresponding thermal images are placed under color images.

This image illustrates the different images captured by the onboard camera

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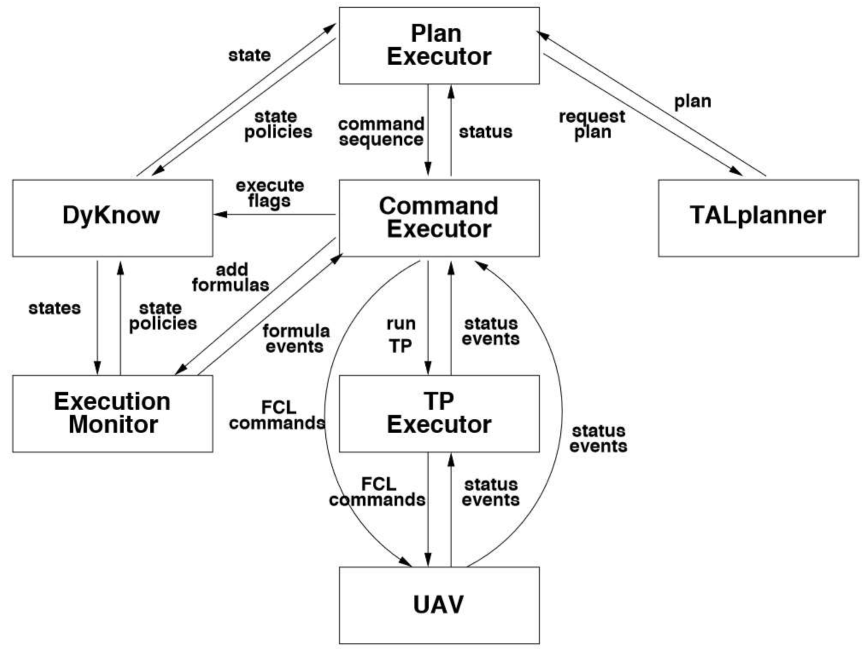

Fig. 9. System Architecture Overview

This image shows a systems diagram of the mission conducted by the authors
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<td>VOCAB: (w/definition)</td>
<td>
Task Planner (TALplanner):

A tool or system for planning tasks and actions in a logical and goal-oriented manner.

Execution Monitor:

A system or component that oversees the execution of plans, monitoring for deviations or failures.

Logistics Planning:

The process of organizing and coordinating the movement of resources, in this context, for delivering relief supplies.

Deliberative/Reactive System (DRC):

Refers to a system that combines elements of deliberative (thoughtful, planned) and reactive (responsive, adaptive) functionalities.

Modular Task Architecture (MTA):

A framework for organizing and executing tasks in a modular and flexible manner
</td>
</tr>
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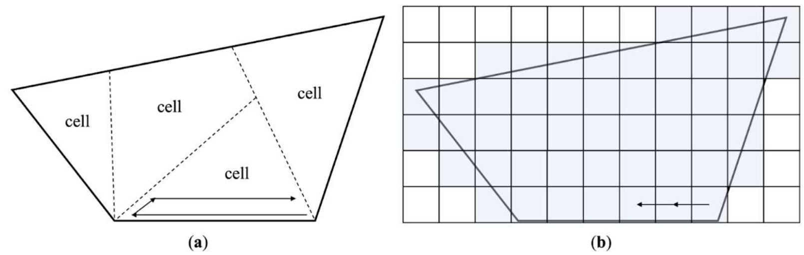
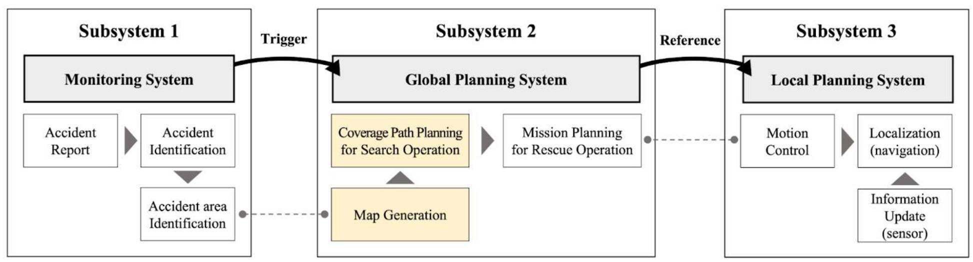
Cited references to follow up on	Doherty, P.: Advanced research with autonomous unmanned aerial vehicles. In: Proceedings on the 9th International Conference on Principles of Knowledge Representation and Reasoning (2004)
Follow up Questions	How scalable is the proposed methodology for larger-scale disasters, and what challenges might arise when integrating multiple autonomous systems in a coordinated effort?

Article #19 Notes: Multi-UAV Coverage Path Planning Based on Hexagonal Grid Decomposition in Maritime Search and Rescue

Source Title	Multi-UAV Coverage Path Planning Based on Hexagonal Grid Decomposition in Maritime Search and Rescue
Source citation (APA Format)	Cho, S.-W., Park, J.-H., Park, H.-J., & Kim, S. (2022). Multi-UAV Coverage Path Planning Based on Hexagonal Grid Decomposition in Maritime Search and Rescue. *Mathematics*, *10*(1), Article 1. https://doi.org/10.3390/math10010083
Original URL	https://www.mdpi.com/2227-7390/10/1/83
Source type	Journal article
Keywords	● overage path planning (CPP) ● global path planning ● local path planning ● cellular decomposition ● grid-based decomposition ● hexagonal grid-based decomposition ● mixed-integer linear programming (MILP) ● computational experiments
#Tags	
Summary of key points + notes (include methodology)	The article discusses how unmanned aerial vehicles (UAVs) can be utilized in maritime search and rescue operations, proposing a method involving hexagonal grid-based decomposition and a mixed-integer linear programming (MILP) model. The focus is on improving efficiency in search operations, especially in challenging ocean environments. The study's findings could have significant applications for emergency search and rescue efforts.- Time Complexity Analysis Analyzed time required for optimal solution calculation based on search area size.

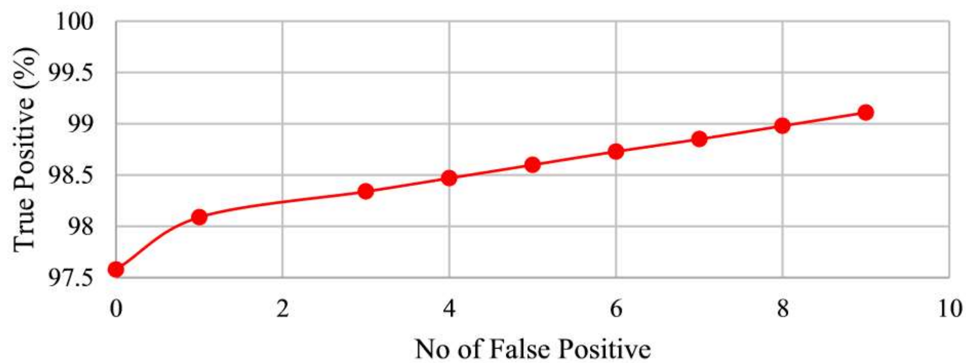
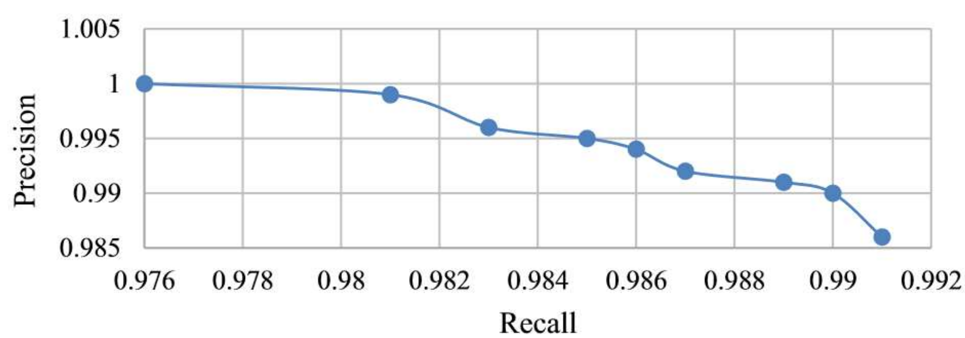
	Computational time grows exponentially with the increase in the size of the search area. Computational time increases significantly when search nodes reach 40. Explored optimal search paths based on the mathematical model. Despite similar shapes, search paths vary significantly. The model can generate optimal routes for diverse search area shapes. Effectiveness of Hexagonal Grid Validated hexagonal grid-based area decomposition effectiveness. Compared search paths on square and hexagonal grid maps. Hexagonal grid reduced search completion times on average by 10.59%. UAV Performance and Search Paths Verified the proposed model's performance with three UAVs. Three UAVs reduced search completion times by an average of 28.4%. Efficient distribution of UAV operations without collisions. Marine Accident Response Proposed model utilizes multiple UAVs for quick marine accident response. Hexagonal grid decomposition allows flexible paths, optimizing search. Potential applications in land-based emergencies anticipated. Experiment Details Intel Core i7-7700HQ, 16.0 GB RAM, Windows 10, and Gurobi 8.0.1 solver used. Python programming language employed in all experiments.
Research Question/Problem/ Need	The study aims to enhance the efficiency of search operations, especially in environments where direct human access is challenging.

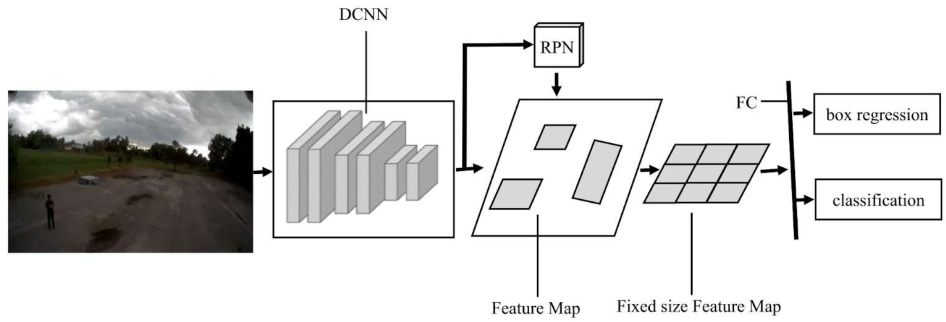
Important Figures	 **Figure 2.** Methods to divide search area. (**a**) Cellular decomposition method; (**b**) grid-based decomposition method. This figure shows the cellular and grid decomposition methods used by the algorithms in this study.  **Figure 3.** Maritime search and rescue (SAR) system architecture. Systems diagram of the algorithm used in this paper
VOCAB: (w/definition)	Coverage Path Planning (CPP): Planning a path that covers a target area efficiently. Mixed-Integer Linear Programming (MILP): Mathematical modeling technique for optimization problems with linear objective functions, where some of the variables are required to be integers. Hexagonal Grid Decomposition: Dividing the search area into hexagonal grid cells for path planning. Computational Complexity: The amount of computational resources required to solve a problem. Global SAR Plan: A comprehensive plan for search and rescue operations covering the entire search area. Local SAR Plan: A plan that is continuously modified based on updated environment information during the search and rescue operation.
Cited references to follow up on	Queralta, J.P.; Raitoharju, J.; Gia, T.N.; Passalis, N.; Westerlund, T. Autosos: Towards

	multi-uav systems supporting maritime search and rescue with lightweight ai and edge computing. arXiv 2020, arXiv:2005.03409.
Follow up Questions	Are there strategies or optimizations that can be employed to address the increasing computational time with larger search areas?

Article #20 Notes: Faster R-CNN Deep Learning Model for Pedestrian Detection from Drone Images

Source Title	Faster R-CNN Deep Learning Model for Pedestrian Detection from Drone Images
Source citation (APA Format)	Hung, G., Sahimi, M., Samma, H., Almohamad, T., & Lahasan, B. (2020). Faster R-CNN Deep Learning Model for Pedestrian Detection from Drone Images. *SN Computer Science*, *1*, 116. https://doi.org/10.1007/s42979-020-00125-y
Original URL	https://www.researchgate.net/publication/340510754_Faster_R-CNN_Deep_Learning_Model_for_Pedestrian_Detection_from_Drone_Images
Source type	Journal Article
Keywords	Surveillance Search and Rescue (SAR) Image-based Object Detection Outdoor Environment Convolutional Neural Network (CNN) Inception-v3 Region Proposal Network (RPN) Precision Recall F1 Score
#Tags	
Summary of key points + notes (include methodology)	The study focuses on the application of the Faster R-CNN deep learning model for pedestrian detection in drone-based images, addressing challenges in uncontrolled outdoor environments with varying views and distances. The motivation stems from the cost-effectiveness of drones and the success of deep learning models in image-based object detection. The main contributions include investigating the use of Faster R-CNN for pedestrian detection, using newly collected drone-based

	images. The methodology involves employing a pre-trained deep convolutional neural network (Inception-v3) for feature extraction, a region proposal network for candidate box generation, and a fully connected layer for classification and localization. The evaluation is based on precision, recall, and F1 score, with the model achieving 98% precision and 99% recall on a new dataset. Comparisons with the YOLO model and evaluation on the UAV123 dataset show competitive results. The study concludes by suggesting future applications of Faster R-CNN in real-world drone-based inspection tasks.
Research Question/Problem/ Need	The research problem or need addressed in the study is the development of an effective pedestrian detection system using unmanned aerial vehicles (UAVs) or drones
Important Figures	 **Fig. 8** True positive versus false positive  **Fig. 9** Graph of precision versus recall on new dataset This image is important as it shows the accuracy of the algorithm they created.

<table>
<tr><td></td><td>

This image shows the architecture of the detection model the authors of this paper constructed</td></tr>
<tr><td>VOCAB: (w/definition)</td><td>Convolutional Neural Network (CNN): A type of neural network designed for image processing, featuring convolutional layers for feature extraction.

Inception-v3: A pre-trained deep convolutional neural network architecture used for feature extraction in image-related tasks.

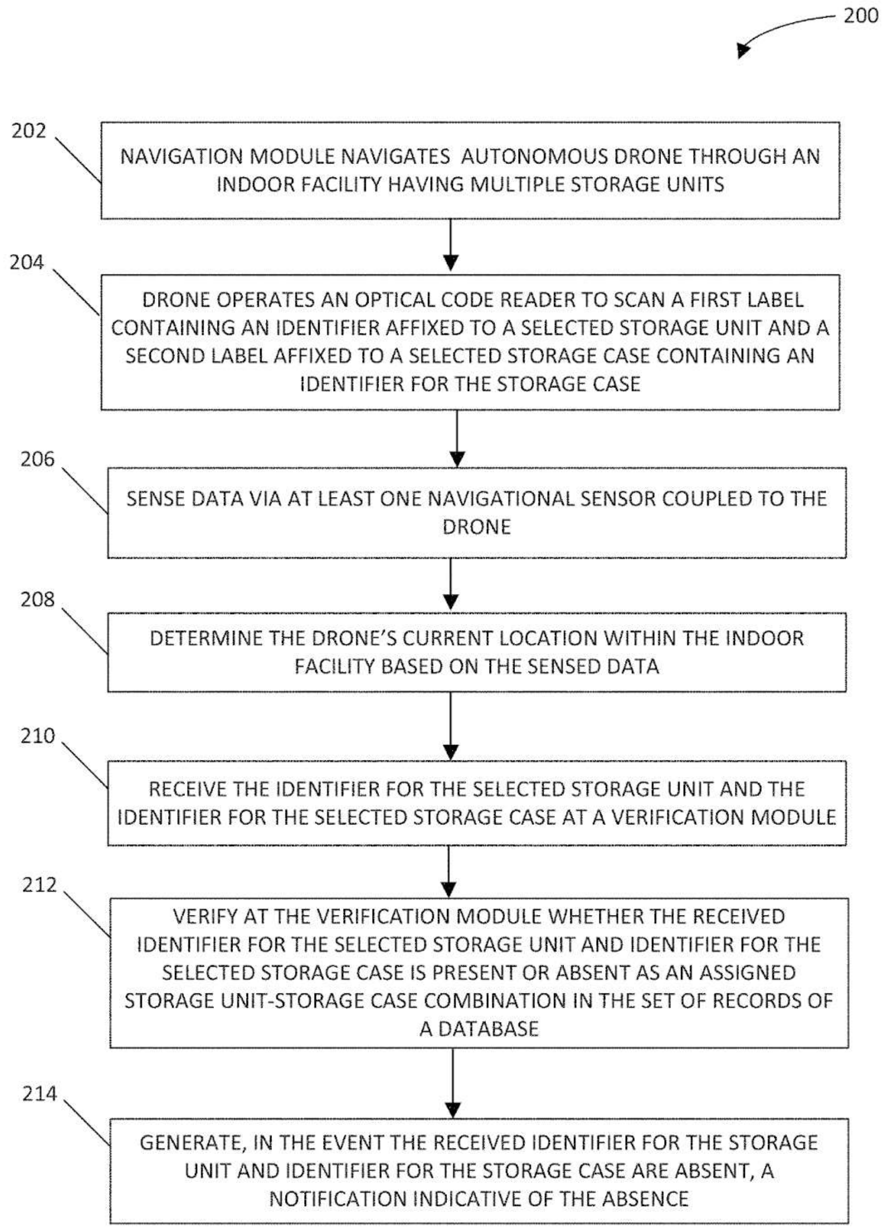
Region Proposal Network (RPN): A neural network component that proposes candidate object regions for further processing in object detection tasks.

You Only Look Once (YOLO): A real-time object detection system that processes images in a single forward pass of the neural network.

Image Processing: The manipulation and analysis of visual information in images to extract meaningful insights or enhance specific features.</td></tr>
<tr><td>Cited references to follow up on</td><td>Zhang H, et al. Pedestrian detection method based on Faster R-CNN. In: 2017 13th international conference on computational intelligence and security (CIS), IEEE. 2017.</td></tr>
<tr><td>Follow up Questions</td><td>In the evaluation of the pedestrian detection system, were there scenarios or conditions in which the model performed less effectively?</td></tr>
</table>

Patent #1: Systems and methods for autonomous drone navigation

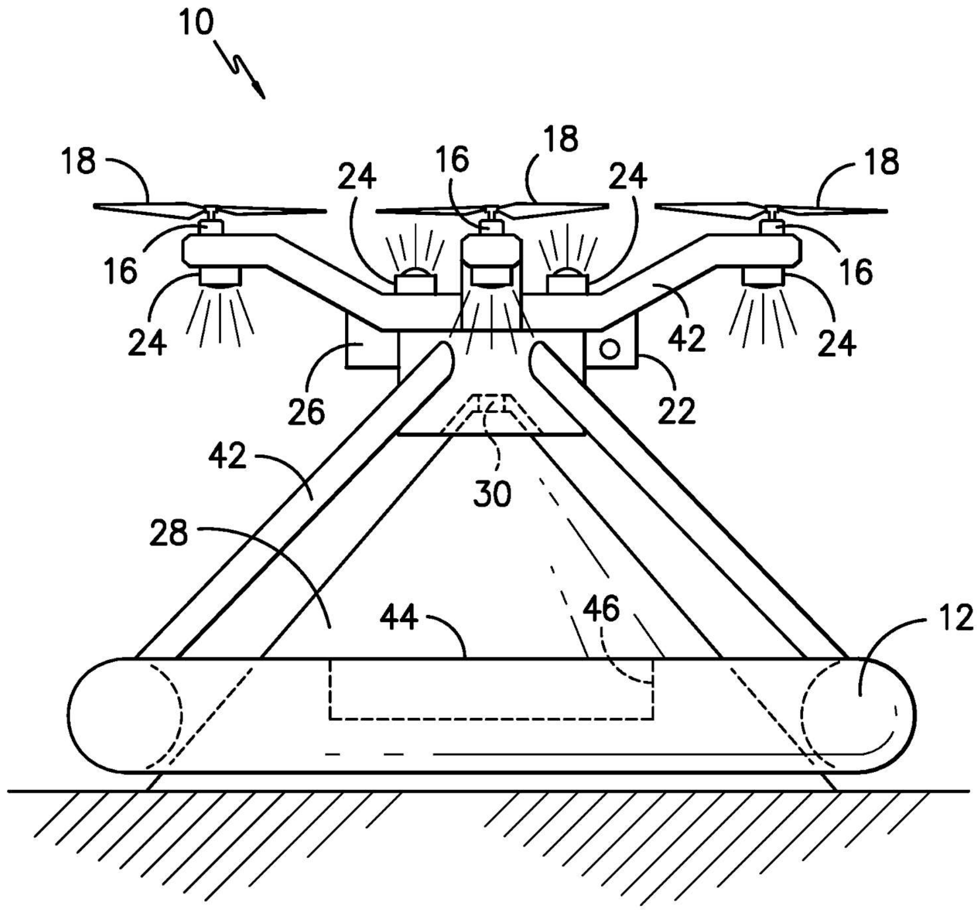
Source Title	Systems and methods for autonomous drone navigation
Source citation (APA Format)	O'Brien, J. J., HIGH, D., Natarajan, C., & Jones, N. G. (2019). *Systems and methods for autonomous drone navigation* (United States Patent US10378906B2). https://patents.google.com/patent/US10378906B2/en?q=(Autonomous+drone)&oq=Autonomous+drone
Original URL	https://patents.google.com/patent/US10378906B2/en?q=(Autonomous+drone)&oq=Autonomous+drone
Source type	Patent
Keywords	
#Tags	
Summary of key points + notes (include methodology)	● The patent acknowledges the increasing use of drones in various applications, including delivery, inspection, and surveillance. ● It highlights the limitations of existing drone navigation systems, such as reliance on GPS signals which can be unreliable in certain environments. ● The invention proposes a system and methods for enabling drones to navigate autonomously using a combination of sensors and algorithms. ● The system utilizes sensors such as LiDAR, cameras, and ultrasonic sensors to perceive their surroundings. ● These sensors provide data about the environment, including obstacles, landmarks, and other relevant features. ● This data is then processed by algorithms to generate a map of the environment and determine the drone's position within it. ● The algorithms also plan and execute the drone's flight path, allowing it to navigate autonomously and avoid obstacles.
Research Question/Problem/	Current methods of autonomous navigation are heavily reliant on GPS which is

Need	often unreliable
Important Figures	 FIG. 2 This image is important as it shows the system flowchart of the device invented by the authors in this patent.
VOCAB: (w/definition)	Sensor fusion: The process of combining data from multiple sensors to create a

	more complete and accurate picture of the environment. Geofence: A virtual boundary that restricts the drone's movement to a specific area.
Cited references to follow up on	Morlin - Yron , Sophie , Are flying robots the perfect co - workers ? , http : / / edition . cnn . com / 2016 / 05 / 12 / africa / drone - scan - inventory technology - south - africa / index . html , viewed Aug . 17 , 2017 .
Follow up Questions	How does the system handle situations where sensor data is unreliable or conflicting? How does the system account for different weather conditions and their impact on drone navigation?

Patent #2: Unmanned aerial vehicle search and rescue system

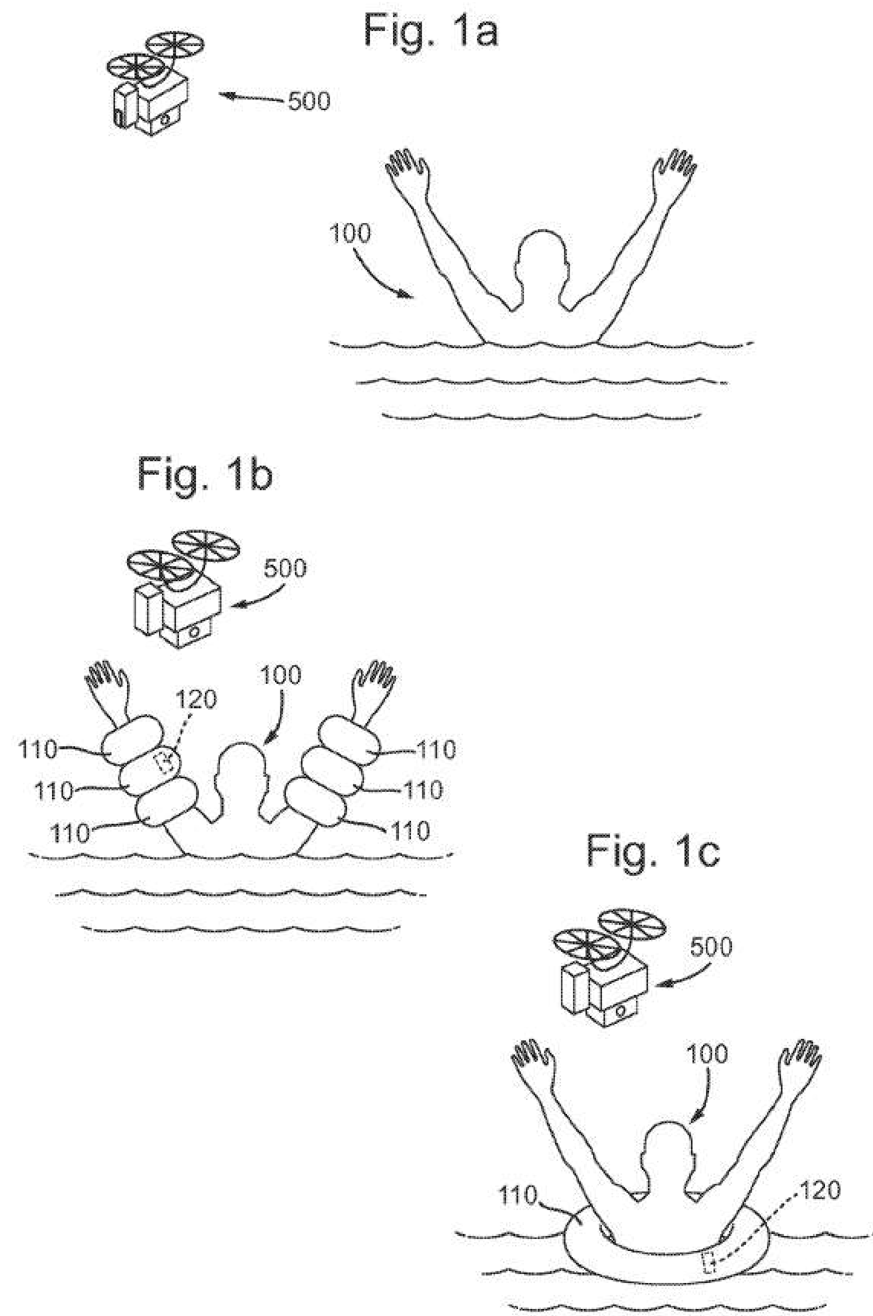
Source Title	Unmanned aerial vehicle search and rescue system
Source citation (APA Format)	Moses, T. L., & Ross, M. S. (2020). *Unmanned aerial vehicle search and rescue system* (United States Patent US10668997B2). https://patents.google.com/patent/US10668997B2/en?q=(Search+and+rescue+drone)&oq=Search+and+rescue+drone
Original URL	https://patentimages.storage.googleapis.com/fd/29/5f/d17aff98250b9a/US10668997.pdf
Source type	Patent
Keywords	Unmanned aerial vehicles (UAVs) Search and rescue (SAR) Real-time data Inaccessible areas Emergency response
#Tags	
Summary of key points + notes (include methodology)	This patent describes a system and method for using UAVs to search for survivors in various situations. It involves deploying UAVs with cameras, microphones, and thermal imagers to search an area, communicate results, and assist with rescue efforts. Software on a ground control station allows monitoring, real-time data visualization, and communication with UAVs.
Research Question/Problem/ Need	The traditional search and rescue methods are often slow, inefficient, and unable to reach inaccessible areas.

Important Figures	 FIG. -2B- This image is an overall image depiction of the invention the authors of this patent made.
VOCAB: (w/definition)	Thermal imager: A device that can detect heat signatures. This is useful for locating survivors at night or in other low-visibility conditions. Data fusion: The process of combining data from multiple sensors to create a more complete picture of the search area. Interoperability: The ability of different UAV systems from different manufacturers to work together seamlessly.
Cited references to follow up on	NA
Follow up Questions	How does the system ensure that UAVs don't collide with each other or with obstacles in the search area? What communication protocols are used to ensure reliable and secure communication between UAVs and the ground control station?

Patent #3: Method and device for rescue mission assistance

Source Title	Method and device for rescue mission assistance
Source citation (APA Format)	Ökvist, P., & Arngren, T. (2021). *Method and device for rescue mission assistance* (United States Patent US20210276675A1). https://patents.google.com/patent/US20210276675A1/en?q=(Search+and+rescue+drone)&oq=Search+and+rescue+drone&page=1
Original URL	https://patents.google.com/patent/US20210276675A1/en?q=(Search+and+rescue+drone)&oq=Search+and+rescue+drone&page=1
Source type	Patent
Keywords	Unmanned aerial vehicle (UAV) Floatable foam Recognizable device Distress Localization
#Tags	
Summary of key points + notes (include methodology)	This patent describes a method and device for assisting in rescue missions. The method involves using an unmanned aerial vehicle (UAV) to locate a body or object in distress, and then to release floatable foam and a recognizable device near the object. The recognizable device can be a light, a sound signal, or a radio beacon. The foam can help to keep the object afloat and visible, while the recognizable device can help rescuers to locate the object more easily.
Research Question/Problem/ Need	locating and assisting people or objects in distress, particularly in situations where traditional search and rescue methods are difficult or impossible to use

Important Figures



This image is important as it shows the overall function and structure of the authors' invention.

Fig. 3a

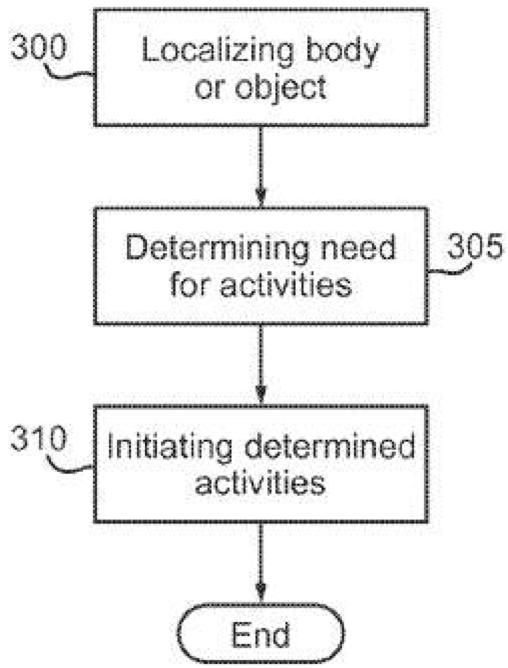

300
Localizing body or object
Determining need for activities
305
310
Initiating determined activities
End

Fig. 3b

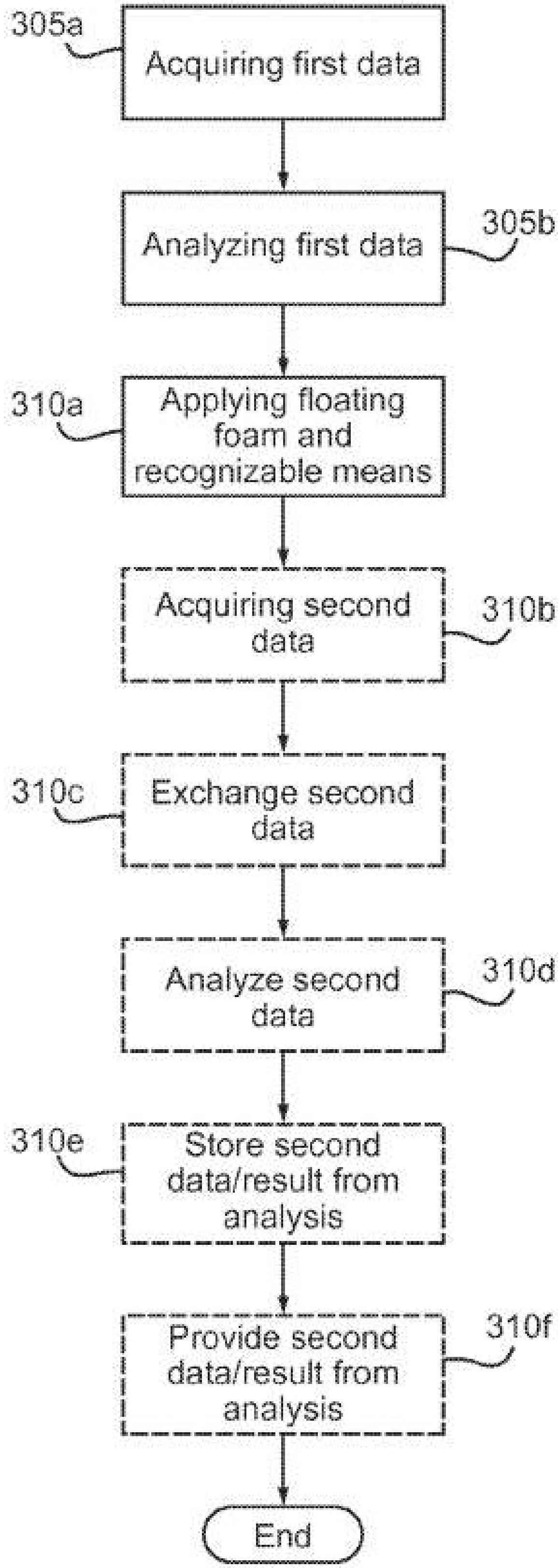

305a
Acquiring first data
Analyzing first data
305b
310a
Applying floating foam and recognizable means
Acquiring second data
310b
310c
Exchange second data
Analyze second data
310d
310e
Store second data/result from analysis
Provide second data/result from analysis
310f
End

	Figure 3 is important as it shows the systems flowchart of the device
VOCAB: (w/definition)	localization unit: A unit that is used to determine the precise location of an object. IMU= Inertial Measurement Unit
Cited references to follow up on	NA
Follow up Questions	Can the system operate effectively in all weather conditions and terrains? What are its limitations in terms of wind speed