

## Lost Hiker Tracking Drones: A Review

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**Abstract:** Hiking has been common attraction for spending the weekends or vacation to get relief from stressed life. It might be the dense forest or between the thick bushes in the country side, hikers sometimes lose the path where they want to reach the destination, it can be returning back to the starting point as well. The trails and land marks are the best way to identify the path when there is no GPS or use of technology, and when the trails and land marks are changed or vanished due to the extreme climatic conditions of the nature, that's where the trouble occurs as hikers tend to get lost. There are plenty of rescue operations to save the hikers when they get lost, but usage of drones are an alternative solution to track down the hikers. When the drones identify the hikers, it is easy for the rescue team to carry further operations as a safety precaution. Drones can not only detect the lost hikers but also can drop packages, whether it may be a temporary ready-to-eat meal, first aid or a small survival kit. This paper discusses how the drones technology can help in finding the lost hiker. It can be said that the drones are the cheap and shortest way to track the lost hikers.

**Keywords:** Hiking, artificial intelligence, drones, forest, life safety, fastest response, eco-friendly.

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### I. Introduction

#### Hiking

Hiking is walking on well-made and wide trails which may be man-made too. It is always an interesting event either as a sport or just a recreational activity. People in various countries do hiking at different places at their own style. Aim of the hike may be enjoying the nature and scenic, roaming in forest or may be climbing a small hillock. In general, the places would be far away from the city life. Normally the holidays or special vacations are the time for hiking. The good news is that the hiker enjoys the nature and the fresh air which gives relaxation to body and stress life, but the bad news comes when hikers get lost while doing what they love. It is easy to lose the path specially when it is in the dense forest where the tracks which were setup tend to lose its path over the time period due to the atmospheric conditions which take place at the forest.

Some of the countries which have forests namely, India, Burma, Vietnam, Cambodia, Siberia, Sweden, Columbia, Brazil, Guiana, Zimbabwe, Norway etc. where people still live near the forest's area. For example, In India, there are many places which is not developed specially the villages near to the forests or Western Ghats where people live their daily life with the wild atmosphere. The school children and college students must walk for long distances to attend the classes for education every day. Since the roads are long to walk, they tend to take shortcuts between the thick bushes just to cover up distance and time, as the transportation in the rural areas are limited. This can be considered as hiking in a daily basis.

Even though when the path is known by travelling every day, sometimes people tend to lose the path, it is may be due to the climatic conditions, as when it rains the surface tends to change a bit, the thick fog causes problem to walk through, etc. But people tend to get on to the track as they would be knowing in-and-out of the forest area. But what if a person who is new to this place and comes to visit his relatives to spend his vacation.

Figure 1 – a picture taken from an article, shows a family who is spending their quality time hiking in-between thick forest and natural trails for walking. It is said in the research that kids who are spending some time outside sleep better, do better in school and implement lower levels of stress and anxiety. [1]



Figure 1 – Family hiking.



Figure 2 – The Queen's Route hiking trail

Figure 2 – a picture taken from the visit Norway website, shows The Queen’s Route, which is marked hiking trail between the historical fisherman’s villages Nyksund and Stø in the Vesterålen archipelago. The route is a round trip which winds its way along the coastline, the white sand beach Skipssanden, and over mountaintops 400 meters above sea level with an incredible view of the Atlantic Ocean. In 2015 the trip was named one of the top 10 most spectacular hiking trails in Norway by visitnorway.com. Vesterålen has over 150 marked trails and paths. [2]

Forests are the pieces of land which is untouched by the technology such as signal transmitters for the cell phone communication, long range GPS, or it can be power supply as well. These conditions put the people into trouble specially who is lost in-between forest area. To find the person who is lost on the way passing through the forests or hiking, the technologies are limited to human interference. The drones can be an alternative solution for these situations. According to Global Forests Resources report 2005 of the Food and Agriculture Organization of the United Nations, it is estimated that 30% of the land is covered by the forests, as shown in the Figure 3. [3]

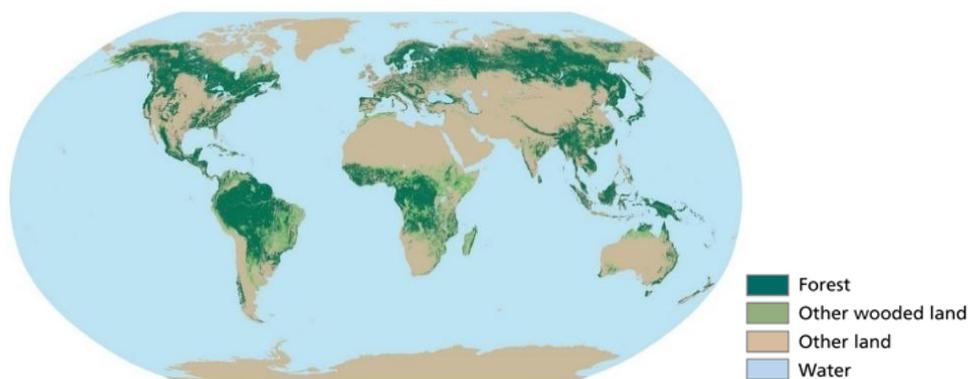


Figure 3 – World map of forest, land and water geography

### Drones

An aircraft that does not carry a human operator and is capable of flight with or without human remote control is defined as unmanned aircraft and those systems whose components include the necessary equipment, network, and personnel to control an unmanned aircraft is termed as unmanned aerial vehicle. Drones can also be called as Unmanned Aerial Vehicles. [4]

Drones vary widely in their configurations depending on the mission. There are various classifications for the drones based on different parameters. According to the Journal, “Classifications, applications, and design challenges of drones: a review” by M. Hassanalian and A. Abdelkefi, Drones are categorized into different types as mentioned in the Figure 4. [5]

According to the site of the drones, in a report “Types of Drones: A Beginner’s Guide to Drone Models”, gives an overall view of the Drone models. Figure 5.A to 5.S. [6]



Figure 5.A – Military Drones

Figure 5.B – Multi-Rotor Figure 5.C – Fixed-Wing



Figure 5.D – Very Small Drones Figure 5.E – Small Drones Figure 5.F – Medium Drones



Figure 5.G –Large Drones Figure 5.H –Very Close-Range Figure 5.I – Close Range



Figure 5.J – Short-Range Figure 5.K – Mid-Range Figure 5.L – Quadcopters & GPS



Figure 5.M – Delivery Figure 5.N – Photography Figure 5.O – Racing

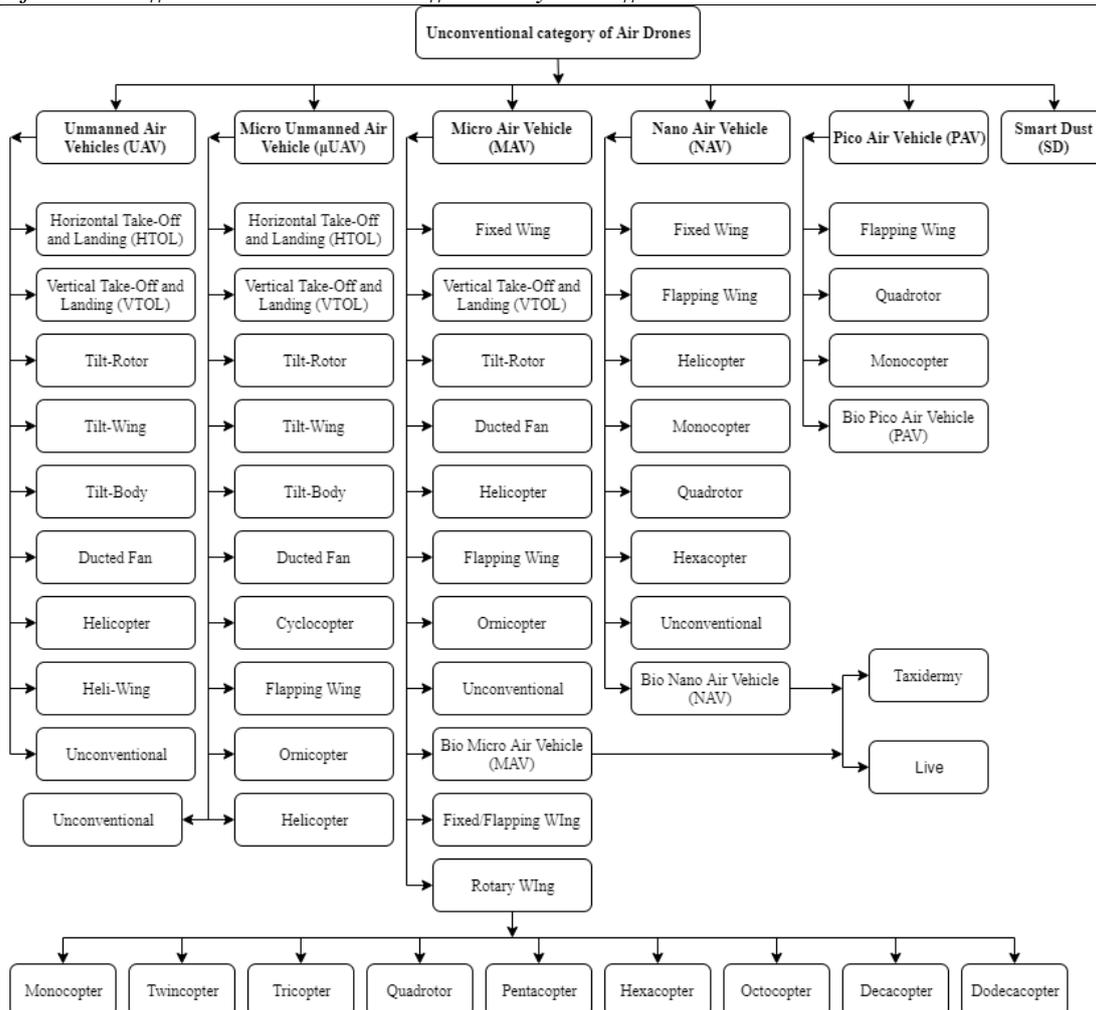


Figure 4 – Different Type of Drones

## II. Objective

The objective is to find the lost hiker at forest or remote area using the artificial intelligence, the drone technology enables drones to follow man-made tracks and trails. When hiker is lost in the dense forest, the atmosphere is difficult to survive for a hiker who is not aware about the forest habitat. It might be the insects or the animals which might harm the hiker in some cases. Normally these things occur during trekking, but trekking is for more than a day of typically minimum of 2 days, but hiking is for mostly a complete day. Even though the hiking has tracks to ease the hiker to follow up the path to reduce time, enjoy the nature and reach safe without losing the path, sometimes mistakes happen. Drone technology will not only track down the hikers but also helps the hikers by providing rapid safety precautions, it could be the ready-to-eat meal, first aid, survival kit, maps or a direction to get out. The drones also ease the rescue team to make necessary rescue operations by the rescue team if at all the hiker’s life is threatening or in extreme danger. The usage of drones at extreme weather conditions such high winds, high rain fall, etc., would be a challenge to track down the hikers, but most of the time better side is that it will not only reduce time and cost but also it can be fastest way to track the lost hikers.

## III. Survey of Lost Hikers

In an article, “What’s Killing America’s Hikers?” which was published by Vicki Parker on 26<sup>th</sup> February 2017, on the website “Sky Above Us”, gives information regarding the statistics of lost hikers. Every year there are bunch of people who never get the chance to reveal their stories out to the world about their adventurous hiking experience. Even well-prepared hikers cannot control avalanches, failing GPS’s, snow storms, swollen rivers, displayed logs, lightning, territorial bears, mountain lions, scree slopes, slippery rocks, snake bites, among other hazards. Even though the trails are made for the ease of hikers so that they won’t get lost but then there is the other side of the coin to be faced when turn comesto the hikers. [7]

Each year, it is estimated that more than 280 million people visit the National Park Service’s (NPS) designated recreation areas, 192 million people visit U.S. Forest Service (USFS) forests and grasslands, more than 500,000 permits are issued for the Bureau of Land Management’s (BLM) 253 million acres. All these numbers include background skiers, climbers, backpackers, or mountaineers, mere onlookers can step outside of their vehicles at an overlook to face a brush with death. Hiking injuries are limited in thousands compared to the million count; it seems to be a small number but most of those are preventable. Specially where there is increase in number of visitors which implies increasing exposure, the potential for tragedy rises. As the Outdoor Industry Association recently noted in its participation study, “hiking is one of the top five most popular outdoor activities”.

[7]

On an approximation, the NPS reported search and rescue (SAR) incidents and on an average, 35 SARs resulted in hiking-related fatality. The Table 1 shows the statistics on NPS year wise.

[7]

The highest percentage of deaths for years have been consistently attributed to three things: Table 2 shows the year wise percentage of hiking related deaths.

[7]

1. Lack of knowledge
2. Lack of experience
3. Poor Judgement

If the hiking is near the water falls where altitude comes into pictures, only the helicopters are the fastest rescue operation methods which is widely used, which costs the NPS over 5\$ million dollars each year. According to SARs reported by NPS, hiker’s age of 20 – 29 is observed as highest rescue operations which is tabulated in Table 3.

[7]

Hiking is a solo activity, but it also comprises of group setting but normally when the group is not a family then the hikers often simply elect to hike alone. While hikers may be self-sufficient (food, water and gear), this approach to life in the outdoors falls short of the experience, judgement, and physical conditioning necessary to survive the unexpected.

[7]

Year	Search and Rescue (SAR)	Hiking Injuries
2011	3582	817
2012	2876	922
2013	2348	826
2014	2658	829

Table 1 – NPS year wise statistics

% SAR Ascribed to	Year					
	2009	2020	2011	2012	2013	2014
Falls	7.22 %	9.77 %	9.34 %	9.41 %	9.67 %	10.03 %
Physical Condition	13.52 %	16.81 %	17.81 %	23.24 %	25.09 %	22.81 %
Lack of Experience	9.06 %	9.77 %	10.90 %	13.65 %	9.99 %	8.05 %
Poor Judgment	13.64 %	15.02 %	14.36 %	19.15 %	18.42 %	18.84 %

Table 2 – Year wise Percentage of hiking related deaths

Year	Ages						
	0 – 12	13 – 19	20 – 29	30 – 39	40 – 49	50 – 59	60+
2006	328	488	864	648	533	458	286
2007	697	442	653	428	422	480	312
2008	280	414	945	820	459	432	388
2009	290	481	721	479	397	460	501
2010	292	496	807	554	474	504	439
2011	234	455	728	453	480	532	478
2012	237	479	802	480	409	527	506
2013	166	379	677	397	335	349	389
2014	207	304	590	411	348	388	494

Table 3 – Year wise Percentage of hiking fatalities according to age groups

According to the article, "Survival Statistics: Survival of the Common Sense Challenge" published on *Be Found Alive* with reference to "Dead Men Walking: Search and Rescue in U.S. National Parks", *Wilderness and Environmental Medicine* (Volume 20, Number 3), 2009., Between the years 1992 – 2007, the national parks were host to 78,488 individuals involved in 65,439 search and rescue (SAR) incidences. These implies: 2659 fatalities, 24,288 ill or injured individuals, and 13,212 saved. [8][9]

The interesting part of this article is the facts which provide huge numbers,

1. Estimated number of SAR missions in US each year: 50,000
2. SAR operations aiding lost individuals: 36 %
3. SAR operations in national parks to find lost hiker: 40 %
4. Duration of average search: 10 hours
5. Average daily cost to operate a full-scale SAR operation: 32,000 \$
6. Most likely group to be SAR targets:
  - a. Men, ages 20 – 25
  - b. Men, ages 50 – 60
7. Leading activities requiring assistance:
  - a. Hiking: 48 %
  - b. Boating: 21 %
8. Fatalities:
  - a. Hiking: 22.8 %
  - b. Suicides: 12.1 %
  - c. Swimming: 10.1 %
  - d. Boating: 10.1 %

There are several survival tips where an hiker should be aware of, some of them are: [10][11]

- Using brightly colored traps and clothing
- Using signal mirrors or three blasts on whistle to attract attention
- Adding green plants to the fire to create a smoke signal
- Using flare guns if carried along while hiking
- Movement and contrast are the key to being seen if hearing a rescue plane or helicopter
- Stop and rest when you start to feel tired
- Stop and fix small problems while they are still small
- Having enough water and food with proper hygiene
- Staying away from unknown plants (which may cause skin allergy)
- Staying away from animals, birds and insects (which may harm)

#### IV. Rescue Operations and Types

There are many different definitions of search and rescue, depending on the agency involved and country in question.

- **Canadian Forces:** "Search and Rescue comprises the search for, and provision of aid to, persons, ships or other craft which are, or are feared to be, in distress or imminent danger."
- **United States Coast Guard:** "The use of available resources to assist persons or property in potential or actual distress."
- **United States Defense Department:** A search is "an operation normally coordinated by a Rescue Coordination Center (RCC) or rescue sub-center, using available personnel and facilities to locate persons in distress" and rescue is "an operation to retrieve persons in distress, provide for their initial medical or other needs, and deliver them to a place of safety". [12]

Search and rescue (SAR) are the search for and provision of aid to people who are in distress or imminent danger. The general field of search and rescue includes many specialty sub-fields, typically determined by the type of terrain the search is conducted over. International Search and Rescue Advisory Group (INSARAG) is a UN organization that promotes the exchange of information between national urban search and rescue organizations. The duty to render assistance is covered by Article 98 of the United Nations Convention on the Law of the Sea (UNCLOS). [12]

The below mentioned are some of the commonly used rescue operations methods, [13][14]

1. **Human Rescue Squad:** A Squad of rescue team where they are individually professional trained with special skills who can track the hikers easily. These skills are most commonly used in military combats training but here it is limited to only search and rescue missions. Figure 6.A. shows a Human rescue squad on a rescue operation.
2. **Search and rescue dogs:** The use of dogs in search and rescue (SAR) is a valuable component in wilderness tracking, natural disasters, mass casualty events, and in locating missing people. Dedicated handlers and well-trained dogs are required for the use of dogs to be effective in search efforts. Search and rescue dogs are typically worked, by a small team on foot. Search and rescue dogs detect human scent. Although the exact processes are still researched, it may include skin-rafts(scent-carrying skin cells that drop off living humans at a rate of about 40,000 cells per minute), evaporated perspiration, respiratory gases, or decomposition gases released by bacterial action on human skin or tissues. There are several types of dogs trained for specific techniques, such as, Air scent, Trailing, Cadaver / Human Remains, Disaster and Articles. Figure 6.A. shows a rescue dog with its apparel.
3. **Aircraft:** Fixed-wing aircraft are generally best suited for searching large open land areas above the timberline, for example they are useful in spotting obvious clues such as people, tracks, tents, motor vehicles and downed aircraft. Helicopters are better for more specialized missions, to search areas which are more difficult to spot from fixed-wing aircraft, such as cliffs and gullies, for example. Helicopters make a lot of noise. This may help attract the victim of a search who, in turn, may attempt to attract the attention of those on board the helicopter. Helicopters can be used to transport searchers and/or equipment to remote search and rescue assignments, reducing time and energy spent by rescuers, and to help extricate victims by several methods, including hoists and slings. And perhaps most importantly, helicopters can be used to evacuate and transport injured victims to nearby hospitals. Figure 6.B. shows a typical rescue helicopter which is used in the forest of the mountains.
4. **Ground / Air search specialist:** Individuals trained to the Technician level of Wilderness Search or a validated training organization. Their primary responsibility expertise is in ground search. Air Search Specialist are trained to conduct air search and rescue from an airborne platform.
5. **Rope Rescue Specialist:** Capable of recognizing hazards, using equipment, and implementing techniques necessary to conduct rescue or removal of victims.
6. **Water Rescue Specialist:** Capable of recognizing hazards, using equipment, implementing techniques necessary to operate at water rescue incidents.
7. **Trench Rescue Specialist:** Capable of recognizing hazards, using equipment, implementing techniques necessary to operate at trench rescue incidents
8. **Collapse Rescue Specialist:** Capable of recognizing hazards, using equipment, implementing techniques necessary to operate at structural collapse incidents involving all types of construction.



Figure 6.A – Human Rescue Squad



Figure 6.B – Rescue Dog



Figure 6.C – Rescue Helicopter

## V. Drone Technology

Though many believe that main use of drones as a way for the military to enhance their general operations, targeting and spying, there are many ways that drones are saving lives from the battlefield. One among those are the lost hiker tracking drones. Drones are enhancing rescue efforts by picking up the slack where helicopters and night vision goggles fall short. Search and rescue missions can be dangerous, time-consuming and exhaustive for those involved; however, drones provide unmanned aircraft support that saves time and hundreds of possible volunteers by scanning the darkness through thick trees, water or rocks to find those hikers who are in trouble. The thermal heat scans taken by the drones have already earned a name for themselves by saving those in need from spending freezing nights exposed to the elements in an emergency.[15]

In an article, “Drones are being 'taught' to search for missing people: AI software works with quadcopters to explore forests and woods” which is published by Ryan O'hare for Mail Online on 10<sup>th</sup> February 2016 gives details information of how drone is being used in Switzerland rescue team to find lost hikers in the forest. Swiss scientists have developed an artificial intelligence software that can be used with drones to search forest and mountain paths and help rescuers track down lost hikers. [16]

Forests can be wonderful places to escape to and explore nature, but they can quickly become daunting if you wander too far off the beaten track. But technology could be the answer to those who find themselves a little too lost in nature, in the form of search and rescue drones. In Switzerland, rescue teams are frequently dispatched with special operations and plans to search for lost or injured hikers, receiving in the region of over 1,000 calls a year. Scientists at the Dalle Molle Institute for Artificial Intelligence and the University of Zurich, who developed the software for quadcopters, said their drone AI means search and rescue teams could soon have added mechanical manpower and In these environments, any little error may result in a crash, and robots need a powerful brain in order to make sense of the complex world around them. Figure 7.A. shows a drone in between a forest region. [16]



Figure 7.A – Drone in a forest

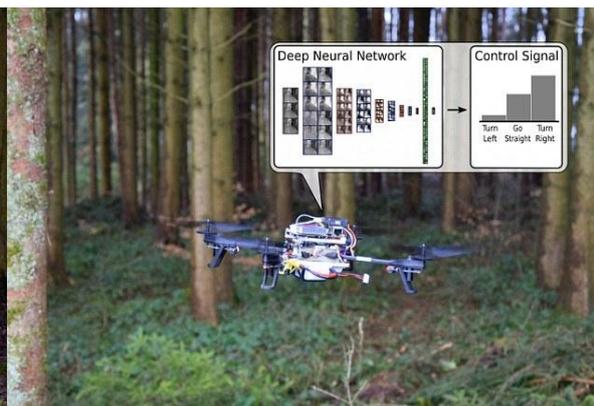


Figure 7.B – DNN and Control Signal



Figure 7.C – Trail Detection

AI helps to navigate obstacles in the real world and track paths by analyzing images captured by two on-board cameras, like the one's which is used in smart phones instead of using sensors to detect. This ease the drones to identify man-made trails in the forests or between thick trees which can prove tricky at times even for seasoned hikers. During the training phase which was conducted in their research work, the AI software learned from 20,000 images of forest trails taken from a helmet camera. When the experiment was tested in a new trail in training, the software was able to find the right path at 85 % of the time, which indicated higher than human testers, which was 3 % higher than human who found the trail 82 % of the time. Figure 7.B. and 7.C. shows the usage of Deep Neural Network and Control Signal. [16]

“A Machine Learning Approach to Visual Perception of Forest Trails for Mobile Robots” is the journal paper which shows the different approach based on a Deep Neural Network (DNN) as this is the first letter that describes an approach to perceive forest trails, which is demonstrated in the journal paper on a quadrotor micro aerial vehicle. [17]

In an article, “Drone Spotting Technology Can Now Contribute to Finding Lost Hikers” by ben on 9<sup>th</sup> August 2016 on Trackimo talks about “Finding Lost Hikers with Drones and How It Works”. The idea is simple and straightforward. A lightweight drone would be used for aerial recon, identifying the lost hikers. The technology in the sentry would be standout Infrared (IR) signature that would be given off by such hikers in the cold of the wilderness. Since the drones would be able to carry out their own search missions at a height and distance, it can prove advantageous as well. It can also be used by the rescuers who cannot be sent to every look and corner of a dangerous location, which makes these drones an indispensable device in such circumstances. During winters, this technology could just be the saving grace for the hikers who get lost under the harshest of weather conditions. Drones are very small and very light, so it can be carried out anywhere at any time easily in a backpack. The setup as well takes less time to get into fully operational mode. It requires the pilot to toss it high into the air just to get the initial take-off of the drones to take control and letting the drone do its own task. The device is also capable of recording videos, which it can save for later viewing or even transmit to a portable handheld device that comes with the whole package. This can be key in rescuing lost hikers in the future. Also, to prevent these rescuing drones from getting lost in finding lost hikers, the need to install a real-time tracker like Trackimo into it is an advantage. [18]

In an article, “Fleets of drones could aid searches for lost hikers” by Rob Matheson, MIT News Office on November 1, 2018, MIT researchers describe an autonomous system for a fleet of drones to collaboratively search under dense forest canopies. The drones use only onboard computation and wireless communication – no GPS required. Each drone is Equipped with laser-range finders for position estimation, localization, and path planning. When the drone flies, it creates a 3-D map of the terrain. Algorithms help it recognize unexplored and already-searched spots, so it knows when it’s fully mapped an area. An off-board ground station fuses individual maps from multiple drones into a global 3-D map that can be monitored by human rescuers. When located, the drone would tag the hiker’s location on the global map. Humans could then use this information to plan a rescue mission. The drones are programmed to identify multiple trees’ orientations, which is far more distinctive. With this method, an algorithm calculates the angles and distances between trees to identify the cluster. In the paper, the researchers compared their new search strategy with a traditional method. Compared to that baseline, the researchers’ strategy helped the drones cover significantly more area, several minutes faster and with higher average speeds. In the future, they hope to design the drones to communicate wirelessly when approaching one another, fuse their maps, and then cut communication when they separate. The ground station, in that case, would only be used to monitor the updated global map. [19]

**Drones in Search and Rescue: 5 Stories Showcasing Ways Search and Rescue Uses Drones to Save Lives,**

1. Drone lights up efforts to save hiker trapped on ledge at night in Utah – In January of 2019 a search and rescue team in Snowy Canyon State Park, Utah.
2. Drone helps find missing 88 year old man Luis Reyna Zuniga in Brownsville, Texas – In January of 2019 found an old man missing at 5:30 p.m., with the efforts of search and rescue team members using the drone (with thermal camera) were able to find the old man at 11 p.m. in tall grass in a field by a levee.
3. Drone helps find two cousins trapped on a mountainside in Iceland – In April of 2018.
4. In February of 2018, search and rescue personnel working with the Lincolnshire Police in the U.K. used a drone equipped with a thermal camera to find a man who had been thrown from his car after a car accident.
5. In June of 2017, two hikers were reported missing in Pike National Forest in Colorado. The local search and rescue team was called to look for them, and more than twenty-five volunteers showed up to help. People looked on foot, with ATVs, and there was also a K-9 team. But it was the team using a UAV that found the two hikers. Using the drone, they were able to find the missing hikers in an area spanning thousands of acres in just two hours. Although the incident took place in the summer, temperatures drop quickly at night in the mountains, and the two hikers would have faced a life-threatening scenario if they had been forced to spend the night in the forest. [20]

**VI. Merits and Demerits**

<b>Merits</b>	<b>Demerits</b>
Compactible and efficient	Cannot be used in extreme weather conditions
Less weight and parts	Easy to track hiker when they can make noise or movement
Less time consumption	Communication with an off-board ground station for map merging
Can be used at any location	Complete rescue operation cannot be carried out unless external help
Can drop emergency packages	Thermal cameras may fail to sense heat
Easy to operate including beginners	Need to develop efficient algorithms

## VII. Conclusion

Hiking is an adventurous task when it comes to a hobby or a professional way. Getting lost in the dense forest or countryside is a common human error. Search and rescue operations are carried out in order to save the lost hikers. Almost all SAR operations are averaged around 10 hours. The drone technology is another such operation which will take less time to detect the lost hikers. When the hikers are detected from the drones, the further rescue operations are carried out depending upon the amount of rescue required. If the hiker's life is in extreme danger then high priority rescue operations are carried out, in other cases the drones can carry emergency survival packages, whether it may be the first aid, emergency food supply, etc. This paper has provided information regarding the rescue operations which were carried out recently. When we look deep, the number of lost hiker cases registered may be less compared to overall population, but ultimately humanity (human's life) has precious value which cannot be measured in numbers. The future of drones will be focused more on the self-detecting capabilities without the usage of any GPS, improvements towards the field of algorithms used in the drone, more use of artificial intelligence and multipurpose usage of drones.

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