DroTain - Autonomous Drones Helping the Mountain Rescue Save Lives

Disaster Relief, STEM Projects

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***Abstract*—Mountain rescue is part of voluntary services that ensure that we all are safe when we venture in the mountains. Many technical aids are used to make rescue missions easier. With DroTain, the team vision wants to develop a drone to help save lives. This paper focuses on how the mountain rescue is currently acting, how drones can support them and how this project can be implemented.**

***Index Terms*—Aerial, Mountain Rescue, First Aid, Drones**

I. Introduction

Mountain rescue refers to search and rescue activities that occur in a mountainous environment. This tends to include mountains with technical rope access issues, snow, avalanches, ice and glaciers. Mountain rescue services are crucial for safety in mountainous areas. Carried out by professionals, often on a voluntary basis, it takes some time to get to the injured person. In such situations, every single minute can decide about life and death. The difficult and remote nature of the terrain in which mountain rescue often occurs has led to the extensive use and development of specific equipment and techniques. As such, helicopters are broadly used to retrieve victims from dangerous spots and search dogs may be deployed to find a casualty. However, helicopters are not always able to reach particularly small and tight spots.

For this reason, we have been developing DroTain - a drone not only capable of providing first aid kits and communication channels via text-to-speech technologies to victims but also finding and locating them using thermal images when lost in deep forests, for instance. The drone's goal is not to replace helpers, but to support them in their missions and reduce mission duration and costs. Inspired by the objective of the 2019 Aerial [1] competition at ECER [2], which is about aiding an injured person via a drone, this paper focuses on how drones can help provide first aid to victims and allow communication with them. Features and possible implementations of such drones will further be elucidated in this document.

II. State of the Art

Mountain rescue has to cope with a large field of different missions. Everyday tasks include avalanches, hiking, climbing and canyoning accidents and the associated and additional search operations. The forest accidents are few, but also have to be considered. Also, some local stations in various ski areas engage themselves in slope and other winter sports rescues. Since mountain rescue covers so many areas, we want to support them with DroTain.

A. The Course of a Rescue Mission

In order to get help from the mountain rescue, you have to contact them on the correct emergency number after an accident. The Mountain Rescue often refers to the emergency number for the Mountain Rescue 140, which is looked after by the Austrian Red Cross, and the European emergency number 112 on various platforms, such as on its homepage, at ski lift and gondola stations, etc. to alert them in emergencies and mountain accidents. These numbers are mainly dialled by people seeking help.

The calls arrive directly at the control centre, where they are then answered by the dispatcher. The dispatcher notifies the responsible mountain rescue site either by phone or by text message via the personal mobile phones of the emergency services. If this process is carried out by text message, the responsible local office must confirm the departure for the operation by making a call back to control centre 140.

An example of an alarm text would be for instance: 'Operation for mountain rescue "local station", place/mountain of the accident, sea level in meters, what happened / what injuries are there?'. In addition, the local station can send another text message in which a new meeting point is identified.

In general, the local operations centre is the meeting point where a short briefing is held. A decision will also be made about taking along of the necessary resources. Furthermore, the deployment costs incurred will be calculated and recorded. The rescue operation is logged accurately from the time of notification of the accident.

Of course, reinforcement does not always take place in exactly the same way, because in the case of avalanches, for instance, several locations will be notified at the same time in accordance with the emergency plan. In addition, the control centre subsequently alerts other necessary emergency organisations, such as the Alpine Police, the emergency medical helicopter or the avalanche dog squadron from the mountain rescue services of the respective country if necessary.

If helicopters of the Federal Armed Forces are needed, the communication must take place over the national warning centre, which is settled with the national fire-brigade command. This centre must also be notified if an avalanche train is required. Afterwards, the injured will be safely rescued from the mountain with the appropriately selected technical aids and brought to the required medical care as quickly as possible.

B. Technical Aids Used in a Rescue Operation

In addition to various means of transport such as helicopters from the police or the federal army, buses, Ski-doos or quads, mountain rescue requires many other aids in order to be prepared for the most diverse conditions. Stretchers for injured persons such as mountain stretchers or mountain bags for all seasons, as well as securing materials, among others Dyneema rope sets and karabiners, are also part of the standard equipment.

Technical assistance by GPS and radio devices as well as mobile phones is not to be excluded. As only private drones are in use at the moment, we would like to support the rescue operations with DroTain and simplify the search for, communication with and care of the injured.

C. Important Information for Mountain Rescue in Case of Alerting

In order to help people well and precisely, mountain rescue requires essential information during the alerting process. The exact location of the injured person is indispensable. With the help of the wind direction, places or conspicuous places in the immediate vicinity, as well as further distances of the injured persons and a detailed description of the location, the location can be determined as accurately as possible even without coordinates.

What happened is also essential for the operation. Which injuries and the description of the accident process, as well as the number of injured persons, must also be recorded in order to be able to prepare the appropriate medical care and adequate technical aids. It is also important to ask who the contact person is.

Callers get to know that they should be reachable on the phone and that they should save battery capacity, being asked to only do the most important calls.

D. Costs and Duration of a Rescue Mission

Salvage and rescue operations on the mountains are always of longer duration: On average, it takes several hours while complicated rescue missions can take several days. The ascent with partly very heavy equipment plus the safe removal of the injured persons prolongs the missions. Of course, such complex operations are not free of charge. There is a flat fee of 200 Euros per hour of operation [3]. Circumstances that could complicate the rescue are expected to result in a surcharge of up to 50%. Such circumstances are night operations, for instance, but can also be acute avalanche dangers that complicate rescue actions.

Low temperatures and very strong winds also hinder efficient work. The same problem arises with large deployments, where massive personnel disposition is required. Helicopter operations are invoiced by the respective operator, such as police, armed forces or the ÖAMTC. Currently, one flying operation with an ÖAMTC helicopter costs about 3500 Euros. [4]

Every day, mountain rescue saves many lives. The rough terrain requires them to take countless dangers on themselves. Since accident sites are often difficult to reach, we want to support these operations with the help of drones to find casualties as well as provide medical care and communication channels to them in order to save many people's lives.

III. Concept

A. Using Technology for Saving Lives

Technology is being used in almost every aspect of day to day life. There are myriads of commercial projects in the field of robotics and drones - we think that it is also important to realise projects that are not primarily focusing on generating as much profit as possible but on public welfare instead.

This project tries to realise this and to do so, it focuses on two core principles:

1) Provision of Supply Kits to Casualties: Most drones are capable of carrying and transporting light loads. This can be utilised for delivering a package consisting of a water bottle, a granola bar, a survival blanket and a first aid kit. This package may be dropped beneath the casualty, therefore eliminating any risks connected to the landing process. Below is a figure depicting such a dropping process.

Figure 1. A supply kit in mid air, being dropped by the drone

2) Localisation of Victims Buried by Avalanches and Lost People: As stated above, this task is carried out by search dogs as of now. However, even dogs can't access particularly small or narrow areas. In addition to that, they are often potentially endangered when trying to find victims, and, in some cases, become subject of a rescue mission themselves. For the sake of reducing or eventually eliminating risks for animal helpers, DroTain drones are equipped with a thermal imaging camera and are therefore capable of detecting people under very thin layers of snow or when parts of the body stick out of the

snow, such as a finger. Of course, this technique can not replace search dogs, but instead, help them to find victims and therefore shorten search time.

While infrared heat cameras are not able to detect casualties underneath thick layers of snow due to how these cameras work [5], they could prove particularly useful for localising lost people in e.g. deep forests.

B. Combining DroTain with an Application for Alerting Emergency Forces

Alerting may be initiated by a call at a dispatcher for the mountain rescue. Relevant information is then gathered via asking the classic ”What happened?”, ”Where did it happen?”, ”Who is involved?” and ”Who is calling” questions. Determining the exact location in such remote terrain can be quite difficult, especially when callers are disoriented. All information can be summarised in an app accessible by all emergency forces involved, for deducing the location of the accident. Of course, data collected by the drone, including live imagery from its camera, may also be used to help localise the casualty and detail the situation.

Furthermore, an app available for people at risk (when climbing in the mountains for example) can be used to initiate an emergency and transmit GPS-data to the directing centre. Extensive questions can also be asked and answered within the app for gathering even more relevant data, as depicted in the figure below where the victim is asked to give more information. By using this technique of alerting, however, the soothing effect of a phone call is lost but can be compensated by using the location data provided to send a drone carrying a supply kit to the victim and establish a stable voice link.

This app might also be connected to fitness gadgets such as the Apple Watch Series 4 [6] featuring automatic fall detection and alarming emergency services to automatically initiate mountain rescue missions and transmit important data listed above.

Figure 2. A screenshot of the application, notifying the casualty that help is on its way.

IV. Design

A. Organisational Aspects

1) After Use: With state-of-the-art technology, drones can reach a flight time of about 30 minutes or more. [7] Hence the question arises what happens to the drone when the battery is at a critical level after a rescue mission and can not make the return flight. A possible solution to this problem is simple: If no mountain rescuer is within pick-up range, the drone transmits its GPS-coordinates to the directing centre for initiating its later retrieval.

2) Availability and Maintenance: The drones are on call and ready for use constantly. To make that possible, they have to be on a board that charges the drones wirelessly via induction for ensuring a full battery without having to unplug them manually before takeoff is possible.

In the course of maintenance, the first aid kids have to be attached to the drones after a mission manually.

3) Network: The densest possible network of drones would be ideal for ensuring reasonably short arrival times and efficient usage of battery. Multiple drones may also be used for large-scale searches.

The drones are connected to a base station via a radio or mobile radio connection, depending on the application area of each drone. A mobile radio connection comes with the advantage of allowing the drone and base station to communication over a longer distance.

B. Technical Implementation

1) Hardware: For the first tests a DJI Inspire 1 was used. The current purchase price for this model is about € 2,000.-. For future approaches the second generation of this model may be used, featuring even more load capacity required for transporting the supply kit. With a purchase price of € 3,339.- the DJI Inspire 2 still is an affordable model that also features many integrated sensors, including a thermal imaging camera.

This drone can be operated using a remote control developed by DJI which can be connected to a smartphone making first attempts of autonomous flights possible.

In a later development phase, the DJI-drone has to be further developed for fulfilling all requirements, such as a safe dropping mechanism. This might also lead to a redevelopment of the drone.

Currently, the biggest problem for alpine rescues using helicopters is the weather. Starting, flying and landing of helicopters is practically impossible in weather conditions such as the night sky, fog or rain. Therefore a custom drone specialized for rescue operations may be built, which could implement features such as water-resistance, allowing the drone to operate in rainy or very humid environments.

2) Software: The drone can be programmed using a mobile SDK (software development kit). These SDKs provide a set of development tools, including convenient methods for efficient programming such as code libraries, needed to create complex and sophisticated as well as simple and straightforward applications. These tools allow for effective autonomous and smart programming of the drone.

However, it has to be further elaborated whether, and how, artificial intelligence such as IBM's Watson [8] can be used for localising casualties and for efficient communication between the drone and the victim. We can well imagine that artificial intelligence can be used to improve detection of human thermal prints. Furthermore, natural language processing algorithms may be used to provide a soothing conversation with casualties while emergency forces are on their way. Implementing a text-to-speech technology is of course not mandatory as the dispatcher could also talk to the accident victim directly. Using such technology could, however, relieve dispatchers.

For implementing the supply kit drop mechanism an Arduino has to be used as long as only a genuine DJI Inspire 1 is available to us. The Arduino [9], which is a single-board microcontroller for building interactive objects and digital devices that can operate and control both physically and digitally, can be programmed using Arduino IDE, an open-source integrated development environment. The Arduino IDE provides a software library from the Wiring project [10], which contains many common input and output procedures.

3) Interplay: Good synergy between hard- and software will greatly improve the performance of DroTain. For instance, a high-resolution camera can be combined with artificial intelligence to enhance localisation. Furthermore, smart and efficient software design and power management can lead to longer flight duration, enhancing the overall usability of the drone.

V. Conclusion

Mountain rescue is a very strenuous task. Volunteers are sacrificing their free time for our safety. Their engagement should not be taken for granted by any means, instead, steady developments should make their job easier. By pursuing exactly that purpose, DroTain is a project with immense potential - supporting mountain rescuers **and** saving lives. It can also reduce mission costs and shorten mission duration drastically. Furthermore, the alarming app helps in gathering relevant and vital information and shows them clearly in one place. Although the project is only at the beginning of its possibilities, it can achieve much more with further development.

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