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Emergency Response Supported by Drones and Experts Perceptions

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Abstract. Emergency situations require quick responses from both experts and those who need support in risk situations. People's perception of emergency situations and its solutions has become an important element of academic and practical research. In this context, the lack of real-time responses can affect sensitive environments and emergency scenarios causing irreparable damage. Thus, this research aims to support specialists involved in emergency response, providing them tools and resources to support their decision-making process. The work proposes a collaborative solution supported by a web application and drones. This solution aims to collect information in a collaborative way of the emergency situation, through the specialists' awareness during a real emergency action. In addition, the results of the research streamline the capture of information, in less time, aiming to minimize the loss of knowledge of specialists. This information made available in an easy way allows the response team to have greater security for actions, generating greater support for decision making, thus speeding up emergency care. This work was evaluated by specialized Firefighters, who already work with drones in actual emergency situations, in Rio de Janeiro, Brazil.

Keywords: Emergency, Information System, Collaborative Systems, Decision-making Drones, Perception.

1 Introduction and Motivation

According to [1], the world market for the use of drones, to support emergency situations, should reach an investment of approximately US \$ 14 billion by 2024. This growing investment aims to support emergency response teams, which need to be able to respond immediately to these situations when requested [2]. Through an effective emergency response, an incident can be prevented from evolving into a disaster [3]. Even with this promising scenario, emergency responses are not always quick nor captured

in a systematic and representative way. As a result, these situations can become confusing, as the lack of information makes the emergency situation seem fragmented, and the available resources may not be properly addressed. In addition, this lack of information generates communication failures between those involved and overloads the command of the operation, causing a lack of establishment of common priorities and objectives [4].

In risky situations, such as emergency situations, the use of information and the collection of expert perceptions can support and help to quickly identify the environmental elements in a given time and space, the understanding of their meaning and the projection of their impact at the moment or in the near future [5], [6], [7], [8]. For this, it is necessary to use mechanisms capable of collecting information from the individuals involved in order to support the decision.

Risk factors, in emergency situations, present both to the response team, and to people who need some support in this environment, have a great impact on the emergency response [2]. In this case, the time factor is extremely important, which can mean loss of life, destruction or non-preservation of the environment. Therefore, we consider the importance of assisting decision-making in emergency situations through obtaining, communicating information, and the experts' perception. Perception techniques are used in a system to provide information that supports users' decisions. For group activities, where individuals are expected to have a perception of what is happening, there is a need to provide mechanisms that facilitate the assimilation of perception information so that it is made available to the users [9].

From this perspective, this research aims to investigate how the participants' perception of an emergency situation can support the responses generated. For this, a web solution was designed and developed to support the agents of the emergency response teams, responsible for decision-making, in the action of collecting the experts' perceptions through their observations. This collaborative solution is supported not only by a web application, but also by the use of a drone, with the objective of speeding up the emergency response and exposing fewer human lives during the solution of emergency situations.

For the evaluation of this research, an experiment was conducted with firefighters from the state of Rio de Janeiro (Brazil), and also with an operational team of drone pilots. This experiment was organized in two phases: (i) experiment with drone operation specialists and (ii) collect the perception of the experts involved during the experiment. In total, there were the participation of 6 specialists from the High Command of the Firefighters who brought their perceptions about the usability and potential of applying the technological solution experienced in future emergency situations.

This paper is organized into five sections. Section 2 presents concepts of emergency, disaster and related risk and work. Section 3 presents the Communication and Perception approach and its characteristics that underlie the analysis. Following this, Section 4 presents the discussion and evaluation of the research. To conclude this paper, Section 5 presents our conclusions that highlight the goals achieved and the limitations of this research.

2 Related Works

During an emergency, there is a threat condition that will require urgent action. An effective emergency response can prevent that threat from turning into a disaster. Emergency management includes the creation of plans, arrangements to guide and bring responsibility to all actors involved in responding to the needs of an emergency situation [6], [10]. This situation is characterized as the entire rescue planning and intervention process aimed to reduce the impact of emergencies and responses, helping to mitigate significant social, economic and environmental consequences for the community [11].

There are disasters that can occur without an alert phase, in which the response comes after the action. The response can be supported by preparedness actions taken before disaster strikes. When looking at the elements involved in a disaster, we identified the emergency cycle, which consists of four phases:

1. Prevention - first phase and includes actions aimed at preventing the occurrence of disasters, or reducing the impact of the consequences;
2. Preparation - second phase and includes actions that seek to improve the capacity of individuals and organizations in the face of disasters;
3. Answer - third and more complex phase that encompasses the set of actions taken to help and assist the affected parties, in addition to having characteristics such as: “unpredictability, (high) speed of events, (high) number of people involved, short lead times. decision and action, unavailability of resources, uncertainty about the situation, pressure and stress on those involved” [4]; and,
4. Reconstruction - fourth and last phase, and includes actions for the purpose of recovering the affected parts, such as the reconstruction of an affected community, allowing the return to normality, and always taking into account the minimization of new disasters.

During reconstruction the lessons learned are applied to prevent the effects of new disasters. These lessons support preparation for the response [12]. The authors report that certain types of disasters can be predicted, and we can consider that this alert phase, may or may not exist, and occurs before the disaster, placing itself in the emergency cycle before the response stage. Some examples of disasters that can be predicted are tropical storms and tsunamis, and in scenarios like these, the population can be alerted by the authorities to prepare.

Within the context of an emergency, decision making will vary depending on the complexity of the scenario. There is a discussion about the factors that can affect this decision making, such as the effort made and the chance of it being correct. In addition to these, other factors are relevant, such as the number of sources of information to be considered during the process, and the restriction of processing and memory when a decision maker is under stress, for example. It is also important to note that the information is inserted in the entire process that generates the knowledge required for decision making [8].

According to [13], another factor that requires attention is the communication of risks associated with perception to build a relationship of trust and credibility between

the parties involved or exposed to the risks. The author defines that four risk communication paradigms: (a) High risks versus apathy: sometimes individuals are apathetic when facing a serious risk and need to be alerted; (b) Low risks versus high concern: sometimes people are uncomfortable with a small risk and need to be reassured; (c) High risks and high concern: sometimes people are uncomfortable with a serious risk and need to be guided; (d) Low risks versus apathy: sometimes people are apathetic when facing a small risk and do not need attention. For the author, low risks can be related to a clear and immediate communication, which can be established with the use of an artifact such as drones, taking the information immediately, together with the perception of each agent involved.

2.1 UAV

Drones have been used to capture images and support organizations in emergency situations with firefighters, police, humanitarian actions, among others, to provide more efficient aid to the affected regions. Also known as UAVs (unmanned aerial vehicles), they are machines that have been gaining popularity and have seen a dramatic increase in use in recent years [10]. These artifacts are capable of flying without human presence, can be autonomous or remotely controlled, can also be equipped with cameras, allowing the recording of the flight, or even its visualization in real time.

According to [1] over the years, the use of drones has increased, as well as a variety of applications have emerged to meet this growth demand. This artifact has been used as search and rescue operations, which can significantly benefit affected areas (often in large areas) and collect information on the presence of victims and their possible locations [14], [15]. These vehicles are also used in urban searches and rescue to assess damage in areas impacted by natural disasters (dimensioning phase), in which a disaster has hit an urban area with multiple locations, such as buildings or other structures suspected of housing people where survivors can get stuck, demanding rescue, and emergency care.

According to [16], another advantage of using drones is that, by identifying the risk area and the location of the distributed team, it can facilitate rescue work. In this context, experts can, through information capture, a greater number of elements, because different from perceiving means having knowledge and understanding of the events that occur within the group members. For example, knowing who is responsible for a given task, their position and information about the scenario for emergency response situations, having the specialist's knowledge and their perception of the affected area, and possible actions through drone images can mitigate the effort of the emergency response.

2.2 Perception of Support System

The term perception is defined as “knowledge that something exists, or understanding of a situation or subject at the present time based on information or experience” [17]. In aviation, specifically in war, in which the pilot needs to decide quickly and reach the goal, perception leads the individual to better understand the activities he performs and

produce more relevant results for the group [5]. In order for individuals involved in an emergency situation to participate effectively in the work, they must be informed about changes in the shared space in the course of group interactions. Perception implies knowledge about what is happening at the moment in the group and also about past activities and future options [18]. The representation known as the 5W+1H Framework, identifies six basic questions that must be answered when one wants to help an individual to understand something of which he has no prior knowledge. Perception information, therefore, is an answer to these six fundamental questions, as described below:

- Who - information on the presence and availability of individuals in the group, and identification of participants involved in an event or action?
- What - information about the occurrence of an event of interest to the group.
- Where - spatial, location information, the place where the event took place.
- When - temporal information about the event, the moment when the event occurred.
- How - information about how the event occurred.
- Why - subjective information about the intentions and motivations that led to the event.

The following approaches are used to develop a perception mechanism: (i) Interface component - interface components integrated into the system to present perception information to users. (ii) Notification: automatic notifications about events that occurred during group interactions. (iii) Annotation: annotations to enable the user to record ideas, suggestions and comments, especially useful in asynchronous interactions. (iv) Consultation and navigation through the group's memory: search for information about the interactions and activities of each user regarding certain artifacts.

There are two ways to collect the information generated by the expert's Perception. They can be synchronous or asynchronous mode. In synchronous mode, individuals interact at events in the same shared work space at the current time, with immediate notifications, availability for interaction. As for the perception in the asynchronous mode, the participants are informed about the interactions that occurred before the moment when they connect to the system. According to [10], support for perception is derived from a summary interpretation of a complete sequence of events that occurred in a time interval. Information must be at a higher level, such as changes to a given artifact. For [19] [5] there are three main elements of perception, they are:

- Perception of the current situation;
- Understanding of this situation; and
- Projection of the future condition.

In the perception of the current situation the focus is on automated perception of the current situation. To provide the necessary information component, the system must be able to collect, filter, analyze, structure and transmit data. In understanding the situation, perception is not just a view of reality, it is the correct perception of what is relevant to the current reality necessary for a correct, protective, tactical, and strategic response. The last element corresponds to the projection of the future condition, based on the perspectives of different perceptions that individuals infer about their perceptions.

This research concentrated efforts on the perception of the current situation, promoting the exchange of knowledge between specialists at the time of the situation in response to the emergency.

3 Research method and solution

As we presented in the previous section, information technology through the use of drones can provide decision makers in a geographically distributed environment with the same information as the first stage of situation awareness [5]. The web application “Drones to the Rescue” was developed exactly for this purpose. The original idea was to keep individuals aware of what is happening through the recovery and capture of information in a disaster situation. On the other hand, with the capture of the experts' perception it was possible to review the system to be used in the initial phase of disasters as an emergency response and even in the rescue phase. In this section, we describe the initial idea of the application and its use after expert analysis. The initial version of this application and the previous discussion can be found in [20].

3.1 Perception and support to cooperation - Drones to the Rescue solution

The proposed solution involves three applications: two existing applications, which are responsible for capturing images via drone (DJI Go and Autosync for Google drive), and making them available in the cloud, respectively, and the main application which is the website developed by the authors (Drones to the rescue – developed by the authors) for viewing, editing and collaborating content from the experts' perception. This solution seeks to support the prevention and response stages, within the emergency management cycle, but it can also be useful for the other stages.

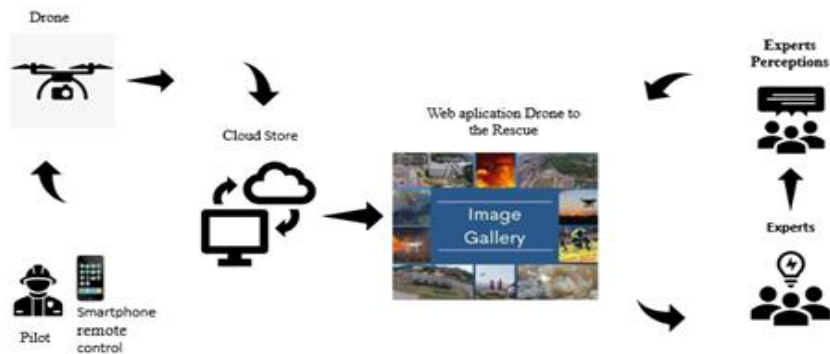


Fig. 1. Drones to the rescue solution and the cooperation among different roles and technology.

In the thought solution, the source of the images, which serve as a central element in the solution, is the camera attached to the drone. The tool “Drones to the Rescue” developed by the authors for collaborative visualization and interaction with the content gives full support to images that were obtained by other means, such as smartphone cameras, photographic cameras, satellite images, drawings, among others, however the authors decided to focus only on the images obtained by drone. The images collected by the drone are stored in the gallery and sent to specialists. Then, each specialist analyzes the image and inserts their observations and analyzes on the location of the incident. After this action, the images are shared with the team's specialists, returning to the gallery. These detailed images of information from the experts returns to the Gallery to support other emergency response actions. As it is shown in Figure 1, the imagens captured are presented by the Drones to the Rescue application.

Drones to the Rescue was developed to be a tool for viewing the images obtained by drones. This tool allows the editing of images, the insertion of comments and perceptions of specialists involved, and being collaborative. Figure 2 presents the tool's screen and allows users to interact, supporting the decisions of specialists in emergency situations.



Fig. 2. Screen for image capture in Drones to the Rescue.

The tool presents a gallery with the original images obtained by the drone and stored in the cloud (Google drive) and others that have already been discussed and edited by the roles involved in the emergency. This gallery can be accessed by the featured image on the home screen or by the “Gallery” button on the top menu of the home screen.

4 Experiment results and discussion

Firefighters experts were invited to participate in the experiment. The initial phase of the experiment deals with explanations about the drone, the stages of capturing and transferring images to the cloud (remote storage), and the website tool that allows the

images editing, comments and visualization. The next phase consisted of presenting the study by simulating a fire in a building that collapses in a university area. During the experiment, all experts had access to the tool in order to observe and collaborate with the domain explored in the experiment. These actions were possible from the images previously captured by the drone (Figure 3) of a set of buildings under construction. The central idea was to capture the experts' perception by sharing individual knowledge and externalizing it during the experiment. The information input was captured and taken for analysis by other specialists in response to emergencies.

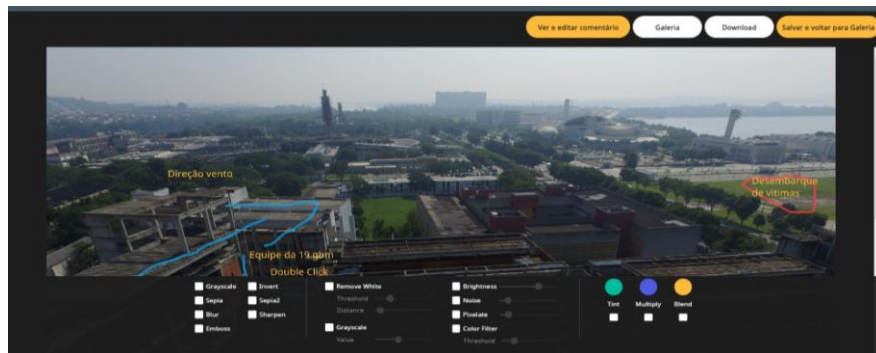


Fig. 3. Image capture.

At the end of the experiment, the specialists portray their experiences, perceptions, and difficulties. In addition, questionnaires were applied to everyone involved so they could evaluate the solution presented and tested.

4.1 Experiment answers

The questionnaires were carried out with 5 (five) specialists, official firefighters of the Fire Brigade to collect these specialists' opinions and perceptions concerned to the applicability of Drones to the Rescue application in an emergency. The main goal of this investigation is to validate the solution usability and the ability of this solution in capture the specialists' perception inside an emergency. The forms were created in Google Forms. Among the respondents, most had over 20 years of experience in the field of emergency responses, all men and mostly pilots of manned and unmanned aircraft.

The "DJI GO" application, was chosen as part of the solution presented, and analyzed during the experiment. In the evaluations, the respondents reported that the artifact meets the needs of image capture and local download, and the importance of compatibility with DJI drones was highlighted, since all the devices of the specialists are from this manufacturer. The interviewees highlighted that the tool performed a good capture, but that the analysis "depends a lot on the technical knowledge applied by the pilot in the operation of the drone", as well as the presence of adequate cameras for each situation.

Regarding the application "Autosync for Google Drive", which was chosen for the solution with the purpose of sending images automatically to the cloud, the firefighters

informed that it would comply with the proposal. Respondents pointed out that the tool would greatly assist firefighters' operations with drones, as today much time is lost in this transmission. In addition, it was informed that the tool would be efficient, as long as there is a well-functioning internet at the place of use.

In general, in terms of ease of use, the tool "Drones to the Recue" was evaluated as intuitive, and "allowed the insertion of the information desired by the specialists", being even interesting for the operation of the firefighters. It was said that the availability of information made through it already "would help operations in the field", so the return was very positive.

Regarding the collaboration theme, they said that the material generated by other specialists through the tool was useful for analyzing the simulated situation, but they did not elaborate in more detail. When asked what tools they apply today in the operation, with a focus on those that allow collaboration, they reported the main use of WhatsApp, as well as the use of Google Drive, Google Maps, YouTube and Facebook (for streaming video), Pix4D (for mapping), SISGRAF and ICad (internal fire brigade platforms). Regarding these tools, they stated that they are "of great use, important for spreading information about the incident", and that they support the operation. A need was also indicated, related to streaming video from the drone's camera, as it would need to be private, and today with the tools they have available it is possible to do it only in public. Another point raised is the delay and the large number of steps until the transfer of photos from the drone to the team working in the emergency, taking today a crucial time in responding to it. In addition, they pointed out that some market tools that exist today, which could support them, have high acquisition and maintenance costs.

Respondents highlighted the importance of transferring images automatically and suggested transferring short videos as well. Regarding the "Rescue Drones" tool, they stated that it concentrates several important functionalities, present in other tools separately, and presents advantages over those used for similar purposes by firefighters, at the present time. They pointed out the "importance of the proposed tool for coordination and registration, for monitoring the emergency event, and for the knowledge and management of the resources available on site". They also said that it can be a facilitator when complemented by other systems in an emergency setting.

The experiment also made it possible to capture experts' perceptions as active participants in emergency response action. For this study, we used two of the elements of perception presented by [19] they are: the perception of the current situation and understanding of this situation. At first, the study focused on gathering information extracted from the expert's perception of the real situation. That is, how this specialist is situated in the context and his actions carried out from the interpretation of the images. In a later moment, the perception of the specialist was sought from the understanding of his role and the tacit knowledge of the specialist. At this stage of the research, perceptions for future impacts were not considered but we believe the images discussed by the emergency professionals using the functions of the application Drones to the rescue can support this kind of perception.

Therefore, the answers collected by experts, support the idea of participants' perception in an emergency. Existing an emergency situation, where it is necessary to have reliable information and a low response time, a solution that will allow data capture,

visualization, collaboration and information based on the experts' perception can reverse situations of high degree of complexity.

5 Conclusion

In this paper, we discussed the use of “Drone to the Rescue” application, which was originally designed to capture contributions of different experts in the images took by a drone. We introduced the original definition of perception of the situation and inserted the observations of specialists in the retrieval of information. As presented in section 2, we believe that the perception of emergency responders is based on their own experiences. This information being externalized, it can be retrieved and used in future actions for decision making.

As suggestions brought through the interviews and questionnaire, are: compatibility with systems already used by firefighters, transmission of video feed in real time, access control, support for videos, best reference in photos, organization of content to support at least 3 aircraft in a better way, display of aircraft location in real time on the map.

Also, we need more research on the privacy problem in sharing images. With the study of the domain of emergency management, collaborative decision making, perception of specialists, drones and their uses, the authors was able to propose a collaborative solution to support decision making in an emergency scenario, by obtaining images via drone, and providing information on the scenario in a practical way, and collecting the experts' perception and this were the objectives achieved within the central theme of the work. According to the participants' answers, the goal was successfully achieved by this research. The solution presented the necessary functionalities for the emergency response, provide ways for the capture the specialists' perception and support images viewing, editing and collaboration in an emergency.

For future work, we believe that the evolution of the “Drone to the Rescue” can serve other applications such as: monitoring and support in refugee camps, rescue through monitoring of regions susceptible to terrorist attacks, monitoring of droughts and forest fires, etc. In addition to improving image organization: grouping images captured by source, when there is more than one drone operating, and organizing original and edited images so that they are associated. Also, for future work, we believe the specialists perception should be investigated in more details, exploring how it could support emergency decision and how perception understanding could support technological solutions development.

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