CHALLENGES OF USING DRONES AND VIRTUAL/AUGMENTED REALITY FOR DISASTER RISK MANAGEMENT

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ABSTRACT:

Natural and man-made disasters can severely destroy environments and they make conditions difficult to access the affected areas and to provide assistance. The conditions on-site could be dangerous and unstable and there is an increasing need for life-saving decisions to be taken quickly to minimize evolving hazards and to start relief operations. The accurate and timely data gathering is important to produce a full information about the calamity. In recent disasters drones are deployed extensively to help find people quickly, provide imminent reliable imagery and data by flying closer to the ground. They are used to create disaster maps and assess damage after earthquakes, landslides, hurricanes, etc. The fast transition into the digital age makes new technologies become available to enhance and expand drone capabilities in disaster risk management, such as Virtual Reality (VR) and Augmented Reality (AR). The paper tries to analyze how VR can be used to plan operations in a controlled manner before deadly events strike by creating disaster simulations in digital environments, enabling the rescuers to practice as many times as necessary until they are able to achieve mastery of the life-saving techniques. The paper also analyzes how drones, equipped with cameras, devices and AR, can be used to create different types of maps that help rescuers locate critical spots. These can also facilitate the location of people in need, and can survey constructions to find critical damages.

1. INTRODUCTION

Natural and man-made disasters destroy environments, often making conditions extremely difficult that relief workers are unable to access areas and provide assistance. Natural disasters can be considerably deadlier and more destructive than their engineering or industrial equivalents. They may result from weather-related causes (hurricanes, cyclones, storms, floods, heatwaves, tormadoes), or movements at the surface of the earth that may provoke earthquakes, volcanic eruptions or tsunamis (Fachot, 2017). Dangerous or nuclear chemicals can leak into the environment for various reasons.Some causes include factory or power plant malfunctions, spills during transportation or even terrorist attacks. Often after natural disasters infrastructure supply lines are cut and disabled. When roads, bridges, communication cables and gas and water lines are compromised, the safety of residents in the area is also compromised. In such cases drones have the ability to take on roles where relief workers and manned vehicles fall short. To mitigate suffering and further damage, rescue teams can utilize drones to support infrastructures, deliver supplies and establish communication In these and similar instances, measuring the damage and providing relief must be swift and effective.

Although drones have received mixed criticism because of their associations with invasion of privacy, areas that are prone to large-scale disasters such as earthquakes and flooding benefit greatly from visual imaging and 3D mapping (Srinivasan, 2018). Drones, also known as unmanned aerial vehicles (UAVs), can be used to detect and enter damaged buildings, assisting rescue robots and responders on the ground by speeding up the search for survivors through prioritizing which areas to search first.

Manned aircrafts are often too expensive to use, satellite mapping does not meet high-resolution needs, and both take too much time during emergency situations. The use of drones to map disaster areas provides greater advantages in costs and in rapid response times when compared to traditional methods. Drones can be deployed quickly, generate high-resolution and 3D mapping, identify hotspot areas that have sustained the most damage and upload the data in real time to coordinate relief efforts.

Drones are able to provide aid in monitoring for radiation exposure, repairing destroyed areas and rebuilding efforts, while minimizing nuclear fallout exposure for relief workers. Relief workers often find it difficult and dangerous to assess structural damage from natural disasters. They often encounter buildings that are on the verge of collapsing, potential explosions due to chemical leaks and places that are hard to access such as tunnels and bridges (Nelson Jr., 2017).

In areas that are nearly impossible to reach, drones can deliver supplies such as water and food to those in need, eliminating the risks of placing human-operated aircraft in harm's way. Drones can eliminate the risks that pilots face and can increase the effectiveness of battling fires. Unmanned aircraft are able to fly in low visibility and can drop fire retardants more accurately and safely. Bigger drones can transport people and supplies, while large numbers of smaller drones can be deployed to provide greater situational awareness.

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Drones that are outfitted with communication systems have the added benefit of being able to sustain contact between the command center and firefighters on the ground.

For these reasons and beyond, drones are being used more often in emergency and disaster response situations. This unmanned technology has vast potential. It is already proving its ability to save lives and prevent damage in dire situations.

Drone services are evolving quickly to meet utility industry needs. Rescue services should keep in mind that once they do decide to use drone-based inspection, the data collection, management, and analytics challenges that are part of the digitized inspection (Mazur et al., 2017).

The drones, have already begun to reshape the way public safety officials and emergency responders conduct a post-mortem on disasters. They are an invaluable resource for emergency triage and insurance damage assessment, helping emergency managers and first responders to quickly and safely gather visual aerial data that improves the response and recovery efforts following a disaster (Segarra, 2018).

Many public safety entities are deploying drones in their incident management workflow and for good reasons (EKU Online, 2015). Instead of sending people into potentially dangerous situations, drones allow first responders to safely view and assess dangerous incidents from a safe distance. Deployable in under a minute and capable of providing instant video streaming, drones act as a second set of eyes that can be positioned anywhere at a moment's notice.

Monitoring an active situation, finding objects of interest, and gathering time-sensitive data requires speed and accuracy. Vast areas of difficult terrain can be covered in a short amount of time and operations can continue unimpeded through the night. Addressing transportation and evacuation routes, damaged electricity grids, flooded neighborhoods, washed-out roads, and affected industrial sites will form the bulk of the challenges facing local, state and federal authorities.

After a hurricane drone teams dramatically accelerate the search for missing people by quickly surveying large areas of land and highlighting thermal signatures and observing critical situations from a safe perspective. They also aid in disaster relief, allowing government and humanitarian organizations to distribute emergency supplies, especially in the absence of viable roads following natural or other disasters.

While flying over ravaged landscapes caused by hurricanes and natural disasters, drones can collect GPS coordinates, real-time video and still images of the damage, helping first responders set priorities back at mission control.

This data can be overlaid on area topography and maps using operational intelligence technology to show specifically where and how the landscape has shifted, as is often the case with powerful earthquakes, floods and other natural and manmade disasters that can decimate identifying landmarks.

Disaster relief needs to be quick and efficient and it relies increasingly on sophisticated high-tech systems. These include various types of robots, Virtual Reality (VR) and Augmented Reality (AR) tools.

2. VIRTUAL REALITY AND AUGMENTED REALITY

Virtual Reality (for the portion that impacts events) involves experiencing an event through the use of special cameras that offer 360 degrees and it gives a realistic perspective of what is being viewed, very similar to attending in person. Virtual reality also includes interaction with fellow virtual attendees.

Another interesting application of VR is venue inspections - the ability from event planners to visit sites without being there. We will leave it out for the time being as it is not strictly related to the actual event experience.

Augmented reality adds contextual information offline experience. The benefits are towards engagement and bridging the lack of information. Augmented Reality in simple terms animates stuff. Augmented reality places an important role to satisfy the need for information.

Virtual Reality has one key benefit for the time being in events - it helps to connect remote audiences to events. Virtual reality creates a virtual world for users to interact with. It is more about what users feel or experience in that world than how they connect with it. Augmented reality, on the other hand, blends elements of a virtual world with the real world, so it is more about how the user interacts with those various elements and the components of the real world.

Virtual Reality is well-suited for the training and simulation sectors, while augmented reality is better positioned in the commercial, industrial, educational and medical sectors.

Virtual Reality offers only one plausible form factor so far - that of a wearable helmet or goggles. Augmented reality has at least five different form factors in the commercial sector alone and offers one form factor designed specifically for mobile technology (Pene, 2016; Ryver, 2017).

3. DRONES AND VR/AR IN NATURAL DISASTERS VIRTUAL REALITY AND AUGMENTED REALITY

Augmented reality and virtual reality are no longer theoretical concepts, and both have advanced considerably in their design and use in a wide range of industries (Ryver, 2017; Solaris, 2017).

Drones can be deployed quickly in areas considered to be too unsafe for humans and are used to guide rescuers, collect data, deliver essential supplies or provide communication services.

Drones with AR are valuable in managing many disasters; floods, hurricanes, wild land fires, landslides and hazardous material spills. Drones are catching on as valuable tools for many reasons. Small drones are affordable and accessible communities of all sizes. A drone delivers the view available from a helicopter at a fraction of the cost. Drones are agile, able to fly at low altitudes, offering detailed inspection of storm damage. Drones may be equipped with a variety of sensors including infrared cameras which can find a human in the dark when many search and rescue missions occur (Clark, 2017).

When Augmented Reality is added to a drone, operational efficiency for emergency management is further improved. Augmented reality overlays such as street names and landmarks are blended in real time on the video; the overlays add instant location information leading to faster decision making.

If a drone is flying over a street that is blocked or destroyed the extent of the damage is obvious with AR. The location information may be relayed immediately to incident commanders. Armed with this knowledge, the commanders dispatch assistance and resources via the most direct route to those in need (UNITAR, 2017).

Drones with AR improve relief efforts in other ways. Pilots may add notes to homes which have been checked for survivors or add other information such as, downed power lines, pets or any information useful to incident managers. Homes can be evaluated for livability or insurance claims.

In the critical moments after a disaster, the first concern is to save lives and assess the extent of the damage. Equipped with a small drone and AR the operator can do the following (Clark, 2016):

- Mark locations to search for survivors.
- Scout the extent of the damage and send information about closed bridges and roads to the command center.

As the disaster recedes and it is time to restore services augmented reality can assist in the following ways (Clark, 2016):

- Show locations of storm drains to be checked for debris.
- Show identifiers for power line poles. Poles will show in the correct location whether or not they are still standing.
- Locations of fire hydrants, gas main valves and more may show as overlays.

Because augmented reality is primarily designed to enhance how users interact with the world around them, there are a lot of potential uses cases for this technology in all facets of threat modeling (Bonasio, 2019; Ryver, 2017):

- Overlaying power lines, water pipes and gas line assets onto a standard map image for field workers in the energy and utilities sector;
- Nuclear reactor safety inspections and walkthroughs;
- Structural inspections of all types in any factory, manufacturing plant, steel mill, oil refinery or oil extraction platform;
- Structural inspections of civil structures;
- Implementation of heads-up displays in all types of automobiles, including self-driving cars, to assist automotive engineers with their work on traffic patterns and algorithms; and
- Visual data modeling for data scientists, statisticians, mathematicians and risk management professionals.

Augmented reality could become advanced enough to allow information security professional to visualize the physical paths an adversary might take through a network, building, city block or industrial facility. It could also provide penetration testers with three-dimensional virtual threat models of applications, software and solution blueprints (Knight, 2018).

Since virtual reality is designed to provide a wearable experience for end users, it can be used to simulate catastrophic disasters in industrial sectors without putting users in physical danger, destroying company or industrial property, or harming the physical environment. It could make an excellent threat modeling tool for physical threats.

In the industrial sector virtual reality can be used to simulate a nuclear reactor meltdown, a large fire in a high-rise office building, a coal mine collapse or a major infrastructure failure. Similarly it can be applied to replicate a citywide blackout, emergency response in disaster zones, and earthquake and aftershock damage (Chibac, N., 2017).

There are also many possible use cases for virtual reality in the defense sector. It may be used to simulate terrorist attacks, train special forces for overseas missions where the precise physical layouts of buildings are other structures may be unknown, conduct urban warfare exercises and test advanced aircraft.

3.1 Virtual Reality Benefits

The VR technology can be used to prepare for disasters in a number of ways. For example, people can be immersed in a virtual environment that allows them to get advanced tactical training. They can perform the planned operations in a controlled manner even before the problem strikes. In this digital environment they can practice as many times as necessary until they are able to achieve mastery of the techniques. They will get used to the chaos so that their actions will become automatic. They will no longer be rattled when faced with a real threat (EKU Online, 2016).

Disaster preparedness workers can also engage in more strategic training sessions, which require high levels of critical thinking. These can provide a series of mental challenges that will force them to think of the most sensible solutions while being under time pressure. The experience is similar to what chess players have when they play against quality opposition. They need to think of each move carefully and consider the possible consequences several steps ahead when each situation generates multiple threats.

Narrative immersion can also be implemented using VR technology. Individuals will be presented with a story set in a world that mirrors our own. The experience is similar to watching a movie but with a greater level of engagement. There is no screen at a distance. Viewers are inside the storyline and may be able to change its course.

3.2 Advantages of VR Disaster Response Training

This type of training has plenty of advantages over conventional methods. Rescuers are able to practice the skills that they need in an environment that does not threaten their well-being. It allows them to get used to the experience and become highly proficient before trying things in real-world situations. Training modules can be packed with a comprehensive array of scenarios that they might encounter in the field. The 3-D environments can be created with an excellent level of accuracy. They can depict specific cities, coastal areas, etc. (Hughes, 2017).

One of the best reasons for using this technology is its cost-effectiveness. It is much easier to recreate disasters digitally than in real life. Once the simulation programs are completed, they can be used by any number of rescuers. The modules can be quickly deployed in different departments and across multiple cities.

3.3 Challenges of Traditional Disaster Preparedness Methods

In the conventional method, rescuers were taught in a classroom setting where information was provided by the instructor. Web-based training enabled people to view pre-recorded sessions from their homes and go through them at their own pace. Trainees could be asked to perform exercises and real-life drills. VR is a cost-effective option that can make training uniform across all levels.

4. CONCLUSION

Drones are the best solution nowadays when it comes to assessing damage and spotting people in distress. In future drones will take on an increasingly important role in natural disaster response, search and rescue, firefighting and other disaster management activities, reducing the risk to human life during operations, and limiting damage to assets by enabling first responders to work proactively.

Drones can perform critical tasks as disasters unfold, including spotting people in need of urgent help. Evidence suggests drones may have certain advantages over traditional search-and-rescue efforts, including speed, as well as they can provide help in the aftermath of disasters to assess damage to buildings, roads and bridges, power lines.

Combining drones with VR/AR technologies paves an efficient way for disaster management by plannig operations in a controlled manner before different type of hazards strike by creating disaster simulations in digital environments, enabling the rescuers to practice as many times as necessary until they are able to achieve mastery of the life-saving techniques.

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REFERENCES

Bonasio, A., 2019. AR Drone Technology That Can Help Save Lives. https://vrscout.com/news/ar-drone-can-help-save-lives/

Chibac, N., 2017. Project SpiceVR Drone meets Virtual Reality, https://future.hamburg/en/project/vr-entering-virtual-realities/

Clark, L., 2016. Drones and Augmented Reality - Help when Disaster Strikes. https://leslie-clark-yjy4.squarespace.com/pressrelease/2016/10/3/drones-and-augmented-reality-help-when-disaster-strikes

Clark, L., 2017. Technology to the Rescue - Drones and AR for Tornado Response, https://leslie-clark-yjy4.squarespace.com/pressrelease/2017/6/14/technology-to-the-rescue-drones-and-ar-for-tornado-response

EKU Online, 2015. 5 Ways Drones are Being Used for Disaster Relief. https://safetymanagement.eku.edu/blog/5-ways-drones-are-being-used-for-disaster-relief/

EKU Online, 2016. How the Department of Homeland Security Can Use Virtual Reality for Disaster Response Training, https://safetymanagement.eku.edu/blog/how-the-department-of-homeland-security-can-use-virtual-reality-for-disaster-response-training/

Fachot, M., 2017. Dealing with natural and industrial disasters. https://www.iecetech.org/index.php/issue/2017-06/Dealing-with-natural-and-industrial-disasters

Hughes, H. S., 2017. How the UN is Using VR to Show Life After Disaster. https://www.pdnonline.com/gear/techniques/video-filmmaking/un-using-vr-show-life-disaster/

Knight, R., 2018. Preparing for the Next Disaster, http://insideunmannedsystems.com/preparing-for-the-next-disaster/

Mazur, M., Hewlett, Ch., Morrison, A., 2017. Commercial drones proving their worth in disaster relief. https://usblogs.pwc.com/emerging-technology/commercial-drones-for-disaster-relief/

Solaris, J., 2017. Augmented vs Virtual Reality at Events. The Debate that Never Was. https://www.eventmanagerblog.com/augmented-vs-virtual-reality-at-events

Nelson Jr., K., 2017. Drones can help when disaster strikes, but only when they're allowed to. https://www.digitaltrends.com/cool-tech/rescue-drones-hurricane-flood-disaster-relief/

Pene, B., 2016. 5 ways virtual and augmented reality is changing our lives. https://www.weforum.org/agenda/2016/07/5-ways-virtual-and-augmented-reality-is-changing-our-lives

Ryver, K., 2017. Virtual Reality, Augmented Reality and Futuristic Threat Modeling, https://securityintelligence.com/virtual-reality-augmented-reality-and-futuristic-threat-modeling/

Segarra, F., 2018. How Drones Improve Disaster Response And Relief From Hurricane Florence. https://connexicore.com/blog/drone-response-natural-disasters-hurricane-florence/

Srinivasan, S., 2018. Drones, aerial imagery, 3D models and VR. https://www.techforwildlife.com/blog/2018/1/16/drones-aerial-imagery-3d-models-and-vr

UNITAR, 2017. Innovative Applications for the Humanitarian Community. https://www.unitar.org/about/news-stories/news/innovative-applications-humanitarian-community