Contributions regarding the capitalization of capabilities offered by autonomous systems to reduce losses caused by calamities, natural and man-made accidents

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***Abstract*—This paper analyzes the fast evolving landscape of autonomous systems in the context of disasters aiming to find innovative solutions for reducing casualties and damages.**

***Index Terms*—autonomous systems, disasters, emergency situations, drones, losses**

I. Introduction

In the face of escalating natural and man-made disasters, the development of advanced, technology-driven disaster risk reduction (DRR) strategies is more critical than ever. Drones, or unmanned aerial vehicles (UAVs), are rapidly transforming disaster response due to their ability to be deployed swiftly, reach inaccessible areas, and gather real-time data with minimal human risk. Their applications are diverse, ranging from pre-disaster monitoring and early detection to post-disaster search and rescue operations, damage assessment, and supply delivery.

II. State of the Art

Drones have become indispensable in DRR across multiple stages of disaster management. Their ability to operate in diverse environments, rapidly gather data, and provide an aerial perspective has made them invaluable in natural and man-made disaster scenarios in both. Main uses for these systems consist in:

- **Real-Time Monitoring and Early Warning Systems:** Drones are extensively used in disaster-prone regions to monitor conditions and provide early warnings. Equipped with advanced sensors, thermal cameras, and data-processing algorithms, they can detect signs of potential disasters such as wildfires, floods, and landslides. In Europe, the FireDrone project leverages drones equipped with infrared cameras to detect temperature anomalies in forested areas, enabling early wildfire detection and prevention [1]. Similarly, in the U.S., UAVs have been deployed in wildfire-prone states like California to monitor temperature changes and wind patterns, assisting fire management teams in making preemptive decisions [2].
- **Post-Disaster Damage Assessment and Mapping:** After disasters, drones can provide a quick and comprehensive overview of the damage, especially in regions that are difficult to access. European authorities have used UAVs for detailed mapping in earthquake-hit areas, creating 3D models that help assess building stability and prioritize response actions. For instance, study demonstrated that high-resolution imaging from drones significantly reduced the time required for structural assessments in Italy following an earthquake [3]. In the U.S., drones have also been instrumental in hurricane-hit regions, where they assess damages and aid in resource allocation for faster recovery [4].
- **Search and Rescue (SAR) Operations:** Drones are increasingly utilized for SAR operations, especially in areas where ground-based search is dangerous or time-consuming. Equipped with thermal imaging cameras and AI-based image recognition, drones can locate heat signatures of people trapped in disaster zones. European projects such as the ARSENAL project in France have developed UAVs capable of detecting survivors amidst rubble using advanced heat sensors and pattern recognition [5]. In the U.S., the usage of drones in SAR missions has been successful during large-scale natural disasters, such as hurricanes and wildfires, significantly reducing search times and increasing the likelihood of survival for those in need [6].
- **Supply Delivery to Isolated Regions:** Drones are proving effective for delivering medical supplies, food, and water to disaster-stricken and isolated areas. This capability was particularly valuable during the COVID-19 pandemic when European health authorities deployed drones to transport medical supplies to remote hospitals and

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healthcare facilities in mountainous regions [7]. Similarly, in the U.S., during hurricane recovery efforts, drones were used to deliver essential supplies to regions cut off by flooding, supporting the continuity of relief operations [8].

- **Data Collection and Predictive Analysis:** Equipped with AI and machine learning algorithms, drones can now process vast amounts of real-time data, enabling predictive analysis and forecasting of disaster-related impacts. European researchers, in partnership with agencies like the European Space Agency (ESA), have developed UAVs that monitor and predict landslides, allowing for targeted evacuation plans [9]. In the U.S., FEMA has incorporated drones into their risk assessment frameworks, utilizing data collected by UAVs to predict disaster severity, optimize resource allocation, and improve disaster preparedness [10].

Despite the advancements, challenges such as regulatory limitations, data privacy concerns, and technical limitations, especially in terms of real-time data processing and network connectivity, pose significant barriers to full-scale drone deployment in DRR. Nonetheless, the progress made suggests promising future applications, provided these obstacles are addressed through technological advancements and updated policies.

CONCLUSION

Drones have shown tremendous potential in disaster risk reduction by providing rapid data collection, real-time analysis, and operational support during emergencies. By focusing on targeted applications, such as monitoring, damage assessment, search and rescue, supply delivery, and predictive analysis, drones enhance situational awareness, reduce response times, and ultimately mitigate losses caused by disasters.

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