Jean Monnet Chair Conference Proceedings in Risk and Crisis Communication in the EU

Risk and Crisis Communication in the European Union

JEAN MONNET CHAIR
Risk & Crisis Communication in the EU

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ONLINE CONFERENCE

RISK AND CRISIS COMMUNICATION IN THE EU

NOVEMBER 29–30, 2024

Editor:
Amalia Triantafillidou
Department of Communication and Digital Media
University of Western Macedonia

ISSN:3057-4595

Harnessing Augmented Reality, Crowdsourcing, and Big Data: Enhancing Collaboration and Responsiveness in Crisis Communication

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Abstract. This paper explores the role of augmented reality (AR), crowdsourcing, and big data within journalism, emphasizing how these technological trends improve crisis prevention, preparedness, responsiveness, and recovery, by fostering collaboration and engagement among audiences, journalists, and NGOs. Through qualitative analysis of three case studies, this paper provides answers to key research questions, enhancing comprehension in the field of crisis communication and contributing to the existing body of literature. The results suggest that augmented reality, crowdsourcing and big data are pivotal for improving communication during crises situations. They also highlight their role in fostering a collaborative culture among audiences, news media, and NGOs to effectively navigate crises, such as the Russo-Ukrainian war and the Gulf Cooperation Council crisis, while facilitating a more adept response to emerging challenges, thereby enhancing overall responsiveness. Lastly, they indicate the successful application of these technological trends across various crises scenarios, including COVID-19 pandemic and Australia's bushfires in 2019, promoting transparency and enhancing coordinated crisis resolution.

Keywords: augmented reality (AR); crowdsourcing; big data; journalist-audience collaboration; responsiveness; crisis communication

1. Introduction

In recent years, emergency situations such as the COVID-19 pandemic and natural disasters have posed significant challenges, influencing public health systems, the economy and the functioning of governmental institutions. These events exemplify the concept of a 'crisis' defined as the perception of an unexpected incident that threatens and impacts an organization's performance, generating unpredictable and negative outcomes (Coombs & Holladay, 2010; Bányász, 2023). Related examples include the COVID-19 outbreak that disrupted healthcare systems and economic stability across the globe and environmental disasters that cause infrastructure breakdowns,

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affecting organizations' strategic goals in an unpredictable way (Anand et al., 2022; Haupt, 2021). In this context, 'crisis management', a process designed to prevent or lessen the damage a crisis can inflict on an organization and its stakeholders, has become a critical discipline, providing structured models that facilitate institutions to effectively respond to unexpected disruptions (Coombs, 2007; Haupt, 2021; Palen et al., 2007). Among these frameworks, the PPRR model comprises four key phases: prevention, preparedness, response and recovery. Each phase addresses a specific aspect of a crisis lifecycle, including actions that prevent and reduce the likelihood of a crisis, alongside recovery efforts that minimize the negative impact of unpredictable events. However, responding to a crisis also requires effective communication that ensures the proper design and delivery of emergency information directly to the public (Anand et al., 2022; Seeger et al., 2021).

According to Coombs (2010), crisis communication has been widely accepted as the collection, processing and dissemination of information necessary to address emergency situations (Coombs, 2010). Moreover, it includes two primary elements: 'managing information', which refers to the collection, analysis and distribution of crisis-related data that enable effective decision-making while also underline emergent challenges and threats, and 'managing meaning', which pertains to influencing public perceptions of a crisis and the organizations involved (Bowen & Zheng, 2015; Coombs, 2019; Palen, 2007). Subsequently, media organizations play a pivotal role in facilitating effective communication during crises, providing citizens with reliable and up-to-date information and legitimizing decisions taken by political leaders in response to emergency situations, while also shaping public perception of their appropriateness and broader impact (Council of Europe, 2021). In this regard, news publishers utilize digital tools and communication channels, ensuring the rapid and efficient distribution of crisis-related data to the public. For example, during the pandemic, social media was used for disseminating information and personal testimonies that covered the human side of the crisis, while the existence of visualizations into daily news improved understanding of COVID-19 (Sheng et al., 2021).

However, the ever-evolving technological landscape is driving transformations in the field of crisis communication and media coverage of emergency situations due to the rise of technological trends like augmented reality (AR), crowdsourcing, and big data (Nielsen et al., 2023). Although previous studies (Aldin Alhaffar et al., 2023; Ardito et al., 2021; Bag et al., 2023; Fromm et al., 2023; Sheng et al., 2021; Vermicelli et al., 2020; Yoo et al., 2023) have highlighted the importance of technological innovations in enhancing crisis communication, especially during the pandemic, there is a need to further examine how augmented reality, crowdsourcing and big data reshape journalistic coverage during emergencies (Chen & Zhang, 2024; Jin & van der Meer, 2025; Vermicelli et al., 2023), developing a collaborative relationship among news media and the public.

For these reasons, this study examines the role of augmented reality, crowdsourcing, and big data within journalism, focusing on how these technological trends strengthen collaboration and engagement among media outlets, non-governmental organizations (NGOs) and the public, ultimately contributing to more effective communication and coordinated responses to unpredictable events. To achieve its purpose, this study presents a comprehensive literature review regarding the use of these technologies by media organizations in emergency situations and analyzes three case studies involving their application in responding to crises that currently affect Europe, providing answers to key research questions. Consequently, through the presentation of

coherent and evidence-based findings, it expands and contributes to the existing body of knowledge on the application of these technological trends in the field of crisis communication.

2 Theoretical Background

2.1. Technological trends in the field of crisis communication

Given the constantly changing technological landscape and global risk uncertainties, the role of technological solutions during crises has become quite important (Ardito et al., 2021; Bag et al., 2023; Nielsen et al., 2023). In this context, emerging trends such as augmented reality (AR), crowdsourcing and big data have gained prominence in the field of crisis communication (Bányász, 2023; Vermicelli et al., 2020; Yoo et al., 2023). Analytically, 'augmented reality', an emerging technology that can superimpose digital information on users' views, holds great potential for providing real-time and clear guidance to emergency response staff during an emergency (Dzermansky et al., 2021). With this technology, users can monitor digital data, information, images, and the real world at the same time. Due to this advantage, augmented reality was successfully applied to guide the maintenance and assembly tasks in the manufacturing industry. Additionally, its integration into the field of crisis communication represents a significant advancement in how information is conveyed during emergencies. In this regard, augmented reality enhances situational awareness by overlaying digital information onto the physical world, providing users with critical, context-specific data in real-time. This capability is particularly valuable in high-stress situations such as natural disasters or emergency evacuations where timely and accurate information can be the difference between safety and danger (Dzermansky et al., 2021; Yoo et al., 2023).

Additionally, 'crowdsourcing' is another technological trend that gained prominence in crisis communication and is associated with different types of online collaboration: 'crowdfunding', where the crowdsourcer asks citizens for financial contributions, and 'co-creation', a process that enables news makers and the public collaborate to produce journalistic content through crowdsourced data (Aitamurto, 2019; Tavra et al., 2021). In fact, crowdsourcing requires digital platforms, such as social media and specialized apps, that facilitate the collection of users contributions and which have been proven invaluable in providing real-time insights during emergencies. For instance, social media and open-source platforms have been extensively used during natural disasters to gather firsthand accounts, monitor public sentiment, and track the spread of misinformation (Aldin Alhaffar et al., 2023; Nielsen et al., 2023). Consequently, their application in crisis communication enables media organizations and public authorities to collect crowdsourced data, providing constant updates during crises (Vermicelli et al., 2020).

'Big data' and 'big data analytics' have also gained ground in crisis communication, allowing the extraction of large volumes of unstructured information that support decision-making during emergencies (Bukar et al., 2022; Chernobrov, 2018). Specifically, their role has become crucial, as they enable contemporary media organizations and political leaders to gain vital information regarding a crisis event, supporting precise targeting of messages and better resource allocation. Notable examples include the utilization of big data analytics in tracking the spread of a crisis,

assessing the needs of affected populations and allocating resources effectively (Bag et al., 2023; Sheng et al., 2021).

2.2. Using technological trends in contemporary journalism for managing emergencies

The incorporation of augmented reality, crowdsourcing, and big data into journalism has attracted significant attention during emergencies, as these trends offer new opportunities for collaboration and effective crisis management. Through a range of innovative tools and techniques, citizens, journalists and NGOs can work together to address emergencies more efficiently (Dzermansky et al., 2021; Pánek et al., 2017).

To begin with, various applications of augmented reality have been explored within the domain of crisis communication. One of its primary uses is detected in disaster management, where it aids first responders, by providing real-time data overlays, such as building layouts, victim locations, and hazardous material warnings. Additionally, augmented reality can significantly improve situational awareness, allowing responders to make quicker and more informed decisions. For example, AR systems could be instrumental in enhancing the efficiency of emergency response teams by providing crucial data at a glance. Augmented reality is also being employed to disseminate vital information to the public during crises. For instance, in scenarios such as hurricanes or floods, AR applications can guide individuals to safe zones or provide updates on the status of emergency shelters (Schwarz et al., 2016).

The adoption of augmented reality in journalism during crises has helped bridge the gap between complex real-time events and audience understanding, enhancing the ability to visualize and interact with data in meaningful ways. Augmented reality has emerged as a game-changing tool in crisis journalism, enabling reporters to provide contextualized, real-time information. Specifically, it is useful during natural disasters, political crises, or public health emergencies, where visualizing dynamic changes in the environment can help people make informed decisions. Research has indicated that AR significantly improves the public's ability to respond effectively to emergencies by offering visual and interactive representations of otherwise complex or abstract data. By offering immersive and accessible real-time updates, AR enhances the public's understanding and reaction to evolving crises. AR-based storytelling enables users to actively engage with content, leading to greater information retention and comprehension, which is critical during fast-moving crisis events. AR systems can also help users visualize disaster recovery efforts by showing real-time satellite data or drone footage overlaid onto digital maps, offering a clearer understanding of both the immediate impact and the response measures being taken (Johnson et al., 2021; Milgram & Kishino, 2019; Yoo et al., 2023).

Crowdsourcing has also become an essential tool in journalism, particularly in improving crisis communication by gathering real-time data from the public, enabling faster, more accurate responses while fostering public involvement in managing emergencies (Aitamurto, 2019). The integration of collaborative technologies and open-source platforms has further enhanced the role of crowdsourcing in journalism, bridging individual contributions with structured, data-driven crisis management tools. Media organizations and governmental mechanisms can now utilize such technologies to better manage crises by collecting, visualizing, and mapping real-time data. For example, Ushahidi, a Kenyan non-profit, developed an open-source software, that has been widely

used by media organizations during crises as it allows citizens to submit crisis reports via mobile phones, creating a temporal and geospatial archive of events (Pánek et al., 2017; Ushahidi.com, n.d; Vermicelli et al., 2020). OpenStreetMap, another open-source platform, provides detailed maps that are constantly updated by users. These maps are often used to validate the impact of crises and generate infographics that visually depict disaster spread (Anthony, 2018).

The aforementioned examples highlight the significance of collaborative tools in journalism, with the purpose of providing effective crisis management through crowdsourced data collection. Journalists are increasingly turning to platforms like Ushahidi and OpenStreetMap that allow real-time crowdsourcing, enabling citizens to contribute, access, and critique crisis information, fostering a more collaborative and participatory approach to news production. This shift marks a departure from traditional solitary reporting, empowering journalists with dynamic public input during crises (Aldin Alhaffar et al., 2023; Aitamurto, 2019; Anthony, 2018).

Big data and big data analytics are also crucial in order for effective crisis management to be achieved. For instance, social media data from citizens, which are considered high volumes of users' information, can enhance understanding of an emergency, ultimately leading to more effective and robust crisis communication (Aitamurto, 2019; Boersma & Fonio, 2017; Chernobrov, 2018). By harnessing social media data, journalists and governments can gain a complete picture of a crisis, with the aim of identifying potential risks and challenges (Jensen, 2022). With the advent of digital tools, such as Twitcident, that detect, follow and monitor users' posts on social networks for the purpose of maintaining security in urban environments, journalists can gather firsthand information during emergencies, allowing them to report on related events more accurately and promptly (Boersma & Fonio, 2017; Bukar et al., 2022). Although big data offers significant advantages in crisis situations, they introduce major challenges for journalism. As media experts shift towards automative processes, where algorithms utilize huge amounts of data to generate news content with minimal human intervention, the risk of simplifying complex stories and failing to capture significant aspects of crises is increased. Consequently, concerns regarding the quality and accuracy of news being disseminated during crises have also emerged (Lewis, 2014; Sheng et al., 2021).

3. Methodology

Considering the impact of augmented reality, crowdsourcing, and big data in the current media landscape, alongside the emergence of recent socio-political crises (e.g. the Russo-Ukrainian and Israel-Palestine war), this study aims to examine how these technological trends enhance collaboration and engagement among audiences, journalists and NGOs during crisis situations. By focusing on EU-based media and NGOs which have recently adopted related technologies to effectively contribute to crisis management, it evaluates their transformative role in contemporary crisis communication. To address its purpose, this paper has employed a 'case study research' which refers to a qualitative approach with the investigator exploring a bounded or multiple bounded systems (cases) over time through detailed data collection from various sources (e.g. observations, articles, documents and reports) (Creswell, 2007). According to Yin (2003), case studies are a preferred strategy when "how" or "why" questions are being posed, as they facilitate

a comprehensive evaluation of the outcomes and are frequently used in social sciences. (Yin, 2003).

Taking the above into account, this paper examines and analyzes the following case studies (Table 1):

Table 1: Presentation of the cases studies

Case study	Creator
GCC's crisis coverage by using augmented reality for empowering digital storytelling (Hill, 2017).	Al Jazeera English
"Eyes on Russia Map" using crowdsourced data to depict Russia's invasion in Ukraine (Barney, 2023).	Centre For Information Resilience (CIR)
Static maps using big data from MapBox and OpenStreetMap for Ukraine war (Al Jazeera, 2024).	Al Jazeera

The case studies were selected according to the following selection criteria (Table 2):

Table 2: Selection criteria of the case studies

Selection criteria
Created by NGOs and/or EU media organizations.
Incorporation of augmented reality, crowdsourced and big data into design processes.
Addressing recent crises constantly affecting the EU public sphere.

The examination of the case studies is based in three stages. The first includes the presentation of each project, providing insights into their purpose and the technologies applied in their design. This aligns with Creswell's emphasis on detailed data collection in case study research, allowing for a comprehensive understanding of the context and the significance of each example (Creswell, 2007). The second focuses on the examination of audience engagement, analyzing how audiences participate and interact with each project. This stage involves the presentation of the media and materials used during each project's design and aligns with Yin's assertion that case studies provide insights into why and how these projects effectively foster audience interaction and comprehension (Yin, 2003). The third includes an assessment of the influence and effectiveness of the case studies in managing and communicating about the crises they represent. This entails presenting data that justify the impact of each project on public perception and crisis management. It also aligns with Creswell's emphasis on reporting case-based themes to reveal broader patterns and implications stemming from the individual case studies, while reflecting Yin's focus on evaluating case studies' outcomes (Creswell, 2007; Yin, 2003).

Following the aforementioned stages, this study provides comprehensible results with the aim of answering key research questions:

R.Q.1 How do augmented reality (AR), crowdsourcing, and big data enhance the effectiveness of crisis communication and management within the European Union, particularly among media organizations and non-governmental organizations (NGOs)?

R.Q.2 How do these technologies improve public engagement and collaboration between citizens, journalists, and NGOs during crisis management efforts?

4. Results

4.1. Gulf Cooperation Council crisis by Al Jazeera

The Gulf Cooperation Council (GCC) crisis, which unfolded in 2017, is a key case in the evolving landscape of crisis communication, particularly highlighting the role of augmented reality (AR), media innovation, and digital storytelling. The conflict centered around diplomatic tensions, with Saudi Arabia, the UAE, Bahrain, and Egypt imposing a blockade on Qatar, accusing it of supporting terrorism, which Qatar denied (Hill, 2017; Istituto Affari Internazionali, 2024).

During the crisis, Al Jazeera, a Qatari-based global media network, leveraged cutting-edge AR technology to deliver a dynamic, real-time explanation of the situation. By incorporating AR into its news broadcasts, Al Jazeera not only engaged its audience visually but also provided an immersive, contextualized narrative that made the complexities of the crisis more understandable. The use of AR allowed for enhanced storytelling, combining traditional news reporting with digital overlays of data such as updated flight paths, transport routes, and geopolitical maps (Hill, 2017). AR's role here went beyond just adding visual appeal—it offered a strategic communication tool. By integrating AR maps into their broadcasts, Al Jazeera could dynamically show the blockade's impact on citizens and businesses. The visual representation of import-export routes, for instance, highlighted the economic isolation Qatar faced, while the use of digital tools such as Viz World maps brought a tangible dimension to an otherwise abstract geopolitical issue. This visual interaction allowed viewers to not only consume information but to engage with it more deeply, facilitating a better understanding of how the blockade affected daily life (Hill, 2017).

Figure 1: *Illustration of the use of AR to explain the Gulf Cooperation Council Crisis by Al Jazeera* (screenshot from https://www.newscaststudio.com/2017/10/26/al-jazeera-augmented-reality/)

Al Jazeera during 2017 has renewed their studios using new venues features having a surreal design that combine massive video walls, glossy surfaces and architectural elements of the building itself to create a dynamic and functional newsgathering environment. They have created a studio with 16 Sony HDC cameras and more than 30 Motion Analysis Tracking sensors/cameras to track three Sony HDC cameras for immersive, augmented reality graphics generated through Vizrt. They have also created a smaller studio that is dedicated to immersive graphics, with a large video wall and motion-tracking camera system. For our case, Al Jazeera used a combination of AR graphics with Viz Virtual Studio, Viz World maps, and a video wall powered by Viz Engine. Rather than attempt to recreate the buildings in detailed 3D in Vizrt, however, the network opted to use simplified, blocky shapes that not only created a clean and modern look but also helped draw the eye to the map details (Vizrt).

The maps were designed as glassy floor slabs, using transparency to merge real and virtual elements. Bright gold, red, and pale orange highlighted countries and routes, while a dog-legged video wall displayed a virtual Doha coastline, creating seamless transitions. This high-end AR integration fostered interactive storytelling, making it central to news production. During the GCC crisis, Al Jazeera's use of AR underscored how emerging technologies can transform crisis communication and position media as leaders in digital innovation.

4.2. Eyes on Russia project by CIR and C4ADS

In January 2022, the Centre of Information Resilience (CIR), a UK-based non-profit organization, in partnership with the Center for Advanced Defense Studies (C4ADS), launched the "Eyes on Russia" project (eyesonrussia.org, n.d; Strick, 2024). The project aimed to collect, analyze and verify data contributed by citizens such as videos, photos, satellite images and other media related to Russia's invasion of Ukraine, developing an interactive map that offers policymakers, journalists and the public reliable information on the war's progression (Strick, 2024). The map is considered the updated version of the "Russia-Ukraine Monitor Map" which was previously developed by CIR in collaboration with the open-source intelligence (OSINT) community, including partners like Bellingcat and the Conflict Intelligence Team (Strick, 2023). Its aim is to provide timely, accurate information on the invasion's impact by using data contributed by citizens, volunteers and organizations across Europe, stored in a database of over 20,000 verified videos and photos (Strick, 2024; Wheeler, 2022).

Additionally, the project's general design allows users to interact with the represented data, providing interactive visualizations that depict the consequences of Putin's military adventurism and various functions like search features and filtering options. For instance, users can filter and display data on the map by category, sector, event date range, or by using the free-text search box (Centre For Information Resilience, 2022; Chow et al., 2024; eyesonrussia.org, n.d; Strick, 2023). Moreover, users can insert keywords, such as location names, into the free text box and use the timeline of verified data, identifying the dates associated with the data (e.g. data from February to March 2023 etc.).
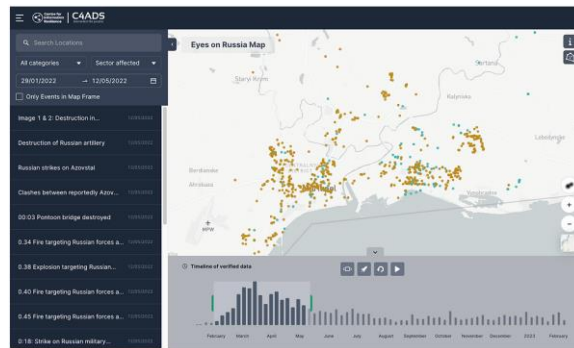
Figure 2: *Mariupol's depiction with the data from February to May 2022* (screenshot from https://www.info-res.org/post/eyes-on-russia-documenting-conflict-and-disinformation-in-the-kremlin-s-war-on-ukraine)

At this point, it is worth noting that most of the map's represented data (e.g. videos, images etc.) come from international media, research centers and citizens' posts on social media. For instance, the Footage likely from an Inokhodets UCAV showing Russian strikes on Azovstal is a title of a video displayed on the list below the maps' main categories, which was reposted by a user's account on X and was incorporated into the project.
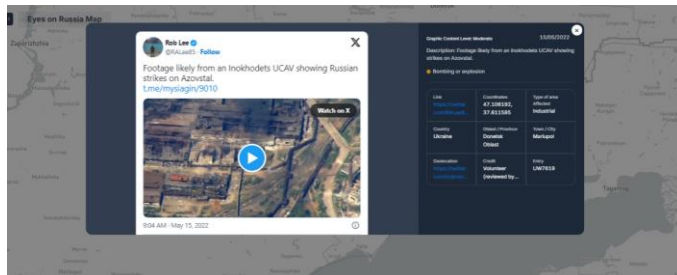

Figure 3: *Users contributions to the "Eyes on Russia Map"* (screenshot from https://eyesonrussia.org/)

Furthermore, the map is publicly viewable on both desktop and mobile and as of July 24, 2023, has had over 3.5 million total views (Strick, 2023). Its data has been used by various EU media to effectively cover the Russia-Ukraine war (Barney, 2022; Centre For Information Resilience, 2022; Strick, 2023). For example, The Guardian used the map's infrastructure damage data on its daily news reporting to expose hundreds of incidents of infrastructure damage from September 2022 to January 2023 (Voce et al., 2023). BBC was based on CIR's analysis of images of Staryi Krym for its Panorama program to reveal that more than 1,500 new graves had been dug there since the last image analysis in June 2022 (Andersson, 2022). Lastly, one of the major contributions of "The Eyes on Russia" project is the transparency it brings, providing real-time data and a detailed visual representation of the Russo-Ukrainian conflict. This real-time documentation has been crucial for

journalists, policymakers, and justice bodies in understanding the conflict, documenting damage to civilian infrastructure and archiving evidence for accountability and justice efforts. (Barney, 2022; Strick, 2024; Strick, 2023).

4.3. Series of static maps into daily news by Al Jazeera

Since 2022, Al Jazeera has incorporated a series of static maps into their daily news, creating a narrative of the war between Russia and Ukraine. For instance, on February 24, 2022, the day Russia invaded Ukraine, Al Jazeera published an article titled *Mapping Russian attacks across Ukraine*. This article aims to explain the multifaceted impact of the Russia-Ukraine conflict, detailing how it started, its immediate effects, and the broader implications for the international community in terms of security, economy, and politics (Al Jazeera Staff, 2022; Barney, 2022). For such purposes, the article includes a series of static maps that depict data from open-source mapping platforms such as OpenStreetMap, platforms that provide geolocation data such as MapBox and non-profit, non-Partisan think tanks. These maps contribute to the broader narrative of the war by presenting data such as confirmed locations in Ukraine that came under attack on February 24, 2022 (Al Jazeera Staff, 2022; mapbox.com, n.d; wiki.openstreetmap.org, n.d).
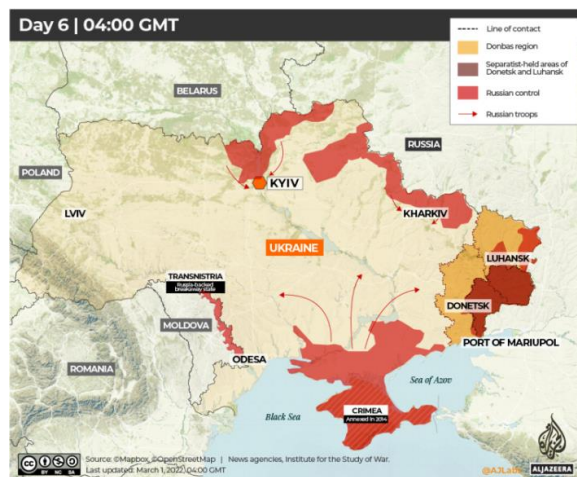

Figure 4: *The first map of the article that shows known locations in Ukraine that had come under attack on February 24, 2022* (screenshot from https://www.aljazeera.com/news/2022/2/24/mapping-russian-attacks-across-ukraine-interactive)

In this context, these maps enable readers' to better understand the impact of the Russian invasion of Ukraine as well as the political framework that shapes the relations between those countries. For instance, a static map shows NATO's expansion in the Balkans since 1949, paired with references to Russia's demand for non-expansion, helping readers better understand the roots of the Russia-Ukraine war. (Al Jazeera Staff, 2022). Such combinations can also be observed in various articles associated with the war in Ukraine. For instance, a news article titled Infographic: Military capabilities of Russia and Ukraine which was published on February 25, 2022, by Al

Jazeera highlights the years of tensions between Russia and Ukraine while it is also referring to the avoidance of the direct involvement of the West in the war that had just begun. In this case, maps are vital for visualizing the Russia-Ukraine conflict, detailing troop movements, invasion routes, and strategic sites. They illustrate NATO's presence in Eastern Europe and track military advances, offering readers essential insights into the ongoing crisis and ground control. It is worth mentioning that Al Jazeera also uses hyperlinks into such articles that enable readers to detect a greater range of information about the war (Duggal, 2022).

Figure 5: *A map that depicts the Russo-Ukrainian conflict step by step* (screenshot from https://www.aljazeera.com/news/2022/1/25/infographic-military-capabilities-of-russia-and-ukraine-interactive)

Furthermore, the creation of these maps relies on vast amounts of data from key sources used by Al Jazeera. For instance, OpenStreetMap is a collaborative, open-source platform offering extensive geolocation data contributed by users globally. MapBox provides high-value mapping datasets, supported by over half a billion monthly active users, enhancing the maps' credibility and accuracy (mapbox.com, n.d; wiki.openstreetmap.org, n.d). Therefore, Al Jazeera's approach in terms of covering Russo-Ukrainian crisis provides a better understanding regarding the causes, the effects and the progress of the war. Visualized content enables readers to create an overall image in terms of the implications of the particular crisis, increasing public awareness. Al Jazeera's constant updates regarding the ongoing conflicts also enhance decision-making processes in order for governors to effectively manage the particular crisis (Barney, 2022).

5. Discussion and future research

Taking the results into account, this paper offers thorough and comprehensive answers to the aforementioned research questions. Specifically, Augmented Reality transforms passive information consumption into interactive experiences. Al Jazeera's coverage of the Gulf Cooperation Council crisis leveraged AR to overlay digital data onto real-world environments. This visual aid allowed audiences to comprehend complex geopolitical situations more intuitively. The real-time visual updates, such as transportation routes and economic impacts, bridged the gap between abstract information and tangible outcomes for affected citizens. Beyond AR as a visualization tool, it acts as a crucial strategic asset for media organizations. By allowing media entities to present crises with layers of interactive, real-time data, AR doesn't merely facilitate understanding but fosters informed decision-making. NGOs and government bodies could use AR in broader applications like disaster preparedness and response planning, making AR a central technology in preemptive crisis mitigation.

Moreover, the ability to gather real-time data from the public during crises, as seen in "The Eyes on Russia Project," showcases the transformative potential of crowdsourcing. By tapping into the collective intelligence of the public, crowdsourcing this initiative has managed to create a multidimensional, real-time dataset that can be used by media organizations, governments, and NGOs to make faster and more accurate decisions. The transparent and verified nature of this data ensures that crisis communication strategies are based on reliable inputs from the public, creating a crowdsourced approach, that not only empowers citizens to participate in crisis reporting, but it also democratizes the flow of information. Instead of relying solely on top-down narratives from journalists or governments, it crowdsourcing ensures a two-way flow of information. Making crisis communication more inclusive, leading to heightened collaboration between citizens, media outlets, and NGOs, and enhancing the overall response to crises.

Additionally, big data's role in crisis communication lies not only in its sheer volume but also in its ability to provide accuracy and depth in news reporting. For example, Al Jazeera's use of big data in daily news enhanced the effectiveness of crisis communication, by providing detailed, static visualizations of the Russia-Ukraine conflict. Through static maps that incorporate data from open-source platforms such as OpenStreetMap etc., Al Jazeera was able to provide accurate and contextually rich information that can potentially be used support media organizations and NGOs during crisis reporting. As seen in the "Eyes on Russia" project and Al Jazeera's news reporting, AR, crowdsourcing and big data promote a collaborative environment where the public, media organizations, and NGOs work in unison. By allowing users to contribute their data and engage with crisis narratives in real-time, these initiatives break the traditional boundaries of crisis reporting. This fosters a more inclusive approach, making public participation a critical element in both crisis communication and management. The three case studies—Al Jazeera's use of Augmented Reality (AR) during the Gulf Cooperation Council (GCC) crisis, the "Eyes on Russia" project, and Al Jazeera's static maps of the Russia-Ukraine conflict—offer distinct approaches to leveraging emerging technologies in crisis communication. While they all aim to improve public understanding and responsiveness in times of crisis, they differ in their use of technology, audience interaction, collaboration, and transparency.

Al Jazeera's AR integration during the GCC crisis is a prime example of how Augmented Reality can enhance user engagement through real-time, immersive storytelling. By overlaying digital data, such as flight paths and geopolitical maps, onto the real world, AR offered audiences a dynamic way to understand the complex crisis. This interactive medium allowed viewer to see the immediate effects of the blockade on Qatar's citizens and economy. In contrast, the "Eyes on Russia" project used crowdsourced and social media data and interactive mapping to provide a real-time, constantly updated portrayal of the Russia-Ukraine conflict. The project allowed users to interact with data, creating an even higher level of interactivity than AR by enabling user contributions. Meanwhile, Al Jazeera's static maps of the Russia-Ukraine conflict, though informative, provided limited real-time interaction. The maps relied on big data but were published as static visual aids, lacking the real-time dynamism of AR or the participatory nature of crowdsourcing.

The three case studies also vary significantly in terms of public collaboration. In the AR coverage of the GCC crisis, the engagement was primarily passive. Viewers consumed the visually enhanced data provided by journalists but had no direct means to contribute to the crisis communication process. Conversely, the "Eyes on Russia" project exemplified active public collaboration, inviting contributions from citizens, journalists, and NGOs. Crowdsourcing was at the heart of this project, with user-generated content such as videos and social media posts forming the backbone of the data presented. This crowdsourced approach fostered a sense of collaboration between the public and media organizations, making the public an active participant in crisis reporting. Al Jazeera's static maps, by contrast, provided no such interactivity. The maps were created using pre-verified big data from platforms like OpenStreetMap, but there was no mechanism for the public to directly contribute or interact with the information beyond reading the maps and articles.

In terms of transparency and accuracy, all three case studies excelled but in different ways. Al Jazeera's AR visuals during the GCC crisis delivered verified real-time data from trusted sources, ensuring that the audience had accurate information. However, this data was controlled and curated by the media organization, with little opportunity for public involvement. On the other hand, the "Eyes on Russia" project had a much more transparent and participatory approach to data collection and verification. Crowdsourced data was rigorously checked by journalists, NGOs, and open-source intelligence communities, ensuring its accuracy while fostering public trust. The open, collaborative nature of the project meant that it was not just media professionals controlling the flow of information, but the public played a critical role as well. Al Jazeera's static maps, while also accurate, lacked the immediacy and interactive verification processes present in the other two cases. The maps were curated using open-source data, but the static nature of the content and lack of real-time updates limited their transparency compared to the other projects.

Real-time responsiveness varied greatly across the three case studies. Al Jazeera's AR coverage provided a near real-time understanding of the GCC crisis through constantly updated visual overlays. This allowed for a more immediate grasp of the evolving situation, but the updates were still tied to the timing of broadcast schedules. The "Eyes on Russia" project was the most responsive of the three, offering real-time updates based on crowdsourced data that was constantly verified and displayed interactively. This allowed users to search for specific data and see how the conflict was unfolding in real-time. In contrast, Al Jazeera's static maps were less responsive. Although they provided detailed visualizations, they were static and updated periodically, meaning

they could not offer the same level of immediacy or real-time engagement as AR or crowdsourced maps.

In terms of raising public awareness, Al Jazeera's AR use during the GCC crisis provided a highly engaging way to convey complex information. The immersive visuals helped audiences better understand the geopolitical impact of the blockade, enhancing public comprehension and engagement. The "Eyes on Russia" project, however, had a broader and more significant impact on global awareness. The crowdsourced and verified data provided an unparalleled level of transparency and engagement, influencing both public perception and policy decisions. The real-time data and interactive nature of the project ensured that the public was not just passive consumers but active contributors to crisis reporting. Al Jazeera's static maps, while helpful in providing a clear geographic understanding of the Russia-Ukraine conflict, lacked the depth of engagement present in the other two case studies. The maps were effective at raising awareness but did not provide the same immersive or interactive experience.

It is worth noting that augmented reality, crowdsourcing and big data have been successfully applied across different types of crises, including natural disasters, public health emergencies etc. For instance, the "Wildfire AR" app overlays real-time data about fire locations, spread patterns, and safe zones onto the user's surroundings. This helps emergency responders visualize fire fronts, smoke zones, and wind direction, which assists in strategic planning and resource allocation (Bhattarai, 2020). Residents benefit by receiving critical guidance on evacuation routes, allowing for timely and safe departures. The real-time spatial awareness provided by AR has been shown to reduce response times and enhance public safety by minimizing the risk of casualties (Bhattarai, 2020). Similarly, augmented reality plays a crucial role in earthquake preparedness. Apps such as "QuakeAlert USA" simulate real-time earthquake impact zones, enabling users to visualize fault lines and affected areas. These simulations empower individuals and communities to conduct evacuation drills and understand safety protocols, fostering a culture of preparedness (Dzermansky et al., 2021).

The interactive nature of augmented reality also helps people practice responses, making emergency actions more familiar and effective when an actual crisis occurs. Augmented reality's benefits extend beyond immediate responses to long-term resilience. Its ability to visualize potential hazards encourages proactive measures, better planning, and improved infrastructure readiness in vulnerable areas. In addition to natural disasters, AR's interactive visual tools have proven beneficial in public health crises. During the COVID-19 pandemic, augmented reality applications were used to demonstrate hygiene protocols and social distancing measures. This interactive guidance not only improved public compliance but also supported healthcare training by allowing medical personnel to practice emergency procedures safely through 3D simulations (Jung, 2022).

Additionally, crowdsourcing played a crucial role in Australia's bushfire in 2019 and 2020, enhancing responsiveness and providing citizens with a greater understanding for the crisis. In this context, news media effectively used social media and crowdsourced data to enhance their coverage, noting hashtags like #AustralianFires and #supportingaustralia that helped mobilize global support and awareness. Furthermore, Facebook's Disaster Map, that included emergency services with real-time data for better risk assessment and resource allocation, was also highlighted

on daily news reporting. Lastly, local media organizations amplified personal stories from affected citizens, strengthening public empathy and understanding (Mack, 2020).

Furthermore, media outlets like The Guardian utilized big data in its coverage of the Covid-19 pandemic to provide their audiences with a better understanding of the crisis. By employing various data-driven methods to track the spread of the virus, analyze mortality rates, and highlight disparities in health outcomes among different demographics, the Guardian made complex information accessible and understandable to the public. Guardian's decision to release their internal data tracking efforts for public use led to a greater engagement, with millions of views on their summary pages. This transparency enhanced collaboration with researchers and citizens alike, fostering the accuracy and relevance of their reporting (Chalabi, 2020).

Future research could explore several key areas to enhance the understanding and application of augmented reality, crowdsourcing and big data in crisis communication. Related studies may focus on how crowdsourced and big data enhances crisis reporting, by creating real-time on-the-ground insights, encouraging fact-checking or supporting resource allocation. A deeper investigation in terms of the strategies used for verifying users' contributions and countering disinformation during emergencies is also required. Moreover, a longitudinal study tracking the evolution of crisis communication tools and their long-term effects on public engagement and media consumption could offer a deeper understanding of the effectiveness of tools such as interactive maps and AR overlays. This approach would shed light on the sustained impact of technological advancements in crisis management and communication. Lastly, research on the integration of Artificial Intelligence (AI) in crisis reporting could reveal both opportunities and challenges associated with automated journalism. Examining AI's role in enhancing the accuracy, speed, and ethical considerations of real-time reporting would contribute to the broader discourse on the future of journalism in crisis scenarios.

6. Conclusions

Overall, this paper underscores how AR, crowdsourcing, and big data have reshaped crisis communication, each offering unique strengths in visualization, public participation, and real-time responsiveness. Al Jazeera's AR coverage of the GCC crisis showcased immersive, real-time storytelling, enhancing audience comprehension but lacking interactive public involvement. The "Eyes on Russia" project, driven by crowdsourcing, democratized crisis communication by enabling public collaboration, verified data sharing, and direct participation in reporting. Al Jazeera's static maps, while highly informative and data-rich, were limited in immediacy and interactivity. Together, these case studies illustrate that emerging technologies can transform crisis communication from one-way reporting into a dynamic, participatory process. They demonstrate that real-time, interactive tools not only improve comprehension of complex issues but also foster public trust and collaboration, crucial in volatile crisis situations.

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