Asia Journal of Management
and Social Science
Vol. 01 / No. 01 / 2023

Multidisplay Environments for Crisis Management and Emergency Response: Enhancing Situational Awareness and Decision-Making

Fazal Wahab

Abdul Wali Khan University, Mardan

Abstract:

Crisis management and emergency response necessitate efficient coordination, rapid information processing, and effective decision-making in dynamic and complex environments. Multidisplay environments (MDEs) have emerged as promising tools to enhance situational awareness and support decision-making processes during crises. This paper explores the role of MDEs in crisis management, discussing their potential benefits, challenges, and applications. Drawing from interdisciplinary research in human-computer interaction, cognitive psychology, and emergency management, this study provides insights into the design, implementation, and evaluation of MDEs for emergency response. Additionally, it highlights future directions for research and development in this domain, aiming to foster innovation and improve the effectiveness of crisis management strategies.

Keywords: *Multidisplay environments, crisis management, emergency response, situational awareness, decision-making, human-computer interaction, cognitive psychology, information visualization, interdisciplinary research.*

Introduction:

Crisis situations, such as natural disasters, terrorist attacks, and public health emergencies, pose significant challenges to emergency responders and decision-makers due to their complexity, uncertainty, and time constraints. In these high-pressure environments, the ability to quickly gather, process, and analyze information is critical for effective decision-making and response coordination. Traditional tools and methods for crisis management often fall short in providing timely and comprehensive situational awareness, leading to suboptimal outcomes and increased risk to life and property. Multidisplay environments (MDEs) offer a promising solution by integrating diverse sources of information into interactive and immersive interfaces, enabling users to visualize and interact with data in real time. By leveraging advances in display technology, information visualization, and human-computer interaction, MDEs have the potential to enhance situational awareness, support collaboration among stakeholders, and improve decision-making in crisis scenarios. This paper examines the role of MDEs in crisis management and emergency response, discussing their benefits, challenges, and applications in various domains. Through a review of relevant literature and case studies, we highlight key design principles, implementation strategies, and evaluation methods for MDEs in emergency situations. Furthermore, we identify gaps in current research and suggest avenues for future

exploration, aiming to advance the development and adoption of MDEs for crisis management purposes.

Background:

Crisis management and emergency response are multifaceted processes that demand rapid decision-making and coordinated action in the face of uncertainty and adversity. Whether it's a natural disaster, a terrorist incident, or a public health emergency, the ability to gather, process, and disseminate information in real time is paramount to saving lives and mitigating damage. Traditionally, crisis management relied on manual procedures and disparate communication channels, often resulting in delays, miscommunication, and suboptimal outcomes. However, advancements in technology have spurred the development of innovative solutions to enhance situational awareness and support decision-making in crisis situations.

One such solution is multidisplay environments (MDEs), which leverage interactive visualization and immersive interfaces to integrate and present diverse sources of information to users in real time. MDEs encompass a range of technologies, including large-scale displays, touchscreens, augmented reality (AR), and virtual reality (VR), that enable users to interact with data in intuitive and meaningful ways. By aggregating data from sensors, cameras, geographic information systems (GIS), and other sources, MDEs provide stakeholders with a comprehensive view of the crisis environment, allowing them to identify trends, patterns, and anomalies that may require attention.

The concept of MDEs in crisis management is not new, with early efforts dating back to the use of command and control centers equipped with multiple monitors and video walls. However, recent advancements in display technology, data processing, and human-computer interaction have expanded the capabilities of MDEs and their potential applications in emergency response. From mobile command vehicles equipped with touchscreen interfaces to virtual command centers that enable remote collaboration, MDEs offer unprecedented flexibility and scalability in supporting crisis management operations.

Key challenges in implementing MDEs for crisis management include interoperability, scalability, and usability. Integrating diverse data sources and systems into a coherent and responsive interface requires careful planning and coordination among stakeholders, including emergency responders, government agencies, and technology providers. Moreover, ensuring that MDEs are accessible and intuitive to users with varying levels of technical expertise is essential for their adoption and effectiveness in real-world scenarios. Addressing these challenges requires interdisciplinary collaboration and iterative design processes to create MDEs that meet the unique needs and constraints of crisis management contexts.

Motivation:

Motivation for exploring the role of multidisplay environments (MDEs) in crisis management and emergency response stems from the increasing complexity and frequency of crises faced by societies worldwide. Natural disasters, terrorist attacks, pandemics, and other emergencies present formidable challenges to emergency responders and decision-makers, requiring swift and

well-coordinated actions to mitigate risks and save lives. Traditional crisis management approaches often struggle to keep pace with the rapid evolution of crises, leading to inefficiencies and suboptimal outcomes. In this context, MDEs offer a compelling solution by harnessing advanced technologies to provide real-time, integrated views of critical information, enhancing situational awareness and decision-making capabilities. Understanding the potential benefits and challenges of MDEs is crucial for stakeholders in emergency management, as it can inform the development of more effective strategies and tools for responding to crises.

Moreover, the motivation to investigate MDEs in crisis management is fueled by the growing recognition of the importance of information visualization and human-computer interaction in supporting decision-making processes. MDEs leverage advances in display technology, data analytics, and interaction design to create immersive and interactive environments where users can explore complex datasets, identify patterns, and collaborate with peers in real time. By enhancing the cognitive abilities of emergency responders and decision-makers, MDEs have the potential to improve the effectiveness and efficiency of crisis response efforts, ultimately saving lives and reducing the impact of disasters on communities.

Furthermore, the motivation for research in this area is driven by the need to address the limitations of existing crisis management systems and practices. While significant progress has been made in leveraging technology for emergency response, many current tools and methods lack the flexibility, scalability, and usability required to adapt to evolving crisis scenarios. MDEs offer a fresh perspective by providing customizable and adaptable platforms that can integrate with existing systems and workflows, empowering users to tailor their environments to specific needs and preferences. By addressing the shortcomings of traditional approaches, MDEs hold promise for revolutionizing how crises are managed and responded to in the future.

Additionally, the motivation to explore MDEs in crisis management arises from the interdisciplinary nature of the field, which draws upon insights from diverse domains such as computer science, psychology, sociology, and emergency management. Collaboration across these disciplines is essential for developing holistic solutions that account for the complex interplay between technological, human, and organizational factors in crisis situations. By fostering interdisciplinary research and collaboration, stakeholders can gain a deeper understanding of the challenges and opportunities associated with MDEs in crisis management, leading to more innovative and effective approaches for addressing the dynamic nature of emergencies.

The motivation to investigate multidisplay environments in crisis management and emergency response is driven by the pressing need to enhance the capabilities of stakeholders in mitigating the impact of crises on society. By leveraging advanced technologies and interdisciplinary insights, MDEs offer a promising avenue for improving situational awareness, decision-making, and collaboration in high-pressure environments. Understanding the motivations behind research in this area is essential for guiding future efforts aimed at harnessing the full potential of MDEs to enhance crisis management practices and save lives.

Objectives:

The objectives of this study encompass a multifaceted exploration of multidisplay environments (MDEs) within the context of crisis management and emergency response. First and foremost, we aim to elucidate the role of MDEs in enhancing situational awareness, decision-making processes, and overall effectiveness during crises. By examining existing literature and case studies, we seek to identify the specific benefits that MDEs offer to emergency responders, decision-makers, and other stakeholders involved in crisis situations. Furthermore, our objective is to provide insights into the design, implementation, and evaluation of MDEs, thereby informing future research and development efforts in this domain.

Secondly, we endeavor to highlight the challenges and considerations associated with the integration of MDEs into existing crisis management systems and workflows. This includes technical challenges related to data integration, system interoperability, and scalability, as well as human factors such as user experience, cognitive load, and decision support effectiveness. By acknowledging these challenges, we aim to facilitate the development of practical solutions and best practices for the successful deployment of MDEs in real-world crisis scenarios.

Additionally, our objectives extend to the exploration of ethical and privacy concerns surrounding the use of MDEs in crisis management. As MDEs often involve the collection, analysis, and dissemination of sensitive information, it is crucial to address ethical considerations related to data privacy, security, and consent. Through an ethical lens, we aim to foster a more responsible and transparent approach to the design and deployment of MDEs, ensuring that they uphold principles of fairness, accountability, and respect for human rights.

Moreover, we seek to examine the diverse applications of MDEs across different domains of crisis management, including natural disaster response, public health emergencies, and counterterrorism operations. By analyzing real-world case studies and examples, we aim to illustrate how MDEs can be tailored to meet the specific needs and challenges of various crisis scenarios, ultimately improving preparedness, response coordination, and resilience in the face of adversity.

Overall, the objectives of this study are to advance understanding, stimulate discussion, and catalyze innovation in the field of crisis management through the lens of multidisplay environments. By addressing key research questions, identifying practical insights, and fostering interdisciplinary collaboration, we aim to contribute to the development of more effective, efficient, and humane strategies for mitigating the impact of crises on society.

Multidisplay Environments: Concepts and Technologies:

Multidisplay environments (MDEs) represent an innovative approach to information visualization and interaction, particularly in contexts where complex data needs to be comprehensively understood and analyzed. At their core, MDEs integrate multiple displays, ranging from traditional computer monitors to immersive virtual reality setups, to create a unified and interactive information space. These environments enable users to simultaneously view and interact with various data sources, enhancing their situational awareness and decision-making capabilities.

One of the key concepts underlying MDEs is the idea of spatial information organization. Rather than presenting information in a linear or static manner, MDEs leverage spatial arrangements to represent data hierarchies, relationships, and context. By organizing information spatially across multiple displays, users can navigate through large datasets more intuitively and gain insights that might be obscured in traditional interfaces.

The technologies powering MDEs continue to evolve rapidly, driven by advancements in display technology, graphics processing, and human-computer interaction. High-resolution displays, such as large-format video walls and curved screens, enable MDEs to present detailed information with clarity and precision. Additionally, interactive input devices, such as touchscreens, gesture recognition systems, and motion-tracking sensors, allow users to manipulate data and control the environment seamlessly.

Moreover, MDEs often incorporate immersive technologies, such as virtual reality (VR) and augmented reality (AR), to enhance user engagement and immersion. VR-based MDEs can transport users into simulated environments, where they can interact with data in three-dimensional space, while AR-enabled MDEs overlay digital information onto the physical world, augmenting users' perception of their surroundings. These immersive experiences can be particularly valuable in training scenarios, where users need to practice decision-making and response strategies in realistic yet controlled environments.

Overall, the concepts and technologies underlying MDEs hold significant promise for a wide range of applications, including crisis management, command and control, scientific visualization, and collaborative decision-making. As these technologies continue to mature and become more accessible, MDEs have the potential to revolutionize how we interact with and understand complex information, empowering individuals and organizations to make more informed decisions in dynamic and high-stakes environments.

Definition of MDEs:

Multidisplay Environments (MDEs) represent a paradigm shift in how information is presented and interacted with in various applications, including crisis management and emergency response. At its core, an MDE consists of multiple display surfaces interconnected to form a unified visual workspace. These display surfaces can range from traditional computer monitors to large-scale video walls and immersive virtual reality environments. The defining characteristic of MDEs lies in their ability to seamlessly integrate and coordinate information across these displays, enabling users to interact with data in a more natural and intuitive manner.

One key aspect of MDEs is their capacity to support simultaneous visualization of multiple data sources, such as maps, sensor feeds, live video streams, and textual information. By organizing and presenting this information across multiple displays, MDEs enhance situational awareness by providing users with a holistic view of the operational environment. This comprehensive view enables users to identify patterns, detect anomalies, and assess the impact of various factors on the crisis situation.

Furthermore, MDEs facilitate collaborative sensemaking by allowing multiple users to interact with the shared visual workspace concurrently. Through features like multi-user input and distributed coordination tools, MDEs enable teams of emergency responders, decision-makers, and subject matter experts to collaborate effectively in real time. This collaborative approach fosters information sharing, mutual understanding, and collective problem-solving, leading to more informed decisions and coordinated responses.

In addition to supporting real-time interaction and collaboration, MDEs also enable users to customize their visual workspace according to their specific needs and preferences. Through flexible layout configurations, customizable data visualization techniques, and adaptive user interfaces, MDEs empower users to tailor their environment to suit the demands of the crisis situation and their individual roles and responsibilities.

Overall, MDEs represent a powerful tool for enhancing situational awareness, supporting decision-making and facilitating collaboration in crisis management and emergency response scenarios. By leveraging the capabilities of multiple display surfaces and advanced interaction techniques, MDEs enable users to effectively navigate the complexity and uncertainty inherent in crisis situations, ultimately leading to more efficient and coordinated response efforts.

Components and Features:

Components and features of multidisplay environments (MDEs) play a pivotal role in shaping their effectiveness in crisis management and emergency response scenarios. At their core, MDEs consist of multiple display screens arranged in a cohesive layout, often augmented by advanced computing systems and interactive technologies. These displays serve as windows into various sources of information, ranging from live feeds of sensor data to real-time communication channels. By aggregating and presenting this diverse information in a coherent manner, MDEs enable users to gain a comprehensive understanding of the crisis situation and its evolving dynamics.

One key component of MDEs is their information visualization capabilities. Through intuitive graphical representations, such as maps, charts, and diagrams, MDEs translate complex data streams into actionable insights. By leveraging techniques like data fusion and spatial-temporal visualization, MDEs help users identify patterns, trends, and anomalies in the data, facilitating rapid decision-making in time-critical situations. Moreover, customizable display layouts and interactive controls empower users to tailor the visualizations to their specific needs and preferences, enhancing usability and efficiency.

Another important feature of MDEs is their integration with sensor networks and data fusion systems. By interfacing with a wide array of sensors, including cameras, GPS devices, and environmental monitors, MDEs can ingest real-time data from the crisis environment. Through sophisticated data fusion algorithms, MDEs integrate and synthesize this disparate sensor data into a unified situational picture, providing users with a comprehensive view of the crisis landscape. This integration enables users to monitor critical parameters, detect emerging threats, and assess the impact of interventions in real time.

Furthermore, collaboration tools and communication interfaces are essential components of MDEs, facilitating seamless interaction among emergency responders and stakeholders. Through features such as shared workspaces, chat channels, and video conferencing, MDEs promote collaboration and coordination across distributed teams. By enabling real-time information sharing and decision support, these communication features enhance situational awareness and foster effective teamwork in crisis situations. Moreover, MDEs support multi-modal interaction modalities, accommodating diverse user preferences and accessibility needs.

Lastly, scalability, flexibility, and robustness are key features that distinguish effective MDEs in crisis management contexts. Scalable architectures and flexible deployment options enable MDEs to adapt to varying operational requirements and resource constraints. Moreover, robustness against technical failures and disruptions ensures continuous functionality and reliability, even in challenging environments. By prioritizing these features in the design and implementation of MDEs, stakeholders can maximize their utility and resilience in supporting emergency response efforts.

Integration with Crisis Management Systems:

Integration with crisis management systems is a pivotal aspect of maximizing the effectiveness of multidisplay environments (MDEs) in emergency response scenarios. These systems serve as the backbone for coordinating resources, disseminating critical information, and facilitating decision-making among response teams. Seamless integration between MDEs and crisis management systems ensures that real-time data streams, such as sensor data, incident reports, and resource allocations, are readily accessible and effectively visualized within the MDE interface. This integration empowers users to monitor unfolding events, analyze situational dynamics, and formulate response strategies in a cohesive and coordinated manner.

One of the primary advantages of integrating MDEs with crisis management systems is the ability to aggregate and synthesize heterogeneous data sources into a unified display environment. By accessing data feeds from disparate sources, including geographic information systems (GIS), weather monitoring systems, social media platforms, and communication networks, MDEs can provide comprehensive situational awareness to decision-makers. This holistic view enables stakeholders to identify emerging threats, assess their impact, and allocate resources accordingly, thereby enhancing the overall responsiveness and resilience of emergency response efforts.

Furthermore, integration with crisis management systems facilitates seamless communication and collaboration among distributed response teams. MDEs can serve as a shared workspace where stakeholders from different agencies and jurisdictions can interact, share information, and coordinate response activities in real time. Through features such as interactive maps, chat functionality, and synchronized views, MDEs promote transparency, interoperability, and mutual understanding among diverse stakeholders, thereby fostering a more cohesive and coordinated response to complex emergencies.

Moreover, integration with crisis management systems enables adaptive decision support functionalities within MDEs, leveraging advanced analytics and simulation capabilities to assist decision-makers in evaluating alternative courses of action. By integrating predictive modeling tools, risk assessment algorithms, and decision support systems, MDEs can help anticipate future developments, assess the potential consequences of different response strategies, and optimize resource allocation decisions in dynamic and uncertain environments. This proactive approach enhances the resilience and effectiveness of emergency response efforts, enabling stakeholders to mitigate risks, minimize losses, and expedite recovery processes.

Integration with crisis management systems is essential for harnessing the full potential of multidisplay environments in emergency response contexts. By seamlessly connecting MDEs with existing information infrastructures, stakeholders can leverage real-time data streams, facilitate communication and collaboration, and enhance decision support capabilities to effectively respond to crises and mitigate their impact on communities and infrastructure.

Benefits of MDEs for Crisis Management:

Multidisplay Environments (MDEs) offer a multitude of benefits for crisis management and emergency response efforts. Firstly, MDEs enhance situational awareness by providing stakeholders with a comprehensive view of the crisis scenario. Through the integration of various data sources, including real-time sensor data, satellite imagery, and social media feeds, MDEs enable responders to gain a holistic understanding of the situation, identifying critical trends, patterns, and anomalies that may not be apparent through traditional means. This enhanced situational awareness allows responders to make informed decisions quickly, allocate resources effectively, and prioritize response actions based on the evolving needs of the situation.

Secondly, MDEs facilitate decision-making by providing intuitive and interactive interfaces that enable users to visualize and analyze complex data in real time. By presenting information in a clear and accessible manner, MDEs empower decision-makers to assess alternative courses of action, evaluate their potential impact, and collaborate with other stakeholders to develop and implement effective response strategies. Whether coordinating rescue operations, managing evacuation routes, or allocating medical supplies, MDEs provide decision-makers with the tools they need to navigate the complexities of crisis situations and make timely, evidence-based decisions.

Moreover, MDEs foster collaboration and communication among stakeholders by providing shared workspaces and communication channels that facilitate information sharing and coordination. In crisis scenarios involving multiple agencies, organizations, and jurisdictions, effective communication is essential for ensuring a coordinated and cohesive response. MDEs enable responders to share real-time updates, exchange critical information, and coordinate response efforts in a centralized platform, reducing the risk of miscommunication, duplication of efforts, and conflicts between stakeholders.

Furthermore, MDEs support training and preparedness activities by providing realistic and immersive simulation environments that enable responders to practice and refine their skills in a

safe and controlled setting. By simulating various crisis scenarios, responders can familiarize themselves with emergency procedures, test different response strategies, and identify areas for improvement before facing real-world challenges. This proactive approach to training and preparedness not only enhances the effectiveness of response efforts but also increases the resilience of communities to future crises.

Overall, the benefits of MDEs for crisis management are manifold, ranging from enhanced situational awareness and decision-making to improved collaboration and training capabilities. As the complexity and frequency of crises continue to increase, the integration of MDEs into emergency response systems will become increasingly essential for mitigating the impact of disasters and protecting the safety and well-being of communities.

Enhanced Situational Awareness:

Enhanced situational awareness is a critical component of effective crisis management and emergency response strategies. It refers to the ability of individuals and organizations to perceive, comprehend, and anticipate events and developments within their operational environment. In the context of multidisplay environments (MDEs), situational awareness is augmented through the integration of real-time data feeds, sensor information, geospatial mapping, and other relevant sources of information into interactive and immersive interfaces.

One key aspect of enhanced situational awareness enabled by MDEs is the consolidation and visualization of disparate data streams. By aggregating information from various sources, such as surveillance cameras, weather sensors, social media feeds, and communication networks, MDEs provide users with a comprehensive and up-to-date understanding of the crisis situation. This holistic view allows stakeholders to identify patterns, trends, and anomalies that may be indicative of emerging threats or opportunities.

Moreover, MDEs facilitate the interpretation and analysis of complex data through intuitive and interactive visualization techniques. By presenting information in a visual format, such as maps, charts, graphs, and timelines, MDEs enable users to quickly grasp the spatial and temporal dimensions of the crisis, identify relevant relationships and dependencies, and assess the potential impact of different courses of action. This visual clarity enhances decision-making by reducing cognitive overload and enabling rapid assimilation of information.

In addition to improving individual awareness, MDEs also support collaboration and information sharing among multiple stakeholders involved in crisis management efforts. By providing a common platform for communication and coordination, MDEs enable real-time data exchange, shared situational awareness, and synchronized decision-making across organizational boundaries. This collaborative approach enhances overall response effectiveness by leveraging the expertise and resources of diverse stakeholders and promoting a unified response to the crisis.

Furthermore, MDEs enable proactive monitoring and early warning capabilities, allowing organizations to anticipate and mitigate potential risks before they escalate into full-blown crises. By continuously monitoring relevant indicators and triggering alerts based on predefined

thresholds or patterns of concern, MDEs empower decision-makers to take timely and targeted actions to prevent or mitigate adverse outcomes. This proactive approach helps to minimize the impact of crises, reduce response times, and enhance overall resilience in the face of evolving threats and challenges.

Summary:

Multidisplay environments (MDEs) offer a promising approach to enhance crisis management and emergency response efforts by providing stakeholders with comprehensive situational awareness and decision support capabilities. By integrating diverse data sources and leveraging interactive visualization techniques, MDEs enable users to rapidly process information, collaborate effectively, and make informed decisions in dynamic and high-pressure environments. Despite their potential benefits, the adoption of MDEs in crisis management faces various challenges, including technical limitations, human factors, and ethical considerations. Through interdisciplinary research and collaboration, stakeholders can address these challenges and capitalize on the opportunities presented by MDEs to improve the effectiveness and efficiency of crisis response efforts.

References:

- Endsley, M. R. (2017). Design and Evaluation for Situational Awareness Enhancement. In Designing for Situation Awareness: An Approach to User-Centered Design (2nd ed., pp. 1-24). CRC Press.
- McNeese, M. D., & Wickens, C. D. (2001). Engineering management of multiple display systems for multitask environments. Human Factors, 43(4), 588-604.
- Lee, E. Y., & Lee, J. H. (2019). Design and Implementation of Decision Support System for Disaster Response Using Multidisplay Environments. Sensors, 19(7), 1663.
- Yamada, K., Ogasawara, T., & Hirata, H. (2016). Development of a 4D Multidisplay System for Disaster Response Operations. Journal of Computing and Information Science in Engineering, 16(2), 021012.
- Lee, Y., & Ko, I. (2018). Smart Operation Room Using Multidisplay Environments for Crisis Management. Journal of Medical Systems, 42(3), 47.
- Kiefer, P., Benfield, J. A., Yamada, K., & Hirata, H. (2019). Situation Room: Developing an Immersive and Collaborative Multidisplay Environment for Disaster Response. IEEE Computer Graphics and Applications, 39(4), 47-58.
- Chen, W., Chang, C., & Hou, T. (2020). Development of a virtual reality-supported multi-display system for disaster management. International Journal of Information Management, 50, 324-338.
- Luh, H., & Lin, C. (2018). Developing a Collaborative Virtual Emergency Operations Center for Disaster Management with a Multi-Display System. International Journal of Environmental Research and Public Health, 15(11), 2476.
- Dalton, J., Daud, N., Dalton, C., & Abdul Rahman, A. (2019). Human computer interaction in disaster response and management: Opportunities and challenges from HCI 2016 workshop. International Journal of Disaster Risk Reduction, 35, 101081.
- Zou, Z., Song, Y., Peng, M., & Wang, Y. (2020). A dynamic real-time collaborative platform for emergency management based on multi-display technology. International Journal of Disaster Risk Reduction, 46, 101505.
- Wei, C., Li, W., Wang, J., & Yang, Y. (2017). Design and application of multi-display collaborative decision-making system for emergency command. IOP Conference Series: Earth and Environmental Science, 103(1), 012035.
- Wang, H., Du, Z., Sun, Q., & Shi, Y. (2019). Research on Multi-Display Collaborative Emergency Decision-Making System. IOP Conference Series: Earth and Environmental Science, 251(5), 052026.
- Hung, T., & Shih, F. (2017). Application of multidisplay integrated system on a unified emergency command system. IOP Conference Series: Materials Science and Engineering, 261(1), 012044.
- Zhang, X., Shi, Y., Chen, L., Yang, X., & Shu, J. (2020). A Multi-Display Collaborative Decision-Making System for Urban Emergency Management. Journal of Sensors, 2020, 8820380.

- Xu, Y., Wang, Y., & Wang, Y. (2018). Multi-Display Decision Making System for Urban Emergency Management Based on Cloud Computing. International Journal of Security and Its Applications, 12(2), 85-96.
- Yang, J., Chen, L., & He, W. (2019). A Multidisplay Collaborative System for Emergency Management Based on Large-Screen Wall Technology. IEEE Access, 7, 149125-149133.
- Ma, J., Lin, L., Yan, Y., & Cui, Y. (2018). Research on intelligent emergency decision-making system based on multi-display. Journal of Physics: Conference Series, 1069(1), 012006.
- Li, Y., Liu, B., Li, Y., & Feng, X. (2019). The Application of Multi-Display Technology in the Urban Waterlogging Emergency Management. Water, 11(2), 233.
- Chen, W., Huang, C., Chou, Y., & Cheng, J. (2020). Development of a Multi-Display Collaborative System for Emergency Response with Enhanced Scalability and Flexibility. Sustainability, 12(5), 1835.
- Lee, Y., & Lee, J. (2019). Development of an Interactive Simulation Platform for Emergency Response Training with Multi-Display Environments. International Journal of Environmental Research and Public Health, 16(4), 617.
- Wang, X., Chen, J., Li, L., & Zhou, X. (2020). Development of a Smart Operation Room System for Emergency Management Using Multidisplay Environments. Journal of Healthcare Engineering, 2020, 8845152.
- Fan, H., Liu, X., Zhu, L., & Cheng, Y. (2018). Multi-Display Collaborative Virtual Reality Emergency Management System. Journal of Software, 13(10), 617-625.
- Jeong, Y., & Cho, K. (2018). Design of a Multi-Display Collaborative System for Emergency Response. Journal of Korean Institute of Industrial Engineers, 44(5), 476-486.
- Luo, H., Zhu, L., Yu, H., & Zhai, J. (2019). Design and Implementation of a Multi-Display Collaborative Emergency Management System Based on Service-Oriented Architecture. Journal of Sensors, 2019, 4760452.
- Wang, Q., & Zhang, H. (2019). Research on Urban Emergency Management Collaborative Decision-Making Based on Multi-Display Technology. IOP Conference Series: Materials Science and Engineering, 572(6), 062033.