Proceedings of the 2nd Workshop on Mobile Resilience: Designing Mobile Interactive Systems for Crisis Response

TECHNISCHE UNIVERSITÄT DARMSTADT

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Abstract

Information and communication technologies (ICT), including artificial intelligence, internet of things, and mobile applications can be utilized to tackle important societal challenges, such as the ongoing COVID-19 pandemic. While they may increase societal resilience, their design, functionality, and underlying infrastructures must be resilient against disruptions caused by anthropogenic, natural and hybrid crises, emergencies, and threats. In order to research challenges, designs, and potentials of interactive technologies, this workshop investigated the space of mobile technologies and resilient systems for crisis response, including the application domains of cyber threat and pandemic response. The workshop was part of the *ACM International Conference on Mobile Human-Computer Interaction (MobileHCI 2021)* [1], which took place from Sept. 27 to Oct. 1, 2021. The conference was conducted virtually and organized from Toulouse, France. As a follow-up of our first workshop on mobile resilience [2], the *2nd Workshop on Mobile Resilience: Designing Mobile Interactive Systems for Crisis Response* [3] was held on Sept. 27, 2021 and organized by Marc-André Kaufhold, Christian Reuter (Technical University of Darmstadt), Tina Comes (Delft University of Technology and University of Maastricht), Milad Mirbabaie (Paderborn University), and Stefan Stieglitz (University of Duisburg-Essen). Since only the workshop proposal paper was published in the ACM Digital Library [4] as part of the MobileHCI 2021 adjunct proceedings, we decided to publish the individual workshop contributions at TUprints. After a short introduction of the motivation, goals, contributions, and schedule of the workshop (section 1), the four contributions of the workshop are integrated (sections 2-5). The document concludes with closing remarks on the program comittee (section 6).

Contents

Mobile Resilience '21

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1 Introduction of the Workshop

The digitalization by information and communication technologies (ICT), including recent innovations based on artificial intelligence, internet of things, mobile applications, or social media, exerts an increasing influence on contemporary and future societies. Thus, the terms of smart cities and smart rural areas were coined to leverage digital innovation in urban and rural areas [5], [6]. Besides everyday use, ICT can be used to enhance societal response to anthropogenic (e.g., bombings, cyberattacks), natural (e.g., earthquakes, floods, hurricanes), or hybrid disasters [7]–[9], which is currently demonstrated by the deployment of contact tracing apps during the COVID-19 pandemic [10]. However, others challenges arise from this:

- How can the functioning of societal and related ICT be secured in anthropogenic, natural, or hybrid extreme situations, crises, and catastrophes [11], [12]?
- In light of an increasing exposure of digital infrastructures, how can we increase preparedness and response capabilities against cyber threats [13]?
- How can big crisis or social data be prepared for a meaningful analysis by authorities and organizations, also mitigating the issues of information overload and low information quality [14], [15]?
- How can the availability, integrity, reliability, and resilience of critical infrastructures in digitally interconnected areas be improved in the future [16], [17]?

These are only some questions that society needs to address to increase its *resilience* [18]. In this context, resilience can be understood as "the ability of a [socio-technical] system to cope with perturbations such as crisis and shocks while preserving its functions" [19]. While *resilient systems* have been described by the characteristics of absorption, recovering, adaptation, or transformation [20], research characterized *(mobile) technologies for resilience* by the properties of accessibility, diversity, evolvability, and usability, amongst others [21]. At the same time, the research field of crisis informatics [22] increasingly investigates the potentials and limitations of artificial intelligence [23], social media [24], and mobile technologies such as crisis and warning apps [25], which constitute a relatively new public service for citizens and are specifically designed for the dissemination of disaster-related information and communication between authorities, organizations, and citizens [26]. However, another emerging challenge lies in fighting "infodemics", i.e., the dissemination of misinformation in pandemics [27]. Furthermore, if critical communication or energy infrastructures fail, for instance, the distribution of recommendations and warning messages is challenged and requires alternative infrastructures [16].

1.1 Goals

In this workshop, we wanted to explore the overlapping space that both *mobile interactive technologies* and *resilient systems* yield as fields of research. Specifically, in the second iteration of the workshop it was of interest to us how to integrate mobile applications into cyber incident and pandemic response. Thus, we seek to produce empirical findings related to design opportunities for resilient mobile and interactive systems. Furthermore, we aimed at working out the state of research in the fields of mobile interactive technologies and resilient systems. Lastly, avenues for further research and the potentials of both fields were in the scope of this workshop. Key topics of the workshop included but were not limited to:

- Case studies, surveys, use cases, and theories on mobile, social, and technological resilience, including application domains such as crisis response, cyber threats, infodemics, or pandemics
- Algorithms and systems for user-centered analysis of big crisis data, including cyber situational awareness, open source intelligence, social media analytics, credibility and relevance assessment, or social sensors
- Concepts and technologies for contact tracing in pandemics or stakeholder collaboration, including authorities, computer emergency response teams, rescue organizations, and citizens
- Human and technical factors in decentralized infrastructures, edge computing, and wide area networks for crisis management and response
- Innovative analysis, (interaction) design, and evaluation of resilient mobile or social (crisis) information systems
- Functionality, robustness, usability, and user experience of resilient technologies such as mobile crisis and warning apps or wearables
- Best practices, methods, and strategies for the development and deployment of resilient (mobile) technologies in diverse application domains

1.2 Contributions

The submissions to the workshop addressed some of the open issues mentioned above. Researchers from fields such as human-computer interaction, cyber security, crisis informatics, emergency communication, mobile information systems, and digitalization of human agglomerations were invited to submit abstracts or short papers for presentation and discussion at the workshop. The workshop was held as a virtual conference and followed a half-day format, including four workshop contributions of 30 minutes. Each workshop contribution comprised a 10 to 15min presentation followed by a discussion or interactive session. The following contributions have been accepted for presentation:

The first contribution *Optimal Rescue Sequences Under Time Pressure Induced by Degrading Health States* by Rabeaeh Kiaghadi and Martin Fränzle examines the use of robots to resuce several patients exposed to potentially fatal incidents under time pressure. In this approach, a time-variant survival function is allocated to each patient which illustrates the decreasing probability of them surviving over time, whether being rescued or self-healed. The desired task for the agent, which has been defined as a dynamic travelling salesman problem (TSP), is to maximize the expected number of rescued alive patients considering time as its primary budget resource. The algorithm consists of a modified genetic algorithm with a heuristic cost function that considers all changes at each step of the robot's path and replans when it is necessary. Similar to actual search and rescue missions, the severity of patients' condition is categorized into different groups of high, medium, low, and lost.

The second contribution *A Concept for Creating Mobile Games for Enhanced Disaster Preparedness in Cooperation with Local Communities* by Michael Klafft, Ivana Harari, Agnieszka Dudzinska-Jarmolinska, Ricardo Antonio Gacitua Bustos, and Solhanlle Bonilla Duarte presents a concept on how to use local knowledge and user-generated content from previous disasters in order to create mobile games that support disaster risk awareness and disaster preparedness. The concept involves students or pupils from the area at risk who will not only create the games but also act as multipliers and disseminate the games and disaster knowledge locally, thus increasing the resilience of the local population. The approach is currently being tested as part of a mobile computing class at Universidad Nacional de La Plata in Argentina. During game design, a particular focus is placed on accessibility issues, thus ensuring that the designed games are suitable for a wide-ranging audience.

The third contribution *Deploying Mobile-based Disaster Relief Systems Trained on Social Media Data*" by Thomas Chen outlines the limitations of existing machine learning datasets for damage assessment based on satellite imagery or social media data. As for datasets sourced from social media, a notable recent development is the Incidents Dataset from Google Images, which is comprised of images of damage incidents largely resulting from natural disasters. The baseline model that the author employed was tested on data from Twitter und Flickr. Instead of utilizing satellite-based remote sensing, this data sourced from on the ground presents new opportunities. However, given that the dataset is a very recent development, there have not been enough subsequent studies based on it to determine its efficacy compared to satellite imagery pipelines.

The fourth contribution *Towards Strategies and Technologies for Actor-Specific Communication of Cyber Threat Warnings* by Marc-André Kaufhold, Ali Sercan Basyurt, Marc Stöttinger, Stefan Stieglitz, and Christian Reuter presents both qualitative and quantitative empirical findings on the use of traditional, mobile, and social media for crisis communication. While previous research focused on the use of mobile devices during natural harzards, this contribution also discusses challenges for communicating anthropogenic hazards, especially cyber threats and their potential impact on critical and sociocultural infrastructures. Finally, it presents a mobile app established in Germany for communicating natural and anthropogenic hazards, also describing strategic and technological potentials to increase citizens' prevention and response capabilities against cyber threats, which is subject of research within the CYWARN project.

2 Optimal Rescue Sequences Under Time Pressure Induced by Degrading Health States

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Extended Abstract

The world we live in faces hazardous incidents every day. In most of cases, rescue operations come across difficulties because the environment is unknown. There are tons of financial and life losses in each incident and in unexpected scenarios such as search and rescue, decision making plays the key rule [1]. The faster we could decide what to do, the lesser the losses would become. That is why time is one of the most important parameters in decision making and time management would be the priority of any decision making procedure for such incidents [2]. Otherwise, the consequences will be irrecoverable. However, there are scenarios in which no human can perform efficiently. Although human physical abilities may be limited, his intelligence is not. Thus, the need of having a secure alternative solution for such circumstances has become of crucial importance. This is where robots set foot in.

The problem we addressed in our work is to follow a time-cost trade-off considering the uncertainties and probabilities we come across under actual emergency dynamic circumstances. A robot is walking in an unknown area to rescue several patients that have been exposed to possible fatal incidents [3]. A time-variant survival function is allocated to each patient that illustrates the decreasing probability over time of them surviving, whether being rescued or self-healed. The desired task for our agent, which has been defined as a dynamic travelling salesman (TSP) problem [4], is to maximize the expected number of rescued alive patients considering time as its primary budget resource.

Travelling salesman (TSP) is considered a combinatorial NP-hard problem, for which there has been several solutions proposed in the available literature. In order to find an optimized path for TSP, heuristic and metaheuristic algorithms have been carried out. Hereby, we utilize a genetic algorithm as a baseline approach to which we adapt this probabilistic dynamic decision making problem of search and rescue. Although the genetic algorithm becomes computationally expensive when the number of parameters increases, it is still one of the best algorithms in finding an optimal solution by using various combinations of genetic operators [5].

Our algorithm consists of a modified genetic algorithm with heuristic cost function updating the current plan based on changes in accumulative likelihood of other patients staying alive. Since the state of patients' health condition varies over time, it is the robot who should take the best approach in order to rescue as many patients as possible [6], [7]. For this to be done, our algorithm considers all changes at each step of the robot's path and thw robot replans it if necessary. Similar to actual search and rescue missions, the severity of patients' condition is categorized into different groups of high, medium, low, and lost. As a result, our TSP problem has been broken down into four interconnected problems based on these priority levels.

Taking the mentioned approach into account, the results illustrate that the proposed algorithm follows our mindset as if a human was to decide under the simulated circumstances instead of the robot. The proposed algorithm will be economic with regard to a maximized number of patients rescued in an optimized amount of time. Presuming confronting an unexpected variation in data, namely a new patient is found on the robot's mission path, patients' health condition changes, or a patient loses life prior to being rescued, this algorithm is feasible enough to be adapted.

With the advent of embedded technology pursuing, among others, substantial autonomous decision-making, Human-Computer-Interaction is becoming an inevitable part of many applications, permitting and securing human influence and intervention. Currently, our strategy embedded into the decision-making is exclusively utilitarian, based on a defined scheme of assigning equal values to the lives of patients without any differentiation based on, e.g., altruistic indiviuals' will to sacrifice themselves for others or societally agreed preferences based on, e.g., age or gender. Consequently, the HCI is restricted to the interaction of patients with robotic agents. However, in an actual incident where robots are not the only agents performing search and rescue operations, ethical aspects and personal attitudes come into play. It might become a matter of concern whether the optimal sequence of a rescue mission provided by a robot's calculation would be reliable/acceptable for human agents to follow regarding their moral beliefs. If ethical aspects and personal attitudes should be taken into consideration, the design of HM interfaces permitting to express and respect these will be an interesting future topic to study.

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3 A Concept for Creating Mobile Games for Enhanced Disaster Preparedness in Cooperation with Local Communities

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3.1 Introduction

Enhancing disaster preparedness and resilience is a key objective of disaster management agencies and authorities. In order to achieve this goal, authorities often use top-down communication approaches – usually based upon disaster management practitioners' analysis and scientific evidence – to inform the public about potential hazards and recommended disaster preparation and mitigation measures. This approach is based upon the information deficit model (IDM) of risk communication, which stipulates that a lack of disaster preparedness is primarily caused by information deficits, i.e., by lack of knowledge about relevant risks, and recommended protective action. However, based on a literature survey about the IDM, Abunyewah et al. [1] conclude that the information deficit approach has not been very effective because it "situates the public in a passive, disentangled role". They therefore propose an amended model that includes community participation as an additional success factor and show that such participation can significantly increase the citizens' intention to prepare for disasters. Unfortunately, participation with the public – albeit being widely acknowledged as necessary – is a "currently unrealized means of governing socio-environmental challenges" [2] such as disasters, as Cook and de Lourdes Melo Zurita state. Appleby-Arnold et al. [3] argue that authorities should involve citizens to develop "cultures of disaster preparedness, which are informed by citizens' values and experiences rather than imposed from above". Following such an approach "will help community members learn from each other about local hazards and disaster risks, and so strengthen community spirit for improved community responses in the event of a disaster" [3]. In order to foster such community involvement, different types of activities involving disaster survivors have recently been developed and tested in cooperation with schools, universities, and volunteer organisations [4]. One such example are disaster days with public discussions about disaster risks and disaster preparedness, another are courses at schools and universities which use testimonies of disaster survivors and photographic materials provided by eyewitnesses to create open educational resources about historic disasters from citizens for the citizens. Another promising approach to better involve citizens in risk communication are digital serious games [5], i.e., computer or mobile games which focus on disaster learning while actively enganging the player and enhancing the impact of learning through an appeal to emotional factors. In this paper, we will propose an approach how to combine community participation and the development of mobile serious games from citizens for citizens in order to enhance disaster preparedness and resilience. In the next section, we will provide an overview of previous research on digital serious games for risk communication. Thereafter, the concept of the proposed approach is presented, and we conclude with an outlook on future research.

3.2 Digital Serious Games for Disaster Preparedness and Resilience

Serious games have been widely used to enhance disaster risk management. In their 2018 study, Solinska-Nowak et al. [6] identified and analyzed 45 such games, which included a mix of single-hazard and multi-hazard approaches. The most frequently addressed disaster risk was flooding (27 out of 45 games), followed by earthquakes (10 games), droughts (7), and storms (7). The majority of games focused on the early phases of the disaster management cycle, with 39 games emphasizing disaster preparedness and 25 games addressing disaster prevention and mitigation, whereas only 22 games included aspects of disaster response and just 7 games also included the recovery phase. However, these findings did not only include digital but also some analog serious games, and the statistical findings do not differentiate between the two types of serious games. Gampell et al. [7] specifically analyze disaster-related videogames, and they also find a focus on the early phases of the disaster management cycle, with 12 out of 15 games addressing preparedness, 8 out of 15 addressing mitigation, and 10 out of 15 addressing disaster prevention. Although the impact of disaster-related digital serious games still needs to be analyzed more systematically and comprehensively [8], available research findings show the benefits of game-based learning for disaster preparedness. For three digital games on landslide disasters,

for example, Chun-Hsiung et al. [5] found that computer games significantly enhanced the players' willingness to learn, learned content, and learning attitude. Learners found the learning environment more attractive than in traditional approaches and games stimulated the "learners to complete required learning tasks".

A number of mobile disaster games has also been developed. [9], for example, present a mobile game for earthquake and tsunami disaster education and demonstrate that the learning impact was positively evaluated by users. Mobile games provide several advantages compared to desktop-based games. They can be played (almost) everywhere anytime including at the locations at risk, they can be played on an everyday device most people have access to, and the use of extended or augmented reality functionalities allows for an in-situ experience of disaster risks at the locations / zones at risk. George and Oliva [10] outline potential benefits of including immersive / extended-reality technologies in digital disaster-learning games for schools. However, while doing so, they emphasize the importance of including teachers, pupils, community leaders, and volunteers in the game creation process, thus once again advocating for strong community participation, including in game design.

While previous research underlines the potential of digital games for disaster prevention learning in general and of mobile games in particular, there is, to our knowledge, no systematic approach so far on how to involve the community in the creation of such games. We therefore propose a concept on how such a co-creation approach could look like and report how it is currently being implemented and tested at a university in Argentina. In doing so, we place a focus on the issue of mobile human computer interaction and argue for including accessibility aspects in the game design and creation process in order to make the created products usable for as many people as possible.

3.3 Creating Mobile Games for Disaster Preparedness with Local Communities

The proposed approach strives to include the local community in three phases of the development process: game design, content creation, and implementation. In order to be able to conduct all three phases with the community, it is necessary that some participants either have or are currently learning programming skills, e.g., as part of a university course, or an advanced course in informatics at high school. Please note, however, that game design and content creation can also be conducted independently of the implementation. Basis of all activities is an introduction to local disaster risks and into fundamentals of risk communication (approx. 2 hours). We also propose to provide a link to a website with easy-to-implement protective measures (e.g. nature-based solutions to mitigate the impact of heat waves or floods) and access to a platform that provides disaster-related information created by citizens, such as survivor interviews or multimedia materials from private archives. A prototype of such a platform is currently being implemented as part of the CITADINE research project [11]. This platform enables participants to familiarize themselves with disaster impacts and the consequences of historic disasters (from the own region or from similar disasters in other regions of the world). If possible, we also propose to invite at least one disaster survivor to discuss his or her experiences with the group of citizens working on the mobile application. Finally, we propose to include an introduction to mobile design principles and accessibility on mobile devices if participants are not yet familiar with these concepts. The design and development process then proceeds as follows:

- Game design: After the introductory phase, we propose to conduct creativity workshops (e.g., a design thinking workshop) to develop initial ideas of mobile disaster games. Initial ideas are then detailed with storyboards. At this stage, we propose a discussion and review of the proposals with regard to suitability, feasibility, and required implementation effort (in particular if students or volunteers will do the latter). Revised concepts can then be detailed and concretised using wireframing and mock-up tools. At this stage, accessibility issues need to be discussed, and all solutions should offer at least one theme of the user interface that does meet accessibility requirements for visually impaired people. The user interface should also be suitable for use with screen readers to support use by blind people to the greatest possible extent.

- Content creation: Content needed for the implementation of the game can either be provided via the aforementioned platform with open educational resources or, if suitable content is missing, it can be created in cooperation with local disaster survivors and eyewitnesses. Our experiences so far indicate that most survivors of natural disasters do communicate quite frankly about their experiences and are willing to share their knowledge as well as –if available - also often photographic material of the disaster that they experienced. In order to facilitate this information collection process, community participants have access to suitable interview guidelines and a structured schema for the classification of content. Provided that informed consent is given by the survivors, tagged interview segments and multimedia materials can then be uploaded to the open educational platform in order to further enrich available materials for the ongoing as well as future projects.

- Implementation: It is desirable that the implementation will also be conducted by (some) of the participants involved in the project, i.e., "by the community for the community". The concept behind this approach is to encourage members of the local community to advertise their own disaster game among family, friends, and peers, thus enhancing its impact. However, as our concept foresees an implementation as part of university or school projects, the somewhat limited programming skills of the developers need to be taken into account. In addition to possibly limited skills, lack of access to dedicated game development platforms and engines may also limit the feasibility of solutions. Nevertheless, experience from previous mobile programming courses shows that students are usually able to successfully implement solutions such as quizzes, memory games, or games where selection decisions have to be taken (e.g. with regard to evacuations). One question related to mobile human computer interaction will be to what extent programmers with limited experience will also be able to meet accessibility criteria.

3.4 Preliminary Results

At the time of submitting this article, the proposed approach is being tested with approximately 15 informatics students of Universidad Nacional de La Plata in Argentina. All students were participants of the User Experience Design UED course, a subject which belongs to the last year of the undergraduate degree in Computer Science. In the practical part of the course, the students' task consisted of developing an educational serious game about disaster topics or related themes. In addition to the steps identified in section 3, sudents were provided with comprehensive information about the issue of floodings, which are the most serious threat from natural disasters in the region. Some topics about serious game development and related usability best practices were added to the original curriculum in order to provide necessary additional knowledge for the students. Student projects then had to complete different stages of the user centered design process using different usability techniques. User investigation, context analysis, benchmarking of apps for catastrophes, focus groups to evaluate the preliminary designs, usability best practices research and accessibility compliance, prototyping, heuristic evaluation, and usability testing were some of the engineering methods the students had to apply. Initial results look promising but are still at the implementation stage, thus the effectiveness of the approach cannot be fully evaluated yet.

Initial results show that the students interpreted the topic of "mobile games" broadly. While most students chose to implement accessible responsive web apps (e.g., quizzes or a tool to create digital photoalbums about disasters enriched with multimedia materials), one group also decided to develop a haptic IoT solution: an interactive real emergency backpack which reacts to the items that users try to put into it while preparing for an emergency. The backpack shall provide positive haptic, auditive, or visual feedback if the selected item is suitable for, e.g., an evacuation, and negative feedback if it is not. Regarding the development of accessible responsive web apps, we present an example by Daniel Cesanelli and Francisco Ale [12] who are in the process of implementing a puzzle that supports learning about nature-based solutions for flood preparedness using materials from the CITADINE platform. The gameplay is as follows. Initially, the user is presented briefly with a photo of a nature-based solution, as can be seen in Fig. 1. Pieces of that image are then mixed and have to be reconstructed in the correct way by the user (Fig. 2).

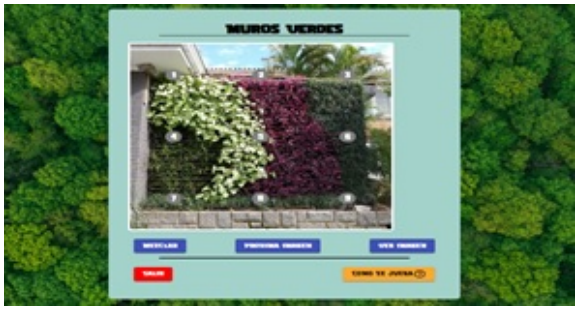

Figure 1: Presentation of the initial picture

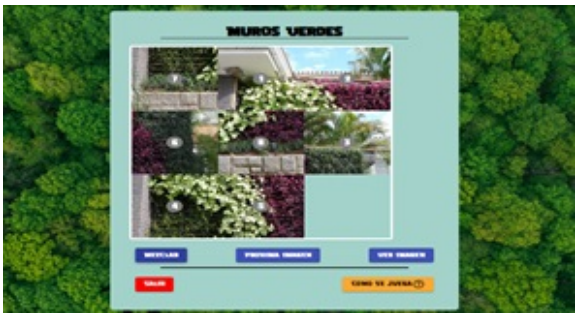

Figure 2: The puzzle

When the user puts all the pieces in order, an embedded educational video is shown to explain how to make use of the presented solution at home and how the proposed measure can enhance disaster resilience. An example of such a video can be seen in Fig. 3. The user can adapt the game according to his requirements. The app allows some accessibility configurations like contrast, difficulty level, or the possibility to set up the use of numbers to identify each picture to reduce complexity during the game interaction (Fig. 4). At the time of submitting the final version of this paper, the students were beginning with usability and accessibility testing of their prototypes. Students will have to check that the apps comply at least with the A and AA levels of the WCAG 2.0 guidelines. Also, they will have to test the games with different profiles of users with regard to different ages, disabilities, and experience.

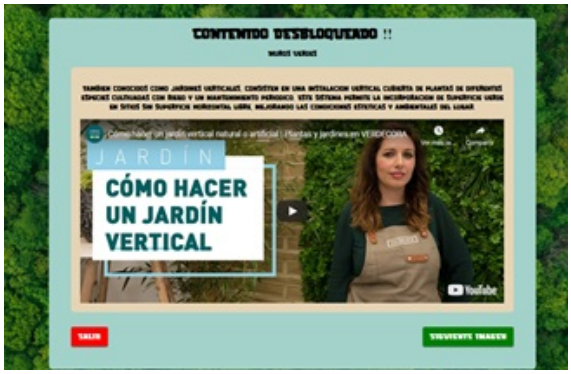

Figure 3: Educational video on vertical gardens

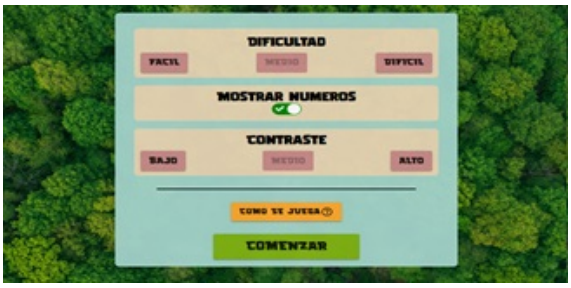

Figure 4: Accessibility settings

3.5 Conclusion and Outlook

In this paper, we showed that it is in principle possible to develop mobile serious games to increase disaster resilience as part of university courses. Successfully implemented formats included quizzes and puzzles (with puzzles being more suitable for devices with larger screens such as tablets). IoT based game solutions such as the interactive emergency backpack are also feasible for students with good programming skills. Once the development, evaluation, and optimization of the student projects has been completed, the next step will be the practical evaluation of these mobile games developed by the local students for the community. This will include the following dimensions: attractiveness of the games for the players, dissemination and uptake, and – most importantly and highly influenced by the two factors before – the contribution of the games to enhanced disaster preparedness and resilience, i.e., what players were able to learn during their play. We also plan to test the concept a second time during the winter term 2021/2022 with students in Germany. Goal of this second test will be to see if and how the proposed concept works in a different regional and cultural setting. A second dimension of future work is to make more content on regional disasters available as open educational resources. One approach here could be to analyze if it is possible to get access to photographic materials on disasters collected by automated reporting tools for disaster professionals, which have been proposed by [13]. However, one key challenge that would have to be addressed here is how to make sure that only suitable materials will be provided, i.e., material that is ethically acceptable (e.g., not showing dead bodies), and which does not violate any other personality rights or copyrights.

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4 Deploying Mobile-based Disaster Relief Systems Trained on Social Media Data

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Keywords: Deep Learning, Computer Vision, Damage Assessment, Social Media Analytics

Extended Abstract

In the deep learning and computer vision communities, multidisciplinary applications, particularly for humanitarian aid and relief, have become popular research problems to tackle in recent years. In the scope of climate change and the resultant increase in natural disaster frequency and intensity around the world, one of these applications is disaster analysis and relief. Crucially, to complete these tasks, there must be datasets available that provide real-time, accurate training data for the development of convolutional neural networks and other deep learning architectures for the timely allocation of resources. Some data sources that have been utilized in previous works include satellite imagery, drone imagery, and social media posts. Natural disasters are an omnipresent threat to countless communities across the world. In order to aid in the targeted and efficient relief and recovery during and after these devastating events, computational methods for analysis and assessment of the damage incurred on infrastructure are necessary. Disasters cause many lives lost, significant building damage, and economic loss across the board. Particularly, in machine learning and computer vision methods, well-curated datasets are needed.

Previous datasets specifically for building damage assessment have largely sourced imagery from satellites or social media. For instance, the xBD dataset, which is currently considered the most comprehensive satellite imagery dataset for building assessment pre- and post- natural disaster, is sourced from the Maxar/DigitalGlobe Open Data Program. In terms of satellite imagery datasets for detecting and classifying building damage, most of the datasets that preceded xBD only contained images from one region of the world and/or images that only represented damage resultant from one or a small number of types of natural disasters . This particular dataset allows for the use of change detection (bitemporal analysis), given that pre- and post- disaster images are provided for each location. However, there are only two snapshots in time for each location; therefore, there is not a wide range of opportunities to conduct more detailed analyses. While many previous papers have trained models with varying accuracy metrics on the test sets and have also delved into presenting interpretable methodologies, they have all been largely based on this one dataset, which is limited in scope despite being known as the most comprehensive of its kind. As previously mentioned, works conducted on datasets preceding xBD were even less generalizable, given that they only contained data from specific geographical or disaster categories. It is precisely due to the fact that images are taken from only two unspecified temporal locations — at one point before the disaster occurs and at one point after — that deep learning models trained on this data do not yield results as desirable as possible. This is in combination with the poor visual distinction between ”major damage” and ”minor damage” category labeled ground truths.

As for datasets sourced from social media, a notable recent development is the Incidents Dataset, which is comprised of images of damage incidents (largely resultant from natural disasters) from Google Images; the baseline model that the author employed was tested on data from Twitter and Flickr. Instead of utilizing satellite-based remote sensing, this data sourced from on the ground presents new opportunities. However, given that this is a very recent development, there have not been enough subsequent studies based on this dataset to determine its efficacy, especially compared to satellite imagery pipelines.

5 Towards Strategies and Technologies for Actor-Specific Communication of Cyber Threat Warnings

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Keywords: Cyber Threat Warnings, Mobile Crisis Apps, Social Media Communication

Extended Abstract

In a globalized world with a growing number of cyber threat situations, citizens, and states are faced with a multitude of challenges [1]. This has been brought back to public attention not least by the WannaCry ransomware in 2017, which infected over 230,000 computers in over 150 countries, or the doxing of German politicians, journalists, and celebrities in 2018/19. Such cyber-attacks pose an increasing threat to socio-cultural infrastructures, as they can cause a breakdown of important communication channels, the disclosure of personal data, and the failure of critical infrastructures (CI). Technological developments in the context of digitalization, such as the Internet of Things or smart cities, enable ever greater connectivity in private and professional contexts. Especially media and information infrastructures are threatened by cyber-attacks, as they are increasingly built on IT infrastructures, and the potential danger of cybercrime for citizens, authorities, and companies is increasing [2]. In consequence, Computer Emergency Response Teams (CERTs) were established in authorities and enterprises as focal points for preventing, receiving, and responding to computer security incidents. On state level, CERTs provide cyber security reports for ministries, consult small- and medium-sized enterprises (SMEs), including critical infrastructure (CI) providers, with regard to security incidents, or provide information on how to better protect against cyber threats for citizens.

In crisis informatics, there are numerous case studies in which the dissemination of content on social media and the warning via crisis apps was examined before, during, and after crisis situations [3], [4]. A large number of these case studies focus on Twitter communication during man-made crises, such as the terrorist attacks in Brussels [5], and during natural disasters, such as hurricane Harvey [6]. Influential actors in crisis communication have already been identified as well as typical content that is observable over the course of crises [7]. In this context, it has been shown that emotional messages in particular spread faster during crisis situations [8]. In addition, other factors such as the length of the message, the addition of URLs, images, and videos as well as the number of followers of the authors play an important role in the effective dissemination of crisis-related information [9]. Furthermore, depending on sociodemographic factors (e.g., age, education, gender, income, or region) citizens use different media, such as crisis apps, radio, social media, television, or websites, to stay informed during crises [10], [11]. However, little attention has been paid to cyber threat communication yet. In particular, there is a lack of research on the effective and targeted dissemination of cyber alerts to specific actors, as most studies to date have focused on how to reach the largest possible user base on social media.

Therefore, this workshop presentation illustrates both qualitative and quantitative empirical findings on the use of traditional, mobile, and social media for crisis communication [4], [12], [13]. While previous research focused on the use of mobile devices during natural harzards [14], this contribution also discusses challenges for communicating anthropogenic hazards, especially cyber threats and their potential impact on critical and sociocultural infrastructures. For this, it presents the design of a security dashboard for the collection, analysis, and preparation of cyber threat and vulnerability information for citizen communication. Finally, it presents a mobile app established in Germany for communicating natural and anthropogenic hazards, also describing strategic and technological potentials to increase citizens' prevention and response capabilities against cyber threats, which is subject of research within the CYWARN project [15].

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6 Closing Remarks on the Program Comittee

The interdisciplinary workshop on mobile resilience was organized by the following people:

Marc-André Kaufhold is a postdoc at the Chair of Science and Technology for Peace and Security (PEASEC) in the Department of Computer Science at the Technical University of Darmstadt, Germany. He is project manager in CYWARN (2020-2023, BMBF), researcher at the ATHENE mission SecUrban, and associated member of the LOEWE centre emergenCITY. His research focuses on the user-centred design and evaluation of mobile apps and social media in the context of crisis and security research, comprising about 80 scientific articles in the fields of Crisis Informatics, Human-Computer Interaction, and Information Systems.

Christian Reuter is Professor at Technical University of Darmstadt, Germany. His chair Science and Technology for Peace and Security (PEASEC) in the Department of Computer Science with secondary appointment in the Department of History and Social Sciences combines computer science with peace and security research. On the intersection of the disciplines (A) Human-Computer Interaction, (B) Cyber Security and Privacy, and (C) Peace and Conflict Studies he and his team specifically address (1) Crisis Informatics and Information Warfare, (2) Usable Safety, Security, and Privacy, and (3) Technical Peace Research.

Tina Comes is Full Professor at the faculty of Technology, Policy and Management at Delft University of Technology, the Netherlands and Full Professor in Decision-Making & Digitalisation at the University of Maastricht, the Netherlands. Tina also serves as Scientific Director of the 4TU Center on Resilience Engineering and is a member in the Norwegian Academy of Technological Sciences. Her research focuses on the collaborative and informational aspects of resilient societies. Tina investigates the role of information in urgent and ill-defined problems to design better sensemaking and decision support systems, which are applied in areas such as critical infrastructures, supply chain risk, and humanitarian logistics.

Milad Mirbabaie is Assistant Professor for Management Information Systems at Paderborn University, Germany. He has published in reputable journals such as Journal of Information Technology, Internet Research, Information Systems Frontiers, International Journal of Information Management, and International Journal of Human Computer Interaction. His work focuses on the use of digital technologies in the digital society. His application domains are crisis management, digital work, and digital health. In 2017, one of his articles was awarded with the Claudio Ciborra Award at the European Conference on Information Systems for the most innovative research article.

Stefan Stieglitz is Professor and head of the research group for Digital Communication and Transformation (digicat) at the University of Duisburg-Essen, Germany. In his research, he investigates how to make use of social media data. Moreover, he analyzes user behaviour and technology adoption of collaborative information systems in organizational contexts. He is director and founder of the Competence Center Connected Organization. His work has been published in reputable journals such as the Journal of Management Information Systems, European Journal of Information Systems, Journal of Information Technology, and Business & Information Systems Engineering.

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