

Implementation of Information System in Crisis Management Using Modeling and Simulation

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Abstract — Crisis is complex situations and their systematic study requires the application, experience and research from a multidisciplinary spectrum. Various formal research methods have been applied in the complex context of crisis. Crisis research has to be planned with the focus towards real world applications. In today's digital age where online communication is a source of information dissemination has hijacked one and all modes of communication. Therefore it has become an unbeatable instrument in crisis management if utilized efficiently. With the advancement in crisis informatics theory, novel applications, techniques and creative ways of getting hard to reach data, crisis prediction and management has taken a new form. There are various challenges in studying exercises, training versus real time situation. The decision makers face difficulty in devising the preparation and response mechanism because of the uncertainty and complexity.

Keywords - Crisis; Serious Gaming; Virtual Community; Social Networks

I. INTRODUCTION

In an increasingly dynamic evolving environment that impacts complex networks of socio technological and economic systems, the usual paradigm of crisis handling are challenged. The information from heterogeneous sources and actors lead to decisions whose implications need to be accessed across organizations. Therefore, there have to be decision making processes and tools which aim to provide actionable and relevant information to responders, policy makers and public. There needs to be well structured, effective decision support systems which enable collective sense making and collaborate decision making facilitating swift action during a crisis. Information systems have to be designed for performance assessment, humanitarian logistics, robust decisions support and agile solutions. The execution of planning is done in uncertainty therefore the processes and modeling needs to be iterative, agile and adaptive in nature Disconnected cluster of peoples where groups of peoples are not all connected.

II. SURVEY AND BACKGROUND

A. Understanding Collaborative Work Practices

In today's world, world of information systems, the prime focus of crisis management should be on practical work that is required for collaborative accomplishment through information systems. The background work on this should be field study, design implication and other observations which enlighten the process of emergency management with respect to information communication technology There should be incorporation of technologies like social media, decision systems, geospatial systems and GIS.

Designing systems and services to support crisis response, it will enable efficient crisis management and response. There is a need of innovative solutions which incorporate current information systems and technologies to successfully manage crisis. Since diverse people are involved, therefore interdisciplinary approaches have to be designed to incorporate human factors. There should be methodologies and tools for capturing human experiences and requirements. Multidisciplinary design methods from systems engineering, software development, service engineering need to be incorporated to find a befitting and practical solution. There has been an intelligent marriage of humans and information systems and technology. Best practices and case studies learnt from design projects by industry also help in better understanding. The tools have to be designed keeping human experiences and requirements in mind.

This will enable us to find solutions for the gaps and discrepancies in efficient execution of existing crisis plans.

B. Serious Gaming: Experiencing the Unexpected

Experience the unexpected is a very clear defining statement for a crisis. Another area which could help in crisis management is serious gaming. It provides professionals with a platform of a virtual crisis and enables them to act on it instantly. It offers them virtual exercises of crisis so that they get a varied experience in a safe environment.

C. Towards More Relevant Research on Humanitarian Disaster Management Coordination [1]

Humanitarian crisis requires an immediate and effective response. With the increasing awareness and need for crisis management there are professional and volunteer organizations which come forward for assistance. A major

challenge which has arisen over time is their proper coordination.

Laura et al proposed a field oriented methodology to bridge the gap between humanitarian best practices and academic state of art. In disasters which involve large scale humanitarian organizations on site, lack of effective coordination always stands as a challenge in efficient disaster management [27]. There are innumerable factors that lead to coordination difficulties, two major ones being huge number of actors and voluminous information. Since proper processing of information is not done, it ultimately results in inadequate situational awareness [28]. It is clear that there exists a gap and the best way to bridge it is by developing realistic methods with real data, problems and past and future trends [29].



Figure 1. Inter Organizational and Intra Organizational Graphs in Social Networks

The coordination in an organization takes place at two levels – inter organizational and intra organizational as shown in Figure 1.

For proper HDM, it is critical that there is balancing and proper allocation of skills, funds and resources. There should be coherence and effectiveness of relief operations. Proper training of the network members is important along with implementation of best practices.

D. A Case Study for Monitoring Fires with Twitter

Social Media has proved to be a great enabler in rapid dissemination of information during a disaster. The most prominent feature of a crisis is unpredictability [39].

Authentic information communication is critical during a crisis which if done properly is a great help to proper crisis management. Situational awareness is the first step towards crisis management.

Research on the role of social media in crisis management has adopted a top down approach and bottom up approach.

Robert Power et al has proposed a configurable monitoring system to track near real time tweets describing fire events. The system emphasizes the fire related words in a defined region. And they were then put through a text classifier to determine if they were related to an already

known fire occurrence. A specific fire event which occurred in the Blue mountain regions of NSW in Oct 2013 in Australia, was taken case in point. The investigation started with the collection of all tweets publishes in NSW in Oct, 2013. The Yahoo Planet API was used for geo coding the profile location. High value tweets traced which contained text and images relevant to the crisis. The purpose was to determine if the information shared on social media was authentic and useful to the incident controllers. A free monitor map based on interactive site was developed with an incident manager interface to allow rises to enter area of interest. A text classifier was used to identify tweets of interest especially with associated images.

E. Development of a Virtual Community of Practice on Natural Disasters

After the occurrence of a crisis huge effort is put into identifying the lessons learnt so that so that there is no duplication of errors and successful strategies are also made a note of [38]. The role of communities of practice COP are a very effective way of sharing, enhancing and collaborating among organizations.

Raquel et al has identified from the literature principles of VCOP and specified how they completely apply to a VCOP that aims at spreading and sharing information during an outbreak.

A VCOP was formed with 70 experts from various hierarchical levels who were involved in disaster management organization across Europe. A living document was created which is a web based tool to exchange, share and report lessons learnt among crisis managers and first responders.

F. Facebook and Twitter Adoption by Hurricane Sandy-affected Police and Fire Departments

Apoorva and Amanda in their research reported the findings of their study of emergency managers in online adoption. Sutton and colleagues [14] analyzed the utility of Twitter as used by emergency teams during Deepwater Horizon Oil Spill in 2010. They examined the Facebook, Twitter adoption patterns of a sample of 840 fire and police departments who were affected by Hurricane Sandy. In this case it was observed that facebook was used more frequently by fire and police departments than Twitter. Emergency responders have been doing online research mainly on Twitter. Also the online adoption reaches its peak only around the time of crisis, it is relatively low before and after it. Another observation in this event was that online adoption increases rapidly around a crisis outbreak [36].

G. No Misunderstandings During Earthquakes: Elaborating and Testing a Standardized Tweet Structure for Automatic Earthquake Detection Information [2]

The utility of social media in spreading information during a crisis need not be stated. In a paper by Franses et. al., seismology and social media got together to make a standard tweet structure to be used during earthquake. The tweet was designed to launch a service by INGV. This service tweeted auto detection of earthquake with magnitude greater than 3. The dimension tested for the user, was time format, nature of

date and matching of automated and reviewed data. The respondents highly appreciated the timely information on Twitter regarding the earthquake so the launch of automatic tweet proves useful. As pointed out by [10] little research exists around features and affordances of online media and how each can fit into an emergency management communication Strategy. Twitter Syntax mainly refers to the topics like automated natural language processing [11] and information filtering activities which enable users to produce information in machine readable form [12].

H. Expression and Deduction of emergency scenario based on scenario element model

Chaw Sun et. al. proposed a scenario element model by combining scenario analysis and probability theory [42]. In this model scenarios are considered a carrier of emergencies and they constitute scenario elements like resources and information. These scenario elements are functions of time, space etc. Empirical Analysis proved that Scenario Element Model enables system division for disaster provided support for creation of crisis management plans. Disaster chain is a model which describes one disaster [30]. Scenario Probability and Analysis Model acquires its methods by combining Scenario analysis and Probability Theory [9].

The existing emergency plans are seldom based upon the evolution path of real emergency accidents, and lack quantitative analysis and scientific modelling. There is neither an effective nor an integrated method to assess the rationality of an emergency plan. Most of the existing researches are about conventional rule of emergency evolution while there is lack of contingency plan based upon actual evolution process. This research provides the basic model of scenario elements and the framework of crisis scenarios.

The model presented by this research characterizes emergencies by the feature of time and location. It also expresses emergency qualitatively from three perspectives, its cause, carrier and environment. If combined with the background information and resources of solutions, an emergency is affirmed to contain Hazard Element, Bearing Element, Condition Element and Resource Element which are represented by H, S, C and R, respectively.

The mathematical definition of scenario is given by:

$$SE = \{H, S, C, R\}, SE = F(a, t, \phi, W, v)$$

SE represents scenario element, and every scenario element can be expressed as an F function related to a, t, ϕ , W, v, in which 'a' refers to space, t refers to time, ϕ refers to authority, refers W to property, and v refers to the evolving rules of scenario element.

There is another model which presents underlining relations among different emergency scenarios, and the deduction of the scenario to determine the evolution direction of the emergencies. The mathematical expression of scenarios is as follows.

$$Ms = f(H, S, C, R)$$

Ms refers to the emergency scenario which is composed of various types of emergency elements. This model links different scenarios with other scenarios and represents the emergency with different scenarios.

Scenarios are the temporal and spatial carrier of emergencies, which are also the basic factor for revealing the actual evolution of emergencies. This paper presents a deduction model for emergency scenario based on scenario element theory, builds a scientific framework of emergencies and emergency disposal for practical purposes. These methods provide support for the creation and evaluation of a disaster exercise.

I. The EMSC Tools used to detect and diagnose the Impact of Global Earthquakes from direct and indirect eyewitnesses' contributions

Romy Bosses et al focuses on a strategy and operational tools developed and implemented by EMSC to diagnose the impact of an earthquake by combining social media and crowd sourcing [41]. These collect seismological information and disseminate information for better situational awareness. It also states the advantage of social media harvesting could provide info on indirect earthquake effects. LastQuake is a set of information tools, smartphone application, twitter robots, browser add ons, all based on providing info on earthquakes. The engagement of eyewitness is a unique feature of these tools. EMSC has been consistently promoting and coordinating seismological networks in Euro Med Region with Quake Catcher Network [8].

J. Cross-Media Linking in Times of Disaster

Gahard et al identified that there are links between different types of media. These links can be put to use by combining all information from different links to form a wholesome picture of events [40]. A study of these links help to define a pattern of how these platforms are connected and what is the specific contribution of each source. Tweets, facebook comments, online forums become a part of a linked set of documents called compound documents. This linking behavior has been observed during the floods of Central Europe in 2013, from the perspective of Facebook and Twitter. Exhaustive study has been done on the role of social media in the coverage of disasters mainly keeping Twitter in reference [13],[15],[16],[17],[18],[19].

Micro blogging, social networking, photo video sharing has become the best way to share information, document incidents and provide detailed insight. Multiple platforms for info sharing like Twitter and Facebook have been studied during flood in Colorado and Germany, 2013[37]. After noting down the experiences of digital volunteers [31]. A cross social media application has been proposed for combination of all online information resources to assist the volunteers in crisis response. A National Austrian Security Research Project called QuOIMA [32]. has studied the use of cross social media sources at different levels of popularity, activity and content.

K. Twitter as an instrument for crisis response: The Typhoon Haiyan case study

Ntalla has explored Twitter as a tool for crisis response during a disaster [43]. The case in point taken was Typhoon Haiyan hit Philippines, 2013 where twitter messages were recorded over nine consecutive days. They were analyzed and

compared to the actual events. Tweets proved to be another authentic tool in spreading situational awareness and is also instrumental in motivating people to act. Ntalla et al has identified the type of messages posted after the Typhoon and whether they were compliant to actual events. A comparison between OCHA and Twitter observations gave very encouraging results regarding utility of Twitter as a successful emergency tool.

L. Next Generation, Secure Cloud-based Pan-European Information System for Enhanced Disaster Awareness

Whenever crisis strikes information starts pouring from all sides and it is a challenge to keep the information unadulterated and prevent it from getting misdirected. As challenging as it is, equally critical is that the information flow is streamlined properly so that relevant information can be shared. Marke et al created a Pan European Common Information Space to facilitate efficient Information Management System.

It is very important that a crisis has a boundary [25] and there is effective interoperability between various rescue teams. CIS presents a secure system architecture for communication and information exchange in a Pan European disaster Environment. CIS includes CIES, which is cloud Pan European Information System accessible on the internet. There are a variety of effective information systems like MIKIoBOS [26]. Another similar concept is Precision Environment Concept of Kilgore et al [35].

M. Intuition or deliberation – How do professionals make decisions in action?

Heather et al studied the decision making modes (deliberate or intuitive) in a complex task environment. The paper focuses on the intra personal and environment conditions, which decision makers consider while making decisions. Intuitive Decision making makes solutions based on a pattern making and experience based evaluation [33].

Deliberate decision making strategies are costly in terms of cognitive effort and opportunity cost [34].

N. Bridging the two cultures of risk analysis

This paper explains about the two facets of risk analysis and determining an optimal solution based on the two. Risk analysis can have both the perspectives of being a bane or a boon on the institution. It all depends on the crisis management team how it is portrayed in crowd. For this purpose, the recruitment process of crisis management team must be kept stringent. They must keep prior knowledge about the required psychological behaviour of people who are being recruited at the decision taking positions.

Risk analysis plays a dual faced role. Not only it helps the crisis management team to find out a solution to the critical situations which the firm is likely to face but it also degrades the ability of institutions to take risk (which indeed a very beneficial and essential part of any firm's progress growth and development).

Risk analysis if taken in an optimistic way for deciding the fault tolerance model is appreciated whereas if considered as a hindrance degrades and deteriorates the firm's strength.

O. Introspect model: Competency assessment in the virtual world

Introspect model deals with a unique method of self-awareness which is facilitated throughout a structured debrief. Its major part is to allow individuals to become metacognitive in their crisis management and decision making skills.

Its main motive is that the relevant person makes the most appropriate decision in the correct frame. The right person status is the utopia of safe person concept which is dynamic and optimal at decision making. He is identified through a series of collection process covering aptitude, knowledge and practical ability for the role. Right decisions are mainly governed and decided by simulation based training and assessment. Assessing the candidate's naturalist decision making (NDM) within normal sphere of work provides a criteria for the selection of crisis management candidate. The test scenario created must be realistic, achievable and manageable to facilitate immersion and to ensure credibility of the candidates. Many software have been developed for such purposes, e.g. XVR software is used to produce scenarios which help in assessment and development sessions. The prerequisites for scenario development are: information gathering, incident evaluation, objective setting and planning, command and control, communications and review.

Specific elements of a candidate's roadmap are used to measure statements for a minimum standard of competence. These elements are dynamic and vary according to the scenarios and situations. With rigorous training, the effectiveness of this model has increased in conjunction with immersive learning environment provided to the candidates. It has come up as a decision making language and the decision making sequence has become a subconscious competency of the candidates.

P. Towards a taxonomy of crisis management simulation tools

The paper has presented a taxonomy to describe and classify crisis management simulation tools. This taxonomy aims at helping the stakeholders to choose relevant simulation tools to stimulate their own crisis management tools according to their simulation model

To face a more complex and wider spectrum of crisis situations the crisis management organizations are expected to deal with all kinds of crises. Instead of redesigning the existing crisis management capabilities to face new challenges a solution could be made by sharing and connecting existing capabilities at the local regional and national levels. One of the main objectives of the European Driver project was to propose a test bed i.e. a space for experimentation which would provide physical and organizational platforms, methodologies and tools where management testing and experimentation can be carried out. Considering the diversity in existing simulation tools the main question is how to help the user to select relevant software simulation tools in order to implement the chosen simulation models to test their crisis management tools. To achieve this objective these tools have to be classified to a taxonomy which is based on relevant characteristics to help the users to use the right tools. These tools are regarded as sustainable if they meet two requirements

first they have to be at least mature prototypes and second they have to be freely available. One of the main reason for crisis management complexity is the multiple and tangled up interactions between three heterogeneous systems , the environment impacted by the crisis ,the treatment system and the crisis itself. The taxonomy which has to help the user to select the relevant simulation tools starts with three main entry points which are business level characteristics: domain, ttype and service. Legal characteristics include licensing and trans border area. Technical level characteristics include owner, input/output data, level of maturity ,performance and security.

To improve the selection process and offer the user a better support knowledge based can be created using the taxonomy. The addition of exploitation rules may greatly improve the selection process.

Q. Governing by looking back: Historical analogies and Crisis management

This paper aims at concerning and analyzing the past events and risks faced by the native or other related institutes in determining the future management techniques that needs to be followed in similar situations.

For formulating and developing models for crisis management, experts give major reference to the previous crisis faced by host institutions as well as by others. The algorithm formed, for any crisis is usually made after a proper analysis of previously occurred situations or havocs.

The new or derived models are based on historic analogies and metacognition, after preparing various test cases and possible situations, a prototype is prepared dealing with ideal problems which might to similar to the real ones. When a crisis takes place these models are manipulated and altered depending on the real situation. The prototype selection is based on proper analysis and brain storming of the experts. The decision is taken and implementation is done keeping all the priorities and costs in mind.

Various kinds of predefined models are available with crisis management department which only need to be modified by the respective institution according to their needs, requirements and situations.

The crisis management team needs to go through all the possible risk situations that can be faced by the institution and keep the models in hand. Special and proper attention is paid to the risks which have high probability of occurrence . This probability is firm dependent and has no prior rule or methodology to be followed.

R. Putting plans on track in unforeseen situations:

This research paper focuses on the generation of a precedence plan which provides a sequential way to reach up to a solution or crisis handling technique.

Since a crisis environment is very unpredictable, it makes the response mechanism quite complicated. Multiplicity of approaches yields many decision alternatives which further complicates the response effort.

In such contexts planners normally select a subset of possible scenarios to detail and describe generic procedures. During the plan enactment teams usually need to transform these general procedures into operational and executable

options. These unforeseen situations may render the plan in applicability creating need to find alternative treatments and to make decisions during run time.

While devising an emergency plan, planners aim to name the applicable hazards and design procedures which if followed should make the emergency evolve to unexpected state returning the affected environment to a stable condition with minimum losses. Planners also have to decide what will and will not be included and the level of detail used for the plan. When dealing with less complex environments plan abstraction and decomposition have both been proposed as methods for diagnosing plan applicability and undertaking plan adaptation.

By monitoring the selected plan application and emergency evolution it is possible to identify unforeseen situations. The approach for the ' On the fly adaptation plan' supports managers to identify unforeseen situations, to interpret these situations, their impact on response and to adapt plans while handling an ongoing emergency.

If there is insufficient equipment, the dependency map shows that it has a negative impact on people involved, time and action result. If the current values of these variables cannot handle the variation caused by the unforeseen situation, the plan has a disruption and requires adaptation

S. Using Crowd Modelling in Evacuation Decision Making

This paper mainly focuses on one dimensional crises that focus on crowd evacuation technique. The crises that deal with controlling and avoiding crowd related issues.

For overcrowding crisis prediction and cure, two criteria are followed: Surveillance (raw visual information) and crowd modeling.

The step prior to both these criteria is to get predictive information. It can assist the decision maker in assessing the situations and potentially getting a way for preventing evacuation. But if in case evacuation is inescapable, crowd modelling technique is used. Crowd modelling helps in defining the safest and most dynamic evacuation route. Major factors on crowd modeling are evacuation, decision making, crowd modeling and decision support. In surveillance based crowd evaluation technique, the response is pre-defined which is inferred by the analysis of predictive information whereas in crowd modelling technique, training and real time decision taken under critical conditions. Steps involved in evacuation process are:

Methods for decision support using crowd simulation results:

Live data ----> live simulation ---> return specific results
Live data ----> choosing best possible algorithm---> return appropriate results

Different kinds of modeling can be used in crowd modeling like factor analysis and regression modelling.

T. Crowd security detection based on Entropy Model[7]

Crisis often lead to the occurrence crowd disasters or mass events such as human stampede, illegal public gathering and these events are termed as crowd mutations. These crowd mutations are caused due to terror attacks, explosion, sudden fire, etc. So it becomes necessary to set up alarm during such

situation and warn the crowd for the same. The tool that is used to detect crowd mutations is camera.

The research provides physical entropy model to measure crowd security model. It includes certain simulation experiments and video detection techniques to demonstrate the model. The basic concept that is used is that whenever entropy is higher than that state is known as disordered state and whenever entropy is lower than that state is known as ordered state. So whenever there is sudden change in the crowd movement than there is change in entropy and this change is used to detect abnormal behaviour of the crowd and thus activates warning alarm.

Crowd motion system is assumed to be an open system because if we consider it an isolated system then according to the law of thermodynamics its entropy won't ever decrease and hence we need to consider it as open system. To represent crowd micro state this research has used individual velocity and its probability and to express the crowd macro state Shannon entropy is used.

This method was validated through three experiments. Among these three experiments two of them used videos to extract individual speed while in the third experiment simulation was performed to present the crowd mutation using a model.

In disordered and ordered status analyses, crowd motions were presented by extracting the individual velocities from the video frames. Crowd status entropies were calculated, and compared with theoretical maximum entropy. The line presents the value of the half of the theoretical maximum entropy is the threshold line to distinguish between the disorder and ordered statuses. Results show that the entropy in a crowded state is higher than the threshold value, whereas in an ordered state the entropy state is lower than the threshold line.

In the simulation experiment, a scenario was assumed, in which a crowd behaviour sudden change was included. The sharp crowd status entropy drop was presented and analyzed. The results verified the case that the detection of entropy sudden change is a way to recognize the crowd behaviour sudden change. The crowd mutation from disordered motion to ordered motions which were possibly caused by religion ceremony, or illegal public gathering. This paper is the first attempt to construct an entropy model to describe the crowd macro state. The construction of crowd micro states in this paper make it possible to set up a crowd entropy model.

U. Fast Marching Method for Evacuation in High Rise Buildings[4]

In this research, fast marching method has been applied solve emergency evacuation in high rise buildings. This method uses Eukonial Equation in rectangular grids. As we all know that fire is an emergency that can strike anywhere at any time, all organizations need to have an evacuation strategy in place to be able to handle the untimely occurrence as successfully as possible. The most significant feature of this emergency is evacuation strategy. Fast Marching method was first put forward by J.A Senthian and J.N. Tsitsikites. This is a numerical method to solve Fikonal Equation in the rectangular grid. It has a very fast computational speed so it is

widely used to refactor algorithms. The time complexity of this method is $O(M \log M)$, m being the number of rectangular grids. Eukonial Equation is a kind of special first order differential Equation.

FMM is applied on grid points. Grid points are classified into alive, trial and far away points. Alive points where the value of T is known and these points do not change at all. Trial points are points around alive points but the value of T has to be computed. A set of trial points makes a narrow band These points need to be updated to the alive points to compute propagation's value for trial points is calculated by form 2. T value for far away points are converted to trial points during propagation.

The algorithm gets completed when the value of T for all points are calculated. The prime features for the safety of the people are crowd density, evacuation method and body external dimensions.

For construction, CAD design drawing are used .They have been made grid enabled and digitized so that the algo works under a variety of constructions , grid size being taken as 0.4×0.4 . To calculate the real risk attached to each grid, a real building model was created for this experiment. According to different sizes of different rooms, carbon monoxide sensors and temperature sensors are placed in the rooms. With this, during the fire simulation these sensors record the value of temperature in the room. Least squares method is used for the interpolation calculation. After calculating the risk value of the emergency grid points, FMM is used to calculate the evacuation route. Risk value of the evacuation route is calculated. A new evacuation path needs to be designed to solve some issues like information transmission. To solve this issue wireless model is integrated into temperature and wireless sensors and Zigbee protocols are used for information transmission problems.

V. Influence of heresay model

For proper evacuation during an earthquake, it is critical that there is proper information dissemination on the evacuation areas. This is achieved by hearsay, guidance and bulletin boards. Simulation results prove that location info of the evacuation routes, damaged areas etc are very helpful for people unfamiliar with the area. Therefore in this research, we study the effective methods of evacuation guidance and factors that enable it. In this research a model has been created on information hearsay and evacuation behavior. A model for a virtual city and evacuees behavior has been created. The properties of a city like block size, road width etc is based on GID data on land used in Setayaga Ward, Tokyo, conducted in 2011. The streets in the virtual city are blocked The number of street blockages are determined by node link ratio, which is estimated on the street blockage of Setyada Ward. After getting the knowledge of the location of fuire evacuees tend to avoid fire. Modeling of Evacuees behavior is unfamiliar, normal and familiar. Guides take lead to instruct evacuees. Guides can be further divide into three categories Individual guide, Cooperative Guide and Universal Guide. Information hearsay is at intersections where people can exchange information. Evacuees decide the evacuation route depending on his behavior and guide intervention if any.

W. Investigating images as indicators for relevant social media messages in disaster management

This study brings forward the importance of social media being used as an effective tool in proper crisis management. This can be achieved by proper analysis of the text messages. Proper attention needs to be also given to images, which can give relevant information and enhance situational awareness.

However, geographic context is also taken into account in case of a number of recent studies for example rate the relevance of social media messages related to forest fires based on their distance to well-known forest fire hotspots in France. This study says that disaster-related messages containing an image are more likely to contain on-the-ground information – for example photos taken and posted by eyewitnesses.

In June 2013 almost all river basins in Saxony were affected by intensive floods. For the majority of them the highest alert level, indicating high risk and high damage potential, was reached, including the largest river Elbe. The first signs of a beginning flood situation began at the end of May 2013 and the flood peaks of the river basins were all reached within the first third of June resulting in a 50- to 100-year flood classification for most river basins.

Furthermore, tweets that were geo referenced using a GPS were retrieved. The Instagram data was fetched afterwards the mentioned time period. After the data was retrieved, official data was used for the administrative boundary of Saxony to filter all messages located within the state boundaries during the mentioned time period.

Authoritative data from hazard maps was obtained which correspond to flood-prone areas with high probability of occurrence. Besides factual flooded areas, these areas are also likely to include areas where temporary flood protection measures such as sandbag dikes occur as well as emergency efforts and volunteer activities. Those are of great interest to improve situational awareness. Official water level data of the Elbe River was collected from Waterways administration.

Messages containing certain keywords are searched to separate flood-related (on-topic) from the remaining messages (off-topic). A keyword-based filtering is commonly applied in a first step to select disaster-related messages. Messages that contain one of the following keywords, regardless of case-sensitivity, were thus marked as on-topic also the retrieval of Instagram data was also based on the existence of one of these keywords in the tags of messages.

Furthermore, all the messages that had an image were flagged. Since for Flickr and Instagram image content is mandatory, this applies only for tweets. Images within a tweet are embedded by an URL linking to the image. Then the Euclidean distance between every message and the hazard area was calculated. Then, we first check if on-topic messages tend to be closer to the event than off-topic messages. For this reason, we compare the distance values between on- and off-topic messages for each platform.

After that, we compare the distances particularly for on-topic messages with and without an image to the hazard areas to test if there is a correlation between proximity and existence of image content. This refers particularly to tweets where

image content is optional. To test the central tendency between the respective groups on statistical significance, we compute the Mann-Whitney's U-Test (U test) since the distance values is not normally distributed.

The descriptive distribution of all social media messages shows that the most on-topic messages were posted in the first third of June. Regarding the number of on-topic messages, the Instagram and Twitter dataset show a higher absolute quantity compared to Flickr. However, the proportion of on-topic to all messages is quite low for Twitter (~2%) compared to Flickr (15%).

The spatial distribution created showed a clear focus of on-topic messages around the urban area of Dresden. Instagram and Twitter also show a concentration around Leipzig and Chemnitz. All three cities are situated within hazard areas and on rivers that were affected by the floods in 2013. Considering this, a merge of all sources increasing the density of the mentioned areas but also increases the spatially coverage for areas besides the bigger cities.

According to the spatial relation between messages and hazard areas, on-topic messages of every social media source tend to be closer to the hazard areas. A further separated inspection of all on-topic tweets with and without image shows that on-topic tweets with image are closer to the disaster event. Furthermore, they have a similar distance like Instagram. Both groups also show a similar distribution with numerous outliers compared to on-topic Flickr.

In this study social media messages were analysed for disaster management. For given case study, merging of social media platforms leads to a higher density of disaster-related messages and higher spatial coverage, what is an advantage for widespread disasters like floods. But this does not necessarily result into a higher information value and requires further examination. For instance, users could post the same message content on multiple platforms.

Information shared can be used to enhance existing approaches and achieve a better classification of social media messages. Since disaster-related messages vary in their informative value and on-the-ground information are considered to have a high potential to be relevant. Since checking whether a message contains image content can be fully automated, it is applicable with less effort thus in near real-time. Furthermore, the use of images as indicators may also be used in cases where there is no extensive knowledge of the geographic extent or missing geographical data about the disaster event. Studies have shown that local users are better sources of relevant information [20],[21],[22],[23]. Relevant messages have proved to be close to the crisis event [24]

X. Participatory Radiation Information Monitoring with SNS after Fukushima

This work is about development of inexpensive and accurate mobile radiation detector, named as Pocket Geiger (POKEGA), which was developed to measure the radiation levels in their region and to discuss the results of the Nuclear Disaster in Fukushima, Japan. This project adopts modern communication platforms such as crowd-funding, open source development, and Facebook. This project had three

development phases: start-up phase, evaluation phase, and operation phase.

In Fukushima Daiichi nuclear disaster situation, people wanted to measure and share radiation levels in their area since radiation readings were different. Simultaneously, they also wanted other people to gain knowledge of quantitative risk, radiation protection and appropriate methods of radiation measurement through discussions with experts such as researchers, engineers or medical doctors.

This device known as Pocket Geiger (POKEGA) is connected to Smartphones. It uses GPS and networking features of Smartphones for collecting data.

A photodiode detector is connected to a Smartphone. To get funds this idea was launched in a website named Radiation-Watch.org, to gather volunteer collaborators from all over the world, including the crowd funding site called Kickstarter.com for quicker and more cooperative development compared with traditional methods such as business financing or research funds.

Kickstarter.com assisted to collect money for the starting phases of the project. Eventually Project received many positive messages from backers, especially from Japanese backers, and also received business offers, particularly from US backers. This helped a lot quite effectively not only for financing but also for publicity.

Two Dutch researchers in Netherlands voluntarily offered help to calibrate the POKEGA device in their special facilities. Their examination was very useful to us because it revealed that measurement range for POKEGA.

During this phase two error modes were identified. One error mode was caused especially on sunny days, because the infrared beam of sunshine sometimes penetrated the shade tape inside the POKEGA case. Another error mode happened especially on warm days, because thermal noise generated a false reading. As countermeasures for these problems, improvements were made and parameters were reconfigured.

Most of the posts included photos for example a children's park case, where contaminated soil covered was by a blue colour sheet in a children's park and a poster advised children to leave the area since the background level in the area was very high, while the normal level in Tokyo was much lesser than that. Through data sharing, people learned the radiation levels in various locations, including in places where they do not typically go. The tests were executed mostly by ordinary people. Because POKEGA showed almost the same readings as other detectors, the detector was able to win the user's trust.

Users and experts separately contributed to project development because they individually backed the Kickstarter campaign and helped its publicity distribution. Some professionals personally offered voluntary examinations. Users started sharing radiation levels in their milieus with each other, and experts reported comparative testing results and started communicating technical information based on the open-source style.

Experts provided information for ordinary users through discussions in the Facebook group. Experts also actively contributed to POKEGA development by providing rich technical advice as a result of such collaborative research, POKEGA has evolved throughout.

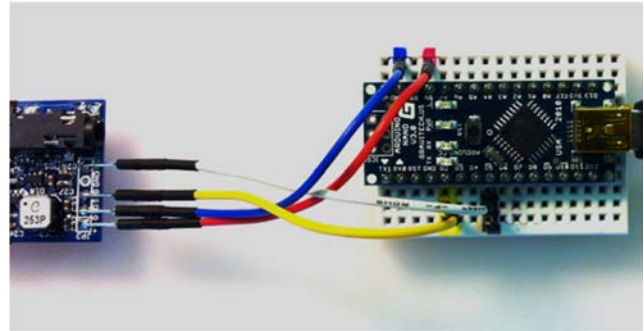


Figure 2. Pocket Geiger (POKEGA) for Radiation Detection

Such direct radiation risk communication was quite helpful for the Users and also could satisfy the Expert's need for self-actualization as experts, which is not permitted in the hierarchical model. POKEGA (in Figure 2) would be widely useful in environment monitoring and risk communication for various hazards such as air pollution, soil and water contamination, or earthquake detection and analysis. Also it can be assumed that the Crowd Verification process plays an important role in quick and wide-ranging monitoring in crisis management and the Mutual Verification process is also effective to ensure reliability of instruments and reduce distrust of citizens by cooperation and discussions between citizen and professionals through social media. Both verification methods are considered to have great potential for future applications such as environment monitoring and product safety.

Y. Agent-based modelling to identify possible measures in case of Critical Infrastructure disruption[3]

This research identifies the critical infrastructures and methods to protect them in case of disasters. The interdependencies between the electricity power grid, water supply and components and health care are studied.

The central activity so far focuses on critical infrastructures (CI) and critical infrastructure protection (CIP). In particular, the project aims at establishing a platform to advise CI owners, operators, local emergency management organizations and research related to CIP.

Key parameters representing a CI are the resources needed for operation as this defines to some extent the dependencies and the self-help capabilities of each individual CI realization. The main focus of this research is on data collection of CI components and potential countermeasures.

The methodology used is agent-based modelling (ABM), because ABM allows the problem to be distributed and take all considerations according to the interests of all parties involved. The selected scenario is projection of an energy grid into 2030. It takes certain assumptions into consideration. Three areas have been taken into count CI, power grid and information and communication technologies (ICT).

Data has been collected for the city of Karlsruhe, located directly at the Rhine River, Germany. 138 relevant facilities have been identified in the water supply and health care sectors. There are three categories of care facilities, care facilities without assisted living, care facilities which provide

additional assisted living, and care facilities with only assisted living.

Certain countermeasures have been provided which are relevant for water supply like use of emergency generators, use of mobile water purification plants and activation of emergency wells. Some measures have been given for health care like providing and stockpiling of drugs, use of emergency generators, allocation of additional waste container, evacuation etc.

A cost function has been defined to incur the cost due to power interruption, though the parameters for the same were not known with complete certainty.

For different scenarios, one can generate a pattern that can be used for preparedness and planning at which time and for which CI support is necessary. Again, here agents will be developed that simulate the distribution of limited resources.

Data collection is one of the most crucial steps in setting up an ABM simulation. Therefore, it is important to collect as much data as possible. The ultimate objective of the research activity was to develop a holistic analysis framework to quantify and evaluate requirements and design decisions of the many players in such complex infrastructures.

Z. Scenario Based Approach for Risks Analysis in Critical Infrastructures[6]

This research emphasizes on Critical Infrastructures, which can be defined as the most important elements of a system's requirement for enabling the proper social functioning and welfare of the public.

This work proposes Cross-Impact Analysis (CIA) for identifying and analyzing risks in CI. Cross Impact risk analysis is a dynamic process under uncertainty scenarios, where heterogeneous and objective risks are assessed. CIA has been successfully applied to emergencies management for crisis scenarios modelling in a collaborative way to achieve "consensus" models for emergency plans generation.

This study attaches a comparative table of most relevant methodologies applied to CIs risk analysis, and later it has discussed pros and cons of those methodology and hence explaining that how CIA can be applied to any sector or type of risk, mixing qualitative and quantitative variables.

The example of CIA application has been given in the research in which certain events in the case of given emergency case were identified and classified in the categories of uncontrollable, controllable and result events. Then data has been taken from the experts and that data is overall estimated probabilities which are taken as input for generating a cross impact matrix.

III. CONCLUSION

All these approaches and methodologies for planning, foresight and risk analysis enable the improvement of emergency preparation and management process. There are improved methods to integrate volunteer's data, decision makers and responders in the quickly changing scenario. We have discussed quantitative and qualitative data integration methods for predicting as well as analyzing the cascading effects in crisis situations. Methods and tools for capturing and

tracking human experiences in crisis management design have been proposed. Now approaches which efficiently merge crisis management with information technology is the requirement of today's age. Interdisciplinary Engineering approaches foster the scientific discussion on design of organization and ICT services for systems for crisis management responses. Diverse arrays of papers have been discussed with collaborative accomplishment of emerging management through information systems. Crisis being low probability but high consequence events require a lot of intelligent synthesis starting from foresight, protection, implementation to evaluation.

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