Attributes for Simulating Spontaneous On-Site Volunteers

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ABSTRACT

Disaster managers report that several disasters would have turned out on a dramatic scale without spontaneous unaffiliated on-site volunteers (SUV). Since SUVs are usually not integrated in chains of command and behave in a certain pattern of its own, coordination of SUVs becomes a challenge for disaster management. One key to coordination is communication and adequate support by information systems. However, real disasters or field tests are usually too expensive, elaborate, and partly impossible when coordination of SUVs is to be exercised or novel tools and methods must be evaluated. Simulating the SUV's behavior by software-agents is considered a constructive solution, however, the specification of simulation settings is an open research field. Therefore, this paper aims at identifying relevant attributes affecting SUVs behavior by a state-of-the-art literature review, classifying and discussing the attributes. Our results provide a sound basis for defining SUV-agents and performing suitable simulations in the future.

Keywords

spontaneous volunteers, disaster management, simulation, coordination, software agents

INTRODUCTION

Recent years have shown an increasing number of natural and man-made disasters worldwide (Dressler et al., 2016). Governmental disaster relief is usually supported by humanitarian organizations (Geißler, 2014). However, demographic as well as sociological changes lead to massive membership declines in humanitarian organizations (Hofmann et al., 2014; Geißler, 2014) changing the relevance of so-called spontaneous unaffiliated on-site volunteers (SUV). Integrating SUVs in disaster management may at least partly balance emerging personnel deficits (Hofmann et al., 2014) and disaster managers as well as practitioner's report that several disasters would have turned out on a dramatic scale without the help of SUVs (Detjen et al, 2015; Geißler, 2014).

Along with the human desire to help, actual options for communication play a critical role during disasters and for managing disaster response: social media and mobile devices dramatically changed the way how citizens perceive disasters by enabling new potentials in information, cooperation, and coordination (Büscher et al., 2014). Beyond the undoubtedly positive aspects (see, e.g., Ludwig et al. 2015, Schweer et al., 2014), SUVs have also caused harm or put themselves into dangerous situations. According to reports, SUVs barely had information about requirements at operating sites and searched for places to help on their own based on subjective or even false information, mainly gained from social networks (Hofmann et al., 2014). Such self-organization does usually not support coordination goals of official disaster managers, in fact, it led to overloads of operating sites impeding officials to work properly (Fernandez, 2007) and to critical shortage on other operating sites mainly in the periphery.

Without doubt, SUVs mean a valuable resource in disaster response. However, this resource should be properly coordinated so that the provided potential is not wasted, the official on-site forces are not set back, and the helpers are not put into danger. Avoiding such nonproductive "help" and providing innovative methods and applications for an effective coordination of SUVs reveal a challenging field of research for IT supported disaster management.

A central key to coordination of SUVs is planning and communication: disasters are dynamic processes requiring the coordination of many logical and physical entities (Simpson, 2014; Aslam et al., 2010) like disaster relief forces, affected people, or even SUVs. While planning and preparation may massively decrease disaster scales in general (Wagner and Agrawal, 2014), integrating SUV in this complex context necessitates adequate methods and solutions for increasing the coordination of SUVs and for predicting the SUV's behavior.

To address this key issues, several disasters in the last decade have led to intensive support of research. In Germany, e.g., several projects like KUBAS, REBEKA, and others are funded by the government focusing on the effective assignment of SUVs in disaster management (BMBF, 2017). Scientific communities, conferences like ISCRAM, or special tracks/issues on general information systems conferences/journals are fostering research in this area. One main challenge for all research effort is the testing and validation of new approaches as well as the proof of concept, e.g., in practitioners' drill. Thus, new approaches are usually evaluated through field experiments. However, field experiments with many SUVs require a large amount of participants, may have durations of some days, and take place on a few locations at the same time. Therefore, such experiments are expensive, elaborate, and partly impossible to conduct (Sautter et al., 2015; Takahashi, 2007; Balasubramanian et al., 2006). Whenever field experiments are not realistic, computer simulation is a common approach to test, evaluate, and optimize real world scenarios and approaches with a minimal effort (Arai and Sang, 2012). Up to now, to our knowledge, simulation of SUV's behavior with respect to cooperation and communication has not yet been part of any research. Agent-based simulations seem to be a sound approach to simulate SUV's behavior in disasters, because it has already been proven to be a proper way to simulate human and social behavior as well as simulating many entities (Wagner and Agrawal, 2014; Mas et al., 2012; Pan et al., 2007; Takahashi, 2007).

With a comprehensive simulation of SUV's behavior in mind, developing software agents first requires the analysis of the real-world behavior and all behavior impacting attributes (Macal and North, 2007). Therefore, the goal of this contribution is the identification of crucial attributes representing and influencing SUV's behavior with respect to their cooperation behavior. This is achieved by conducting a broad literature research including also research from technical science and psychological publications. Based on the identified state-of-the-art, the description and analysis of interdependencies between different attributes is also part of our research and obligatory to provide a valid insight. Following the software-agent's definition by Lind (Lind, 2001), the identified attributes are finally classified to provide a sound basis for developing software-agents and a realistic multi-agent simulation environment for future testing, evaluating, and optimizing volunteer-based research approaches. The following part provides a methodological and comprehensible description of our literature review resulting in the state-of-the-art. Afterwards, the identified attributes are discussed describing the behavior of volunteers and their interrelations. Subsequently, the identified attributes are categorized with respect to specifying software-agents and multi-agent simulation environments. A conclusion with outlook on further research is given in the final part.

RELATED WORK: BEHAVIOR OF SPONTANEOUS VOLUNTEERS IN DISASTER-RELATED RESEARCH

The literature review aims at covering relevant aspects simulating, describing, and attributing SUVs and their behavior. Since research discusses SUVs from various perspectives, the body for our literature was selected in a broad range, e.g. from IT-related, sociological, and psychological research. In a first iteration scientific papers as well as practice reports were identified by a tag word search. The relevant tag words are represented in Table 1 containing all words that lead to a broad overview. The tag words were combined in a logical manner. Although SUVs have been part of international research for years, the relevance of the topic increased at least in Germany after the flooding's 2013. Thus, an additional search for literature and reports in German was performed in a second round. Furthermore, the literature review not only contains scientific papers but also practice and experience reports of official forces, disaster managers, and SUVs themselves. Therefore, for a comprehensive search, scientific databases (ScienceDirect, AISeL, EBSCO) as well as a Google search and Google Scholar were used. Last but not least, the selected literature was supplemented by a backward search on relevant references.

Table 1. Tag Words for Literature Review

German	English
freiwilliger Helfer	volunteer
Katastrophe	disaster, catastrophe
Krise	crisis
Motivation	motivation
Großschadensereignis	major incident
(Helfer-)Attribute	attributes
(Helfer-)Parameter	parameter
Katastrophenhilfe	disaster relief
ungebundene Helfer	spontaneous volunteer
Schadenslage	*- no translation available -*
Erfahrungen	experience
Erfahrungsbericht	report
Simulation	simulation

As a first result of the literature review, recent research approaches propose agent-based simulations as a common and appropriate way to simulate human behavior (Takahashi, 2007). Computer simulation and especially agent-based simulation, is, thus, an integral component of disaster research (Coates et al., 2011; Gonzalez, 2009). The literature review revealed several methods and tools supporting agent-based simulation whereas most of them focus on evacuation scenarios: by simulating individual vehicles, Chen and Zhan used multi agent simulation to evaluate evacuation impacts on traffic flows from disaster areas (Chen and Zhan, 2008). Wagner and Agrawal investigated evacuation scenarios for concert venues, whereby the concert-goer were simulated as agents (Wagner and Agrawal, 2014). The Great East Japan Tsunami in 2011 motivated researchers to simulate the evacuation behavior of pedestrians and car drivers in a tsunami scenario (Mas et al., 2012). Since recent human and social behavioral data of emergency evacuations rely on assumptions that may be unrealistic or inconsistent, Pan et al. developed a multi agent-based framework for simulating human and social behavior during emergency evacuations (Pan et al., 2007). Furthermore, Arai and Sang provided a multi agent-based model for simulating the rescue of disabled people with the help of volunteers (Arai and Sang, 2012). All these studies use software agents to simulate various entities in disasters from different views. Thus, the literature review revealed that agent-based simulation has already been applied for evaluating disaster-related approaches and for observing disaster-related behavior with respect to the movement of people. Nevertheless, none of the related work applied simulation for the cooperation and/or communication behavior of SUVs in the disaster context.

However, outside of the agent-based simulation focus, several researchers have analyzed how SUVs interact, cooperate, and communicate especially via social networks (e.g. Peary et al., 2012; Starbird and Palen, 2011). Peary et al. discus the potential to utilize social media in disaster preparedness and response by analyzing social media after the 2011 East Japan earthquake when volunteers as well as affected people reported and shared a lot of information (Peary et al. 2012). Likewise, Starbird and Palen analyzed volunteers operating via social media. They described the role of so-called digital volunteers by analyzing Twitter posts during the Haiti earthquake in 2010 (Starbird and Palen, 2011). Furthermore, other scientists have provided research approaches and applications to improve communication or coordination of SUVs (e.g. Reuter et al., 2015; Hofmann et al., 2014). Based on recent research outcomes, Reuter et al. presented a cross-social-media application allowing information to be acquired and distributed cross-media and cross-channel for moderating emerging groups of SUVs as well as for structuring information (Reuter et al., 2015). Hofmann et al. presented an app-based system to support disaster managers in coordinating SUVs (Hofmann et al., 2014).

Taking the identified approaches related to volunteers in the context of disaster management into account, a main outcome of the literature review is that recent research mainly has focused on so-called digital volunteers collecting and sharing information via social networks (Kaufhold and Reuter, 2014). Such digital volunteers do not physically help at operating sites but exclusively on the internet. In contrast, the types of physically present volunteers helping and supporting official forces on-site is not in the focus of current research. Furthermore, none of the related research outcomes neither cover, identify, nor discuss relevant attributes influencing the behavior of SUVs.

IDENTIFYING RELEVANT ATTRIBUTES DESCRIBING THE BEHAVIOR OF SUVS

For identifying relevant attributes influencing the behavior and the coordination of SUVs in disaster context, the identified literature body was analyzed again. Since digital volunteers and on-site volunteers are different with respect to their motivation, support, and activities, the following analysis and discussion is focused solely on SUVs who are not professional or voluntary working for humanitarian organizations. SUVs are defined in the following as private persons who are not trained in disaster management and want to help spontaneously after the occurrence of a disaster. They want to support official forces on-site with their physical presence and help. With this type of SUVs in mind, the identified literature body has been analyzed in more detail. Relevant attributes influencing the behavior of SUVs and their coordination were identified by a descriptive exploration following a set of guiding questions presented in Table 2.

Table 2. Guiding Questions for Volunteer Attribution

Who helps spontaneously in disasters?
Why does somebody help in disasters?
What do SUVs do?
When and how long do SUVs help?
Where do SUVs help?
What else features SUVs?

Answering those guiding questions led to a structured identification of relevant attributes which will be explained in more detail in the next part. Overall 25 attributes (A1 – A25) affecting and featuring the coordination behavior of SUVs during disasters were identified. An overview of the attributes and their discussion within the literature are represented in Table 3. A parametrization of the identified attributes or their modeling within software agents were also in the focus of our detailed literature analysis. However, without disclosing a secret, the results show that for nearly all attributes the parametrization and modeling remain subject of further research.

A1: Age. Observations of the flooding 2013 in Germany show that people of all ages, genders and classes were involved in the disaster coverage (Geißler, 2014). Already in 1991, Wenger identified primarily males between 18 and 45 years with higher education as SUVs (Wenger, 1991). However, further observations controvert this assumption outlining that social economic factors and especially age have no influence on spontaneous volunteering (e.g., Auferbauer, 2016). Summing up, an age-based influence on spontaneous volunteering seems not to exists (Auferbauer, 2016; Points of Light Foundation, 2005; Lowe and Fothergill, 2003) or is, at least, not definitely proven. One reason for the ambivalent results is seen in a lacking registration of SUVs in the data of analysed disaster response scenarios (Schweer et al., 2014). Although the influence of age on spontaneous volunteering is not clear, it should be considered as relevant attribute, since it has clear interrelations with other identified attributes like capabilities or time aspects.

A2: Group Affiliation. In 2013, SUVs were primarily students being flexible in choosing assistance intervals (Zisgen et al., 2014; Geißler, 2014; Ebert, 2013). Furthermore, student classes, clubs, religious groups, or employees were exempted for helping (ARC, 2010). Group affiliation in general positively influences the pro social behaviour of the volunteers and, thus, the motivation to help (McDonald et al., 2015; Reuter et al., 2013; Barraket et al., 2013). Being part of a group or a society also increases the motivation to help (Barraket et al., 2013; FEMA, 2013). Therefore, group affiliation is seen as a relevant attribute influencing SUV's behaviour.

A3: Motivation. Motivation is generally described as trigger to participate in disasters (Australian Government, 2015). Furthermore, motivation is the basis to help and can be increased or decreased by other attributes. Many definitions for motivation exist especially from a sociologic view (Geißler, 2014; Falasca and Zobel, 2009). Summing up, individual human motivation is complex and not deterministic, thus, it cannot be completely simulated. However, motivation as the trigger for involvement in disaster coverage and voluntary help is a relevant attribute influencing SUV's behaviour that requires a deeper research before it can be adequately operationalized within software agents.

Table 3. Attributes of SUVs

Number	Attribute	Literature
A1	Age	Auferbauer, 2016; Geißler, 2014; Points of Light Foundation, 2005; Lowe and Fothergill, 2003; Wenger, 1991
A2	Group Affiliation	McDonald et al., 2015; Zisgen et al., 2014; Geißler, 2014; Reuter et al., 2013; Ebert, 2013; Barraket et al., 2013; FEMA, 2013; ARC, 2010
A3	Motivation	Australian Government, 2015; Geißler, 2014; Falasca and Zobel, 2009
A4	Concern	McDonald et al., 2015; Kaufhold and Reuter, 2015; Kircher, 2014; Barraket et al., 2013
A5	Information Channel	McDonald et al., 2015; Reuter et al., 2013
A6	Personal Connections	McDonald et al., 2015; Schweer et al., 2014; Barraket et al., 2013
A7	Social Networks	McDonald et al., 2015; Rizza and Pereira, 2014; Reuter et al., 2013; Barraket et al., 2013
A8	Perception	Kircher, 2014; Büscher et al., 2014; Geißler, 2014; Reuter et al., 2013
A9	Kind of Disaster	ARC, 2010; Fernandez, 2007; Paton, 1996
A10	Weather	Geißler, 2014; Kircher, 2014
A11	Experience	Australian Government, 2015; Geißler, 2014; Barraket et al., 2013; Lowe and Fothergill, 2003; Barraket et al., 2013
A12	Time of Day	BBK, 2014; Geißler, 2014; Paton, 1996
A13	Supporting Tasks	Geißler, 2014; Fernandez, 2007
A14	Task Preference	Schmidt et al., 2016; Kircher, 2014; Falasca and Zobel, 2009
A15	Capabilities	Hofmann et al., 2014; Kircher, 2014; FEMA, 2013; Points of Light Foundation, 2005
A16	Resources	Detjen et al., 2015; Kaufhold and Reuter, 2014
A17	Working Time	Geißler, 2014; ARC, 2010
A18	Time Preference	Geißler, 2014; ARC, 2010
A19	Working Duration	Geißler, 2014; Barraket et al., 2013; Points of Light Foundation, 2005
A20	Operating Site	Detjen et al., 2015; Hofmann et al., 2014; Luqmann and Griss, 2011
A21	Kind of Information	Lange and Gusy, 2015; Kaufhold and Reuter, 2015; St. Denis et al., 2014; BBK, 2014
A22	Location	Auferbauer et al., 2016; McDonald et al., 2015; Luqman and Griss, 2011
A23	Operating Site Preference	Auferbauer et al., 2016; McDonald et al., 2015; Luqman and Griss, 2011; CNCS, 2011
A24	Travelling	Kircher, 2014; Fernandez, 2007
A25	Randomness	Geißler, 2014;

A4: Concern. One leading aspect on spontaneous volunteering is emotional reactions to a disaster that reveal in concerns (Barraket et al., 2013). Concerns are not only emotional reactions to a disaster, they also originate from being directly affected by a disaster or when family members, friends, or somebody within the social network are affected (Kaufhold and Reuter, 2015; Kircher, 2014; Barraket et al., 2013). Concerns can be triggered or enhanced by media and especially social media bringing on-site information to people worldwide what may lead to concerns (McDonald et al., 2015). Concern, thus, is seen as a relevant attribute influencing a SUV's behaviour that also requires further research.

A5: Information Channel. Different media target different groups of people. SUVs are rather willing to help if they read Facebook posts of their friends being already involved in disaster response than watching people on mass media like television (McDonald et al., 2015; Reuter et al., 2013). Furthermore, the information channel is important for targeting different ages and groups of volunteers. In Germany, 70% of the 14-29-year-old are on Facebook while only 7% of the 70+ are (Statista, 2016). Students were the largest and most flexible group of volunteers during the flooding's 2013 in Germany (e.g., Zisgen et al., 2014), thus, information channel is seen as relevant attribute for targeting different groups.

A6: Personal Connections. As touched on concerns (A4), help requests from friends or relatives increase the motivation to help (Schweer et al., 2014; Barraket et al., 2013). Furthermore, a motivated volunteer typically activates more friends resulting in a phenomena known as "snow-ball-effect" that can massively increase the amount of SUVs in disaster relief (McDonald et al., 2015). Personal connections are further relevant attributes, since SUVs start helping within their close social network (Schweer et al., 2014) and extend it to other areas when the risk for family, neighbours, or friends is reduced to a minimum.

A7: Social Networks. People with a pronounced social network are rather supportive and willing to help much longer than people with a less pronounced social network (McDonald et al., 2015; Rizza and Pereira, 2014; Reuter et al., 2013; Barraket et al., 2013). This holds usually for both real and virtual social networks and, thus, is seen as a relevant attribute influencing a SUV's behaviour.

A8: Perception. Perceiving a situation as emergency or disaster is requirement for spontaneous volunteering (Geißler, 2014; Reuter et al., 2013). However, perception of a situation can differ between persons (Geißler, 2014) and may be influenced by media reporting (Kircher, 2014; Büscher et al., 2014). Therefore, perception is seen as a relevant attribute that should be operationalized within a software agent simulating SUV's behaviour.

A9: Kind of Disaster. Different kinds of disasters influence the motivation in various forms (Fernandez, 2007; Paton, 1996). The individual need to help is influenced by the size and scale of the disaster: the more dramatic a disaster is in scale the stronger is the individual will to help (ARC, 2010; Fernandez, 2007).

A10: Weather. In 2013, media reported that the flooding in Germany partly had event-character with musical support at the operating sites combined with good weather (Geißler, 2014). Officials and volunteers reported an increasing number of volunteers because of the summery temperatures (Kircher, 2014) and doubts exist whether the observed support would have been so extensive in case of cold and rain (Geißler, 2014). Although some researchers and practitioners see weather as a crucial factor, research results regarding the influence of weather on SUV's participation is not consistent. Thus, the influence of weather requires further research for adequately operationalizing it within software agents.

A11: Experience. Researchers found that volunteers are rather motivated for helping when they have made positive experiences in prior disasters (Geißler, 2014; Barraket et al., 2013). Principally, experience is not necessary for spontaneous volunteering (Lowe and Fothergrill, 2003), but it clearly influences the individual motivation to support (Australian Government, 2015; Barraket et al., 2013). Experience can be distinguished in those made in prior disasters and those made during current disaster relief. Since both influence the individual motivation, experience should be taken into consideration as relevant attribute.

A12: Time of Day. Research results suggest that the willingness to help is independent of the time of day (Geißler, 2014). However, other research and practitioners report from operating sites massively understaffed in the night (BBK, 2014; Paton, 1996). The influence of the time of day may be obvious and, thus, is seen as relevant attribute for simulating SUVs behaviour. However, its concrete influence requires further research.

A13: Supporting Tasks. During disasters, SUVs do various tasks that support victims and officials reducing disaster scale. In general, their supporting tasks do not require a special qualification (Geißler, 2014; Fernandez, 2007). However, it is obvious that not all SUVs are able or willing to support all kind of tasks (see A14), thus, supporting task is seen as a further relevant attribute.

A14: Task Preference. While tasks differ from disaster to disaster, SUVs have more or less clear preferences and ideas how and where to help. Neglecting such preferences may lead into bad experiences and frustration causing demotivation and negative motivation for further disaster assistance (Schmidt et al., 2016; Kircher, 2014; Falasca and Zobel, 2009). Thus, task preferences are a relevant attribute for modelling SUV's behaviour.

A15: Capabilities. Supporting tasks and task preferences may be influenced by individual capabilities like physical capabilities or the ability to be led by official forces (Hofmann et al., 2014; Kircher, 2014; FEMA, 2013;

Points of Light Foundation, 2005). Thus, capabilities are an important attribute to determine the kind of support that can actually be realized by a SUV.

A16: Resources. Recent disasters showed that SUVs are also providing resources like bottles for water, shovels, food, or occasionally heavy machines. These resources can be valuable for reducing disaster scales, because they cannot entirely be provided by officials (Detjen et al., 2015; Kaufhold and Reuter, 2014).

A17: Working Time. Working time per day of SUVs is reported to be related to their capabilities and mainly lying between 4 to 8 hours (ARC, 2010). Beside these findings, there are reports that at least students are willing to work much longer (Geißler, 2014).

A18: Time Preference. Although students (and other groups) are timely flexible to assist during a disaster, they have individual preferences over their time (Geißler, 2014; ARC, 2010). Time preferences also include time slots made available through work (ARC; 2010). Coordinating, planning and scheduling SUVs requires to take such preferences into consideration.

A19: Working Duration. On a general scale, supporting tasks usually end automatically for SUVs if and only if the help is no more needed (Geißler, 2014). Depending on the kind of disaster and individual time preferences (A18), durations may vary from some hours to weeks or even months (Barraket et al., 2013; Points of Light Foundation, 2005). Thus, at least for some disaster situations, working duration is a relevant attribute to a SUVs willingness to help.

A20: Operating Site. Operating sites define locations where SUVs might be needed. Some disasters (e.g. flooding) may have many operating sites, while others get along with one location (e.g. terrorist attack). An operating site is characterized at least by its location, the amount of current and needed SUVs, and the required supporting tasks (Detjen et al., 2015; Hofmann et al., 2014; Luqmann and Griss, 2011).

A21: Kind of Information. Information about operating sites influence the SUV's decisions: operating sites with high demand for volunteers are preferred over those with no need for volunteers (Lange and Gusy, 2015; Kaufhold and Reuter, 2015; St. Denis et al., 2014; BBK, 2014). The kind of information that volunteers receive on different channels and/or media also might influences their decision and, thus, should be seen as relevant attribute for SUVs behaviour.

A22: Location. The location where SUVs live or where they are when deciding to help plays a critical role in selecting operating sites. Usually SUVs tend to help on operating sites that are near to their location (Auferbauer et al., 2016; McDonald et al., 2015; Luqman and Griss, 2011).

A23: Operating Site Preference. As mentioned before, SUVs select their operating site first within their social network and then in a close area to their own location according to the information about need for support (Auferbauer et al., 2016; McDonald et al., 2015; Luqman and Griss, 2011). SUVs, thus, have individual operating site preference (CNCS, 2011).

A24: Travelling. Recent disasters have shown that SUVs usually are pedestrians, however, when individual cars are used for getting to an operating site, additional challenges like blocking emergency routes near the operating sites were reported (Kircher, 2014; Fernandez, 2007). Thus, the kind of getting to the operating site is seen as further relevant attribute for SUV, since it might be influence disaster coordination.

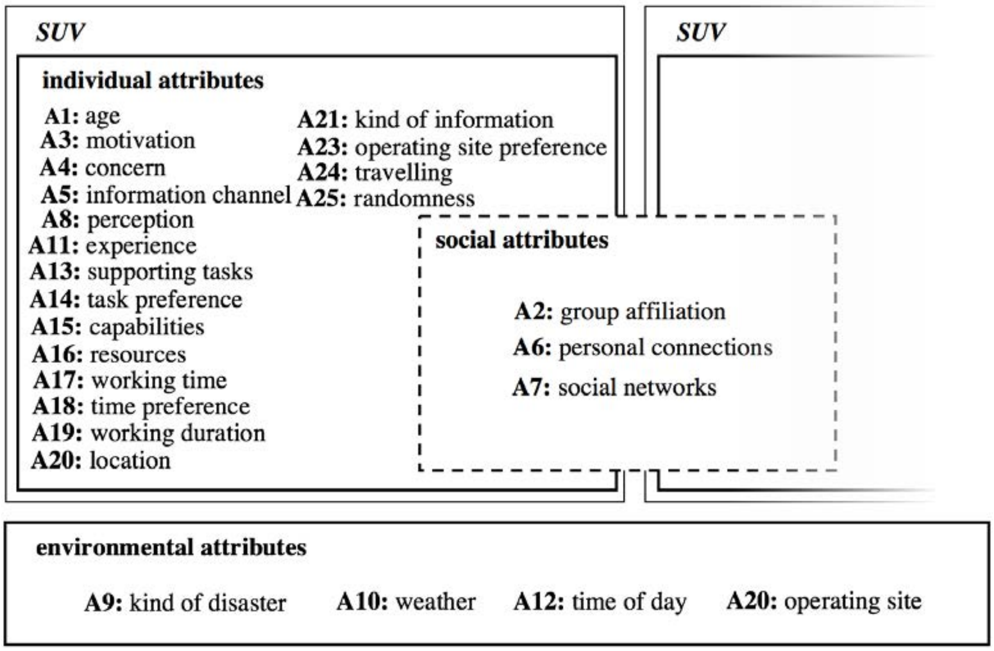
A25: Randomness. Motivation combines only a part of the factors influencing actual behaviour of the SUVs and it is impossible to collect and depict all factors influencing motivation, time preferences, or working durations (Geißler, 2014). Since a SUV may have concrete time preference and high motivation to help, there is still a probability that something unexpected happens preventing him or her from actual helping. Thus, for simulating such fuzziness, a further attribute called randomness is seen as relevant for simulating realistic SUVs behaviour by software agents.

Attribute Categorization and Interrelations

Altogether, 25 attributes were identified featuring or influencing the behavior of SUVs. Although the identified attributes are focusing on different aspects, there exist obvious interrelations. A major insight is that motivation seems to be the key to actual supporting activities and that other attributes affect and trigger motivation directly or indirectly. A further insight is that due to complexity reasons the interrelations are subject of further research. However, some connections can already be identified by the underlying literature body.

Beside the missing concepts for operationalizing the attributes and their interrelations, the identified attributes can be grouped into individual, social, and environmental attributes. This is a contribution to modeling SUVs as software agents and simulating their behavior with multi-agent systems in the future, since some attributes affect the individual behavior of a software agent (e.g. decision to help) while others affect their cooperation results (e.g. group affiliation). Some attributes can be influenced by the software agent itself (e.g. location), others can be influenced by others (e.g. kind of information by disaster management), others are fix in the short run (e.g. age), and others are externally given (e.g. weather). Classifying the attributes into individual, social, and environmental attributes is a basic step for developing software agents. In general, software agents act in a perceive-reason-act cycle (Lind, 2010) which is determined by how software agents perceive their environment (environmental attributes), derive their actions by an internal processing of the perceptions (individual attributes) and interact with other agents (social attributes). The identified attributes, thus, were grouped in according categories (see Figure 1): individual attributes are those that feature SUVs behavior directly, social attributes are those that are related to interconnections between the agent and other software agents, and environmental attributes are those that are externally given and identical for all software agents, however they are perceived by software agents influencing their individual attributes.

Figure 1. Grouped Attributes of SUVs.



According to our literature review, the presented attributes and their classification is the first step fitting relevant SUV attributes to the perceive-reason-act cycle that is essential for the representation of SUVs behavior in an agent-based perspective.

CONCLUSION AND FUTURE RESEARCH

A comprehensive literature review revealed that increasing research on using the enormous potential of spontaneous unaffiliated volunteers (SUV) for disaster response exists. However, it also revealed that research on coordination and cooperation behavior of on-site physical volunteers is just in its beginning. While several approaches have been developed and discussed, a systematic and comprehensive testing and evaluation is difficult: real disasters are usually not at hand and field tests or drills are expensive, elaborate, or partly impossible. To close this gap, simulations are promising and multi-agent simulations provide an established method to simulate human behavior. Developing software agents successfully, simulating the behavior of SUVs requires an extensive analysis of their real world behavior. Thus, the aim of this contribution was to identify and to analyze relevant attributes from the state-of-the-art characterizing SUV's behavior. Altogether, a set of 25 attributes featuring SUVs or influencing their coordination behavior were identified and classified according to individual, social, and environmental attributes. This provides a first sound basis for designing realistic software agents, their perceive-reason-act cycle, and multi-agent simulation environments in future work. This is seen as a first necessary step to improve the evaluation and validation of novel research methods and tools aiming at effective and efficient coordination of SUVs in disaster response.

The analysis also revealed several limitations and research desiderata: while identifying the attributes, it turned out that the effect of some attributes is not yet clear (e.g., weather, age) and, thus, need further investigation. In order to obtain high quality simulation results parameterizing the identified attributes and their interrelations is also required and, thus, part of further research. These limitations most likely lead to nonrealistic simulation results when starting with simulations according to the current state-of-the-art. However, since quality of results can be expected to improve by taking new insights (attributes, interrelations, effects) into consideration, the development of software agents based on the identified attributes is a consequent next step of our research. This is realized within a comprehensive research project named KUBAS aiming (a) at an IT-based solution for coordinating SUVs and (b) at a general evaluation method to measure the effectiveness and efficiency of approaches, methods, tools and drills aiming at the integration and coordination of (thousands of) SUVs during disaster response. The methodology of the whole research project follows the "Design Science Research Process" proposed by (Peffers et al., 2006). Accordingly, the paper at hand is part of the second phase "objectives of a solution" and with its results it provides an important fundament for the next phase "design and development" focusing on the modelling and technical implementation of SUV software agents.

Last but not least, the identified set of attributes are expected to be helpful for other researchers and application scenarios, e.g., it might support official forces in coordinating SUVs in general by knowing which factors influence the behavior of SUV. Furthermore, the attributes and their classification might facilitate the development of new coordination methods regardless of the use of IT.

ACKNOWLEDGEMENT

This research has been funded by the Federal Ministry of Education and Research of Germany in the framework of KUBAS (project number 13N13939).

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