Volunteered Geographic Information
and its Implications for Disaster Management

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Abstract

Communication technologies and approaches, such as mobile applications and social media enable individuals to share information with others ubiquitously. These voluntarily created data contain geographic information as well as user generated content such as images or text. Researchers and practitioners can gain highly valuable information by analysing and combining those different types of data.

Earlier studies revealed that during disasters, such as floods, earthquakes, and bushfires, people want to help the affected ones and support emergency service agencies voluntarily. One way to do so, is to provide helpful information e.g. about the area or the situation on sight. Based on the derived information, emergency agencies might react faster and more efficient in such an extreme situation. This paper provides a comprehensive literature review on volunteered geographic information. One result of this work is, that attributes such as ‘accuracy’ and ‘consistency’ are mostly used as criteria for quality assessing, while other factors such as “trustworthiness” are not considered intensively.

Keywords: Volunteered Geographic Information (VGI), social media, user generated content, disaster.

1. Introduction

During the last few years, Volunteered Geographic Information (VGI) as well as related concepts such as Geospatial Information (AGI) have gained high attention [27]. This is reasoned by the huge amount of data that is created in social media as well as by the high penetration of mobile devices such as smartphone.

In order to exploit the potentials of those valuable data, researchers as well as governments and industrial organisations have to face new challenges. Not only that it is difficult to collect those data; it is also very challenging to analyse and interpret them in a useful way. In contrast to structured geo-data (e.g. degree of latitude and longitude), user-generated data is much harder to process and to evaluate [21, 47]. For example, user-generated data such as text messages often are incorrect, unclear, unverified, misleading or subjective. On the other hand user-generated data can provide unique and highly useful information in several contexts (e.g. brand communication, market research, political communication as well as in extreme events).

In the last years, disaster management has been identified as one important field that might profit from volunteered geographic information (VGI). It is obvious that the mentioned problems are highly relevant in the context of disaster management. Emergency service agencies rely on verified, accurate and timely information. Therefore, approaches are needed that help to classify and measure VGI based on their relevance and quality for disaster management. This means that besides traditional characteristics of ‘quality’ such as ‘accuracy’ or ‘completeness’ it is also needed to evaluate data towards their trustworthiness [19] in order to derive useful implications. For example, currently it is hardly possible to identify wrong information timely enough to prevent their spreading through the network as rumors [34,42]. Often these misleading information are triggered by for
instance an image or location posting that does not represent the actual setting in an event. Also [48] argue that data, that is created by the crowd has an unclear status of trustworthiness which makes it difficult to build decisions upon those information ([11,32,50]). As a consequence missing information or misleading information could support the evolvement of an extreme events into a disaster bearing the potential to have serious impacts on civilians and economy [16].

Even though there exists a broad spectrum of literature that considers quality of VGI, a comprehensive analysis about the status quo in this field is missing. Therefore, in this paper we seek to identify current literature in order to provide information about measures of ‘quality’ that are used as well as about methods that are applied to process these data. We also draw the attention to the lack of theoretical and empirical research about ‘trustworthiness’ of VGI [2]. We concentrate our discussion about the evaluation of VGI on the context of disaster management because this area is highly affected by the current challenges of VGI analysis.

Thus, our paper is guided by the following questions:

1. Which approaches are employed, in order to ensure quality and trustworthiness of VGI?
2. How can quality and trustworthiness of VGI be measured?

The remainder of the paper proceeds as follows: In the next chapter we present some background information about VGI as well as about social media in disaster management. Next, we describe our method for conducting the systematic literature review. Following, we present the results and we discuss the implications in the context of disaster management. The paper ends with a conclusion and an outlook for further research.

2. Background

2.1. Volunteered Geographic Information

The term “Volunteered Geographic Information” (VGI) has its root in the work of [22]. The authors [21] describe VGI as “a version of crowd-sourcing in which members of the general public create and contribute georeferenced facts about the Earth’s surface and near-surface to websites where the facts are synthesized into databases” [21:112]. VGI are often mentioned in the context of open street mapping (OSM) or other pre-defined settings. In a broader sense VGI means that individuals provide information about certain locations, buildings or characteristics of landscapes by using their smartphones or other mobile devices. Since these mobile devices and mobile applications now have reached a massive user-base, VGI has gained a broader attention [43]. Moreover, the continuously increasing relevance of social media results in huge amounts of digital data that is created on platforms such as Twitter or Facebook. Statistics show that social media are used via mobile devices very frequently and that information are often linked with geo-information [35]. Therefore, the definition of VGI does not only refer to structured geo-data but also to user generated content such as text, videos or images that are linked with a geo-reference. This type of data is also known as Geospatial Information.

Due to the sheer amount of data, the need to interpret content correctly as well as the heterogeneity of data types (e.g. text, video, audio) in social media, analysing this mass information is a very challenging task.

2.2. VGI and Disaster Management

Although there is no general definition for a disaster according to [44] this paper refers to the definition by the United Nations International Strategy for Disaster Reduction (UNISDR): “A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources” [49].

A disaster is the result of a dangerous event, which occurred previously and has an immense negative impact on planet earth and so on human beings, whether on their lives or their material possessions.

Consequently, the management of a disaster “…can be defined as the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters.” [14]

In recent years, several studies about the usage of VGI in disaster situations have been published in Information Systems and other disciplines [29]. By using the wisdom of the crowd especially through social media platforms, new opportunities were revealed and still are unfolding to research and practice.

For example, [45] analysed the information flow on Twitter, during bushfires in Australia and exposed Twitter as a possible additional communication tool to existing ones, during a crisis. The authors also propose to use other social platforms combined, to filter noise and spam in the data. Based on a case study, [26] analysed geo-referenced Twitter messages about the Elbe River Flood in Germany. Their work revealed that
people, which are affected by the flood or close to the affected region do postings referred to the flood. The authors also suggest to extend the analysis by including other social media platforms such as Instagram and Flickr, as geo-referenced tweets are very poor at the moment [26]. Other applications of VGI in the context of disasters and their management are shown in [54] where crowdsourced information are used to create disaster mitigation maps used to enable immediate disaster response. Other authors are going beyond and suggest frameworks to integrate and use different sources of volunteered information in the context of disaster management and instant decision-makings [19, 20]. The effort to improve the quality and trustworthiness of VGI can’t only be seen in the matter that information are created by amateurs and therefore are vulnerable to errors, but the information are also influenced by special circumstances during disasters like stressed people and destroyed infrastructures.

The reason and motivation for putting effort in disaster management research is because of the extended opportunities, people have in the 21st century in order to understand, recover or prevent a disaster, driven by continuous evolving technology. On the other hand research in this field is urgently needed in order to develop more effective approaches to ensure data quality and the trustworthiness of VGI.

3. Research Design and Results

To understand and summarise the current status in research regarding the quality and the trustworthiness of VGI, a systematic literature review is conducted in this paper. We refer on the systematic approach of literature analysis proposed by [10]. Based on its five steps the model guides researchers to identify the most valuable literature depending on the research questions [10]. Besides the definition of the review scopes it includes the following steps: conceptualization, literature search, literature analysis, and synthesis. In the next section, we therefore explain how we conducted the literature analysis. We also describe our most important findings.

3.1. Definition of Review Scope and Conceptualisation

Our scope of review concentrates on those literature in the field of Information Systems that is related to our research topic. The guiding research questions are conceptualized as follows:

For research question 1 we refer to the work of [21] who identified three approaches to improve quality of VGI: (1) crowd-sourcing approach, (2) social approach, and (3) geographic approach.

In this context, crowd-sourcing is not only meant as the ability to solve a problem by the mass as it is described by Surowiecki (2005) in his book “The wisdom of the crowd”, but also as “ability of a group to validate and correct the errors that an individual might make” and furthermore to converge on the truth of the information [21:112]. In contrast to the crowd-sourcing approach, social approaches use trusted individuals or experts as moderators or gatekeepers to proof contributions from other individuals and assure a high quality of the contributions. Often the gatekeepers are arranged in a hierarchical structure. The geographic approach is based on computed metrics from geographic data and the comparison of it to existing knowledge in this field in order to determine the quality of the contributions. Goodchild and (Li 2012) [21] draw on the general example in Geography on the distance of things, i.e. the closer the distance between two things is, the more related they are [21:115].

We conceptualize our second research question by referring to the characteristics for data quality suggested by [48]. The authors describe five criteria, which can be used for measuring quality of VGI [48:486]: (1) completeness, (2) validity (correctness), (3) consistency, (4) timeliness, and (5) accuracy.

Due to the specific nature of social media data and the related challenges (e.g. the need to make sure that information are true) and in line with suggestions by other researchers (e.g. [6], sighted in [19:146]) we understand ‘trustworthiness’ as additional criteria for data quality in our literature analysis.

3.2. Literature Search

The next step contains the actual literature search, which is accomplished in two substeps in this work. First a database search has been conducted and second a backward search [10] has been carried out, by creating a network analysis.

For the database search, the key terms are defined, by deriving the most related key terms towards the topic, and also by using synonyms. In order to gain the most valuable keywords and according to our research questions, the key phrase volunteered geographic information was used in combination with those terms and synonyms that are related to the research question: quality, trustworthiness, reliability, credibility, verification, assessment, and assurance. Based on the set of keywords we started queries in the following IS-related databases: AIS library, ScienceDirect, Springerlink, ACM, and IEEE.

We found 321 research papers that matched the combination of the keywords. As a next step we conducted a manual analysis of the titles and abstracts
of the papers in order to decide whether they are related to one of the research questions or not. We considered about 23 articles to be relevant.

Following, we conducted a backward search (reference-based network analysis) on the relevant papers to accomplish the search process. The reason for conducting a backward search, is to highlight important and considered works by other authors in the community. So each of every reference list of the relevant papers has been taken into account. By creating a network analysis it is also possible to get information about the amount of citations that each paper received by other papers within the network.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Approach</th>
<th>Content of the article regarding the aspect of VGI quality or trustworthiness</th>
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<tbody>
<tr>
<td>Ali and Schmid</td>
<td>Geographic</td>
<td>The authors propose two approaches, the first to improve the data classification the second to check the consistency of contributions. Therefore they use trained classifier based on machine learning.</td>
</tr>
<tr>
<td>Ali et al. (2014)</td>
<td>Geographic</td>
<td>The authors propose an approach to use machine-learning techniques to train a classifier to improve the classification of VGI data points.</td>
</tr>
<tr>
<td>Bajpai and Yadav</td>
<td>Social</td>
<td>The authors propose a data validation approach to increase the validity of VGI data based on a role-based hierarchical model.</td>
</tr>
<tr>
<td>Bimonte et al. (2014)</td>
<td>Geographic</td>
<td>The authors propose an ETL aggregation process based on the credibility of the data to improve the accuracy and validity of data points.</td>
</tr>
<tr>
<td>Bimonte et al. (2014)</td>
<td>Geographic</td>
<td>To assure accuracy and validity of data points the authors propose an aggregation method for the contributed data based on the credibility of the contributing user.</td>
</tr>
<tr>
<td>Bordogna et al. (2014)</td>
<td>Geographic</td>
<td>The authors propose an approach based on a linguistic decision making process. They measure the validity of VGI based on linguistic features derived from the contributed data.</td>
</tr>
<tr>
<td>Brando et al. (2011)</td>
<td>Geographic</td>
<td>The authors propose a method to design new models for VGI by receiving model elements from existing reference datasets like Wikipedia. Therefore classification of contributed data is easier for contributing users.</td>
</tr>
<tr>
<td>Celino (2013)</td>
<td>Crowd-sourcing</td>
<td>Based on a human computation model the author propose a method to aggregate data contributed from different people to a high accurate and consistent data point.</td>
</tr>
<tr>
<td>Comber et al. (2013)</td>
<td>Geographic</td>
<td>The authors propose an approach to improve the accuracy of VGI by comparing the data to a reference dataset.</td>
</tr>
<tr>
<td>Farah (2014)</td>
<td>Social</td>
<td>The author propose a method to increase the credibility and validity of a database by introduce experts checking the contributions of volunteers and to establish processes to guide the contributors to give as much information as possible.</td>
</tr>
<tr>
<td>Hayakawa et al. (2012)</td>
<td>Geographic</td>
<td>The authors use the OSM Merit as a Scoring model to rank users based on the complexity of their contributions. Based on the OSM Merit density of areas the authors are enabled to measure the completeness and consistency of data points in the OSM database.</td>
</tr>
<tr>
<td>Jiang et al. (2015)</td>
<td>Geographic</td>
<td>The authors propose a method to analyse disaggregated land use using POI. Therefore they use a machine learning approach to train a accuracy threshold to improve the accuracy of the VGI data.</td>
</tr>
<tr>
<td>Karam and Melchiori (2013)</td>
<td>Crowd-sourcing</td>
<td>The authors propose approaches to measure the trustworthiness of users and the quality of their changes to OpenStreetMap data. Therefore the authors use a scoring model to determine the trustworthiness of users based on the quality of their changes. To measure the quality of the changes the authors evaluate the coherence of the contributed changes.</td>
</tr>
<tr>
<td>Karam and Melchiori (2014)</td>
<td>Geographic</td>
<td>The authors propose a scoring measure based on the activities of the users. The ranking based on the scoring express measure for the credibility of the user and therefore of the contributions of the user. In addition the authors propose a clustering measure to evaluate the amount of agreement to a user by the community.</td>
</tr>
<tr>
<td>Keßler and de Groot (2013)</td>
<td>Geographic</td>
<td>The authors propose an approach to measure the accuracy, completeness and consistency by comparing the VGI data to a ground truth dataset received by a field study. The authors use trustworthiness as a proxy measure to analyse the impact of data provenance on data quality of VGI.</td>
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| Matyas et al.      | Crowd-sourcing | The authors propose a game-based approach to improve the accuracy of data points. Therefore

<table>
<thead>
<tr>
<th>Keywords</th>
<th>Source</th>
<th>Result</th>
<th>Relevant</th>
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</thead>
<tbody>
<tr>
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<td>6</td>
<td>0</td>
</tr>
<tr>
<td>“Geographic Information”</td>
<td>IEEE</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>AND “Quality”</td>
<td>ScienceDirect</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>OR “Trustworthiness”</td>
<td>SpringerLink</td>
<td>278</td>
<td>12</td>
</tr>
<tr>
<td>OR “Reliability”</td>
<td>ACM</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>OR “Credibility”</td>
<td>OSM</td>
<td>343</td>
<td>29</td>
</tr>
<tr>
<td>OR “Verification”</td>
<td></td>
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<tr>
<td>OR “Assessment”</td>
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<tr>
<td>OR “Assurance”</td>
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<tr>
<td>Backward Search</td>
<td>Network</td>
<td>22</td>
<td>6</td>
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<tr>
<td>Analysis</td>
<td></td>
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</tr>
<tr>
<td>Total</td>
<td></td>
<td>343</td>
<td>29</td>
</tr>
</tbody>
</table>

Table 1. Results of the literature search

Table 2. Approaches applied in the relevant articles
they created a game to collect geographic data which is used with a clustering approach to get accurate data points.

Mooney et al. (2010) [38] Geographic The authors propose measurements for quality in the OpenStreetMap dataset. They propose a similarity measure and approach to compare VGI to a reference dataset to improve the data accuracy.

Mullen et al. (2014) [39] Geographic The authors propose a statistical analysis on the dependency between demographic data and the quality of VGI. Therefore the authors use different aggregation and similarity measures to compare the VGI to the demographic data to improve the quality of the VGI data.

Mülligann et al. (2011) [40] Geographic The authors propose an approach to analyze the spatial-semantic interactions of POI to improve the accuracy and validity. Therefore they use similarity measures and clustering techniques to analyze the feature type of data points.

Mummidi and Krumm (2008) [41] Geographic The authors propose an algorithm to find consistent POI in big databases. Therefore the authors use clustering methods and compared the clustered results to reference databases like the yellow pages. In addition the authors use scoring methods to examine POI which are not found in reference datasets.

Spinsanti and Ostermann (2013) [46] Geographic The authors propose a prototype of a software to assess the data quality of VGI. Therefore they use several steps with machine learning tools and clustering methods to improve the accuracy, completeness, consistency and validity of the VGI.

Yanenko and Schlieder (2012) [51] Geographic The authors propose a constraint satisfaction approach to assure data consistency. Therefore they compared different reports for the same data point which are time-dependent to find inconsistencies and missing values.

Zhang and Chen (2013) [52] Geographic The authors propose an integrated approach to improve the timeliness and consistency of data by using similarity measure together with an HADOOP-based aggregation model and a scoring model to rank the users based on the quality of their contributions.

Brando and Bucher (2010) [9] Geographic The authors suggest an approach to gain an improved quality management in “User Generated Spatial Content”.

Girres and Touya (2010) [20] Geographic The authors perform a quality assessment of OpenStreetMap data. They build on previous work of other authors and conduct the assessment on different elements of spatial data quality, such as accuracy, consistency etc.

Haklay (2010) [24] Geographic The author compare Information from OpenStreetMap with Ordnance Survey datasets towards their Information quality. Therefore the criteria completeness and accuracy are taken into account.

Haklay et al. (2010) [23] Geographic The aim of this paper is to test, if Linus’ Law applies to positional accuracy, as one indicator for spatial data quality of VGI. Therefore OpenStreetMap is taken into account.

Mashhadi and Capra (2011) [36] Geographic In order to gain a better quality control in ubiquitous crowdsourcing, the authors propose a novel technique, by estimating a credibility weight for each information creator and discussing the results.

Zielstra and Zipf (2010) [53] Geographic The authors propose a method to compare VGI data from the OpenStreetMap project to a reference dataset to measure the completeness.

Figure 1 shows the network that resulted among the references. By following the papers, which were cited at least three times overall, we identified 22 additional papers by applying this method and we considered 6 of them as being relevant for our research (table 1).

Nodes in figure 1 symbolize papers, which resulted through the database search (yellow) or the backward search (purple). The size of the bubbles indicates the amount of being cited. The larger they are, the more they have been cited.

As illustrated in figure 1 an amount of 29 out of 343 papers can be considered as relevant and are used for answering the research questions. Those papers are the
basis for the synthesis of the systematic literature review.

To synthesise the results of the search process towards answering research question 1, the papers are first summarised and subsequently analysed. The authors conducted a manual analysis of each relevant paper in order to classify the applied VGI quality approach (crowd-sourcing, social, geographic) and in order to provide a brief insight into the articles content (see table 2). In the following table, the articles and its contribution are briefly described.

3.3. Literature analysis and synthesis

To synthesise the results of the search process towards answering research question 1, the papers are first summarised and subsequently analysed. The authors conducted a manual analysis of each relevant paper in order to classify the applied VGI quality approach (crowd-sourcing, social, geographic) and in order to provide a brief insight into the articles content (see table 2). In the following table, the articles and its contribution are briefly described.

Based on the manual analysis of each of the relevant papers we were able to identify criteria that have been used to measure VGI quality. According to the conceptualization of the research questions (section 3.1), we explicitly searched for the five criteria accuracy, completeness, consistency, trustworthiness, timeliness, and validity. Furthermore we searched for methods that have been applied to actually measure the respective criteria. This part of the analysis aims on answering the research question two. In order to answer the question of how to measure the information we searched for methods that were applied in the 29 articles. Overall we identified six different methods: aggregation, clustering, comparison of reference data, machine learning/constraint satisfaction, scoring, and similarity measurement. These methods describe the way of how the respective authors measured the quality of information:

- Aggregation: Merging the information of volunteers.
- Clustering: Specific information are clustered to groups.
- Comparison of reference data: Collected information of volunteers are compared with existing information, which have been evaluated by experts.
- Machine learning/constraint satisfaction: Techniques to detect true or false information by whether predefined constraints or trained classifiers.
- Scoring: Matching of existing datasets to gain a score level for assessing.
- Similarity Measurement: Comparison of created information of the volunteers by their similarity.

We analysed each of every paper by what and how the authors measure quality and trustworthiness in the papers. Based on this procedure, we identified the related concepts and methods that were applied in the articles, which are briefly presented in following table.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>What to measure?</th>
<th>How to measure?</th>
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</thead>
<tbody>
<tr>
<td>Ali and Schmid (2014) [2]</td>
<td>Accuracy (X)</td>
<td>Clustering (X)</td>
</tr>
<tr>
<td>Ali et al. (2014) [1]</td>
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<tr>
<td>Bajpai and Yadav (2013) [3]</td>
<td>Accuracy (X)</td>
<td>Clustering (X)</td>
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<tr>
<td>Bimonte et al. (2014) [4]</td>
<td>Accuracy (X)</td>
<td>Clustering (X)</td>
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<tr>
<td>Bimonte et al. (2014) [5]</td>
<td>Accuracy (X)</td>
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<td>Accuracy (X)</td>
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</table>
4. Discussion and Implications

4.1 Findings

The study reveals some interesting insights into the current state of the art of volunteered geographic information. Even though we found a quite large amount of articles that deal with the topic in general (343) only 29 of them were classified as being relevant for the topics of VGI quality and trustworthiness.

Regarding research question 1 “Which approaches are employed, in order to ensure quality and trustworthiness of VGI for disaster management?” we found that the geographic approach is most frequently used (in 25 articles 86%) while the crowd-sourcing approach (in 4 articles 14%) and the social approach (in 2 articles 7%) are not frequently used.

This can be explained by the complexity of the different approaches. One reason for the result might be, that in the case of the geographic approach, only the data and a computer are required for the analysis and to improve the quality. For the other two approaches, additional people are needed to perform certain tasks, like data validation. Another reason could be the timeliness of VGI and the extended interpretation of its meaning towards user generated content through social media for example.

As research question 2, we asked “How can quality and trustworthiness of VGI be measured?” Our literature analysis revealed that accuracy (52%), completeness (31%), and consistency (48%) are the most frequently used criteria for VGI quality. In contrast to this, trustworthiness was mentioned in 5 articles only (17%). Timeliness (10%) and validity (31%) were also rarely mentioned. It can be assumed that this result is related to the high frequency of usage of the geographic approach.

The quality of accuracy, completeness and consistency can be assured only by looking at the data. However, trustworthiness, as a complex proxy measure for quality, timeliness and validity are less covered by the literature and it is more difficult to measure.

Regarding the usage of measurement methods, we surprisingly could not find a clear tendency towards one or two specific approaches. Our analysis revealed that comparison to reference data (34%) was most frequently used, followed by scoring (31%), similarity measurement (21%), machine learning / constraint satisfaction (21%), clustering (21%), and aggregation (17%).

The occurrences are nearly equally spreaded over the six categories. The most often-used measurement technique with 34% is the comparison to reference data. This can be explained by considering the technique as the easiest one to accomplish on the one hand and one the other hand as the most reliable one, because of already existing data, which is evaluated by experts. So the data gets the quality and trustworthiness of the reference data, which is already considered as very high.

One aspect, which is focused in this work, is the ability to use more precise information enabled by geo-data, and which volunteers create during such a disaster. Another aspect beside the source could be the visualisation of a disaster-location on a map. Different ways of understanding poor quality issues can be adapted and implemented to deal with trustworthiness and a better quality of VGI in order to ensure a higher resilience for both the affected location, mainly affected people, but also for companies, in particular for their operational processes, decision-making and a higher reliability of business intelligence [48].

4.2 Implications for the Usage of VGI in Disaster Management

We pointed out that VGI that are created via social media (user generated content) are difficult to be analysed. It is not sufficient to measure typical quality criteria. Instead, it is required to evaluate the
trustworthiness of information in order to gain more reliable data sets where decisions can be based on.

The literature review reveals that currently most of the research in this field does not considered complex phenomenon such as trust, but relies on structured technical approaches that are more easier to apply.

As a further research gap, a holistic concept for ensuring a high quality and trustworthiness of VGI during a disaster is missing. Such a concept needs to consider the special requirements of data analysis during disasters (e.g. real-time analysis, trustworthiness of information). Thus it is necessary to have a framework for assessing and filtering the created information. Based on the three identified approaches of [21], the information criteria by [48] and [6], and the results of the systematic literature review, we suggest the following model which serves as an overview of quality measurement in VGI (figure 2).

The suggested model represents a mechanism for ensuring a high degree of quality and trustworthiness in VGI. Therefore, the created information by volunteers is stored in a database. Afterwards each piece of information is analysed by applying methods, that we derived from the literature. Afterwards each piece of information is analysed by applying methods, that we derived from the literature. The adjusted information is filtered into the Geographic Information System (GIS). Subsequently the content is diffused to Emergency Management Agencies.

Figure 2. Quality Criteria and Methods for VGI analysis in Disaster Management

5. Conclusion and Further Research

In this paper a systematic literature review was conducted to point out the status quo towards quality and trustworthiness of VGI in disaster management. Therefore, both a keyword-based database search and a backward search have been conducted. The conducted backward search confirms that the selected papers for the conceptualisation of the systematic literature search were precisely chosen. The authors are highly recognised in the community as the pioneers in this field and thus cited often by other authors. As limitation of this study it is necessary to mention that, even though we considered a large amount of research articles it could still be possible that we missed relevant contributions. Also, there could be a potential bias due to the fact that some articles have the same first author, who could tend to use the same method in their papers.

We only considered five databases and a backward search. As a next step we plan to extend our analyses beyond Information Systems in order to find more insightful articles. However, we think that by applying a comprehensive database search as well as by conducting a backward search, we successfully provided a comprehensive overview about the relevant literature. Although a deeper analysis of the found methods relating to their applications and limitations is not provided during the literature overview, the systematic literature review reveals the current need of an operational mechanism for ensuring quality and trustworthiness of Volunteered Geographic Information. We made a first step into this direction by providing a comprehensive overview about relevant criteria and methods on quality evaluation of VGI. We summarized our findings in a model for evaluating and applying VGI in disaster response.

As a next step it is indispensable to evaluate the suggested framework with real VGI to detect gaps and improve the suggested framework. Besides the discovered aspects of VGI data evaluation, further challenges have to be faced that affect the quality of VGI. This includes: (1) data creation: volunteers are not necessarily experts and so produce nonspecific information causing a poor information quality, (2) data gathering: another aspect of poor or false information could rely on out-dated technology (hardware), API’s, Database or data format, (3) data analytics: this could be driven by inaccurate or incorrect geo-data, (4) data interpretation: in fact, this process step is the most sensitive, because of its interpretation nature. By conducting intelligent machine learning approaches, the subjective perspective on the data could be minimized and thus the risk of misinterpretation could be reduced. Besides challenges of system design (e.g. new ways to collect or process VGI, creating interfaces to other relevant systems) it is also needed to investigate motivation and behaviour of volunteers in order to develop more appropriate systems that deliver high quality and trustworthy data [3, 31, 39]. Each of these aspects requires additional research especially in the discipline of Information Systems.

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7. References


