

ASET: An Intuitive Data Acquisition-Sketching Tool for Disaster Management Systems

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Abstract

In any disaster scenario, the first 24 hours are critical for efficient, quick, and life-saving rescue efforts. An integral part of rescue operations is situation awareness that is powered by real-time data reflecting the emerging and evolving disaster consequences. The proliferation of mobile smart devices presents an excellent opportunity to provide means for data acquisition, processing, and delivery. In this paper, we propose a system that allows users to contribute and query disaster information via their mobile devices. Our system, called Android Sketching and Editing Tool (ASET), is intuitive with an easy-to-use interface that allows users to interact graphically and perform sketch queries. Moreover, we present a case study, where a matching approach is proposed to align sketch maps of volunteers to metric maps.

Keywords: Volunteered Geographic Information (VGI), emergency management systems, qualitative spatial representations, Geographic Information Systems (GISs).

1. Introduction

In the past, geospatial information was collected by experts in national mapping agencies to support Geographic Information Systems (GISs). During the last years, with the increasing availability of low-cost survey devices and software tool, this process became flanked by the Volunteered Geographic Information (VGI) movement: VGI systems rely on the crowd-sourcing concept, thus data collected by ideally many, but not necessarily trained volunteers [1]. VGI systems allow volunteers to contribute, maintain, and use geospatial information. One of the most prominent and successful VGI systems is OpenStreetMap (OSM, www.osm.org) where more than one million volunteers collected and contributed data that is available for everybody.

Tools to acquire spatial data are central when making data available for GISs in critical situations like updating infrastructural data in disaster areas. After strong natural disasters, precise data (in general from satellite images) is usually not available within the first 24 hours [2], and people have only a good chance to survive if they are rescued within 72 hours—the so-called ‘Golden 72 hours’ [3]. Ideally, data would directly come from the field contributed from people in the affected areas. Unfortunately, many people do not have an expertise to work with VGI tools and most of them are not designed to be intuitive and barrier-free, which is important especially in developing countries. Current VGI tools do not support the natural and intuitive data input methods like sketch maps to describe new entities or changes in a given environment (e.g., a new building or a destroyed street network) [4].

In general, emergency management is separated into four phases: 1) mitigation, 2) preparedness, 3) response, and 4) recovery. The mitigation and preparedness phases take place before the actual occurrence of an event. By assessing the

risks and their impacts, appropriate actions can be preemptively conducted to improve the robustness against damages and response efforts effectiveness. During and after a disaster response and recovery efforts will take place. For details on emergency management we refer to [5].

In this paper, we focus on the response phase by developing intuitive and easy-to-use data acquisition tools, which make data about disastrous areas promptly available. We build upon smart-phones and tablets, as they are available and used in most parts of the world, including developing countries. We propose a VGI tool for intuitive data acquisition (and contribution) by means of sketching called Android Sketching and Editing Tool (ASET). ASET allows volunteers to contribute spatial information as sketch maps in the response phase of emergency management.

The remainder of this paper is organized as follows; sketch maps for data collection principles are explained in Section 2. The Android Sketching and Editing Tool (ASET) is described in Section 3. Section 4 describes related work. We conclude in Section 5.

2. Sketch maps for data collection

Sketch maps are useful tools for collecting spatial data in situations where no precise information can be collected. Such situations can arise in the advent of a natural disaster where valuable information can be obtained from witnesses of the impact. The information obtained is based on descriptions of experiences, which can in turn be enhanced, with the use of sketching. Collected sketch maps together with the associated descriptions must then be grounded in a corresponding map in order to make those details shareable. Such crowd-sourced information can also be useful in other situations (see [13, 14] for examples).

2.1. Representation of a sketch map

In order to use sketch maps for spatial data acquisition, they must be understood in at least two ways. First, the objects drawn must be categorized into meaningful conceptual categories. Such categories may be as generic geometric types (e.g. point, line, or polygon), or they may be more on a semantic level as, for example, roads, buildings, landmarks. For simplicity we consider the vocabulary used for these categories to be limited and well defined within the domain of application. Second, the spatial structure of the sketch map as a whole must be characterized in a way that allows to make comparisons between the sketch and a metric map. This characterization involves the use of preselected spatial relations that are robust against the typical schematization and distortions inherent in sketch maps. Once the data described above is available (i.e., sketch), the sketch map can be matched to the metric map using standard model matching techniques (e.g. see [12]) or map matching methods for schematic maps [16].

2.1.1. Sketch objects

As the user adds geometries to the sketch, geometric objects are instantiated with no associated semantic annotations. For each geometric object, a geographic feature object is instantiated once a semantic annotation and/or optionally a name is added. A semantic annotation is a label from one of the categories mentioned in the preceding paragraph. Note that for an application such as a data collection in a disaster scenario, the conceptual categories from which semantic labels are drawn can be more elaborate to include concepts such as “state” of a physical structure. For practical purposes we assume that the concepts represented by the annotations, are organized in a concept hierarchy with a “subsumption” (or conversely “is a”) relation between them in top-down direction and that they denote types of geographic features. In addition each feature type is associated with one of the three spatial entity types point, line, or region. This allows us to make biased interpretations of the geometric input data thereby simplifying the computation of spatial relations.

2.1.2. Spatial Relations

When a geographic feature object is added, certain spatial relations are computed depending on the type. For example, a street or road object participates in a “connectedness” relation with other streets and a building participates in an “alongness” relation with one or more roads. Instances of spatial relations of the same type form a graph in which the nodes represent spatial entities and the edges represent the relation in which the pair of entities participates.

2.2. Matching a sketch map to the metric map

Matching a given sketch map to a metric map involves comparing the feature types of objects and the spatial relations between the sketch objects with those in the metric map. Naturally there are many possible objects that can be matched with a sketched object of a given feature type. The spatial relations serve to restrict the individual objects of the metric map that can belong to the same solution. As an example consider the sketch in Figure 1(a) and the corresponding metric map section in Figure 1(b). A sample of the relations derivable from objects in the sketch map is:

School	<i>along</i>	street(x)
School	<i>leftOf</i>	street(x(x ₂ , x ₁))
Supermarket	<i>along</i>	streets(x, w)
Supermarket	<i>rightOf</i>	street(x(x ₂ , x ₁)).

The matching algorithm will then proceed to find the scenarios in the metric map that match best the sketched configuration by creating an association graph [6]. The association graph corresponds to pairs of objects, one from the sketch and one from the metric map. In order to regulate the size of the association graph, line type objects (e.g. streets or streams) are associated only if there is at least one non-line object in the association graph with which the line-object participates in a relation. Finding the best match then involves finding the maximum cliques in the association graph. This leads to the approach that takes best matches to be the maximizers of the following evaluation function:

$$Best = \max_{(I,J)} \left(\sum_{i \in I, j \in J} S_{obj}(o_i, o_j) + \sum_{i,k \in I, l \in J} S_{rel}(R_{ik}, R_{jl}) \right)$$

For index sets *I, J* of objects of the sketch map and metric map respectively. Additionally, $S_{obj}(o_i, o_j) = 1$ if o_i and o_j have the same feature type and $S_{obj}(o_i, o_j) = 0$ otherwise; $S_{rel}(R_{ik}, R_{jl}) = 1$ if the relation R_{ik} is the same as relation R_{jl} with o_i matched to o_j and o_k matched to o_l and $S_{rel}(R_{ik}, R_{jl}) = 0$.

Consequently, the best matches are those that maximize the number of objects from the sketch map that have been “associated” with objects in the metric map such that all the spatial constraints between any two objects in the sketch map are the same as the constraints between the pair of objects in the metric map with which they are associated. The best match for the example sketch in Figure 1(a) includes the dashed street segment and the labelled objects in the map of Figure 1(b).

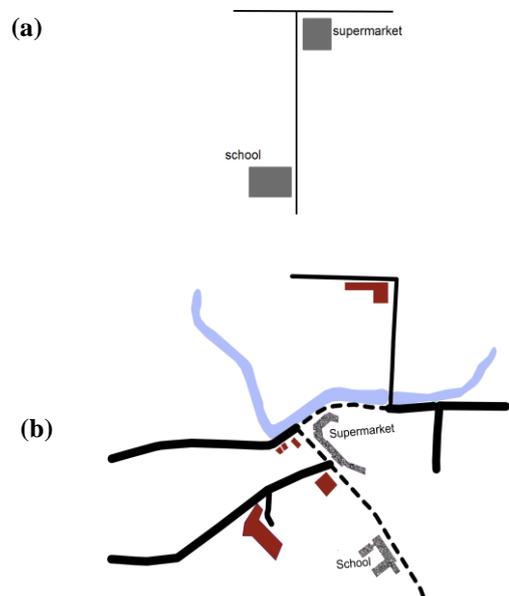


Figure 1: A Sketch map and the corresponding region in metric map

3. Android Sketching and Editing Tool (ASET)

In this section, we describe the interface of the Android Sketching and Editing Tool (ASET). The system architecture is illustrated in Figure 2.

ASET is an open source tool that allows volunteers to sketch objects (e.g., roads and streets) in an intuitive manner by means of gesture recognition libraries for Android smartphones and tablets. Additionally, Scalable Vector Graphic (SVG) and OpenGL libraries are applied to allow for simple and smooth drawing. ASET is implemented in Java and runs on Android-based smart phones and tablets.

ASET supports three kinds of gestures; selection, multi-touch zooming, and multi-touch rotation. A user can select any drawn object by pressing it. With two or three finger gestures on the Minimum Bounding Box (*MBB*) (Label 3 of Figure 3) objects can be rotated and zoomed.

Figure 3 shows a snapshot of ASET. Label 1 of Figure 3 refers to basic functions (e.g., Undo/Redo, Annotation, etc...). The geometries of drawn objects can be exported in XML format with or without time stamps (Label 2).

We note that time stamps are helpful to detect the semantics of objects. For instance, time stamps can give information about start and end point of objects and about total time that is taken to draw it. Figure 3 shows that School *leftOf* street(x_2, x_1)).

Figure 4, shows also the generated geometries with the time stamps of the drawn objects in XML format.

However, the qualitative spatial relations are abstracted from the generated geometries semi-automatically and offline on the server.

Label 3 is attached to the *MBB* of a selected object. The selection allows users to move, rotate, and zoom the according object. Additionally, it is possible to annotate the object (Figure 3, Label 4).

The source code of ASET can be downloaded from (<https://github.com/ramialsalman/PaintSqV1.3>).

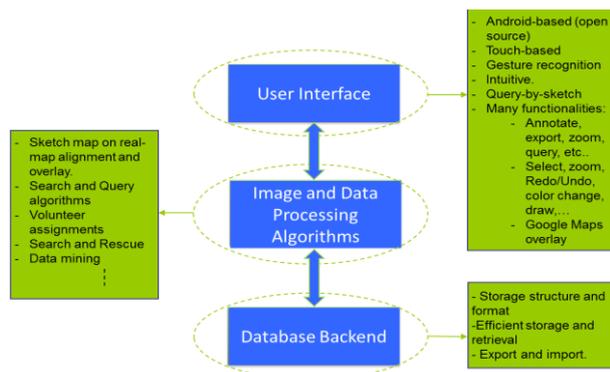


Figure 2: The System Architecture

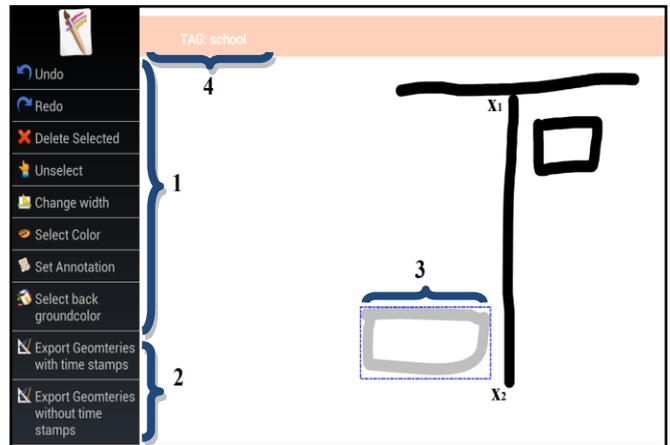


Figure 3: A snapshot of the ASET

```

<?xml version="1.0" encoding="UTF-8"?>
<AppData version="1.0" TimeStamps="TRUE"
NumberOfObjects="4" BG-COLOR="WHITE">
<Object ID="1" Name="school"
CreationTimeStamp="2013-04-15t20-30-59">
<Point X="-0.052801256" Y="0.25309065"/>
<Point X="-0.054681335" Y="0.25665279"/>
<Point X="-0.002784449" Y="0.25422345"/>
<Point X="-0.001432563" Y="0.25110164"/>
<Point X="-0.023398724" Y="0.25004432"/>
</Object>
</AppData>
    
```

Figure 4: The generated geometries of the drawn objects

4. Related work

Recently, several tools and platforms have been developed to respond to natural disasters.

Google Crisis Response [7] and Ushahidi [8] are platforms for empowering people to contribute to the status of disastrous areas. Text messages can be sent via mobile phones or by annotating directly on a digital map. Based on this data a spatio-temporal database of events is created, which can be queried by emergency managers. These platforms do not allow volunteers to sketch disastrous areas using intuitive and sketching tools.

Egenhofer proposed a Spatial-Query-By-Sketch (SQBS) tool for querying geo-spatial databases using a sketch-based interface [9]. This tool empowers users to build spatial queries

by sketching configurations they are looking for. Several visual tools were developed on the basis of the SQBS. For example, visual tools for querying geospatial databases by means of a sketch-based interface are presented in [10, 11]. First, users need to sketch their queries by drawing the objects. Based on these configurations queries are generated to retrieve results from spatial databases. The main focus of these tools is on querying databases rather than on matching a set of sketches. In addition, our sketching tool provides more intuitive interface in a sketching process. For instance, it allows for using gestures to move, zoom in, and zoom out sketched objects.

Usability aspects and barrier-removing approaches are gaining increasing attention within VGI research and applications. One example is MapIT [15], an intuitive tool to map small geographic objects with high geometric accuracy via geo-referenced photos taken with standard smartphones [15]. By building upon photos, gestures based object segmentation, and speech based labeling MapIT removes educational borders for potential VGI contributors.

SketchMapia [17] is presented as a framework to align sketch maps to digital maps. It shows several errors that could be happened in sketch maps (Errors of Distance, Errors of Direction, and Schematic Structure). Further, way-finding scenario is presented to depict how the sketch map with additional information or elements (i.e., landmarks) can be mapped and integrated to metric map (i.e., Google Maps). To accomplish mapping process, five Qualitative Spatial aspects are considered: 1. Landmarks, 2. Street network, 3. Topological relations, 4. Direction relations, and 5. Order relations.

5. Conclusions and Future work

Sketch maps are a powerful data acquisition method. However, combining a matching approach for aligning sketch maps to metric maps with an intuitive sketching tool contributes to the problem of getting data about disastrous areas available as soon as possible (in the response phase). Hence, the Android Sketching and Editing Tool (ASET) is developed to make the data acquisition process much more intuitive and simple. In future work, we will integrate the ASET tool with geo-spatial databases to enable integrating qualitative data. Additionally, we will incorporate the capabilities of tagging and drawing directly on a metric map as additional feature of ASET.

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