Investigating Representations of Places with Unclear Spatial Extent in Sketch Maps

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Abstract This study analyzes different ways of representing vaguely defined places from a set of sketch maps specifically when used in giving route instructions. A total of 30 participants who are familiar with the study area were asked to sketch a route map consisting of pre-identified set of places. The task involved two groups: intra-city route and inter-city route. Sketch maps were analyzed using a previously developed classification scheme to investigate how places with unclear spatial extent are represented. These were then classified into different category of places: *district*, *site and neighborhood*. Results showed that labels and regular shapes are the most preferred, as opposed to other types of sketch representations, regardless of the category of place. It also occurred that a specific place can be classified under one or more categories, which influences the type of sketch representation used.

Keywords Sketch representation · Spatial vagueness · Place · Sketch map · Wayfinding

1 Introduction

When receiving wayfinding instructions from people (either visual or textual), we often are required to interpret imprecise information such as '*go towards the city center*', '*you'll find the place inside the university campus*', '*it is near the castle*'.

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In this case, we are faced with questions such as '*Where does the city center start*?', '*Which part in the university campus*?', '*What did that person mean when referring to the castle*?' Hence, we often encounter vagueness or even ambiguity in such spatial information. Vagueness arises due to poor definition of the object in question or the class of object (Fisher et al. 2006). Sometimes there are cases wherein a person would represent a place by also referring to other features surrounding it. In natural language, qualifiers such as tall or big are vague because of the presence of borderline cases where it is unclear how to classify them. This is also true of places, where it is not clear whether certain locations are part of vague vernacular regions such as city centers, whose boundaries generally are not crisp. Other kinds of vague references in spatial information include natural features such as 'mountains' or 'lakes'. These are characterized by unclear spatial extents and boundaries of the referents. Three distinct categories are of interest in spatial information (Bennett 2010), with the first two being relevant for this study:

- General descriptions of places, which use count nouns such as *downtown*, *marketplace*, *lake* which in many cases have unclear extents.
- Referenced places such as *harbor* or a university *campus* which are associated with specific space but exhibit similar problem with boundaries.
- Spatial relations such as *is near*, *in front of*, *along the* etc. commonly used in qualitative route descriptions.

There may be different methods of representing spatial vagueness but there is no perfect model of visualizing these places because they have their own set of advantages and disadvantages (Humayun and Schwering 2013). This study attempts to understand how people represent places with unclear spatial extent in conveying route instructions. One way to understand how people represent such places is through sketch mapping.

Sketches are used to visualize people's abstract representation of specific places or objects for both learning and communication (Voudouris et al. 2006). With common symbols, patterns and strategies used, people are able to interpret and understand sketches drawn by others (Blaser 2001). It is through this graphic representation that we acquire ideas of how humans store, understand, and communicate information they see (Bertin 1983). This is evident in sketch maps which have been used in many studies of how people represent their environment (Metz 1990; Wise and Kon 1990; Taylor and Tversky 1992). The aspect of correctness has been extensively studied; particularly the distortions in sketch maps (Tversky 1981). Some scholars have looked at possible approaches to address cognitive errors of representations in sketch maps using qualitative methods (Wang and Schwering 2009; Chipofya et al. 2011). Although distortions are inevitable in sketch maps, there are other aspects that make it reliable and effective in communicating spatial information. Sketch maps are static and will not respond to changes in the user's context unlike dynamic maps. They also do not adhere to any standard cartographic conventions and offer a good insight into how people perceive and illustrate vague referents. The level of personalization and flexibility in

sketch maps allows the person drawing to take liberties with representation of vague spatial features. Strategies and distortions involved in representing these places in sketch maps is an understudied topic in spatial cognition.

The paper aims to investigate how places with unclear spatial extent may be represented. Participants were asked to sketch a given route and include pre-identified places which have unclear spatial extent. The task involved two groups to be investigated. Group 1 is a route within the city (intra-city route) and Group 2 is a route from the study area to another city in Germany (inter-city route). The study focused on how participants represent the same pre-defined places in these two different groups as well as what type of sketch representation is used to represent individual place categories—*district*, *neighborhood*, and *site* (described in Sect. 2.2). We first classified these representations from human-generated route sketch maps and then identified the place category to which they belong. Results of this study are applicable to other research areas involving pattern recognition in sketches, generating mobile maps and computer aided drawing.

The remainder of this paper is structured as follows. Section 2 discusses the different types of sketch representations used for the analyses followed by the categorization of places. In Sect. 3, the procedure and materials used in the experiment are explained. The outcome of the experiment is presented in the Results section (Sect. 4) and followed by the Discussion section (Sect. 5). Finally, in Sect. 6, conclusions and outlook for future work are presented.

2 Sketch Representations and Category of Places

2.1 Types of Sketch Representations

Blaser (2001) analyzed sketched objects based on their type, how they are visually portrayed and their purpose. This involves properties of sketched objects such as their shape, outline, fill patterns, completeness, number of strokes, dimensionality and annotations. Our classification uses a subset of these, while focusing more on the semantic properties of vague places. This was classified based on the dimension of how abstract a type is and what visual style is used to depict it (Fig. 1). Less abstract types depict the top-down view or the facade of the object as realistically as possible whereas highly abstract shapes are simply intended as a marker to anchor where the place is situated. It is also observed that by using some visual styles, the sketcher tries to convey that the place in question has unclear extents. Based on these distinctions, the sketch representations are categorized into the following types and used later in our analysis:

(1) *Simple label*—uses text to identify a place. A distinction is made over whether the text simply serves as an annotation to other types or is the sole indicator of a place.

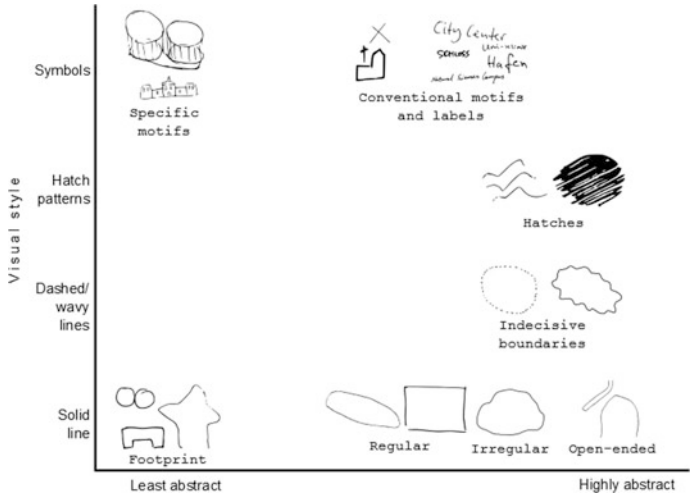


Fig. 1 Types of representations

(2) *Motifs*—the use of graphical symbols to denote the category of a place. Some motifs are specific and depict the actual appearance of a place they represent, whereas others tend to be generic and depict its type.
(3) *Footprints*—a unique pattern identifying the shape of a place such as the layout of a building or any salient feature.
(4) *Regular shapes*—clearly discernable pattern usually in regular and non-arbitrary forms such as circle, rectangle or ellipse. A shape which is outlined by street networks is also regular since the pattern is discernible.
(5) *Irregular shapes*—a representation which has no discernable regular pattern and is not a footprint.
(6) *Open-ended shapes*—a shape that is not bounded in any form and is purposely left open to indicate continuity.
(7) *Indecisive boundaries*—places are represented by wavy, dashed lines or dotted lines which serve to indicate that the drawn extent is approximate.
(8) *Hatch pattern*—series of strokes that give the impression of shaded region.

Figure 1 shows the different representations obtained from actual sketch maps. Highly abstract representations simplify the real world bearing no similarity to the shape or spatial extent of the real object. The less abstract ones attempt to imitate the real shape of the referent in a more recognizable way. Footprints are classified as least abstract since they reflect the shape of the object. Some symbols such as specific motifs are also treated as less abstract, showing a 2.5D representation of a building. Irregular, regular and open-ended shapes are treated as highly abstract.

2.2 Category of Place

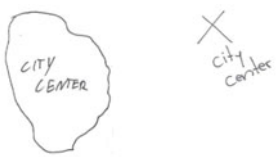
The places chosen in this study differ in how their geometry is represented in sketch maps—either as point or as region feature. To classify these representations in a more generalized way, we refer to Bennett's (2011) definition of the following place-related terms and treat each as a different category of place:

"*District*" refers to geographic regions which do not necessarily pertain to an actual unit of jurisdiction, but to a region of similar size with some (often vague) geographically related integrating principle. An example used in this study is the city center.

"*Neighborhood*" refers to part of the town with a common class of inhabitants or similar standard or buildings but it is also associated with sharing amenities such as shopping outlets and entertainment venues. Examples of places in this study that refer to this category are the Harbor, the Natural Science Campus and part of the University Hospital.

"*Site*" refers to a place where something is situated. This is typically applied to buildings and other large static artifacts. For this study, the examples of this category refer to a smaller region with a specific building wherein its surroundings are also recognized as its part, e.g. the castle and the University Hospital.

Figure 2 shows the different categories of place and some examples of how participants represented these in their sketch maps. One can observe that the type of representation used is not homogeneous, and varies even for a given category.

Category	Examples of Representation*
District	
Neighborhood	
Site	

* from actual drawings by participants

Fig. 2 Category of place

3 Methods

3.1 Participants

A total of 30 participants (15 females, 15 males) took part in the experiment and received 10€ for participation. They are between 20 and 36 years with median age of 26 ($M = 26.8$, $SD = 4.5$). Participants have been residents of the study area for minimum 6 months. Sixty-three percent (63%) had lived in the study area between 1 and 5 years and the rest (37%) lived for less than a year.

3.2 Study Area

The study area is Muenster, a mid-sized city in the northwestern part of Germany. Some vague places were identified within the city to be represented in the sketch map. These places do not have clearly defined spatial extents. Sometimes people perceive a feature to include its surroundings as well.

3.3 Design

Participants were asked to perform a sketch mapping task which required them to draw the pre-defined vague places. They were given a paper sheet of desired size (A4 or A3) and a pen and they could request additional sheets of paper if needed. Participants were equally distributed between two groups. Each person was asked to draw only one sketch map, therefore each Group produced a total of 15 sketches. In Group 1, the participants drew a route within the city. The instruction stated: *Please draw a map of the city. You may include as many landmarks and street names you can remember but please indicate the following places*: Harbor (Hafen); City center (Innenstadt); Castle (Schloss); University Hospital (Universitaetsklinikum); Natural Science Campus (Naturwissenschaftliches Zentrum or NSC). In Group 2, the participants were asked to sketch a route from the Natural Science campus to a specific place within the city center of another city in Germany they are familiar with. Except for the Harbor, all places mentioned in Group 1 were also required to be sketched for the intercity route. The Harbor, due to its location, was intentionally excluded because it may lead to confusion and difficulty in comprehending the instruction. The instruction stated: "*Please draw a route from the Natural Science Campus passing by central train station to the city center of any German town/city that you are familiar with. Please indicate where the city centers are for both cities. Please also indicate the following places in the city*:" Castle (Schloss); University Hospital (Universitaetsklinikum); Natural Science Campus (Naturwissenschaftliches Zentrum or NSC).

4 Results

4.1 Sketch Representation of Places with Unclear Extent

Participants' route sketch maps revealed differences in the representation of places. Table 1 shows the number of participants who used a specific representation type for each place in the sketch maps. The city center is represented in six types of representations—as simple label, motifs, regular shapes, irregular shape, indecisive boundary and hatches. There are no examples of sketch maps representing the city center as footprints and open-ended shape for both groups. Simple labels appeared to be the common type of representation for city center in both groups showing approximately 40% of all representations.

The University Hospital is represented as regular shapes, simple labels and footprints for both groups. For Group (Grp) 1, more than half of the representations are regular shapes and few participants used motifs and open-ended shapes to draw it. This also showed the same result for Group 2.

The Castle, on the other hand, is represented as regular shapes, footprint, motifs and simple labels. Regular shape made up 50% of the representations for castle for both Group 1 and Group 2. For this study, regular shape was the most common representation followed by footprint and motifs for Group 2 and 1, respectively.

The Natural Science Campus was mostly represented as regular shapes for both groups with 50% of the participants. However, it was not represented as hatch for both groups. In Group 1, it was not represented as motifs, footprint, and indecisive boundary. In Group 2, it was not represented as indecisive boundary.

The Harbor is represented mostly as labels (53%) but, it was also represented as simple labels, footprint, irregular shape and open-ended shape. This is similar to the results for the city center.

In general, the table shows that there are different ways of how vague places are represented. Disregarding the place, more than 40% of total representations accounted to regular shape in both groups. Simple labeling amounts to 31 and 22% of the total representations in Group 1 and Group 2, respectively. The third most common type of representation used is footprint (7% for Group 1 and 15% for Group 2).

Table 1 Participants' representations of all vague places in sketch maps

Representations	Castle		Uni hospital		NSC		Harbor		City-center	
	Grp 1	Grp 2	Grp 1	Grp 2	Grp 1	Grp 2	Grp 1	Grp 2	Grp 1	Grp 2
Simple label	2	2	3	3	3	2	8	–	7	6
Motifs	3	2	1	1	0	1	0	–	0	2
Footprint	2	4	2	4	0	1	1	–	0	0
Regular shape	8	7	9	6	8	8	4	–	6	4
Irregular shape	0	0	0	0	0	1	1	–	0	1
Open-ended shape	0	0	0	1	2	1	1	–	0	0
Indecisive boundaries	0	0	0	0	2	0	0	–	2	1
Hatch	0	0	0	0	0	0	0	–	0	1

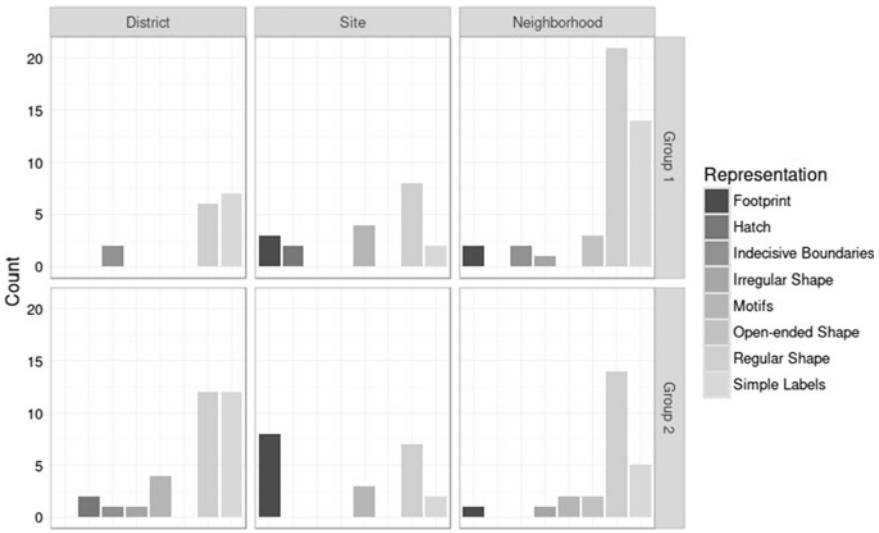
4.2 *Differences in Sketch Representations of Category of Place*

With regard to the differences of representations based on the categories of places, Fig. 3 shows the frequency count of how each category was represented in the sketch maps. District, which is composed of the city center, is mostly represented as labels for both groups. This is followed by regular shapes. A neighborhood, on the other hand, is frequently represented as a regular shape accounting for almost half of the representations in Group 1 (49%) and more than half of the total representations (56%) in Group 2. Regular shapes were also used more frequently (42%) to represent a site in Group 1, while in Group 2 it was footprint (40%). Looking at the other types of representations, hatches are mostly used to represent a district and site. Indecisive boundary and irregular shapes are used to represent both district and neighborhood. Open-ended shapes, on the other hand, are only used to represent a neighborhood. Irregular shapes were used to represent both district and neighborhood. Motifs are drawn to represent all three categories.

4.2.1 Representing a District

City Center

City center is considered a vague region. Inhabitants of the study area often have different perceptions of its actual extent. For example, the administrative boundary



* Representation types for each category are differentiated by shades (dark to light grey)

Fig. 3 Frequency of representation per category of place in sketch maps*

of the city center includes the train station at the lower right. But for many residents, the city center is defined by the area within the Promenade encircling the historical town (see Fig. 4).

As shown in the different sketch maps, some participants have represented it as a shaded region and dashed lines while others used a simple label. The most common representation is a bounded shape with label as annotation (Anacta et al. 2013, 2015). District is mostly represented as labels and regular shapes in both groups. It also shows that districts are not usually represented as footprint and open-ended shape. Looking at how city center is represented, participants also used dashed lines or solid lines to delineate boundary of the region.

4.2.2 Representing Neighborhood

Natural Science Campus

The boundary of the Natural Science Campus is not known to many students. From the university map, the Natural Science Campus is composed of the Physics, Chemistry, Biology, Pharmacy, and Geosciences department buildings (all red buildings in Fig. 5 including research laboratories and other facilities). Although it refers to these buildings, there are participants who include other surrounding buildings such as the Computer Science and Mathematics department buildings as part of the campus. Others refer to nearby buildings such as the University of Applied Sciences (Fachhochschule) as part of the Natural Science Campus.

Harbor

By definition, a harbor is a body of water for anchoring ships, boats and barges. However, the contemporary harbor in the study area is more of a vernacular rather than functional placename. Rather than an actual harbor, for residents and tourists alike, it is a place beside the canal with commercial buildings, restaurants and recreational facilities. Looking at the sketch maps in Fig. 6, the Harbor was

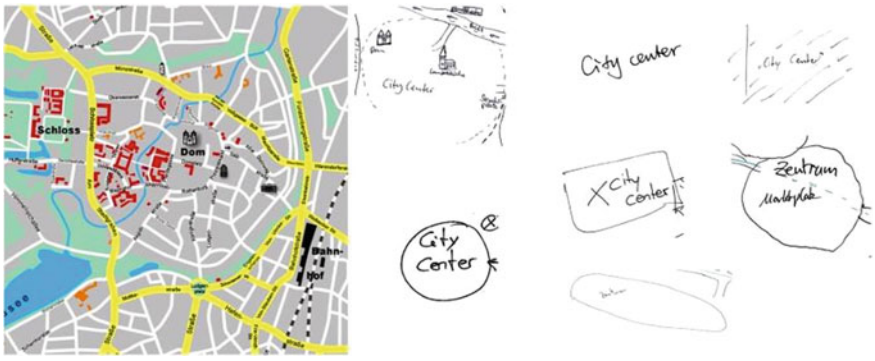


Fig. 4 Metric map (*left*) and participants' representation (*right*) of city center in sketch maps

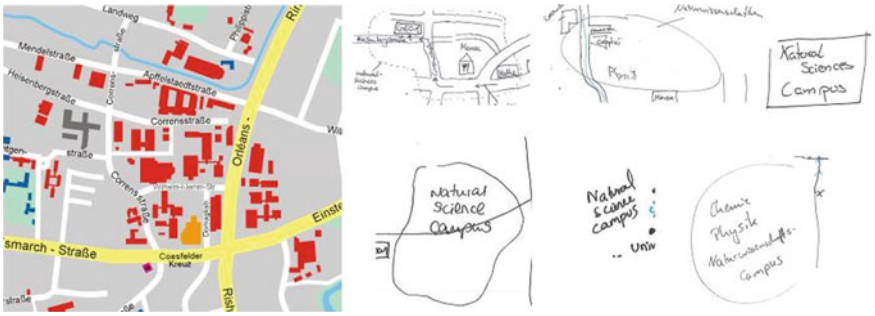


Fig. 5 Metric map (*left*) and participant's representations (*right*) of natural science campus in sketch maps

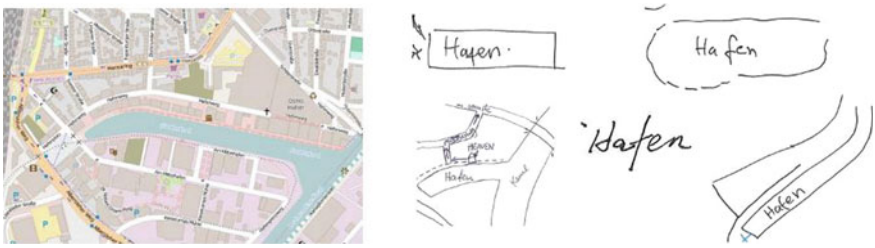


Fig. 6 Metric map (*left*) and participants' representation (*right*) of harbor in sketch maps

represented in different ways with labels being frequently used among all the representations. There were a few participants who represented it as a combination of footprint and open-ended shape.

University Hospital

The University Hospital is also a non-contiguous region wherein its boundary is hardly defined because of other dispersed buildings situated in another area. Figure 7 shows the street map with the location of all the buildings (in blue) that are collectively known as part of the University Hospital. In the northeast part of the map, there are some distant buildings that still belong to the university Hospital. Some participants drew the two multi-storeyed towers to represent the University Hospital but majority represented it as an area including some of its surroundings. Not a single participant included any of the distant buildings as part of the University Hospital. Thus, in analyzing the sketch maps, the University Hospital is considered either as a *neighborhood* or as a *site* depending on what aspect was represented.

In the categorical analysis of the vague places, regular shape is the dominant representation for both groups. The next frequent type of representation is simple label. No representation for hatch was drawn to represent a neighborhood.

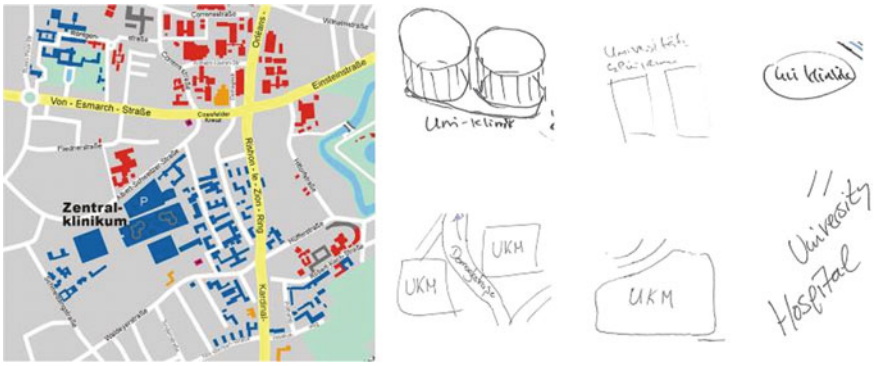


Fig. 7 Metric map (*left*) and participants' representation (*right*) of university hospital in sketch maps

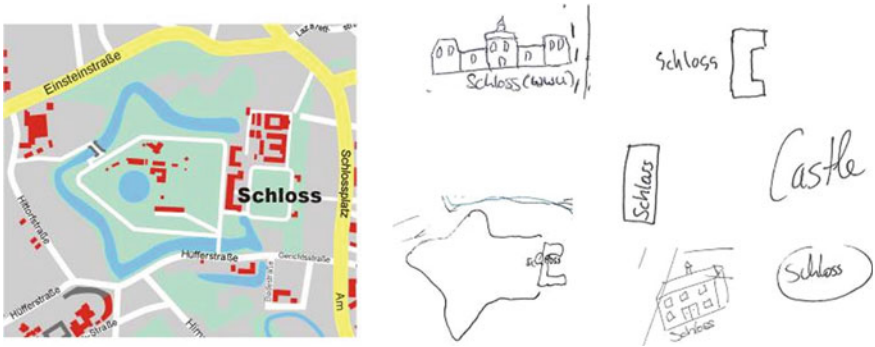


Fig. 8 Metric map (*left*) and participants' representation (*right*) of castle (Schloss) in the sketch maps

4.2.3 Representing Site

Castle

The Castle is a well-defined landmark but sometimes represented as a regional feature. For example, the castle which is shown in Fig. 8 has a distinct building footprint but some participants also drew its surroundings as part of it. In the current experiment, most participants represented the castle frequently with regular shape for both groups. The second most common representation was footprint.

University Hospital

As mentioned earlier, the University Hospital was considered either as an example of a site or a neighborhood. For site, the University Hospital was represented as a footprint. Some participants tend to draw the two towers (see Fig. 6) referring to the

University Hospital. With neighborhood, it was represented mostly as a regular shape. This is followed by a footprint wherein most participants from Group 2 drew this type of representation. Representing the site as a symbol was more common for participants in Group 1. Compared to the other categories, simple label was not represented frequently. No participant represented a site as an irregular shape, open-ended shape, indecisive boundaries or hatch pattern.

5 Discussion

5.1 Types of Sketch Representations

Vague places often appear in everyday communication for instance when describing an environment or giving wayfinding instructions. This occurs in some route instructions wherein participants refer to vague places such as city center as an example of regional landmark for orientation (Schwering et al. 2013). One result of this study is that labels are used frequently even when their use as simple annotations is disregarded. This was not in line with the findings of Blaser (2001) who found a low percentage of use of labels as stand-alone objects. This might be because our study focused mainly on the representation of vague places in sketch maps.

Sketchiness of lines might be associated with vagueness of a place. This is what Boukhelifa et al. (2012) investigated when they look at different visual variables such as blur, dashed and solid lines to qualitatively analyze vague information. This type of representation occurred in our study wherein some participants drew dashed lines and wavy lines to represent regions such as city center and Natural Science Campus. This could be interpreted that participants were uncertain about its spatial extent when drawing such types of representation because these lines were used only for drawing vague places and not for well-defined places on the maps.

In general, the dominant form of representation in the sketch maps is regular shapes. This matches Blaser's (2001) findings wherein 78% of objects have non-complex shapes which is referred in this study as regular shapes. In our case, this appeared more frequently when representing the University Hospital, Castle, and the Natural Science Campus. The city center and Harbor, on the other hand, were represented often as simple labels. One reason might be that participants are not certain of their spatial extent unlike the other places where they refer to specific buildings.

5.2 Sketch Representation of the Category of Places

Participants used different ways of representing category of places. It appeared that the common types of representation for all the categories of places are simple labels and regular shapes. But, it was also shown that there are some representations that

may only apply to a specific category of place. For instance, hatch was never used to represent a neighborhood, but was rather drawn to represent mostly districts and sites.

In representing *districts*, simple labels appeared to be the most common sketch representation. This shows that regardless of the route drawn (intra-city or inter-city), participants use labels to represent the city center. However, more often it is combined with a regular shape. District could also be represented with indecisive boundaries and irregular shape. This is similar to the study of Orleans (1973) wherein urban residents represent it mostly with both regular and irregular shape combined with labels. This presents a clear understanding that district, being a region, has to be drawn in an enclosed figure (which might be the reason why in this study it was never represented as an open-ended shape). Furthermore, district was not represented as a footprint.

When representing *neighborhood*, indecisive boundary and irregular shape were frequently used like the case of district. But, there could also be more than one representation for a specific place. This happens with the University Hospital which is represented either as a site or a neighborhood. Participants sometimes represented the hospital as either point or as a region. This is because some buildings of the University Hospital are dispersed and some participants refer to distinct buildings to represent the whole region (see Fig. 7). This confirms our expectation wherein different categories of places are represented using different types of representations.

In representing *site*, participants frequently use regular shapes. It was not represented as irregular shape, open-ended shape and indecisive boundaries. Perhaps this is because 'site' shows a less abstract representation. This also explains why such category is also represented as motif and footprint. But similar to the University Hospital, the castle, under the site category, is also represented either as point or regional feature (see Fig. 7). Participants not only refer to the building but tend to include its surrounding features referring to it as the entire castle.

The types of representations used to sketch *sites*, *neighborhoods* and *districts* were similarly distributed in both groups. However, Group 2 seems to have used 'simple labels' much less when naming neighborhoods. While labels can precisely identify individual areas, they do so through the semantic, and not visual, uniqueness. They require knowing what the place is, not how it looks like. It seems that the larger spatial extent of the task this group faced (drawing a route to another city), decreases the need for, or relevance of, this particular type of information.

The results provide ideas as to how people's representations of places may be interpreted into whether it refers to district, neighborhood or site. Bertin (1983) extensively investigated different graphic representations to better understand how to visualize data both quantitatively and qualitatively making sense of cartographic principles. This study, on the other hand, provided additional interpretations to some of these visualizations based on how humans represent different categories of places with unclear spatial extent on sketch maps. The results showed the relevance of such places to be represented in a map or any navigation system because people often use it in daily communication (Montello et al. 2003). This might enhance readability of maps as it will show only features of interest to avoid visual clutter.

For example, these representations may be applied in creating schematic maps since spatial relations of places are more important than its actual extent where in many cases, the extent is indeterminable. In designing maps, these types of representations can be used to visualize vague places. Furthermore, when drawing sketch maps for directions, this will help establish a common understanding on how people may interpret it based on the different category of place such as neighborhood, a district or a site. Since people are able to interpret sketches which are abstract, it may help them to understand and interpret similar type of places.

6 Conclusion and Future Work

Interpreting representation of vague places is a challenge since people have different ways of drawing them, i.e. in sketch maps where there are no consistent guidelines. One reason that influenced their sketch representations could be that they have acquired it through reading maps or by experience. Our observations from the experiment suggest that:

- *Vague places with regional extent are mostly represented using labels.* For example, with districts such as the city center, the dominant representation is stand-alone labels. The Harbor, which has an areal extent, is also represented frequently as simple labels.
- *Point features are sometimes represented as regions and vice versa.* Well-known buildings situated inside a region are oftentimes referred to in sketch maps. But sometimes surrounding features are also included in the representation even if the place refers only to a building.
- *Representation may depend on the category of vague place*. A place may be classified as either a site or neighborhood. In this study, it was the University Hospital which was considered either site or neighborhood.

The study provided empirical evidence of how places with unclear extent are represented on sketch maps. The category of place may serve as a basis in classifying related vague places in a more general way which may help build a common understanding in sketched route instructions between the receiver and the giver. The findings may be useful for researchers developing applications for location-based services to visualize places with vague extents on mobile devices. Such places are oftentimes used as reference point in giving wayfinding instructions and it will be interesting to find out how people represent them. This study could also benefit researchers dealing with pattern recognition to understand the semantics of what a sketched pattern represents. For future work, we plan to generate series of sketch maps with the different representations based on the results of this study to find out how people would interpret such an environment. Furthermore, it will also be interesting to generate visualizations that mimic sketches drawn by humans from a set of route instructions in natural language as an alternative to street maps and assess their usability.

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