

Understanding situational use of spatial language for the generation of audible navigation maps

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Abstract. Audible navigation maps require the context-dependent generation of voice instructions. Following a user-centered approach means to learn from verbal descriptions given by people directly involved in navigation activities. The method of think aloud protocols can help to draw conclusions on situational language use. This position paper discusses some aspects of verbal spatial descriptions being collected directly in the field. The focus of the taken position is on effects of context on such descriptions.

Motivation

In nowadays geospatial information systems visual user interfaces are omnipresent. From the early days of these systems, the metaphor of paper maps has coined interfaces for the presentation of spatial information. Increasing display sizes, powerful graphics hardware as well as high human attention while sitting in front of the personal computer screen triggered the successful adoption of visual map interfaces in the last years (MacEachren, 1995). However, information technology increasingly shapes our daily lives, mainly driven by the vision of ubiquitous computing (Weiser, 1991). Pervasive information access (with a continuously increasing focus on spatial information) affords new types of user interaction as well as user interfaces. One of the more promising types of user interfaces is human voice. Being neglected over years, recent technologies on mobile devices like text-to-speech or voice recognition engines foster voice-based user interaction. Although technologies are at hand the question of effective audible communication of spatial information remains. One prominent application domain for audible rendering of spatial information is electronic navigation assistance. While an increasing corpus of scientific work tackles some of the fundamental problems (e.g. cognitively ergonomic direction concepts) (Denis, 1997; Klippel et al., 2004), the context-dependent audible rendering of spatial information has not been tackled to a necessary extent. One of the fundamental questions to answer concerns the use of spatial language for describing spatial sceneries (Le Yaouanc et al., 2010). One possible way of learning about situational spatial language use is to analyze think aloud protocols of people being involved in spatial activities. One such activity is the guided following of pre-defined unknown routes in different environments. This approach has been adopted in the SemWay project, a joint research initiative between Salzburg Research and the

Institute for Geoinformation and Cartography of the Technical University of Vienna. This position paper summarizes some findings on the collection and analysis of think aloud protocols gathered from one group of people being active as pedestrians in cities and one group of people being active as ski tourers in alpine regions. The set-up of the experiments as well as results from the city experiments have been reported in Rehr et al. (2009). The position adopted in this paper discusses the role of context in situational spatial discourse.

Context in situational spatial discourse

Think aloud protocols (Lewis & Rieman, 1994) as mean for the externalization of spatial thought has been widely adopted. Most of the previous and current research focuses on understanding mental maps or cognitive processes through verbal externalizations. Therefore studies focus on verbal externalizations from long-term memory (Denis, 1997), verbal descriptions of stimulus maps (Klippel et al., 2003) or by using pictures as external representations (Raubal, 2001; Le Yaouanc et al., 2010). Less research tackles the question of verbal externalization of spatial thoughts in direct experience situations. However, location-aware audible rendering as communication channel for spatial information only makes sense if descriptions contain direct references to the visible surrounds. Therefore, understanding how people describe their direct surrounds is crucial. Such descriptions can be most successfully collected in field studies, involving people directly in certain spatial situations or activities. One of the crucial questions is how spatial language changes due to contextual influences. Before dealing with contextual influences in spatial descriptions, the term *context* has to be defined (Schmidt et al., 1999). Abowd (1999) categorizes the context of persons or objects in primary and secondary factors. As primary factors he identifies *identity*, *activity*, *time* and *location*. Secondary factors are derived from the primary ones. Taking the primary factors into account, secondary factors influencing spatial language can be summarized as follows:

Identity. Secondary factors of identity are *personal factors* such as *knowledge of spatial concepts*, *previous experience with spatial language*, *sense of direction*, *familiarity with a geographic domain*, *familiarity with a certain environment* as well as *cultural factors* such as *different mother tongues*, *different dialects*, *people from different geographic and/or cultural regions*, *people with different social background*.

Activity. Activity refers to the current activity of the person externalizing spatial thought. The influence of activity means that e.g. descriptions given while walking are different from descriptions given while cycling. More precisely, taking activity into account means to collect think aloud protocols while people are involved in these activities. Collected in this way, descriptions will likely reflect contextual factors of the activity. Another secondary factor of activity is *purpose*. Influencing factors are the *purpose of descriptions*, *purpose of being at a certain location*, *purpose of moving along a route*. Descriptions will certainly change if the purpose of an activity changes.

Another aspect of activity is *dynamics*. Being involved in a certain activity also means that context changes dynamically. Location changes while moving, objects are moving while the activity is going on and also weather conditions may change.

Time. Secondary factors of time in the context of spatial descriptions are *daytime* (e.g. day or night) or *seasons* (e.g. summer or winter). Another secondary factor is the time being available for a certain activity influences spatial thought. People being in a hurry may produce different linguistic externalizations than people being not limited in time.

Location. Secondary factors of location are *geographic region* (e.g. cities or alpine regions), *location or route within the geographic region*, *selection of viewpoints for description* and *visibility of the scenery*.

Some effects of context observed in the think aloud protocols of our field studies

The primary goal of the field studies was to learn from the language people used for the description of spatial sceneries. Analyzing such descriptions will help in the generation of context-dependent navigation instructions. In order to get a good variety of descriptions we involved 20 different individuals for the city routes and 7 individuals for the ski tour. Furthermore we defined 4 different city routes (each route including 24 to 27 decision points) in two different geographic regions (Salzburg and Vienna) and one ski tour in an alpine region with 13 decision points. Participants of the city experiments were all unfamiliar with the environment. Ski tourers were half familiar and half unfamiliar. All participants were native German speakers. Most of the participants came from different geographic regions in Austria; some came from different geographic regions in Germany.

Effects influenced by identity

Unfamiliarity with the environment

People being unfamiliar with a spatial environment describe the environment as directly perceived. This setting ensures that people are not or only to a minimal extent able to use mental maps of the environment. The observed benefits of producing think aloud protocols with people being unfamiliar with an environment are:

- (1) Avoid distortions of spatial relations caused by mental maps
- (2) Avoid abstractions and generalizations
- (3) Ensure that descriptions at decision points only contain references to visible entities
- (4) Foster the anchoring of actions with visible entities
- (5) Foster the selection of a broad variety of visible reference entities
- (6) Foster the use of well-known linguistic concepts for denoting entities

Linguistic concepts denoting physical entities

Since the mental map of the environment is missing when participants are unfamiliar with the environment, people have to name entities with general linguistic concepts instead of proper names. In the field studies proper names were only used in two special cases: (1) if real-world entities are explicitly signed with proper names (e.g. built entities are tagged with signs) or (2) in case of very prominent features with nationwide well-known names such as the river "Salzach" or the prominent mountain "Mönchsberg". Table 1 shows the 10 frequently used linguistic concepts for references to physical entities in the description of actions along two city routes.

Salzburg Inner City Route		Salzburg Periphery Route	
STRASSE (STREET)	62	STRASSE (STREET)	99
TORBOGEN (ARCHWAY)	38	PARK	54
SALZACH	36	HAUS (BUILDING)	28
GASSE (ALLEY)	33	SALZACH	27
KIRCHE (CHURCH)	27	WEG (PATH)	27
MÖNCHSBERG	20	SPIELPLATZ (PLAYGROUND)	22
HAUS (BUILDING)	17	BRÜCKE (BRIDGE)	18
BRÜCKE (BRIDGE)	17	ZEBRASTREIFEN (PEDESTRIAN CROSSING)	17
HOTEL	16	HAUPTSTRASSE (MAIN STREET)	15
BERG (MOUNTAIN)	16	EINBAHNSTRASSE (ONE WAY STREET)	13

Table 1: Most frequently used linguistic concepts for describing reference entities

Differences in the use of direction concepts

As reported in Rehr et al. (2009), participants of the city experiments used a relatively limited set of direction concepts. The analysis revealed 15 frequent concepts. However, a more detailed analysis also revealed varieties between different individuals.

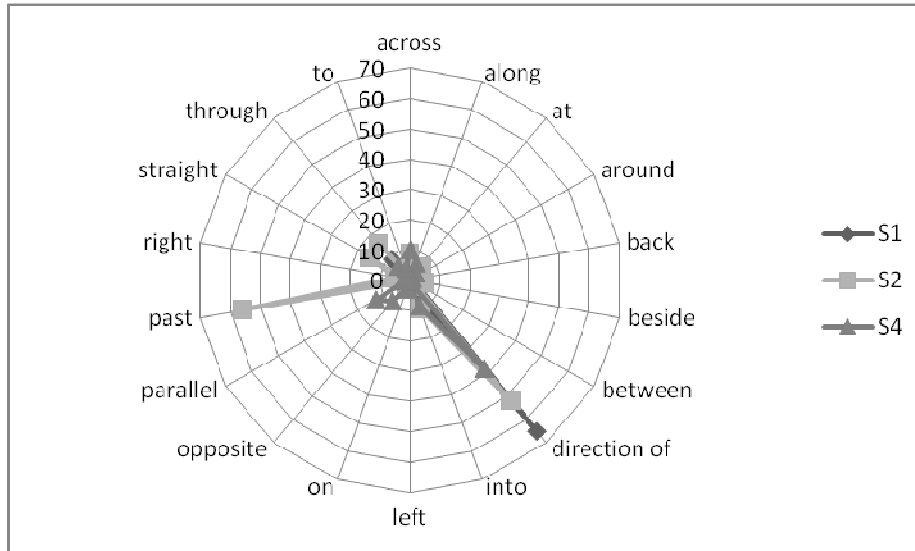


Fig. 1: Comparison of occurrence frequencies of direction concepts used by three different participants along the Inner City Route.

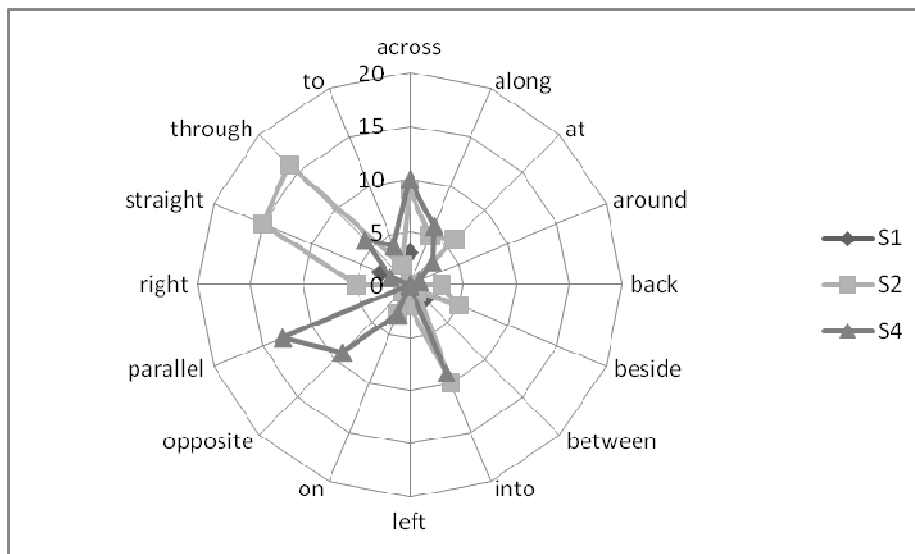


Fig. 2: Comparison of occurrence frequencies of direction concepts used by three different participants along the Inner City Route without the two most frequently used concepts "direction of" and "past".

Fig. 1 and Fig. 2 compare the individual use of direction concepts of three participants along the same route. Fig. 2 shows that person S1 predominantly used the

direction concept "direction of". The direction concept "past" was frequently used by person S2, but not by person S1 and S4. Fig. 2 shows the distribution of the concepts beside the predominant ones "direction of" and "past". Person S2 prefers "straight" and "through", whereas these prepositions are used infrequently by persons S1 and S4. S4 in contrast makes frequent use of the concepts "parallel" and "opposite". "Into" and "across" are more often used by persons S2 and S4 in comparison to person S1. Person S1 predominantly uses the concept "direction of" and infrequently other concepts, whereas the other both persons use a broader variety of concepts, but different sets. These results clearly show that although all three persons walked along the same route, the resulting set of direction concepts differs from person to person. From the findings we conclude that using the real world as stimulus is a good setting for observing individual characteristics of language use, whereas stimulus maps or pictures narrow verbal externalizations. Moreover, the resulting comprehensive descriptions give enough room to explore different factors of identity such as individual preferences, cultural differences or different dialects.

Effects influenced by activity

Anchoring of actions in space

Applying the think aloud method while being involved in activities fosters the expression of actions as well as the anchoring of actions in space. Walking a route motivates participants to think as a walker, hiking with skies motivates participants to think as ski tourers. The field studies revealed a high number of different motion concepts, describing precisely executed actions. Direct experience allows the undistorted anchoring of these actions with visible entities.

Dynamics get represented in language

Using static sources for producing think aloud protocols abstracts away from spatial dynamics. Our field studies revealed that some spatial settings can be best represented by taking dynamics into account. E.g. some of the participants expressed directions by mentioning directions of moving cars ("Walk in driving direction", "Walk against driving direction"). Another example of using dynamics in spatial descriptions are busy streets ("Walk in the direction of the busy street") or "animated" entities like blinking traffic signs ("Walk in the direction of the blinking traffic signs"). Although such context factors are typically transient, the field studies confirmed their role in situational descriptions of spatial sceneries. An open question is how highly dynamic properties of space can be represented in visual or audible maps. Adding such properties would be a beneficial extension to static representations.

Effects influenced by location

Externalization of spatial thought in direct experience situations

Think aloud protocols from direct experience situations benefit from using the whole visible environment as stimulus. This is a clear difference to the use of stimulus maps, containing only abstract representations of the real world. Moreover, stimulus

maps suffer from the drawback that the designer of the map selected the features being represented. Asking people to describe stimulus map also means to have the spatial thoughts of map makers' reflected in the protocols. Another important aspect of direct experience situations is the selection of viewpoints. Pre-selected viewpoints are a problem of generating spatial descriptions from pictures. To avoid influences on the selection of viewpoints in direct experience situations, it is useful to allow participants to stop their walk along a route whenever and wherever they want. Moreover, having the whole visible environment as stimulus motivates participants to produce comprehensive and detailed descriptions. This effect could be demonstrated in the context of the experiments with ski tourers. Due to the enlarged visible space (alpine regions) participants produced significantly longer descriptions than along the city routes. Moreover, the Denis' classification in Fig. 3 shows an increased use of propositions of class 4 (landmark descriptions) in comparison to the city routes and the studies by Brosset (2008) and Denis (1997).

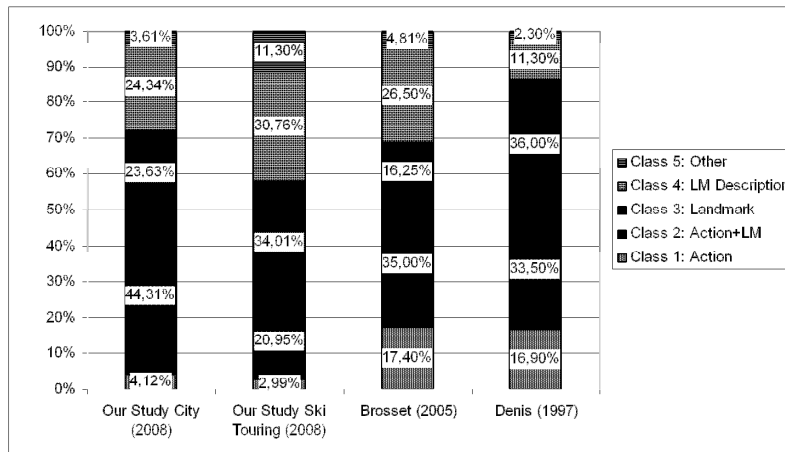


Fig. 3: Comparison of Denis' classifications of propositions from our field studies and propositions from previous studies

Perception of structural characteristics

An interesting result of our field study concerns the perception of structural characteristics of physical entities. By analyzing the comprehensive corpus of verbal descriptions we found that structural characteristics of decision points (such as crossings) or paths (such as streets) are nearly missing. This finding is in contrast to findings from other corpora of verbal descriptions produced from stimulus maps (e.g. Klippel et al., 2003). According to Klippel et al. (forthcoming) the descriptions of crossings contain between 14.3% and 68.4% references to structure. One hypothesis for explaining this difference is that people learning an environment from an abstract 2D representation focus on structural characteristics due to missing alternatives whereas people in direct experience more likely perceive other environmental characteristics. Another hypothesis is that in real-world (3D) environments the perception of 2D (horizontal plane) structural characteristics is more difficult. One

result of our study supporting this hypothesis is the frequent perception of 3D structural characteristics such as archways or passages, whereas different types of crossings did nearly not emerge in the descriptions. Additional work comparing direct experience and stimulus maps is necessary to prove this argument.

CONCLUSIONS

Audible navigation maps require context-dependent and precise verbal descriptions of decision situations. Careful consideration of context factors may improve the quality of such descriptions. Think aloud protocols from people being involved in navigation activities help to analyze contextual influences on language use. This position paper introduces a notion of context and discusses results from field studies being designed to address some of the factors. The arguments highlighted in this paper should not be seen as final conclusions, but as stimulating input for further discussions on the influence of context on situational spatial discourse. Moreover, the list of secondary context factors can give some hints how context could be systematically considered in studies dealing with linguistic spatial descriptions.

Acknowledgements

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