COMMUNITY ACTIVITY: WORKSHOP REPORT

Spatial behaviour and linguistic representation: Collaborative interdisciplinary specialized workshop

Summary: The Collaborative Interdisciplinary Specialized Workshop on Spatial Behaviour and Linguistic Representation took place on April 23–24, 2010, at the Hanse-Wissenschafts-kolleg, Institute for Advanced Study (HWK), in Delmenhorst, Germany. We report the scientific motivation for this workshop and report its outcomes together with the impact of a gathering of this kind for the scientific community[1].

1   Introduction

Research in the areas of spatial cognition and geographic information science has undergone a rapid development within the past decades, as reflected by steadily growing numbers of researchers addressing spatial topics, national as well as trans-regional conferences and meetings, and major research projects spanning a wide variety of related issues, transcending disciplinary boundaries. Recent developments have now highlighted a widespread substantial interest in establishing a reliable basis for combining insights and representation models from various sources. In particular, the existing manifold approaches to interpreting spatial representations in language deserve to be systematically combined with behavioral navigation data, associated cognitive processes and strategies, and formal representation systems capturing cognitively relevant categories and features of space. Substantial steps towards this goal have been brought forward both within the recently concluded tandem project on wayfinding strategies in behavior and language (funded by the Volkswagen Foundation from 2007 to 2009), and by a number of contributions to, and discussions at, the recent COSIT conference in Aber Wrac'h (France, September 21–25, 2009). This activity reflects not only the considerable progress already emerging in this regard, but also the necessity to substantiate interdisciplinary approaches systematically, and clarify open issues. Here we report the proceedings and outcome of a collaborative

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[1]The workshop website is http://www.wayfinding.uni-bremen.de/workshop/.

interdisciplinary specialized workshop on "Spatial Behaviour and Linguistic Representation," which concluded the above mentioned tandem project. The workshop took place on April 23–24, 2010, at the Hanse-Wissenschaftskolleg, Institute for Advanced Study (HWK), in Delmenhorst, Germany. In this workshop, the aim was to bring together experts and discussants working in the areas of spatial behavior and linguistic representation and the relationship between them. More broadly, the workshop pushed further towards the shared goal of a systematic interdisciplinary basis for understanding spatial cognition.

2   Spatial behavior and cognitive strategies

The first session was entitled "Spatial behaviour and cognitive strategies" and included four talks.

In the first talk, Tobias Meilinger presented findings from a series of experiments aimed at investigating the reference frames people use to encode spatial information in memory. His findings suggested that people encode spatial information contained in complex, newly learned environments using multiple local reference frames instead of a single global reference frame. In contrast, evidence for the use of a global reference frame, attributed to prior knowledge acquired from a map, was found in an experiment in which participants were asked to reason about a highly familiar environment. These findings suggest that both the structure of an environment and people's prior experience with it, influence the way people remember and use spatial information.

This conclusion is corroborated by the findings presented in the second talk of the session by Christoph Hölscher. In this talk results from a study investigating wayfinding in a complex multi-level building were presented. The study showed that environmental factors such as the layout configuration and the visual access to key features of the layout (e.g., staircases) influenced wayfinding performance. Moreover, people who visited the building for the first time adopted a central-point strategy (i.e., oriented towards well-known regions) more often than people who had more prior experience with the building.

The choices that people make during navigation were also discussed in the third talk of the session. In his talk, Jan Wiener presented findings linking decision making in the context of wayfinding to gaze behaviour. Specifically, the results from his experiments showed that participants tended to choose paths that allowed the longest line of sight and they gazed more toward the paths they eventually selected.

Finally, in the last talk of the session, Stefan Münzer presented his findings on individual differences in spatial strategies and learning. Specifically, he presented data from a series of studies that used translations of two existing questionnaires as well as a new scale to measure people's self-reported sense of direction and related constructs. Discrepancies in results across different countries as well as correlations of self-reported data with results from behavioural experiments were also discussed.

3   Language as a representation of spatial thought

The second session addressed the question of what can be gained from analyzing language as a representation of spatial thought.

The first talk given by Emile van der Zee first introduced the qualitative trajectory calculus, which allows for descriptions of spatial movements in 2D and 3D modeling verbal

descriptions in a formal way. In his experiments, participants from various countries described movements in their language. Results showed that the linguistic expressions cover the movement concepts in different ways for different languages. In various applications such as route graphs and robot movements, the approach can be used for describing more complex movement situations. The discussion revealed that the study could have an impact on human-robot interaction and the control of robots through spoken language. Moreover, additional aspects such as dependency on social status or gender were discussed.

Matthijs Noordzij addressed differences in the production and comprehension of spatial terms, focusing on route descriptions. Obviously, computer-generated descriptions as they exist today differ from human descriptions. In particular the use of different kinds of perspective (route and survey) plays an important role. Research shows that humans are quite flexible both as instructors and as listeners. Moreover, there is a difference in route instructions between the USA and the Netherlands. In an application study, verbalizations of map data for blind people were generated using various kinds of spatial descriptions. Results revealed that participants preferred "clockwise" descriptions and liked cardinal references less.

Thora Tenbrink's talk introduced the method of cognitive discourse analysis, which addresses the analysis of spatial thoughts as represented in language. Language data are an important source for analyzing thought processes. Various levels of analysis can reveal different kinds of insights. For doing so, not only what is said has to be looked at but also how it is said. An example analysis was presented with respect to a study on the well-known "travelling salesperson problem," showing the significance of various linguistic features used by the participants. A second study focused on route planning in a city. Results revealed that people use graph-based strategies for prospective planning, and direction-based strategies in situative planning. In the discussions, cross-cultural and other aspects were taken up.

4   Representation and modelling frameworks

This session addressed the various ways to think about and represent spatial behaviour.

Christophe Claramunt presented a scheme for formalizing verbal descriptions of landscape panoramas as a temporal sequence of a small set of parameters. These parameters include the distance from the observer to the various objects currently addressed in the verbal description, and the granularity (number and size) of these objects. The resulting string can be thought of as a musical score with the pitch representing distance and rhythm representing granularity. While the uniqueness and recognizability of such representations remains to be investigated, they make clear that verbal descriptions will always lay a timeline through the described landscape, turning the panorama into a story. If the mental representation of places is not about absolute space, but about spatio-temporal events instead, this type of representation may prove useful.

An overview of formal representations of space that allow inferences and decision making was presented by Gérard Ligozat. He stressed that the purpose of qualitative reasoning techniques is to get implicit information out of the data. While geometrically, space is continuous, behavioural and cognitive decisions are not, and will therefore require different, qualitative ways of modelling. Ligozat reviewed such approaches, most notably the notion of constraint satisfaction. Calculi such as RCC-8 allow formally correct inferences about

the spatial relations of regions or spatial patches. While this type of qualitative reasoning is well understood, the relation to natural language poses challenging questions. For example, functionality of places is an issue so far not well represented in qualitative theories of space.

Sabine Timpf presented a general framework for modelling the behaviour of spatial agents which was based on the idea of finite automata. Agents have internal states and depending on these states will select actions that lead to other states. Spatial behaviour is then modelled by planning on the corresponding state-graph. One focus of the approach was on the interaction of multiple agents, each of which was represented in an individual-based model. Thus wayfinding is achieved not only by exploiting one's own cognitive map, but also by communication with other agents or with location-based services on the internet.

Kai-Florian Richter expanded on this approach by discussing direction giving by humans and machines. He identified differences which may be thought of as differences between representations of (Euclidean) space as might be suitable for machines, and representations of spatial behaviour as are needed for human users. As an example, Richter elaborated on the notion of landmarks, especially extended landmarks covering more than one decision point. Examples include line-like landmarks such as a canal to follow, or area-line landmarks such as a forest to pass. In any case, landmarks were treated as objects in the world rather than perceptions that the observer might have.

One common view of this session was the question of what is specifically spatial about spatial representations. If cognitive representations of space deal with behaviors, decisions, and events, rather than with points, metric distances, and angles, it seems that any problem-solving approach developed, for instance, for chess playing or plant decomposition, may be applied just as well to spatial problems. Indeed, the representations presented in this session would readily accommodate also non-spatial systems of knowledge. Still, the spatial cognition community seems to agree on the view that their topic is different from other fields of cognition. It may be worthwhile to more clearly address the question of what exactly this difference is.

5   Interrelations and combinations

This session included three talks aiming at jointly establishing the state of the art concerning interrelations and combinations with respect to spatial navigation behavior, language, and formal representation systems.

In the first talk, Marios Avraamides discussed how various factors influence spatial performance in an attempt to understand how spatial information is encoded in spatial memory. Avraamides introduced several examples where scientists manipulated different variables such as the arrangement and number of objects in a layout, the presence of extrinsic cues, viewpoints and experiment conditions. This stresses the roles of the organizational structure of spatial memories. Avraamides discussed the hypothesis that by manipulating these variables, scientists are merely biasing the strategies that participants use to encode spatial information and to use it when executing tasks.

Hanspeter A. Mallot investigated the relationship between verbal representations and spatial behaviour. While recent theories seem to suggest that non-verbal representation alone would be sufficient to generate functional behaviour, Mallot tested and experimented the alternative hypothesis that language-based representations do support spatial behaviour

even in monologic situations. Subjects were trained to find goals in a virtual maze with clearly nameable landmark information at decision points. The experiment was performed both for a route and for a map learning task. From the results obtained from this experiment Mallot showed diverse types of evidence for the role and importance of spatial language in functional and spatial behaviour.

Finally, Rainer Malaka presented an overview talk on the development of user interfaces and ubiquitous computing. Malaka introduced a number of experiments oriented to the design and development of intelligent interfaces and smart applications that also take into account the intelligence of the user. He stressed the role of so-called human centered approaches in ubiquitous computing. The talk was illustrated by several projects and approaches developed at the Digital Media Group at Bremen University. The general approach follows the idea of embodied interaction, and put particular emphasis on the situated use of a system and the mental models humans develop in real-world environments.

Overall, this session highlighted the close relationship between formal, mental, and language representations of space on the one hand, and the way intelligent interfaces should be developed in mobile and ubiquitous systems on the other hand.

6   Discussion

The talks were complemented by a highly discursive poster session, brought to life by a range of young researchers who presented their own work in relation to the workshop topic. Together with the lively discussions emerging after each single talk at the workshop, this reflects the high level of activity and diversity of research interests concerning the relationships between various types of representation: behavioral, linguistic, and formal.

An open discussion constituted the end of the two day workshop. A substantial part of this discussion centred on identifying novel research topics/questions that afford an interdisciplinary approach. One topic that stood out in the discussion concerned spatial language and maps. While interrelations between the three main research fields represented at the workshop have already been established in research on route descriptions and route knowledge, there are many open issues around the question of how spatial language and maps relate. This relationship should urgently be addressed in targeted research and would certainly be a suitable topic for a follow-up workshop. Further current research issues that emerged during the discussion included language and structural representations, applications of spatial language, cultural differences in spatial language and behaviour, and spatial language and action.

Another point raised concerned the role of interviews with participants in behavioural experiments. While most experimenters consider what participants utter when designing and/or modifying experiments, this is mostly done in informal interviews. The actual linguistic data is rarely recorded or reported. Recent research (e.g., [1]), however, demonstrates that linguistic representation can give very precise insights into what people are doing when solving complex spatial tasks. The value of fast, quantifiable, and comparable methods to analyze linguistic representations was discussed.

The interdisciplinary format of the workshop was seen as successful, interesting, and inspiring. There was consensus that future similar events should continue building bridges between research directions and expand these, for instance to the field of neuroscience.

7   Conclusion

The collaborative interdisciplinary specialized workshop proved to be a highly welcome discussion forum for researchers across research fields as well as degrees of expertise. Unfortunately such opportunities are extremely rare in light of modern scientific publication policies. Both smaller workshops and larger conferences typically either presuppose submission of original work, with various levels of appreciation in the relevant scientific communities, or they let the quality of talks be based entirely on the assessment of short abstracts. In contrast, gathering renowned experts of related fields together with young researchers working in these same areas provides a unique opportunity to raise currently unresolved important research questions as a focus throughout all presentations and discussions. This allows not only to assess the current state of the art in interrelationships and combinations across fields, but also to push this research further in terms of synergies and joint project ideas. This is underscored by a range of concrete outcomes of the present workshop emerging from the energetic spirit of the workshop, which are currently pursued and expected to materialize before long: a joint international research proposal, an edited book on the workshop topic, and various plans for interdisciplinary follow-up workshops.

It is recommended to pursue this alternative workshop format whenever any such opportunity arises.

Acknowledgments

References

[1] SPIERS, H. J., AND MAGUIRE, E. A. The dynamic nature of cognition during wayfinding. *Journal of Environmental Psychology 28*, 3 (2008), 232–249. doi:10.1016/j.jenvp.2008.02.006.

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