Granularity in Route Directions Generated by Systems and Humans

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Abstract. We address spatial granularity in route directions in relation to information needs in a case study that provides a situation involving different modalities of travel (i.e., walking and travel by public transport). Results reveal that the two sets of route directions investigated (human and web-based) provide the most crucial route elements in hierarchically structured ways that reflect the salient structure imposed by multi-modal traveling. However, human route directions account for the asymmetric information needs assumed for the given scenario in a more flexible and coherent way.[1]

1 Information needs

Theoretical considerations let us expect that the pragmatic information needs of a wayfinder [2] are variable and sometimes asymmetric, especially between start and destination, and then again at complex situations in between. Accordingly recent research has highlighted the importance of variable spatial granularity in generating route directions [3, 4]. We focus here on the identification of pragmatic information needs in a real world scenario, and if and to what extent these varying information needs of wayfinders are addressed by automatically generated as well as human route directions. We compare in a case study two sets of route directions for a particular route involving different modalities, walking and public transport, one set automatically generated and provided by web services, the other provided on request by people with recent experiential knowledge of the route.

Consider this scenario: A lecturer at the University of Bremen is planning a trip to the high school in Ganderkesee, a place about $30km$ away. In this situation, as in many cases of requests for route directions, the information needs involved are asymmetric: the wayfinder is familiar with the start region, but not with the train route and the destination area. Route directions considering this asymmetry would consist of intermediate *destination* descriptions (*Get to Bremen main station*) and subsequent *step-by-step* descriptions (*Then take the NWB on Track 2*) which will also include those types of information that now need to be obtained (often in awkward and cognitively demanding ways) from the environment, e.g., a town map. At points of change of transport

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mode, the information need can explode in granularity, as opposed to other parts of the journey in which no further information is needed. Furthermore, the complexity of a transfer point is route dependent. These observations indicate a hierarchy of spatiotemporal granularities of the references, and a non-arbitrary, but complex and route dependent navigation through this hierarchy.

2 Web-based services

We investigated how the trip from Bremen University to the high school in Ganderkesee is represented by two public transport planners, `bahn.de` (a web-based service provided by the German railway system Deutsche Bahn AG), and `efa.de` (a web platform for multiple public and private transportation operators in Germany). Both planners (like most others) are by default mono-modal. Searching for a multi-modal travel, or a travel from place to place, requires a range of actions and decisions by the user, such as switching from standard to extended search mode, and then categorizing their departure and destination information as station or stop names, points of interest, or postal addresses. Then the transport planner generates first an overview of alternative travel options, and then more detail for a selected trip (one instruction per transport mode). For the traveler, the diverse transport modes are of different complexity and effort, hence, not equal (walking requires far more spatial information than traveling by train once the correct train has been identified). At this step, the different requirements for each mode are not reflected by the automatically generated information. However, for some of the different transport modes, hyperlinks lead to additional information: Buses, trams, and trains are further specified by their stop lists, and (at `bahn.de`) a walk is specified by a list of verbal route directions and a corresponding map which is zoom- and expandable, hence, for longer walks the wayfinder can access a full overview as well as more detail (`efa.de` provides static maps in portable document format, but no verbal route directions). However, this kind of information is not available for all parts of the route. Where sometimes a desirable level of granularity is lacking, in other instances the provided granularity exceeds the user requirements. For the train, tram and bus legs, one rarely needs to see all the intermediate stops of the trains, in particular where information in the environment (displays, announcements) help to identify the point of disembarkment.

3 Human Natural Language Multi-Modal Route Directions

We collected natural language data describing the same route as before, involving travel on foot and by public transport. Our analysis focused on systematic patterns concerning the choice of, and switches between, levels of granularity. The data were collected during a visit of a class of 11th grade students (around 17 years old) from the high school in Ganderkesee at the University of Bremen (Cartesium) in April 2007. They had met at the railway station in Ganderkesee that morning and traveled together to the university. Their first task (Task I) was to describe—on a blank piece of paper—the way from Bremen University to their school in Ganderkesee, assuming public transport as medium of transportation. Afterwards (Task II) they were prompted to do the same again for the opposite direction.

The data were segmented into informational units, following [1]. Then an intersection of all data sets was accumulated that contains a generalized schema of the spatial information provided in any data set. We distinguished between *crucial elements* (mentioned by nearly all participants), *spatial units*, and *detail units* (which include explanations and sub-actions), yielding a three-level hierarchical structure. Criteria for categorization as a spatial unit (rather than a detail unit) were spatial (a section between decision points) as well as pragmatic. Crucially, no further clear segmentation and order of the detail units can be provided to yield distinct spatial units. The units were annotated according to the generalized schema, i.e., for each item in the schema, it was noted whether the information was contained in the description. This provides the basis for assessing the relative level of detail of each description in general, as well as concerning the particular places at which it provided either no information, or only the most important information (a spatial unit), or further details (detail units).

Our results showed that almost all of the crucial elements also appeared in the opposite direction, at least as a spatial unit but typically as a crucial element. While the spatial units themselves were also astonishingly similar, reflecting a homogeneity concerning the segmentation of the route, there were remarkable differences concerning the distribution of spatial information. These results suggest that there is a general difference according to the direction of traveling which concerns the amount of *details* given in the spatial instructions, but does not affect the choice of main route elements as reflected in the spatial units.

References to public transport appeared regularly and were particularly enhanced by detailed information. In Task 1, more details were provided for the destination than for the starting location. Also, particularly complex decision points (crossings) were accounted for by providing more detail than elsewhere. In Task 2, several participants only started their route description at the train station in Ganderkesee, leading to a complete omission of the route section from the school to the station. This may be due to an enhanced focus on the destination area, mirroring the findings from Task 1. Also, participants provided further details particularly for those route elements that were considered as crucial, rather than distributing details at random places. This result supports the systematic hierarchical nature of the conceptual route representation that is reflected in the linguistic data.

4 Comparison

On a high level of granularity, the most crucial route elements are accessible in all our data, given the present scenario in which the environmental information together with the average wayfinder's procedural knowledge already covers much of the information needed to reach the goal. Also, both sets of route directions exhibit a clear hierarchical structure. As predicted, the various kinds of traveling mode turned out to be particularly salient. Thus, even the coarsest descriptions contain some mention of the train ride between Bremen and Ganderkesee, along with reference to foot paths. Switches of granularity levels typically co-occur with switches of travel mode. This corresponds to our observation that multimodal travel imposes a salient structure of its own.

Both the human and the automatically generated route descriptions provide additional information on various levels of granularity, though with different foci in each case. The web-based services show a range of alternatives of traveling by public transport, which play only a minor role in the human descriptions. In contrast, for people the direction of traveling makes different features relevant; transport planners do not make this distinction. Thus, the human route directions are more flexible concerning functional complexity: finding the exit of a large train station on arrival is easier than finding the correct track on departure. Additionally, to a certain degree the wayfinder's prior knowledge is accounted for by an increased level of detail in the (unknown) destination area. Such adaptivity to actual requirements would presuppose a great amount of implemented world knowledge in any system providing automatically generated route descriptions.

At a more detailed level of granularity, the particular information required and provided differs substantially in the two data sets. For example, switches between granularity levels are potentially disruptive in the web-based systems: specific information about some (but not all) parts of the route may be accessed by user action, but is not integrated coherently. Crucially, the increased information needs identified for the more complex route aspects is not reflected in any systematic way. It seems that the system design in its current form does not allow for a more cognitively adequate presentation of diverse kinds of information, partly due to the fact that the information is derived from various sources.

In contrast, the human route directions constitute coherent and spatiotemporally structured texts, providing various types of information without any apparent discontinuity whenever switches of granularity occur. The instructions contain particularly detailed information for precisely those parts of the route for which a greater need for information was identified, such as when changing travel mode, or in order to identify the correct turn after a lengthy footpath. However, the absence of graphical depictions (in our data set which in this aspect resembles many naturally given route descriptions) may pose a problem with respect to the development of a mental map suitable for current purposes.

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