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# Where Snow is a Landmark: Route Direction Elements in Alpine Contexts

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**Abstract.** Route directions research has mostly focused on urban space so far, highlighting human concepts of street networks based on a range of recurring elements such as route segments, decision points, landmarks and actions. We explored the way route directions reflect the features of space and activity in the context of mountaineering. Alpine route directions are only rarely segmented through decision points related to reorientation; instead, segmentation is based on changing topography. Segments are described with various degrees of detail, depending on difficulty. For landmark description, direction givers refer to properties such as type of surface, dimension, colour of landscape features; terrain properties (such as snow) can also serve as landmarks. Action descriptions reflect the geometrical conceptualization of landscape features and dimensionality of space. Further, they are very rich in the semantics of manner of motion.

**Keywords:** route directions · natural environment · segmentation · landmark · mountaineering ·

## 1 Introduction

In 1995, Max Egenhofer and David Mark proposed the notion of Naive Geography for the body of knowledge that lay people have about the surrounding geographic world [15] as a counterpart to the formalizations used by professional geographic community. As well as an underlying scientific motivation, they stressed a real practical need for the incorporation of such naive geographic knowledge into GIS, bridging the gap between an average citizen's needs from a GIS, and the (sometimes abstract) spatial concepts embedded in the latter.

Reaching this aim requires that we also understand how space is perceived and conceptualized, not just by experts involved in the implementation of GIS, but also by a greater cross section of society. One oft cited way of gaining such insights is through the prism of route directions. Locomotion is a major way humans discover, and thus presumably construct mental representations of, environmental space [32], and human concepts and schematizations of space are systematically encoded in lan-

adfa, p. 1, 2011.

guage whenever routes are described [48]. Thus, route directions are a readily available external representation of spatial concepts, revealing structures in thinking about and using space. Further, as navigational services become ubiquitous on mobile devices for many modes of locomotion, route direction studies are increasingly relevant in terms of real practical applicability – for example, in choosing which real world features are likely to be salient for a particular application [24].

However, with few exceptions, most research on route directions has focused on urban environments: outdoor (e.g., campus areas [12], neighbourhoods [2], downtown areas [19], cities [13]), indoor (e.g., complex buildings [46], airports [37]), transitional spaces [23]. As observed in [6], one of the few works on non-urban space, extending the range of studies to natural environments remains an important research challenge. Moreover, investigating natural space presents an opportunity to explore the degree to which results from very different urban environments are transferable, and can potentially provide avenues giving new insights into ways in which space may be conceptualized.

To address this gap, we explore alpine route directions and thus discover the features of spatial concepts reflected in this fundamentally different type of environment. Specifically, we address the ways in which the structure of route directions is affected by the properties of the considerably less structured space, and by the more complex activity of mountaineering, as opposed to walking in a city or building. For this purpose, we initially explore the scope of information found to be relevant in alpine route directions, beyond the basic spatial directions. Furthermore, we investigate some major conceptual route elements as known from urban environments: segments and nodes, landmarks and action descriptions.

## 2 Related Work

### 2.1 Route Direction Elements

According to [12], the route description process involves three cognitive operations. The first one is the activation of the internal representation of the environment in question by the speaker, who then plans the route by defining a sequence of segments connecting starting and destination points. The result is what [48] describe as route schematization, namely a network of segments and nodes, i.e., decision points involving (potential) changes of direction. The third stage is the formulation of the procedure, resulting in the verbal description of the route.

Despite, or perhaps because of, the large volume of research on route directions, no single analytical framework with clearly defined units of analysis exists. One reason might be the variety of research questions posed within several disciplines, such as linguistics, cognitive psychology, geography, and computer science [13]. [45] identified several essential building blocks that are frequently mentioned in the studies of route directions – starting point and destination, intermediate decision points, route segments, actions and movement directions, reorientations, landmarks, regions and areas, and distances. In the following we examine critically varying definitions of

some of these elements, with a view on their transferability to the context of mountaineering.

**Segments and Decision Points.** Route segments and decision points (or, links and nodes) are key conceptual elements of route schematizations. There are two different interpretations of the way segments are represented in texts. For [48], a segment is a unit containing enough information to go from node to node. It consists of a starting point, reorientation, path/progression and an end point. Essentially, a segment corresponds to the change of direction, as its starting and end points are decision points. However, as the authors note, this is not a necessary condition, since major intersections or landmarks might also separate segments without a direction change. For [29], on the other hand, decision points and their associated reorientation instructions are not integrated into segments. The latter are seen as straightforward parts of the route (as in, "follow the path", "walk along"). Similarly, [2] singles out pathways (nouns referring to actual or potential channels of movement, such as streets, sidewalks, or trails) and choice points (nouns referring to places where options with regard to the further path exist, with intersection as the most typical example).

Independent of their representation in an analytic framework, segments and decision points are critical conceptual elements of the route schematization. Crucially, they reflect the structure of the environment in an urban context, as segments become synonymous with pathways and are associated with linear features, allowing straightforward progression to the next decision point. Decision points, in turn, are often associated with intersections within a structured urban context. In an urban context, therefore, segmentation of a route as such does not pose any major conceptual challenges. By contrast, it is an open question how routes might be segmented in an environment that offers far less structure, such as the natural setting of a mountain.

**Landmarks and Action Descriptions.** Theoretically, the path from one decision point to the other could be described using metrics (e.g., length of the route segment), as done frequently (and almost exclusively) in automatically generated route directions. However, humans rarely describe routes in this way – typically, references to landmarks are used to demarcate qualitatively the end (or position within) a segment. For Denis [12], landmarks and action descriptions (referred by the author as "prescriptions") are the two essential components of route directions.

Again, definitions vary. According to Denis [12], landmarks can be 3D (building) or 2D (street, square) features of the environment. Within route directions, they can have one of three functions: signalling sites where actions are to be accomplished, helping to locate other landmarks, or confirming the route. In this framework, actions are often prescribed in relation to landmarks, as in "cross X" (X – a street, a bridge, a place) and "take X" (X – a street, a road, a path). Similarly, Montello [33] points out that landmarks are not restricted to point-like features – linear and areal features (e.g., paths, regions) can serve as landmarks just as well. In contrast, Allen [2] regards landmarks as environmental features serving as subgoals on the way from the point of origin to the destination along a specified path of movement. Within his framework, landmarks and pathways (e.g., streets, sidewalks, trails) are two separate elements of route directions. Thus, Allen's pathways would be classified in Denis' framework as landmarks, incorporated as proper parts into the route.

Further addressing the extent to which landmarks are incorporated within a route, [29] differentiate between the functions of the landmarks depending on whether they are on-route or off-route. A special term – *routemark* – has been used for a landmark that represents part of the route and determines the direction of movement (as in, "follow the river") [38].

Since landmarks have been defined in many different ways in the analysis of route descriptions, the question remains as to which features of the environment are essential in serving as landmarks. In the sentence "Walk along the street till the next intersection, where the bakery is, and turn left", the bakery is clearly a landmark, serving to identify the intersection and thereby the decision point. But what about "street" and "intersection", which are not by all authors identified as landmarks? Both are integral parts of the structure of the environment, and serve to segment and structure the route. In urban environments, they represent non-unique features within a network of streets and may not share one of the main characteristics of a more typical landmark, namely saliency. From a more linguistically oriented point of view, streets and intersections appear in descriptions in a similar way to (other) landmarks, reflecting their status as relevant and referable (and thus, arguably, sufficiently recognizable or salient) entities in the speaker's mind. Hence, [6], following [12], annotate all references to geographic objects as landmarks. This approach appears promising for a more natural, non-structured context, especially given the challenge as to understanding "how a continuous land surface, a landscape, becomes cognitive entities" [31].

As already indicated, landmarks are often linguistically related to action description – another important element of route directions. Two major classes of actions are often recognized: changing orientation (as in, "turn right") and proceeding (as in, "walk straight ahead") [12]. These elements are represented by verbs of motion, which fall in the semantic categories of "go" and "turn" [2]. [48] report that the most common actions in their case study were *turn, take a, make a, and go*; specifically, for the verbs expressing progression, the two most frequent ones were *go* and *follow*, used for straight and curved paths respectively. Beyond movement, possible actions are positioning and inspection, such as a check that the current orientation is the intended one (as in, "When you arrive here, you should have the school on your left and the market on your right") [12]. These are related to perceptual experience (as in, "You will see a stop sign") and are therefore often represented by verbs of perception (almost always vision) [2].

**Further descriptive elements.** The spatial elements described so far are typically recognized as a minimum set necessary for successful wayfinding. To capture any remaining elements of route descriptions, [48] differentiate between critical and supplementary information, and [29] note the existence of redundant information in route directions. [12] identifies descriptive components that may specify topological relations between objects and landmark properties, or provide various types of comments and encyclopedic knowledge without direct relevance for the instruction.

However, [16] argue that the type of information included is affected by the purpose of the activity that wayfinding is embedded in. The authors point to several attributes of activities (such as time pressure, effort, focus on destination) that are linguistically indicated by specific markers (such as *quick* or *fast* in the case of time

pressure). Hence, it is conceivable that some types of information may be redundant or non-essential in some contexts, while constituting a highly relevant and integral part of a description in other contexts. Mountaineering represents precisely the kind of context where a simple, spatially focused route description is not always sufficient. In the following, we will take a closer look at this kind of context.

### 2.2 Mountains as Outdoor Natural Space. Mountaineering as Activity

Considering the properties of mountains as a specific type of space, one major distinguishing property pertains to scale. [32] differentiated between four types of psychological spaces on the basis of the projective size of the space relative to the human body and the differing ways in which humans can apprehend them: figural, vista, environmental and geographical. In this framework, a mountain might represent an environmental space, which cannot be apprehended without locomotion – however, it is possible that it may be apprehended by "direct experience" alone [32]. In this respect, a mountain is comparable to an urban space; however, the ways in which the environment can be explored and the kinds of expectations about the environment that can be made on the basis of the information gained from a current position (i.e., within vista space) differ fundamentally.

This is related to another crucial space property – namely, its structure. While built urban space is seemingly structured by objects with more or less bona fide borders (streets, buildings, etc.), natural space represents a (more or less) continuous land surface, raising the question as to how exactly the human mind might structure it into entities [10], [41]. In [23], comparing indoor and outdoor settings, the authors identified further distinguishing structural elements with possible relevance to the mountaineering context. Indoor environments are essentially three-dimensional, while street networks are described in terms of two-dimensional concepts. Landmarks differ structurally – only outdoor environments offer global landmarks such as the sun. Indoor spaces restrict movement in all directions and also fundamentally obscure sight, while outdoor spaces are more flexible and may offer unconstrained lines of sight. Extending these insights, it is fair to say that mountains are likely to be conceived as three-dimensional, they can offer both global and local landmarks as well as an unconstrained line of sight, and they can have restrictions of movement in all directions, depending on the terrain. However, these aspects may vary as mountains are rather heterogeneous and changeable (according to weather conditions, seasons, as well as evergoing natural processes) – and indeed this heterogeneity and changeability is a key distinguishing property of mountains as space.

Unlike navigation in urban space, mountaineering is an activity that requires specific skills in terms of locomotion and navigation. Reaching the summit safely can be a major challenge and thereby constitutes a conceptual goal in itself. While in most contexts wayfinding is a necessity in order to reach a certain destination [16], wayfinding in mountaineering constitutes an essential part of the activity.

### 2.3 Open research questions

To explore human concepts of space in a mountaineering context, it makes sense to start from natural descriptions of using this kind of space. As a genre, alpine literature has a long history. The non-fiction part comes mostly in the form of accounts of ascents published in journals and yearbooks of Alpine Clubs since the 1860s[1], scientific journals [30] and privately [50], offering a rich potential for exploring how this kind of space is conceptualized. For instance, [3], [22] examined the meaning of mountains for the British during the 19th century. Some authors have used the digitized Swiss Alpine Club yearbooks[2] for quantitative analysis, e.g., to address motivation in mountaineering [7], to investigate how texts change over time [8] and for research in geographic information retrieval, with, for example, [36] investigating the possibilities of automatic route extraction, and [14] linking descriptions to geospatial footprints to examine how landscape descriptions vary across space.

While alpine literature thus provides a rich data source for addressing a wide spectrum of research questions, this has, to our knowledge, not yet been used to investigate human route concepts in mountaineering, as seen in contrast to urban space. A variety of approaches have explored how continuous landscapes are deconstructed into discrete entities and represented in language [10], [41]; in particular, the impact of factors such as experience [34], familiarity with landscape [51], local ecology, culture and language [5], [18], [21], [26] has been addressed. However, few authors have studied route directions in a natural context. [6] explored landmark- and action-based elements in orienteering route directions and identified various constructs from the point of view of geometry. [40] investigated the role of landmarks in summer and winter hiking along a specific route in a national park.

In this paper we aim to shed further light on how humans segment space in an unstructured alpine environment, and, furthermore, how landmarks and action descriptions are referred to in this context. In addition, we address the impact of activity on route directions, pursuing insights by [6] and [11] based on case studies on orienteering. In particular, we address the following research questions:

1. What is the *content* and *scope* of mountaineering route directions; to what extent are they focused on spatial information?
2. What constitutes *decision points* and *segments* in an alpine context?
3. In what ways do *landmarks* and *action descriptions* reflect features of alpine space and activities?
4. Finally, we wish to explore whether *generally applicable new insights* into the ways in which space is perceived and conceptualized can be gained by moving from primarily urban, highly structured spaces, to more natural landscapes.

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[1] http://www.alpinejournal.org.uk/
[2] http://textberg.ch

## 3 Data

Typically, research on route directions draws on controlled data collected from participants in a specific place. The increasing volume of user-generated content found online provides an alternative source of data, which some authors have begun to use for wayfinding research [17]. While such data provide little control over (or insight about) participants and circumstances, they offer a rich diversification of places described in route directions, overcoming some limitations of controlled studies that are necessarily constrained to specific populations and environments [12]. This may facilitate research on the specifics of space structure as reflected in the route directions, and help to uncover systematic patterns in texts of the same kind, independent of place.

For current purposes, our data source consists of 19 texts gathered from www.summitpost.org, a US-based platform for "a collaborative content community focused on climbing, mountaineering, hiking and other outdoor activities"[3]. The site's content is created and maintained by its members, who have profiles with basic personal information (including location, age, gender, date of registration). One section of the website is dedicated to routes, to be selected through an advanced search. Search parameters include location (continent, country), route type (e.g., mountaineering, bouldering, scrambling, mixed, etc.), rock difficulty, and grade. The set structure for route directions consists of the sections "Getting There", "Route Description", "Essential Gear", "Commentary", "When to Climb", and "Images". While some of these sections may be omitted, most of the route descriptions provide content for at least the first three of them.

When collecting texts for our small corpus, we extracted the "Route Description" section only, and chose texts of approximately the same length (350-400 words). We ensured that the same author did not appear twice in the corpus, and that the authors appeared to be native speakers of American English (judging from the location indicated in the users' profiles). By setting the route type (mountaineering) and grade (IV and above) as search parameters, we collected routes running on mixed types of terrain (rock, snow, ice) requiring certain skills and equipment from a mountaineer.

## 4 Analysis

Following the principles of Cognitive Discourse Analysis (CODA) [44], we started out with a detailed examination of the content of descriptions in our corpus so as to gain an intuitive understanding of the concepts expressed by route givers. These insights were then operationalized towards a systematic analysis procedure, which involved identifying meaningful segments, specifying their content, and identifying linguistic markers associated with the concepts in question. Since our research questions related to different kinds of linguistic features, this procedure was followed for each of them separately, as detailed below.

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[3] https://www.facebook.com/summitpost.org/info?tab=page_info

Generally, the concept of a motion event has proved to be particularly relevant to our analysis. According to [43], a motion event consists of the elements *Figure* (an object moving), *Ground* (object in respect to which the Figure is moving), *Motion* ("presence *per se* of motion"), and *Path* (the course followed by the Figure with respect to the Ground). Further, as [20] notes, *Paths* can contain information about the starting point of the motion event (called FROM paths), the end point (TO paths) and about the path itself, where the Figure moves along the Ground (VIA paths).

Additionally, the *Manner of Motion* can be included in the verbalization of a motion event. Verbs of motion fall into two broad categories: Manner verbs (e.g., *walk, run, crawl)* and Path verbs (e.g., *enter, descend, ascend*), which convey a sense of directionality but remain neutral about manner [35], [43]. The English language is known to have a large variety of Manner verbs, directionality is then usually expressed by additional elements, such as prepositions ("run <u>into</u> the room") [42]. We use these concepts in the analysis below.

Content and discourse analysis procedures typically require iterative loops [25], [44]. Here we aimed at a coding scheme with exhaustive and mutually exclusive categories (wherever possible) that were clearly defined for replication; this could only be achieved as a result of multiple iteration and modification, with continuous double checking by two of the authors to ensure consistency in the coding. In the following, we present the operationalized analysis undertaken together with our results for each research question sequentially.

### 4.1 General Scope of Alpine Route Directions

To analyse the overall scope of information included in route directions, we identified content categories in the corpus as follows, and counted the words in each category. These categories are mutually exclusive and exhaustively cover all data in our corpus.

*Route* (3,018 words): This category comprises any information about the route as such: general comments on the route, route segments and decision points, introduction of landmarks used for route confirmation, directions, as well as route options. These can be seen as central (prototypical) elements of route directions, paralleling those found in urban contexts.

*Terrain and Difficulty* (1,056 words): This comprises information on elevation, gradient of terrain and exposure, type of surface, and technical difficulty. The following markers (and their derivatives) are typical for the aspect of terrain: *elevation, high, steep, flat, angle, vertical, horizontal, exposure, ice, snow, gravel, sand, covered, rock, surface, textured, slippery, loose, rotten, broken, melting, soft, unstable, decomposed, mixed, pure*. Technical difficulty is often expressed quantitatively, and is typically represented by terms such as *crux, class, grade, resistance, challenge, negotiate, rate, attempt, hard, committing, easy, non-trivial, uneventful, climbable, complicated, technical, manageable, advanced*. Both aspects are interlinked and overlapping, as terrain properties are typically made relevant in the context of activity and challenge.

*Obstacles* (314 words) includes warnings about permanent obstacles such as crevasses, signalled by the following markers: *deal with, beware of, avoid, bypass, watch for, obstacle, detour, hidden, buried.*

*Hazards* (189 words) contains cautions concerning possible hazards, such as avalanches, rockfalls or strong wind. Typical markers are: *exposed to, hazard, falling rock/rockfall, wind gusts, avalanche, prone to.*

*Safe Locomotion* (412 words) comprises instructions concerning equipment: introducing protection opportunities and places where certain locomotion techniques should be used. The markers are mostly mountaineering jargon: *crampons, rappel stations, footwear, climbing shoes, helmet, boots, ice axe, rope (up), chain, strap up, belay, simulclimb.*

*Past Experience* (429 words) accounts for any experience of previous mountaineers (or the author himself) on this particular route. These units are generally marked by verbs in the past tense and first or third person pronouns.

*Miscellaneous* (588 words) contains less frequent units with various further types of information, such as spots for camping and repose, availability of water, traffic on the route, accounts of the views and references to time.

Altogether, these additional content categories add up to roughly the same amount of words (2,988) as the main Route category (3,018). Thus, we note that the overall scope of alpine route directions is centered on spatial information just as much as on further vital aspects of the mountaineering challenge (Figure 1). In the following, we pursue the spatial aspects pertaining to alpine route concepts by applying notions known from urban route contexts: segmentation, and the core concepts of landmarks and actions.

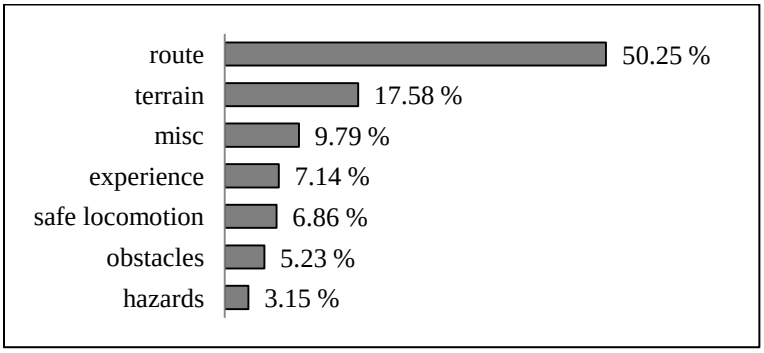


**Fig. 1.** Information categories in percent (n=6,006)

### 4.2 Segments and Decision Points

**Route Segments.** Conceptually, route segments are links between nodes. In verbal route directions, these are units containing information of how to get from one decision point to another. We identified segments in the corpus based on the idea that each segment should add a minimum of spatial knowledge about a specific portion of the route – using Talmy's terminology, the Path of a motion event [43]. To direct from node to node, a segment should include the FROM, the VIA and the TO elements of the Path [20], as in "Climb the final steep slopes from the top of the ropes to the summit". However, such a complete description of a motion cannot be always ex-

pected [48]. One relevant reference can often suffice to describe a segment, as in "Climb up towards the bergschrund where the angle steepens".

For the FROM and TO elements the typical linguistic markers are the prepositions *from, out, of, away* and *to, towards, on(to), in(to)* respectively, as well as Path verbs such as *reach* and *leave* [4], [20], [27]. Upon inspection of our data we further identified the verbs (or verb phrases) *arrive at, encounter, gain access to, obtain, deposit on, lead to* and *take to.* The last three of these were used in the corpus in relation to landscape features (representing fictive motion [43]). Furthermore, subordinate clauses that start with *once* or *after* (and the like), and that contain result-oriented Path verbs (as in, "Once you top out in the Chute", "After cresting the ridge"), indicate the FROM of the next segment with a focus on reaching the TO of the previous segment. Other types of subordinate clauses describe the location of the starting point of a segment; these typically start with *when* (as in, "When it flattens out slightly"). The VIA element was identified as any information on the Path between FROM and TO. It does not necessarily represent a linear landscape feature, can also be area-like, as well as a reference to the terrain properties (as in, "descend the same route", "continue on the close to the north side of the ridge", "deal with the 45 degree crux").

While a prototypical way of encoding a segment could be expected to be a motion event with one of the indicated Path elements, according to our data the presence of a motion verb is not necessary. A segment can be represented by a reference to the VIA element, without a concrete motion action description (as in, "There are 3-4 passes over the range that are negotiable"). As a result, units representing segments were very heterogeneous in terms of linguistic structure. Some contained one or a set of sentences, as in "There's a broad snow covered "pre-summit" ahead of you when you're on the snow. Pass it on the south side or you have to deal with crevasses". Other segments were more simply represented by smaller units such as clauses, as in the following set of segments:

1. From this step a traverse is made left to a small shoulder
2. which is climbed a short ways
3. before traversing left again on to the east face to the second couloir
4. which is climbed for about 25 meters.

Altogether, we identified 253 units containing segments according to our definition. For each segment, we annotated the presence of FROM, VIA and TO elements. Out of all segments, 19 (7.51%) contained all three elements, 96 (37.94%) contained two elements and as many as 138 (54.55%) contained only one element. The VIA element was encoded in 74.21% per cent of segments, the FROM element in 28.57%, and the TO element in 50.79%. The high frequency of the inclusion of the VIA element reflects its importance in alpine route direction; also, the end point of a segment is typically more relevant in a route description than the starting point.

Some further peculiarities are worth noting. In some cases, segments were not necessarily ordered, and did not always pertain to the same level of granularity. A straightforward example is: "The trip starts out as a hike along the Heliotrope Ridge trail. After passing Kulshan Creek the trail curves left and wraps around a small ridge".

Here, the second sentence elaborates the first by specifying the nature of a subsection of the segment. The nature of other parts of this trail remains unspecified. In other cases in our corpus, the same segment could be introduced twice, adding more spatial information the second time: "The other option, and reportedly safer, is to descend into the Hot Rocks area from the Hogsback instead of climbing and traversing under the cliffs, possibly getting pelted by falling ice/rock. You would simply traverse left and down from the Hogsback until below the Chute and then ascend to the ridge". It appears furthermore that the amount of information provided for a specific segment depended on its difficulty; while easy segments were only referred to briefly, more difficult ones were elaborated by prescribing a specific action or describing terrain properties (or resulting difficulty). We leave a more detailed analysis of these interesting granularity phenomena for future work.

**Decision Points.** We now address the ways in which routes are segmented by decision points. Since decision points are the starting and end points of segments, they can be analyzed through the prism of the FROM and TO elements.

We extracted 198 units of this kind from the annotated segments. Next, we were interested in the conceptual features within these units, so as to gain further insights about the nature of decision points in a mountaineering context. Based on iterative inspection we identified the following mutually exclusive categories, which exhaustively cover all references to decision points in our data:

*Intersection* (4 cases): This category comprises all units with a lexeme semantically related to an intersection. In our data, we identified the noun *fork* and the verbs *to branch* and *to fork* as markers of intersections. ("At about 4,700 feet the trail forks", "until it branches about 300 foot up").

*Landscape feature* (129 cases) is comprised of units with nouns that refer to a landscape feature (as in, "From the rock tower", "to the ridge").

*Spatial part of a landscape feature* (21 cases) includes units referring to the regions of the object on the basis of its inherent orientation [28], marked by nouns such as *base, edge, margin, end, top*. They are more specific in their reference to location than units of the previous category and imply certain geometric properties: landscape features in this category are conceptualized as linear ("From the end of the ledge"), or areal ("Walk across the plateau to it's [sic] northeast edge"), or three-dimensional ("From the base of the rocks").

*Accomplishment* (25 cases) comprises units where the decision point is not referred to as an identifiable location as such, but rather conceptualized as lying outside the landscape feature that has just been passed. These units are typically marked by prepositions such as *above, below, past* or by result-oriented verbs in the present perfect tense in subordinate clauses starting with *once, after*. Many of these encode a difficulty of the previous segment, as in "Once past the large bergschrund", and "Once you have crossed the tricky crevassed section".

*Terrain change* (8 cases) comprises units marking a location by referring to a terrain property, usually implying a change, as in "When you arrive at a flatter section" and "When the ridge finally goes vertical".

*Miscellaneous* (11 cases) comprises the remaining units that did not fall into these categories, such as *after a while* and *from there*.

Figure 2 illustrates the distribution of conceptual decision point categories in our data. Notably, the notion of *intersection* is virtually unknown, and only ever used in the context of an actual trail or a trail-like feature of the environment (here, a gulley). Instead, the descriptions rely heavily on *landscape features*, which are sometimes further specified by references to their *spatial parts* (usually those related to "the end" or "the beginning" of the landform). In other cases, when no specific landscape feature appears to be available to mark a location, the accomplishment of a segment or a change in the terrain serve as reference.

It appears that any change of topography has the potential of a decision point, paralleling intersections in an urban environment. This is clearly visible in the following example, where the traveller is advised to keep going although topography is changing: "The ridge eventually disappears but is trail like [sic] still heading in the same direction".

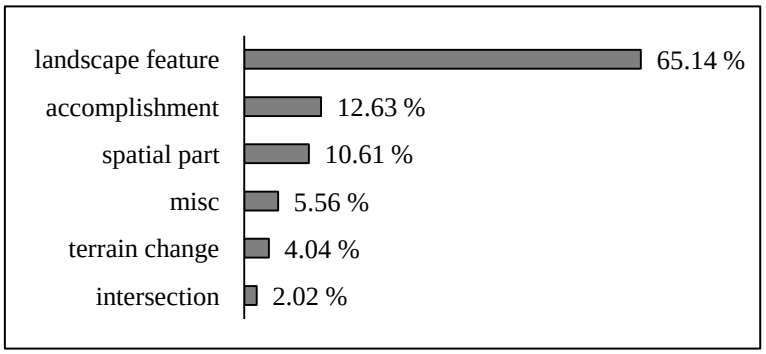


**Fig. 2.** Types of decision points in percent (n=198)

### 4.3 Landmarks and Action Descriptions

**Landmarks.** We classified all non-quantitative references to locations and geographic objects as landmarks. Four major (mutually exclusive) types emerged from our data (Figure 3).

*Landscape Feature* (334 cases): This category constitutes the vast majority of landmarks. These are not only landforms (e.g., *lake, river, gulley*), but also features associated with mountainous landscape (e.g., *moraine, couloir, chute, saddle*), meronyms of a mountain (e.g., *summit, peak, face*), as well as features of a smaller scale (e.g., *step, gendarme, crack*) and non-permanent features (e.g., *bergschrund, crevasse, cornice, snow bridge*). More anthropogenic landmarks include certain areas (e.g., *ski area*), roads and trails, camps and bivouacs, as well as small-scale non-geographic activity-related objects with a fixed location, as in "You will pass one rappel station mid way up this ramp"). Further, this category contains a high number of toponyms, as in "This would take you over Mississippi Head into Zig Zag Canyon (cliffs)".

*Spatial Part of a Landscape Feature* (50 cases) follows the same definition as in the section on decision points. Some of the most frequent concepts include *side, base,*

*bottom, top* (as in, "the north side of the ridge", "base of the east ridge", "bottom of ramp", "top of the tower"). Also, identifiers such as *upper, lower* are often used (as in, "upper Easton Glacier", "the lower left part of the face").

*Terrain* (23 cases) comprises references to locations through terrain properties, which are sometimes accompanied by nouns such as *terrain, ground, section* (as in, "scramble up some nasty loose terrain"). Common terrain properties are those related to surface, such as snow, rock and ice (as in, "climb steep exposed snow"), gradient (as in, "where it is almost flat") and difficulty (as in, "ascend easy ground").

*Constellation* (5 cases) contains units referring to a group of landscape features seen as a whole and is marked by the use of collective nouns (as in, "a series of steep steps") or the plural form of the nouns (as in, "rock islands").

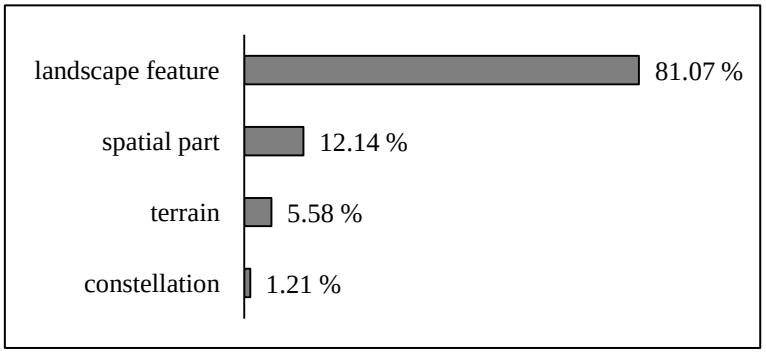


**Fig. 3.** Types of landmarks in percent (n=412)

References to landmarks often contain further descriptive information, related to their properties: type of surface, steepness, dimension (size, depth, width), shape, and colour. Also, visual saliency can be addressed, signalled by lexemes such as *distinct, obvious, prominent, main* (as in, "a distinct red-colored sand peak"), as well as the order in which similar features are encountered in space, made possible by the linear progression along the route and signalled by ordinal numbers as well as lexemes such as *next, final, initial* (as in, "as you approach the second rock pillar").

Such information highlights what constitutes "landmarkness" [39] in our context. Within all references to landmarks, we counted the mention of various properties. For the *Terrain* category, this meant annotating additional information about the terrain – for instance, in "climb steep exposed snow", "snow" was annotated as a landmark of the *Terrain* category, whereas "steep" and "exposed" were annotated as further properties (gradient and exposure). While most landmark references did not contain further features (77.18%, i.e., 318 cases), 74 references (17.96%) included one feature, 18 (4.37%) included two features, and 2 (0.49%) included three features.

Figure 4 highlights their semantic distribution. References to surface, dimension and gradient were most frequent, followed by linear order, difficulty, saliency and colour.

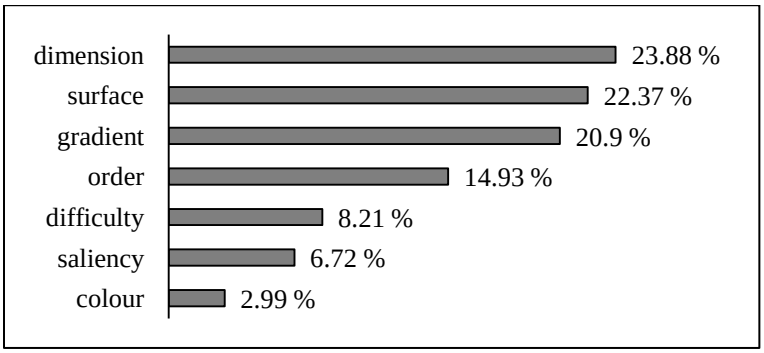


**Fig. 4.** Types of landmark properties in percent (n=116)

**Actions.** In urban contexts, the main actions in route directions pertain to proceeding (e.g., *go, follow*), change of direction (e.g., *turn*), and inspection (e.g., *see*). To address the scope of actions in the mountaineering context, we identified all action-related verbs in our corpus. This excludes, inter alia, verbs related to the description of the terrain and topological relations (e.g., *eases, flattens, drops, joins*). However, we did include fictive verbs of motion [43] that were used with landscape features (as in, "A boulder field leads (N) to the upper Arben Glacier.") since in our context they imply a mountaineer's actions. Altogether, we identified 384 action verbs (tokens). These were further categorized according to the following (exhaustive and mutually exclusive) scheme (see Figure 5).

*Motion* (320 tokens) contains verbs directly related to various types of motion (e.g., *climb, ascend, go, head to).*

*Routefinding* (28 tokens) includes verbs of vision (e.g., *look, see*), verbs related to locating objects (e.g., *find, locate, notice, recognize, ignore*), verbs and verb phrases related to finding (or missing) the right path (e.g., *miss, make a mistake, check options*) as well as efforts at remembering places (e.g., *make a mental note*).

*Protection* (16 tokens) includes verbs and expressions referring to safe locomotion, such as *rope up, set belay, strap up (crampons), use (piton, crampons), protect.*

*Caution* (11 tokens) comprises verbs and expressions such as *beware, exercise caution, be careful, make sure.*

*Repose* (9 tokens) includes verbs referring to rest, such as *camp, enjoy, rest, pitch (a tent).*

Clearly, Motion verbs are most prominent in our data, as could be expected. On further examination of this category we identified 224 Path verbs and 96 Manner verbs. The Path verbs demonstrate a rich semantic variety reflecting various conceptualizations of the geometrical properties of the Path and the Ground, as well as spatial relations between the Figure and Ground. In relation to the Path, there are verbs reflecting the directionality on the vertical plane (e.g., *ascend, descend*) as well as change of direction on the horizontal plane (e.g., *turn, head, veer*). Also, there are verbs specifying contour [43], also referred to as the global shape of the Path [49] (e.g., *contour, swing, curve, wrap*). In relation to the Ground, a rich variety of spatial relations is encoded: approaching the end point (e.g., *approach, get closer*), reaching

the end point or leaving the starting point (e.g., *leave, reach, attain, obtain, arrive, get to, come to*). Further, there are verbs encoding Goal and Source as "containers" (e.g., *enter, exit*), which can be also vertical (as in, "top out in the Chute"). The geometric properties of the Ground element in the motion events are also reflected in verbs that encode one or more dimensions, such as: 1D (e.g., *follow*), 2D (e.g., *cross, traverse*), 3D (e.g., *ascend, descend, drop*). Finally, there is a class of Path verbs and verb phrases related to avoiding the Ground (e.g., *detour, avoid*) or navigating around multiple Grounds (obstacles) on the way to the end point (e.g., *make your way to, mantle your way to, navigate*).

Manner verbs are characterized by a wide spectrum of semantics as well, ranging from relatively general verbs (e.g., *move, go, walk, hike, climb*) to more specific mountaineering jargon (e.g., *downclimb, scramble, glissade, belay, simulclimb, rappel, pitch*).

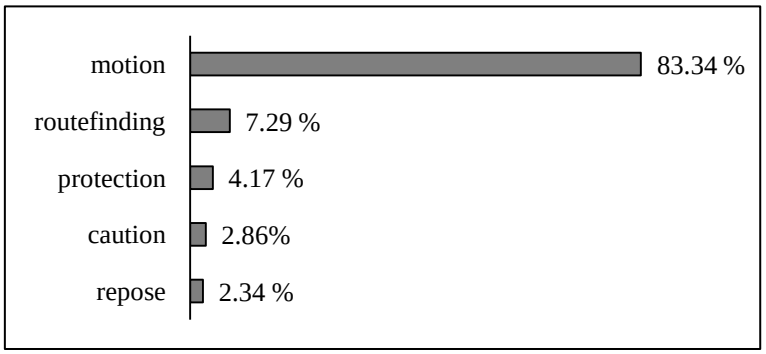


**Fig. 5.** Action classes in percent (n=384)

## 5 Discussion

We set out to explore how language was used to describe mountains as space and mountaineering as an activity through the prism of route directions. In what follows we discuss our results with respect to our research questions and outline the general insights that we derive.

To explore our first research question concerning the scope of alpine route directions, we categorized content and linguistic indicators in our corpus of mountaineering route directions. We found information going far beyond basic spatial information directly related to wayfinding with, for example, comments on terrain properties and difficulty of the route reflecting the central importance of the *locomotion* aspect in navigation [1]. References to obstacles highlight how the structure of alpine space is characterized by difficult or dangerous places that may necessitate careful avoidance. While following the general route may not be a problem, and indeed it may often be visible given long lines of sight in mountaineering contexts, wayfinding is important at a much more local, small-scale level. Frequent comments on the experiences of other parties on the route may be an indication of the changeability and unpredictabil-

ity of certain properties of space, such as the type of surface to be found at a particular point of time at a specific location. The data contained also a large amount of further "miscellaneous" information seen as relevant for mountaineers.

Our second research question concerned the ways in which routes were segmented and indicated by decision points in an environment that does not afford obvious intersections such as those structuring urban street networks. Our results suggested that topographical changes can serve these functions in a strikingly similar way. Decision points are places where one landscape feature is conceptualized as adjoining another, or, on a smaller scale, where some terrain property change is perceivable. Thus, a generally continuous landscape is conceptually structured into discrete landscape features (or landforms). This type of categorization process has already been noted in previous literature – for instance, in regard to differences in the way cultures delimit and label landscape aspects [31]. In a mountaineering context, this categorization reflects the necessity of structuring the landscape into manageable and referable segments. Segmentation according to more local terrain changes may be particularly relevant for small-scale locomotion.

Linguistically, segments vary in terms of Path (FROM/ VIA/ TO) elements encoded. Only a few segments contain all three elements of the Path. 30% of segments do not encode the VIA element, and 85% of segments miss either the FROM or the TO element. In an urban setting Tversky and Lee [48] reported 45% and 75% for the same phenomena respectively. While the VIA element encoding the Path between the nodes may be more relevant in an alpine context, the distribution is still remarkably similar. This result calls for future experiments using controlled variation, ideally as a within-subjects design with different spatial structures as the independent variable. This would allow for more profound examination and comparison of the conceptual saliency of different elements of a motion event according to context requirements.

A further finding concerns the prevalence of the TO element (present in about half of the segments) over the FROM element (less than a third). A general bias towards referring to the goal of a motion event has been found in the previous linguistic studies [27]. In alpine contexts, this may, in some settings, be supported by more open vistas than in an urban context, where visibility of the end point of a segment as well as the path towards it is potentially more common.

Furthermore, the amount of information provided in route descriptions does not necessarily indicate their effectiveness [2], [12], [13]. In [48], the authors suggest two common rules of inference, namely *forward progression* and *continuity*, i.e., if the starting point is omitted, it coincides with the end point of the previous segment, and vice versa. Our data seemed remarkably similar in this respect, with a potential further rule of inference specific to the mountaineering context: *upward* progression, as in "Proceed to the top of Liberty Cap!" The goal of climbing to the summit is clearly common ground for mountaineers, allowing for inferences in this regard [9].

Our third research question pertained to landmarks and "landmarkness" [39] in our natural context. In line with earlier findings [6], landmarks were overwhelmingly represented by landscape features. The three other types of landmarks found in our data – spatial part of a landscape feature, terrain property and constellation of objects – represent different levels in the hierarchical structure of mental spatial representa-

tion. General references to landscape features pertain to navigation on a higher level, leading to the necessity of changing spatial strategies at certain points where the landscape changes – and this sometimes requires more precise information about the landscape features. References relating to terrain properties directly pertain to the lower level of locomotion, which is known to require more detailed small-scale information [47]. A major implication of our findings is the dependence of the granularity of location description on the level of navigation at a specific point of time. Effectiveness of verbal route guidance of mountaineering thus appears to be rooted in flexible switching between granularities. In general, our analysis has reflected some of the findings and current issues discussed in the research on landmarks as summarized and outlined in [39]: the graded membership of the landmark category with better prototypical members (e.g., "distinct red-colored peak") and more uncertain cases (e.g., "when on the snow"), the close interconnection between the properties contributing to saliency (e.g., "when it flattens" has both visual and structural distinctiveness), the role of configurational qualities for landmark perception (e.g., the role of proximity and similarity in the Constellation category), the general high dependency of landmarks on the context (e.g., the case of "rappel station" and "fixed ropes" in our corpus).

Finally, we addressed the ways in which actions were represented in a mountaineering context, and identified an impressive range of variety. In urban contexts, motion-related instructions are typically represented by Path verbs, with some geometric conceptualizations reflected by verbs such as *follow* and *cross*. In contrast, in our data Manner verbs such as *hike* and *simulclimb* frequently attest to the relevance of locomotion in the activity. Furthermore, the wide variety of Path verbs such as *follow*, *traverse*, and *ascend* highlights various geometrical primitives, in line with previous findings by [6]. Verbs such as *exit, top out* further reflect the close interaction with complex space structure by the diverse ways in which landscape features are conceptualized.

A number of insights can be gained from our analysis concerning the diversity of mental representation of space. First, the role of *change* in the natural environment as a structure-imposing factor for segmentation and landmark identification purposes appears to be crucial, and clearly needs further investigation. Second, small-scale spatial relationships appear to be central in mountaineering, reflecting more direct interaction with space and thereby a different mental representation of the environment. This is seen in the frequent description of spatial and topological relations as well as geometric properties of geographic objects on a considerably finer level of detail than usually seen in route directions. Third, from a linguistic point of view, the variety of linguistic structures encoding elements of route directions (in particular, decision points and segments) is intriguing as it surpasses any previous accounts of linguistic features in route descriptions seen in the literature so far. Insights in this area may serve as a contribution to research on automatic itinerary reconstruction from route directions and texts, as well as route generation in navigation systems.

## 6 Conclusion and Future Work

Alpine route directions, as investigated in our, admittedly small, corpus, are semantically very rich, and thereby provide a strong contrast to urban route directions. This pertains not only to the wide spectrum of information that route providers find relevant, both spatial and non-spatial, but also to the highly diverse and creative ways in which segments, landmarks, and actions are conceived and represented in language. Applying cognitive discourse analysis [44] to such data unveils the spatial conceptualizations that underlie the systematic linguistic choices made by speakers.

In natural environments like mountains, routes can be segmented on the basis of changing topography and are generally conceptualized as a sequence of landscape features. Landmarks range from landscape features to references to changes in terrain, reflecting the role of scale in the activity where locomotion is an important component. Action descriptions are rich in the manner of motion as well as in spatial semantics, which further supports the role of close interaction with space.

Future research is needed to address a range of aspects seen in this paper. These include, for example, the geometric conceptualizations of spatial features as reflecting the way complex spatial environment is abstracted and represented, patterns of granularity switches, the role of the element of uncertainty in both the communication situation (anonymity of the receiver) and the space structure (changeability of space). Given the increasing interest in contextual aspects of wayfinding, the investigation of route directions in an alpine environment contributes to our knowledge of how space properties and activities influence the mental as well as the linguistic representation of space.

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