Using a Walk Ontology for Capturing Language Independent Navigation Instructions

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Abstract

Walking is becoming increasingly popular as a leisure activity across Europe. Outdoor equipment has modernized, gained flexibility and lost weight. GPS devices are gaining popularity. More and more websites are created for walkers. On the other hand information about walking paths is still very diverse in terms of source, structure, availability and language. This is why it is still difficult for outdoor enthusiasts to get all the trail information they need. The project WalkOnWeb wants to overcome this type of problems by defining a new publishing model for walking and tourist information. This paper describes the information structures defined by the WalkOnWeb project to solve this problem in an electronic publishing model. It explains what information layers the project defines for a walk and describes the information model in detail, including the different ontologies developed and used in the project. The specific focus of this paper is on the walk and navigation ontologies, including how both are used to create language independent navigation instructions. In this authoring paradigm authors do not describe navigation instructions literally in textual form but they write navigation instructions in a rigorously structured way, selecting possible types of instruction from a list and using standardised concepts taken from the ontologies. This paper describes how this works and how these structures are then used in a prototype to generate a textual instruction in a certain language and walking direction.

Keywords: ontology; multilingual; navigation; walking; OWL; UML; semantic web

1 Introduction

Walking is becoming increasingly popular as a leisure activity across Europe. Outdoor equipment has modernized, gained flexibility and lost weight. GPS devices for hikers are gaining popularity. On the other hand information about walking paths is still very diverse in terms of source, structure, availability and language. This is why it is still difficult for outdoor enthusiasts to get all the hiking path information they need. A real-life example: a young couple is planning a 7-day hiking trip to Crete but they cannot find any decent maps and the only guidebook they can find is in German, while they speak Dutch. Furthermore they want to hike in the opposite direction of the guidebook.

The research project WalkOnWeb [1] wants to overcome this type of problems by defining a new publishing model for walking and tourist information. This model is brought into practice by defining information structures and ontologies for walk information, by developing the necessary applications for content creation and publication and by defining a supporting business model. The three applications being developed are: Walk Planner (a website where hikers can search for walks and download information) Mobile Hiking Assistant (a PDA application that gives location based information in the field) and Authoring Tool (a content management system for creating and maintaining walks).
One of the main problems publishers of walk guides are faced with today is the lack of flexibility offered by paper publications. A walk guide is mostly published in one language and descriptions of the walk are limited to a single walking direction. Translating such guides is a costly operation as is keeping translated versions up to date. The paper publishing model is also very inflexible for hikers: they are limited to walks provided in a book and often it is hard to do partial walks or combine walks from different books.

This paper describes the information structures defined in the WalkOnWeb project to solve this problem in the electronic publishing model. It first explains what information layers the project defines for a walk and then describes the information model. In the subsequent sections the different ontologies used in the project are described and details of the walk ontology and navigation ontology are given, including how both are used to create language independent navigation instructions. Finally the paper focuses on the ontology driven engineering principles used in the project in order to come to conclusions.

2 Information Layers

Based on a thorough study of existing walk guides several information items have been defined that are important knowledge for a hiker when doing a walk. Useful information about a walk includes very diverse types like distance, duration, difficulty level, child-friendliness, type of way marking, road condition, user rating, legal regulations, map availability, etc. These items have been divided in several information layers:

- Points of Interest (POI's): description of interesting places to visit; a key characteristic of a POI is that it is bound to a location on earth (this can be a point or an area).
- Media objects: pictures, rendered 3D map views, sounds, video fragments, etc.
- Narratives: texts describing an interesting issue related to the walk, like stories about nature, culture or history, a description about how to navigate to the walk, weather information, health tips and local events.
- Practical information: any kind of practical information that can be linked to a walk but that can not be categorised in another layer. Examples include health tips or warnings, seasonal differences, viewpoints, links, pet modality and regulations.
- Natural language (NL) route directions: text version of the route directions, describing how the hiker has to proceed on the route and written in a certain language and walking direction.
- Route directions: explanation of the way the hiker has to proceed on the route, expressed in a language and walking direction independent way.

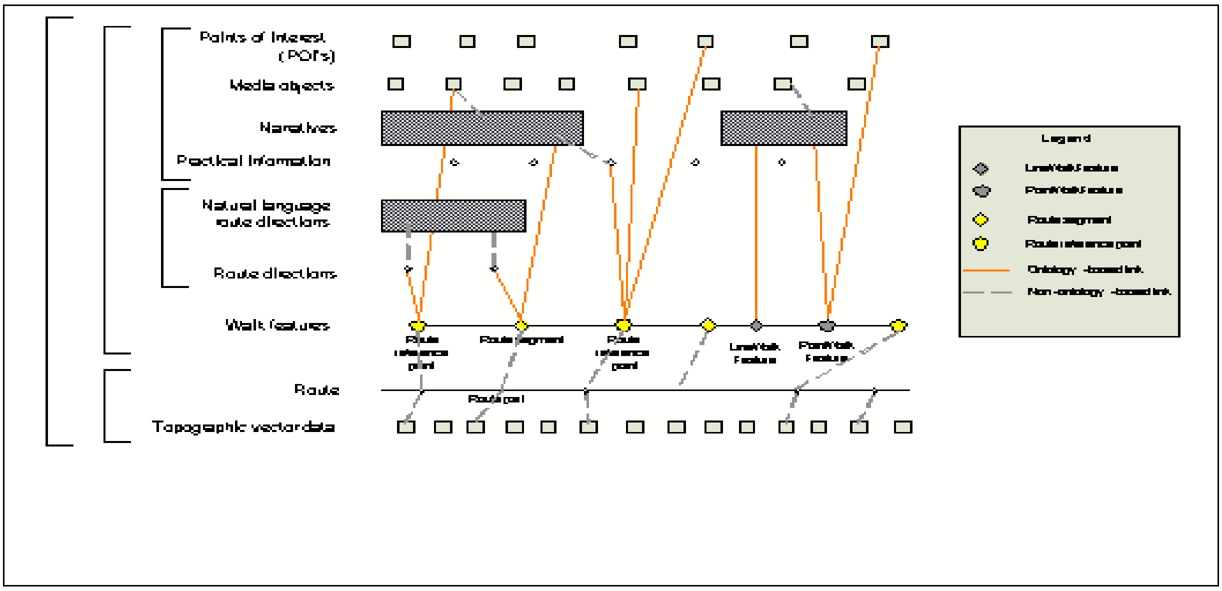

Figure 1: WalkOnWeb information layers

This paper focuses on the route directions layer and the way ontologies are used to express them in a language independent way. All information items described above can be linked to a certain point or part of the walk using the concept of "walk features": places on a walk (either points or lines) where a certain event occurs, like a nice view or passage by a hotel, or where a certain feature is applicable, like practical information. Two other information layers are "route" (the path followed by the walk on the terrain) and "topographic vector data" (a vector-based map containing detailed geographic features). All this information will be combined later into a publishable format on a website or mobile device.

3 Information Model

As a next step in the ontology development a UML (Unified Modeling Language) model [2] has been defined, describing the different building blocks for a walk in terms of information items and the way they are interconnected. The highlights of this model, depicted in the Fig. below, are described in the following paragraphs. The data consist of *atomic information units* so that it is very flexible to be combined and reordered. A key feature is the *strict separation between content-related and geospatial information* to maximize flexibility. Unlike most geographic information applications, for WalkOnWeb the content-related information of a walk is central and geospatial information (where is the walk located on earth) is only one of the various information layers. Of course geospatial information is important – for example for knowing where on the map the route should be drawn – but is not the core without which the other information is useless, on the contrary.

A walk is subdivided in *very small parts* to which information can be linked. At each point on the walk where the hiker needs to change direction or where the hiker might be uncertain on how to proceed, a navigation point is added. The section of a walk between two navigation points becomes a “route segment”. By labelling certain navigation points references can be made between the text and a map; hikers using guidebooks are familiar with labelled points. The major change however introduced by WalkOnWeb is the fine-grainedness of the different points (in between the labelled points) so that navigation instructions can be described in a very systematic and standardised way, instead of writing all instructions between two labelled points in one big paragraph of text, the way guidebooks typically do this today.

Linking information to a location on the walk is done using the concept “walk feature”. This concept allows the system to know at which place on the walk the information is relevant. When, for example, the walk passes through a nature reserve, the location of that reserve (relative to the walk) will be included as a walk feature and the information about the reserve (picture, text,…) will be linked to the walk feature.

Route navigation instructions are recorded in small, language independent information units, each describing how the hiker should proceed at a certain location on the walk. If, for example, the walk crosses a bridge and then turns left after the bridge, this bridge will be a navigation point. Two instructions will be created: one indicating that the route crosses the bridge and one instructing the hiker to turn left after the bridge.
Next to language independent instructions also natural language instructions, written by an author in a certain language, can be added.

An important difference between navigation instructions in WalkOnWeb and those provided for example by route planners on the Internet or by GPS devices, is the fact that in WalkOnWeb they are *created by a human author*. A specifically developed authoring tool allows authors to edit all information about a walk, both the language independent information using the ontology building blocks and the human-written information.

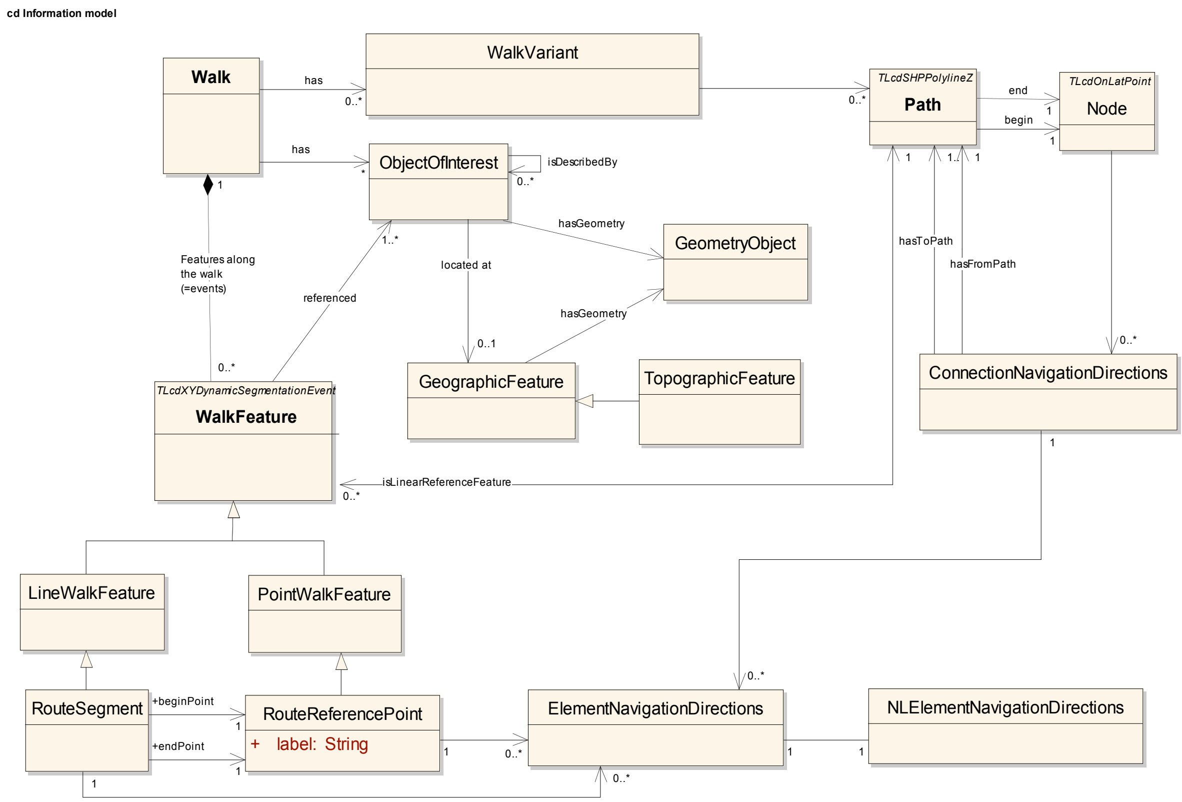

Figure 2: WalkOnWeb information model

4 Ontologies

In the WalkOnWeb information structures a central role is played by ontologies. Five ontologies have been defined, all using the OWL (Web Ontology Language) format [3]: application ontology, general purpose ontology, navigation ontology, topo-ontology and walk ontology.

At the upper level (top-level ontology) the (Euro)WordNet ontology is used to make a reference to general and language-independent concepts. At the intermediate level a number of ontologies are defined that are used by the walk ontology but that could also be used for other application domains:

- General purpose ontology: describes general concepts that can be reused in other ontologies and that cannot be directly defined by navigation or topo-ontology. For example: road condition types, soil types and types of time indication.
- Navigation ontology: describes navigational concepts like directions (left/right, north/south,…) and types of spatial relations.
- Topo-ontology: describes concepts and relations that exist in a vector based topographic database. For example: types of waterways.

The lowest level consists of the application specific ontologies: walk ontology and application ontology. The walk ontology is used for formalizing the information structures used to capture all information about a certain walk, while the application ontology captures all type of application specific items like types of narrative text and categories of interest. If the application would be turned into a cycling application typically only the application specific ontologies would change. Instead of a walk ontology a "cycle ontology" could be created.

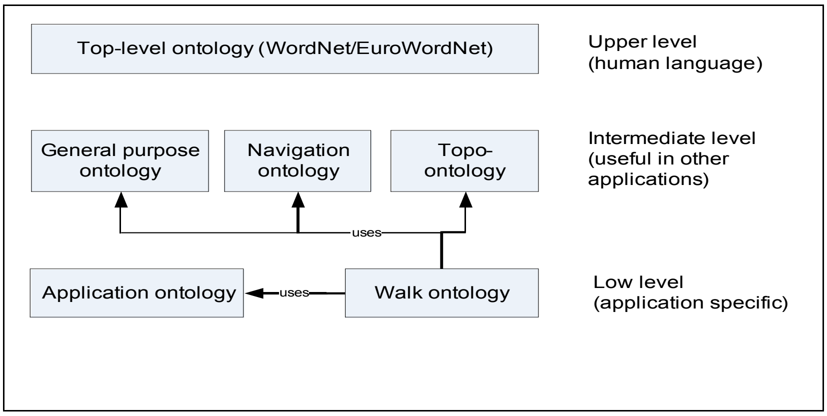

Figure 3: Ontology structure

5 Walk Ontology and Navigation Ontology

For developing the ontologies we used the guidelines as defined in [4]. As a first step we determined the domain and scope of the ontology. One of the main purposes of the walk ontology is to capture navigation instructions in a language and walking direction independent way. This means that an author is able to create navigation instructions by using his or her language and by describing one walking direction. The system should then be able to reuse that information for generating instructions in other languages and/or the other walking direction.
For this reason authors should not start with typing navigation instructions manually but they will use a limited vocabulary. Therefore they will select from a list of possible, standardised instructions and other building blocks to enter additional information. This exactly is the key focus of the navigation ontology.

As a second step in ontology development we looked at existing ontologies in order to define what can be reused. For some parts of the application a fair amount of existing work could be reused. For metadata we used the Dublin Core Metadata Element Set [5], for the top-level ontology we selected EuroWordNet [6], for public transport information we reused some elements from an ontology developed by the IM@GINE-IT project and for categorisation of POI's we used the VATGI standard (Information flow and exchange standard for Value Added Thematic Geo-Information) to some extent. For developing the building blocks for the navigation ontology we built on work performed by Corona and Winter at Vienna University of Technology in 2001 [7] [8] [9]. They have laid the foundations for an ontology for representing instructions to move from place A to place B. Some of these concepts have been taken over in the WalkOnWeb ontology related to the navigation directions. The key idea taken over from their work is the way in which navigation instructions to hikers can be classified (depicted in Figure 4).

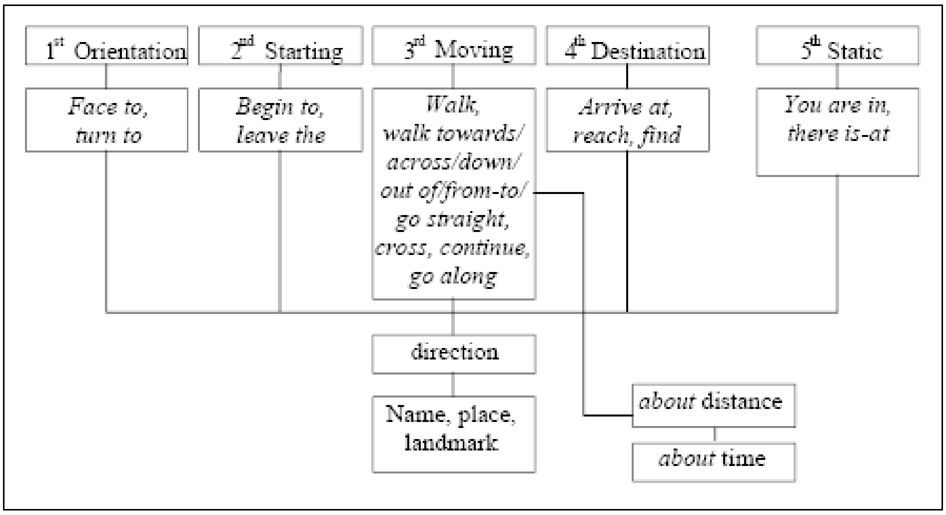

Figure 4: The actions in an ontology for pedestrian navigation (after Corona & Winter)

Based on these ideas finally the ontology classes and properties for navigation instructions were defined. Three parameters characterize each individual navigation instruction: the type of navigation instruction, the direction in which the hiker should proceed and the combination of a geographic feature and a spatial relation. For example: if the author wants to instruct the hiker to "turn right and follow the power line" he will use the navigation instruction "ChangeMovement" to indicate that the hiker has to change his walking direction. He will further indicate "Right" as the applicable direction, select "Power line" as geographic feature and choose "Follow" as spatial relation. Now the author has created a reusable navigation instruction using the building blocks from the walk and navigation ontologies.

The referenced geographic feature is typically a feature that can be found on a topographic map. All possible types of geographic features are described by the topo-ontology. So, when a vector based map is used, the ontologies can be used in their full strength: an author is able to click on a feature on the map in the authoring tool and the tool can know directly what type of geographic feature this is and which spatial relations are possible. For example: the relation "cross" will be possible for a bridge and for some types of small rivers but not for a canal.

The list of possible types of navigation instructions is captured by the walk ontology class ElementNavigationDirections and its subclasses (see Figure 5 unten). An ElementNavigationDirections individual can be one of the following:

- Location: Describes the current location from which the navigation continues, starts or end.
- Action: Actions that the hiker has to take in order to reach the destination from the current location:
  - Orientation: Orientation action that the hiker has to perform in order to be able to start the movement towards the destination. At this moment the hiker has not started moving yet.
  - Starting: Description of the start of the movement, for example pointing to a geographic feature that we have to pass before the next instructions are applicable. At this moment the hiker has not started moving yet.
  - Movement: Movement that the hiker has to do in order to reach the destination from the starting point:
    - ChangeMovement: movement requiring a change of direction.
    - ContinuationMovement: movement not requiring a change of direction
  - Destination: Description of the end of the movement, for example pointing to a geographic feature that we have to pass before reaching the final destination. At this moment the hiker has not finished moving yet.
- NegativeDirections: Direction that the hiker should NOT take in order to reach the destination. E.g. do not take street X on the left.
- PublicTransport: Public transportation that has to be taken for this part of the route, e.g. a ferry boat.

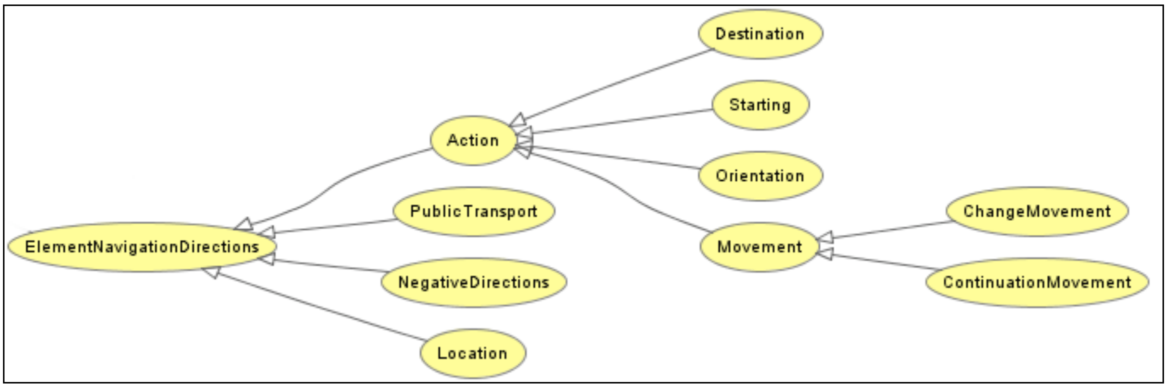

Figure 5: Types of navigation instruction

The Fig. unten depicts the main navigation ontology classes. Both Direction and SpatialRelation are referenced from an ElementNavigationDirection. A Direction can be either a CompassDirection (North, South,…), RelativeXYDirection (left, ahead,…), RelativeZDirection (up, down) and ClockDirection (clockwise, counter clockwise). For SpatialRelation two subclasses exist: MovementSpatialRelation, typically containing verbs like "enter", "follow", "pass by" or "proceed until", and StaticSpatialRelation, typically describing prepositions like "above", "before", "between", "to", "in front of" etc. Depending on the type of ElementNavigationDirection a different set of Directions and SpatialRelations are possible. For example: a ClockDirection can be applied to an entire walk (the walk runs clockwise) but not to a navigation instruction (it is not common to instruct a hiker in the field to "turn clockwise" – "turn right" makes more sense).

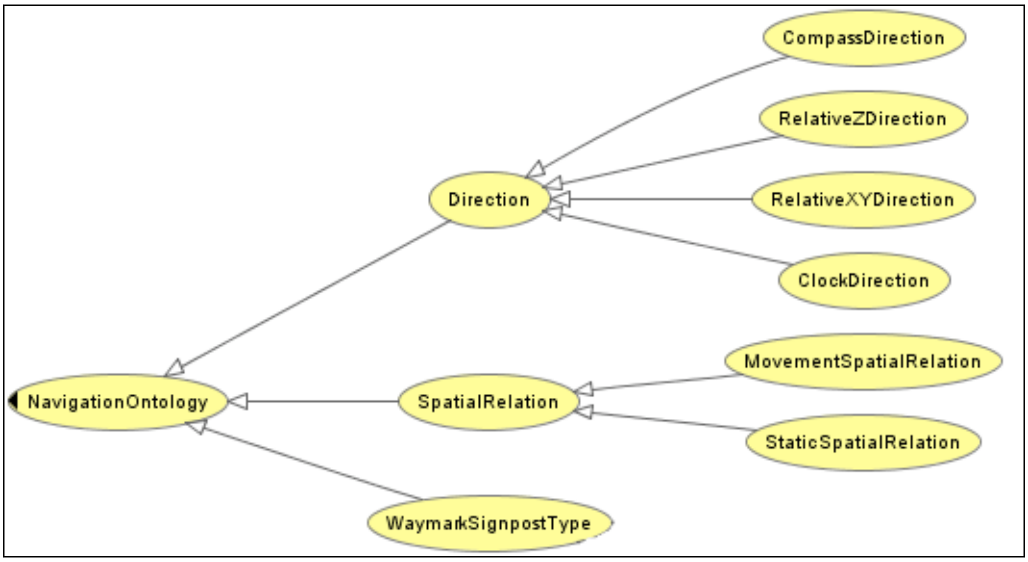

Figure 6: Navigation ontology

6 Navigation Directions Prototype

In order to test the developed ontology in practice a number of walk guidebooks have been converted manually into the ontology structures. This work was typically done by the guidebook publishers themselves as this is mainly content-related work; converting a free-form written text into an ontology based structure requires a lot of reasoning, interpretation and domain knowledge.

A prototype has been set up to test the use of this ontology for creating location based content that is both rich and independent of the language or walking direction. This "navigation directions prototype" converts the ontology-based navigation instructions into a readable text format. For example: the author has created a navigation instruction typed as ChangeMovement, selected "left" as direction, "river" as geographic feature and "after" as spatial relation. The navigation directions prototype will then compose a textual instruction from these building blocks. In the given example this becomes "turn left after river": ChangeMovement becomes "turn" and the other words are taken from the navigation ontology individuals. As these individuals can have property values in different languages it is possible to compose a text in different languages. The RelativeXYDirection individual “Left” e.g. has a property hasText in which texts can be stored in different languages: “left” in English, “links” in Dutch or “à gauche” in French. When generating the given instruction in French, the text “à gauche” will be used: “tourner à gauche après rivière”.

Obviously this is not sufficient for creating a text generation system in multiple languages. Apart from using different words languages also differ in grammar. Therefore the prototype has been built using a different - easily adaptable - template for each language. Other refinements include splitting words in certain situations; for example in Dutch some verbs are split up in two words when used in negative sense or when the verb has an object. The system has been designed as generically as possible so that, when a language is added to the system, only the ontology has to be adapted and a template for the new language has to be added. This is still far from a full linguistic sentence builder which is typically used in text generation systems like automatic translators, but this was beyond this project’s scope.

Kemmel_4a

Language	Generated desciption	Opposite generated desciption
Dutch:	ga niet rechtdoor maar ga Schoonemaegdstraete in, ga naar rechts	verlaat Schoonemaegdstraete, ga naar links
French:	ne pas aller tout droit mais entrer dans "Schoonemaegdstraete", tourner à droite	quitter "Schoonemaegdstraete", tourner à gauche
English:	don't go straight ahead but enter "Schoonemaegdstraete", turn right	leave "Schoonemaegdstraete", turn left

Kemmel_4a-4b

Language	Generated desciption	Opposite generated desciption
Dutch:	volg Schoonemaegdstraete	volg Schoonemaegdstraete
French:	suivre "Schoonemaegdstraete"	suivre "Schoonemaegdstraete"
English:	follow "Schoonemaegdstraete"	follow "Schoonemaegdstraete"

Kemmel_4b

Language	Generated desciption	Opposite generated desciption
Dutch:	ga Wezel Dreve in, ga naar links	verlaat Wezel Dreve, ga naar rechts
French:	entrer dans "Wezel Dreve", tourner à gauche	quitter "Wezel Dreve", tourner à droite
English:	enter "Wezel Dreve", turn left	leave "Wezel Dreve", turn right

Figure 7: Navigation directions prototype

Knowing this limitation, the first results of the navigation directions prototype are promising. Generated texts are rather schematic, but clear and readable in all three languages included in the system (Dutch, English and French). Figure 7 shows a sample of generated texts in these three languages. Small refinements like splitting up verbs (in Dutch) and adding conjunctions like “but” greatly improve readability.

As an extension to the prototype also navigation directions in the other walking direction are generated. This means: the direction opposite to the one used by the author when describing the walk. For reversing an instruction we use the same template structure and we use the knowledge contained in the navigation ontology to find the applicable concepts in the other direction. The navigation ontology knows for example that the relation “leave” becomes “enter” in the reverse direction. Some relations however, like “after”, cannot easily be reversed because this is a very relative concept that might not be applicable at all in the other direction. It might be tempting to reverse “Turn right after the border sign” in “Turn left before the border sign” but this is not correct in many cases. The border sign might not even be visible when walking in the other direction. This means that the author should adapt his way of describing walks in such sense that he only refers to landmarks that are visible in both walking directions.

Our prototype showed that it is impossible to automatically invert all instructions without limitations. When reversing the direction, some types of navigation instructions become unusable. For example, when you instruct a hiker to “orientate himself towards the church” before he starts walking, this instruction becomes superfluous in the other direction: at that moment he has already arrived at that location and he does not need orientation anymore. As a consequence we should allow authors to create navigation instructions which are applicable only in one direction.

Next to possibly superfluous information, opposite direction instructions can be plain wrong when you simply invert them. Reversing the sentence “don’t go left but turn right” would give “don’t go right but turn left” but this could be wrong in many occasions. If this is a T-crossing for example there is no “right”; the opposite text would have to be “don’t go straight ahead but turn right”. To avoid giving wrong instructions to hikers our strategy is rather to skip possibly incorrect information than to give the information anyway.

Kemmel_7-7a

Language	Generated desciption	Opposite generated desciption
Dutch:	ga rechtdoor verder en volg Chemin de la Glaise en ga naar boven verder en steek naamloze beek over	ga naar beneden verder en steek naamloze beek over en ga rechtdoor verder en volg Chemin de la Glaise
French:	continuer tout droit et suivre "Chemin de la Glaise" et continuer en montant et traverser "naamloze beek"	continuer en descendant et traverser "naamloze beek" et continuer tout droit et suivre "Chemin de la Glaise"
English:	continue straight ahead and follow "Chemin de la Glaise" and continue uphill and cross "naamloze beek"	continue downhill and cross "naamloze beek" and continue straight ahead and follow "Chemin de la Glaise"

Kemmel_7a

Language	Generated desciption	Opposite generated desciption
Dutch:	kruispunt D213: ga rechtdoor verder en steek D213 over, ga Poperinghe Cruysse Straete in	kruispunt D213: verlaat Poperinghe Cruysse Straete, ga rechtdoor verder en steek D213 over
French:	continuer tout droit et traverser "D213", entrer dans "Poperinghe Cruysse Straete"	quitter "Poperinghe Cruysse Straete", continuer tout droit et traverser "D213"
English:	continue straight ahead and cross "D213", enter "Poperinghe Cruysse Straete"	leave "Poperinghe Cruysse Straete", continue straight ahead and cross "D213"

Figure 8: Generating longer sentences

The figure oben shows the system’s ability to generate longer sentences as a combination of multiple navigation instructions. Generated navigation instructions will be shown later to hikers on a web page (Walk Planner application), printable document, or a mobile device. Depending on the usage situation, slightly different instructions could be generated; for example for mobile devices the instructions can be expected to be more concise than on a paper print.

7 Conclusions

With this prototype we have demonstrated the usefulness of an ontology for creating rich content in a flexible way. One of the main reasons for using ontologies is their ability to express rules in a formal but still descriptive way. Creating such an ontology requires a lot of domain knowledge and fine-tuning is always necessary by testing the ontology concepts with real-life data. For that reason the Protégé tool [10] proved to be a great asset: it was used not only for developing the ontologies but it also allowed non-technical persons to input sample data in the ontology structure without knowing any details of OWL. Editing this way however is a very time-consuming activity and not user friendly at all for authors. Therefore an Authoring Tool is being developed, allowing authors to edit walk information in a faster and more user friendly way, but still respecting the ontology structures.

For authors this new way of describing a hiking path requires a major attitude shift. Authors might be intimidated by this type of applications as these might replace their tasks to some extend. Another argument against this application is its linguistic limitations: authors prefer bringing variation in their texts, making them more prosaic, but with this system this is hardly possible. On the other hand, if authors write in this more standardised way it could save them time in describing rather dull navigation instructions (“hard” data) and leave them more time for writing side information like historic facts, nature phenomena, cultural events and the like (“soft” data). Imagine today an author who goes in the field with a Dictaphone to record all navigation instructions and who has to type these voice recordings at home. With this system the same author would take a PDA in the field, enter location-aware navigation instructions by selecting from some drop-down menus and importing all this at home using the Authoring Tool application.
Even with this new way of authoring, the bottom line remains that decent navigation instructions for pedestrians should be written by a human author. Electronic maps at this moment do not support automatic generation of navigation instructions for walkers and it is unlikely that they ever will. Instructions for a hiker should be much more detailed than for a car driver and they encompass aspects that are very hard to be included on a geographic map.

8 Further Work

The prototype described in this paper only covers a small part of the entire electronic publishing framework that is being developed by the WalkOnWeb project. Currently the ontology structures are being used also during application development, bringing into practice the usefulness of semantic web in software engineering [11]. Using this ontology driven software architecture we are able to automatically generate the data-related parts of the applications from the ontology files. This greatly improves the adaptability of the source code and allows a real ontology centred approach throughout the project. The interested reader might want to check the programme of the ISWC 2006 conference [12] as a paper will be submitted for that conference focusing on the ontology driven engineering aspects of this project.

A detailed description of the ontology structures, including the ontology files, is available on the project website [1] in the document "D3.2.1 Report on geo-ontologies and data structures for hiking paths". Readers interested in trying the prototype online are invited to join the Project Interest Group, after which they will receive a password to access the prototype. For more information visit http://www.walkonweb.org or send an e-mail to info@walkonweb.org.
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