USER ADAPTATION IN A PEDESTRIAN GUIDANCE SYSTEM FOR THE BLIND

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Abstract: Among today's emerging pedestrian guidance systems (i.e. able to automatically answer questions of the form "How should I go from localization *a* to localization *b* ?), some are dedicated to blind people; fewer if any focus on impaired people as well as people without any deficiency. Contrary to this, the "ouvej" system relies on representing impairments as a part of the *user's profile* in order to be adaptable to any kind of user. Furthermore, we consider that benefits of the user modeling involved in such adaptation mechanisms go beyond the only impairment category in order to respect the user's preferences in itineraries and itineraries descriptions, by modeling itinerary environment. Whereas existing adaptive system often rely on the use of explicit feedback from the user, we propose to limit adaptation-related interactions by using implicit user evaluations inferred from observations of users interactions with the system. This article focuses on blind pedestrian users using a vocal interface. After detailing our approach, we detail our itinerary and user models; Then the implicit as well as explicit itinerary evaluation mechanisms are described; Next sections focus on the actual adaptation and expected benefits of inferences between different users; Our prototype is then described. We conclude by presenting our first observations, future work and evaluation.

1 INTRODUCTION

Among numerous recent guidance help systems for the pedestrian research works or products, often inspired of existing guidance system for vehicles, some are dedicated to visually impaired people ("Vikktor Trekker" by Visuaid; works of the polytechnic institute of Lausane (Rouller et al., 2002) and LIMSI (Gaunet and Briffault, 2001)). Such prototypes typically involve the Global Positioning System technology for user localization, exploiting electronic map for the guidance.

Our study is part of the "Ouvej" project[1] which goal is to provide a general ubiquitous guidance help system for any pedestrian. In short, such a system should be able to automatically answer questions of the form "How should I go from localization *a* to localization *b* ?". User's potential deficiency has been taken into account since the beginning of this project: the answer to the prior question can't be answered the same way for someone without any deficiency than for someone moving in a wheelchair. Moreover, the best medium for providing such information might not be the same for different kind of user. Thus, emphasis has been put on the necessary user adaptation of the end-user interface as well as the content of the assistance itself (i.e. description of the itinerary). This article addresses the particular issue of the visually impaired user using a vocal (telephonic) interface.

After detailing our approach, we detail our itinerary and user models; Then the implicit as well as explicit itinerary evaluation mechanisms are described; Next sections focus on the actual adaptation and expected benefits of inferences between different users; Our prototype is then described. We conclude by presenting our first observations, future work and evaluation.

2 APPROACH

Interviews and observations have shown that blind people are often reluctant to use a phone or any talking device while walking and consider it dangerous.

[1]directed by Mission Handicap (Universit Claude Bernard, Lyon 1), assisted by Liris-Insa (INSA-Lyon) and E.O.-E.D.P.S, and founded by Region Rhne-Alpes

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The main reason given for that is that the cognitive load is generally too heavy to handle both activities. Moreover, it is often impossible to use a phone while using a cane or following a guide dog. Thus, the moves using a voice-based interface for the blind must be achieved in a set of two steps : (1) the system is asked for an itinerary and replies; (2) The user follows the given itinerary description.

Thus, the main concern about our user adaptation mechanism is to provide a description of an itinerary being (1) as detailed as possible in order for the user to be able to follow it, and in the same time (2) as short as possible in order to be easily memorized by the user. This optimal detail level for a description is related to :

- Each user (different users need different level details);
- Each itinerary, which complexity isn't a priori known.

In order to adapt the itinerary description to user's needs, the user could be asked for desired detail level by the system. But then, it should be asked for each itinerary, which is not a suitable solution : the benefits of adaptation would be cancelled by the extra time involved in this interaction. Contrary to this approach, we consider that the user adaptation can be achieved using a minimal amount of user explicit feedback: as we are fully aware of the whole history of the user's interactions with the system ("*use traces*") should be sufficient to set optimal parameters for each user and each itinerary detail level.

We propose to use this knowledge to determine the best parameters for an user according to its past use traces, and to take part of other user's traces in order to predict those parameters for the new user of the system, and for each itinerary. Such user modeling related techniques have proven to be useful for a wide range of applications, performing tasks that can be classified into document filtering, document personalization and interface adaptation (Kobsa and Wahlster, 1989) (Leake, 1996).

3 VOCAL USER INTERFACE DESCRIPTION

The use traces study is closely related to the actual user interface. However, the implicit feedback provided by the user while interacting with the system not necessarily implies the use of a single interface. Indeed, the same simple feedback is expected to be collected with other user interfaces of the system, as those interfaces have to be designed to do so.

Once asked for an itinerary, the system replies by

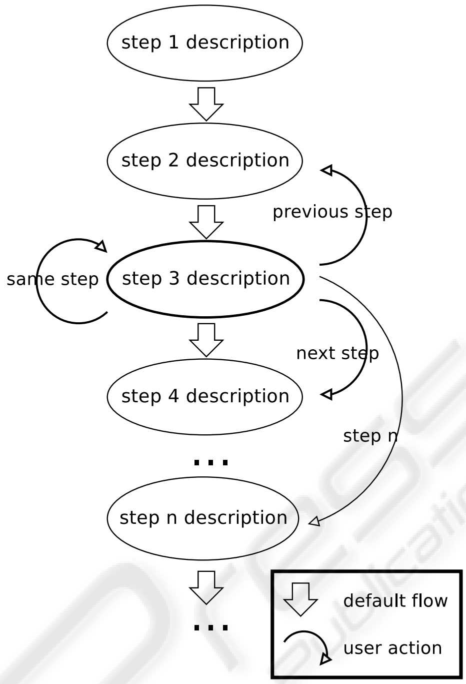

Figure 1: Simplified vocal interface flow

reading a sequence of itinerary segment descriptions[2] or *steps*. The simplified vocal user interface (limited to itinerary description), is described figure 1. If the user doesn't interact at this point, the normal flow is used. At any time, the user can ask for the next step, the previous step, or a step specified by its number.

Use traces consist in a record of these actions, labelled with the ongoing step number. We consider that the analysis of the user circulation into the itinerary description represents its implicit evaluation: a poorly formulated description will not either not be well remembered by the user, or lead to difficulties in the moving process, leading the user to ask for the segment description again. On the contrary, a well formulated itinerary description will rarely be asked many times, and often passed. Use traces exploitation is detailed in section 5.

However, the interface permits the use of explicit user feedback for critical adaptation tasks. Such a feedback is expected to be used in the case of an impossible itinerary: for instance, blind people often won't accept to cross a road that is not "securized" (e.g. that might have traffic light, but no associated vocal message)[3]; thus, this crossing will be considered impossible for an user, regardless of the particular itinerary in which it takes place. Such an adap-

[2]This itinerary decomposition into segments results from the itinerary computation (see 4.1)

[3]although some might

tation could be handled using the same mechanism as above (use implicit feedback contained in the use traces), but could result in dangerous situations if the user is unaware of the possible adaptation.

4 USER AND ITINERARY MODELING

4.1 Itinerary model

The modeling of an itinerary has been achieved by studying real-life itinerary descriptions dedicated to french-speaking blind people[4]. These descriptions have been reformulated using a set of generation rules of the form defining an itinerary description grammar, which use a subset of change of localization (i.e. movement) classes (Muller and Sarda, 1998) (Mathet, 1998), as well as localization categories (Sarda, 1997).[5]

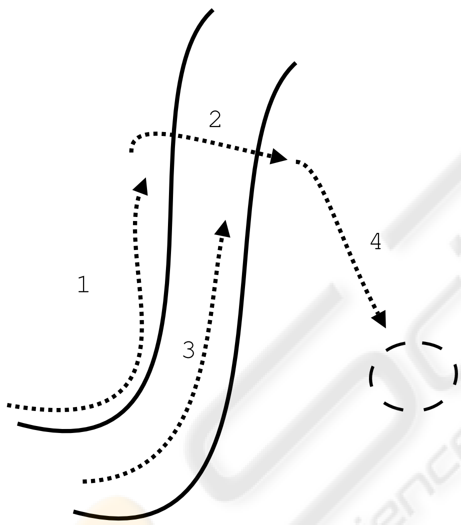

Figure 2: Minimal movement types set

Each step of an itinerary can be fully defined by an *action* and a *final localization*, both being potentially implicit :

- An action is defined by associating an item (a road, a pedestrian crossing, a sidewalk, a stair, a doors, etc.) optionally labelled with item categories (buildings, stairs, etc.) with a movement: go alongside; go across; follow; go in a direction (see figure 2). Both action and movement being optionally given a set of descriptions.
- A final localization is an item, and a set of optional descriptions.

As we mentioned above (section 2), a fully detailed description will be more precise, being more helpful for the user to conceive an inner personal map of its environment while making it more difficult for him to remember the described itinerary. However, the shortest description might not be the best one, as it could lead to misconceptions, even at the scale of a single itinerary.

Thus, the output description can be adaptated to the user's need by including or not (1) optional descriptions of an item that may include relative localization of the item according to the user's position ("the crossing situated at your left"), localization of the item according to other items (e.g. "the stairs situated in front of the tramway rails"); (2) reference to user awareness of an item, based on a prior use found in user's history; (3) free-form optional description. The adaptation process includes also the choice of the form of the sentence used for an action description (for instance: explicitation of optional actions or localization).

The generation process of the description of an itinerary uses a set of parameters which are necessary directly mapped on each of these options (e.g. maximal length of the description text, description of specific items); Hence, the referred as *(description) construction parameters*.

Due to the nature of the description corpus, our itinerary modeling is closely related to blind people's moves. Sighted people, for instance, might find it peculiar to be told to walk until the lowering of a sidewalk (which is especially useful when followed with a cane) as it is not the kind of item they use in their everyday moves. Such users will prefer using visual items, use building names, etc.

However, the above itinerary modeling can be easily extended to non-blind people: instead of conceiving specific itineraries for each user categories (that are hardly to be defined), an adaptation process for the itinerary building can be achieved in filtering the items and actions according to the user's actual moving possibilities provided be explicit feedback[6]. Indeed, the limit is thin between sighted and visually impaired people as visual impairment itself not only covers a wide range in intensity, but also in categories. Furthermore, given a visual deficiency, some people might consider themselves blind or not. Thus, we consider possible for two blind people to have less in common than a sighted and a blind people.

As a result, a step is a bag of (action,item) set (and their associated descriptions). Given two different users, the same item is possibly optionally used for

[4]Thanks to E.O.-E.D.P.S.

[5]The correctness of our modeling could be closely related to the language used in the corpus.

[6]However, some actions forms have to be added to widen the range of possible itinerary descriptions

the first and mandatory for the other, as well used, or not, in an action.

4.2 User Model

As suggested by their name, *user modeling* based systems often introduces attributes in the user profile that are not closely related to way the user interacts with the system, especially if impaired people were expected to be involved (Jeribi, 2001). Such attributes might include user's age, sex, impairment specification, etc. This knowledge permits direct and easy adaptation, and has proven to be useful (Kobsa, 2001).

However, the use of such a knowledge, being sociological, cognitive or physiological results in supplementary constraints in the reasoning that blur analysis of the system reasoning capabilities. For instance, observation of visually impaired people's move have suggested user's age as a good factor for determining the detail level of an itinerary description: the youngest need less optional descriptions and memorizes more easily a given description than the oldest. But a closer look shows that this difference might in fact be related to the locomotion school he did belong (or not), this criterion being not necessarily related to the person's age, but merely to the age the person became blind.

On the contrary, considering the only use of the system by the user has the benefits of (1) helping to avoid the temptation of adding a priori and uncertain knowledge about the user; (2) making it easier to observe the dynamical functioning of the reasoning system itself (Pierre-Antoine Champin, 2002).

5 ITINERARY STEPS EVALUATION BY USERS

User adaptation of step and step description relies on user's evaluation of itineraries steps. These evaluations are constructed whether explicitly or implicitly (i.e. built from the user traces), as shown in 3; Explicit evaluation are used for critical tasks (the user reports an itinerary he isn't capable to follow), implicit evaluation for evaluating the descriptions. Evaluations of itinerary as well as descriptions is done as a whole, subsequent reasoning being used to determine its inner element contribution in the evaluation.

Given an itinerary search session and the corresponding itinerary formed of the ordinated step descriptions of steps, the session use trace is a time-stamped sequence of pairs of steps and step descriptions actually heard by the user.

This trace is interpreted as follows : starting from the second occurrence of a step, the associated evaluation will be removed one point. To the contrary, description of steps that are heard only once will gain a point.

As the description form of a given description is determined by the values of its construction parameters $\{p_1 \ldots p_n\}$ such as optional items and actions descriptions, optional item localization, free-form optional description and form of the sentence (described in 4.1), the role they play in the positive as well as negative evaluation of a step description has to be determined.

Thus, as possible values of each construction parameter p_i consists in a set of m discrete values $p_{i,1\ldots m}$, evaluations are directly used for the evaluation of each construction parameter value. Evaluation for parameter value $p_{i,j}$ is noted $E(p_{i,j})$. Each evaluation given by an use trace is added to previous evaluations of each parameter-parameter value pair, as illustrated figures 3 and 4. A confidence level for each parameter value is given by the number of evaluations.

trace	param. value	evaluation
t_1	$v_{p_i,1}$	-2
t_2	$v_{p_i,2}$	-2
t_3	$v_{p_i,1}$	1
t_4	$v_{p_i,3}$	-3
t_5	$v_{p_i,3}$	1
t_6	$v_{p_i,3}$	1

Figure 3: Example: evaluations for different parameter values $v_{p_i,1\ldots3}$, for p_i

trace	$E(p_{i,1})$	$E(p_{i,2})$	$E(p_{i,3})$
t_1	-2		
t_2		-2	
t_3	1		
t_4			-3
t_5			1
t_6			1
total	-1	-2	-1
evaluations nb	2	1	3

Figure 4: Example : addition of step evaluations on related parameter values $p_{i,1,\ldots,3}$, for a given parameter p_i

The eventuality must be considered of a step description being intrinsically difficult to follow, either due to an inaccurate transposition of the real environment into its representation in the itinerary model (including possibility of changes in topology since this transposition), or to actual difficulty of the move. In order for this difficulty not to be attributed to the construction parameters in the case of a negative evaluation of the step, the evaluation must be associated not only with a set of construction parameters, but also with the step whose description is evaluated. Hence, the cumulated evaluation serves as a weight for construction attributes evaluation.

6 ADAPTATION TO THE USER

The direct feedback provided by the user (explicit evaluation) in the case of a an impossible itinerary is stored as a (action, item, truth value), the truth value being a boolean value representing the user's actual possibility of a given action on a given item. Thus, corresponding adaptation consists in a simple filtering on the item and actions defining an itinerary step, ensuring a step to be suitable for an user.

Adaptation of the itinerary description is basically used by using the most adapted construction parameters values while building the itinerary description for a given user. These values are selected using the implicit evaluation process described above. Note that the implicit nature of user evaluations not necessarily implies the indirect parameter evaluation described above; however, both help achieving the same goal of adapting to the user with a minimum amount of feedback. For this reason, mechanism directly involved in the adaptation filtering does not dependent on specific evaluation mechanism.

Construction parameters includes low-level parameters (directly mapped to the elements of the itinerary model), as well as higher level parameters, such as :

- Maximal length of the description text;
- List of reliable item categories for optional description;
- Inclusion of free form optional descriptions;
- Inclusion of references to user's past itineraries, for each item known by the system to have been used by the user (as stored in use traces).

As the system relies on submitting various parameter values to each user, it is possible that invariable in time use of the highest-ranked construction parameters would result in keeping the first good value. Thus, special care must be taken in the choice of the construction parameters value in order to provide an evaluation of each one, while keeping in mind that the benefits of learning from an user will be lost to him if the system keeps using alternative construction parameters values.

7 FURTHER INFERENCES

As a common difficulty of user adaptation resides in the model instance initialization phase (often referred as "cold start"), subsequent reasoning must be involved. As our system is to be used by many users, inferences can be drawn between users.

The stereotype approach (Rich, 1979) reposes on a classification of users according to their profiles (user model instances). As a result, a default profile is established for each class, using a-priori knowledge (static stereotypes) or clustering algorithms. Hence, a new user is associated a class, thus an associated default profile. However, stereotypal reasoning is not limited to user's profile initialization: many inferences can be draw between domain objects and their attributes (e.g. an item; its label) and user attributes (e.g. user evaluations of construction attributes. However, such inferences are beyond the scope of this article (see (Kay, 1994) for further explanations).

8 PROTOTYPE

The prototype is build upon a web server, a geographical database represented in the form defined by the itinerary modeling, and an user model (UM) database, containing evaluations of construction parameters, use traces, and the list of possible (item, action) pairs.

The adaptive mechanisms of the system (user modeling relative part of the prototype represented fig. 5) are currently not implemented, but the vocal interface, as well as localization of users using the GPS technology are functional. Thus, the corpus used in our itinerary and environment modeling has been already tested on blind people inside Campus de la Doua (Lyon 1) , as well as the overall functioning of the prototype.

Both interface and content (itinerary and itinerary description) can be described using XML grammars, thus permitting to realize a two pass adaptation based on w3c standards (Heckmann and Krüger, 2003), although only the content part has been discussed here.

When asked for an itinerary by an user, the systems extracts a sequential set of steps from the geographical database presented as an itinerary description XML document(1). An itinerary description transformation style sheet (stored in XSLT) is extracted from the UM database, which is applied to (1);

As the system is not limited to its use with the vocal interface we described but have to be multi-modal, another transformation step is done by applying an output format style sheet to the form-independent result of the previous transformation in order to generate the appropriate format : VoiceXML for a vocal interface, HTML for desktop computers (small sized for PDAs), etc.

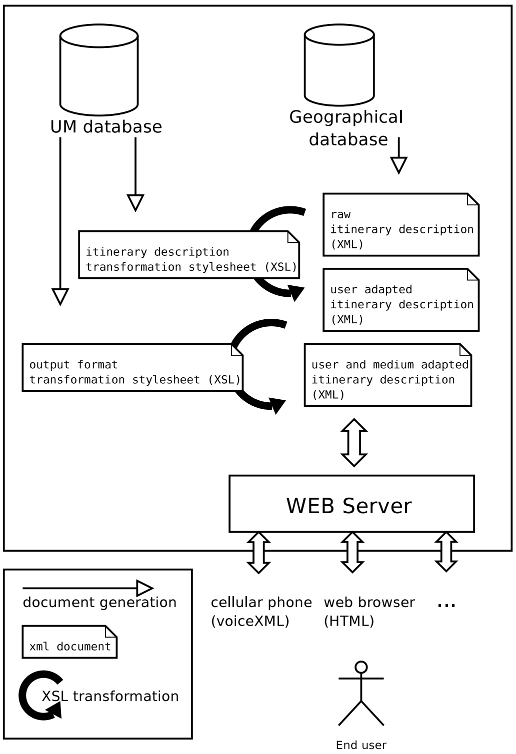

Figure 5: Simplified interface and document adaptation framework

9 CONCLUSIONS

The adaptation process described in this paper will be studied besides its actual implementation in order to determine its appropriate work conditions. Dynamical aspects of this study will include analysis of the number of generation parameters and the number of generation parameters values relatively to the convergence of a profile; sensibility to initial conditions will be observed in order to predict the role of stereotypes as a possible profile initialization. These observations will be used as a starting point for potential inter-user reasoning.

Preliminary tests using our prototype have shown the accuracy of the corpus used for itinerary modeling; the implementation of the user modeling in the prototype will permit evaluation of this modeling itself, as well as our user-evaluation process for the particular guidance task. Clustering techniques applied on the resulting user profile corpus will be used in order to compare preexisting classes with system-use related class, and evaluate their accuracy.

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