Towards behavioral adaptation for people with intellectual disabilities in a mobility context

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ABSTRACT
Accessibility is one of the major current challenges in the HCI field. The task of wayfinding corresponds to the process of determining and following a path between an origin and a destination. It implies great difficulties for people with intellectual disabilities (ID): Fear of getting lost, difficulties in learning routes, memorization of relevant landmarks. However, these people wish for more independence in their travels. In this paper describing a work in progress, we propose adaption principles for a navigation aid system dedicated to people with ID. To address important issues encountered by people with ID, two aspects are particularly highlighted: step-by-step guided learning process of routes with selection of relevant landmarks; personalization. We first modeled our proposal as a UML state-transition diagram. Then we created mock-ups in order to better illustrate the proposed principles.

Author Keywords
Wayfinding; adaptation; people with intellectual disabilities; navigation aid system

ACM Classification Keywords
•Human-centered computing ~Human computer interaction (HCI)~Interactive systems and tools•Human-centered computing~Accessibility~Accessibility systems and tools

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INTRODUCTION
Navigation aid systems (NAS) are very common nowadays. They make it easy to reach a destination, even if you don't know its location or the environment. However, navigation, whether aided or unaided, is a relatively complex cognitive task. NAS propose almost exclusively survey representations (maps seen from above), as well as verbal instructions which are not well adapted to human cognitive functioning. Some people may therefore find themselves in great difficulty during a wayfinding task, especially people with intellectual disabilities (ID) [1]. We define here wayfinding by the process of determining and following a path or route between an origin and a destination [4]. From this observation, our objective is to design and evaluate NAS, which are adapted to people with intellectual disabilities. Such systems should help them during their pedestrian journeys without to make them dependent on the technology.

The following section presents a brief state of the art on wayfinding, and on behaviors and difficulties encountered by people with intellectual disabilities. Then, adaptation principles are proposed in order to answer their problem of autonomy in the urban mobility. Different mock-ups illustrate this proposal. The paper ends with a conclusion and research perspectives.

STATE OF THE ART
People with ID have specific functioning, needs and difficulties. In particular, they report significant differences in the urban mobility situations they encounter and in their problem-solving strategies, compared to a control group. They seemed to be more often lost, in conflict with another person, in a dangerous situation or in a situation involving a disruption in the transportation schedule. They more often choose to ask another person for help rather than change their route [3]. In addition, they seem to recognize relevant landmarks less effectively than typical subjects, which leads to an impact on their wayfinding performance [1]. People with ID are so not encouraged to go out, even more for trips they do not really know much about or not at all. Whether it comes from themselves or from their relatives, the fear of not being able to find their way back is an obstacle to their independence. However, it is quite possible for them to learn specific routes through individualized and supported learning [2,8]. Unfortunately, this learning based on regular training is particularly time consuming.

Literature provides guidelines for improving ID people navigation through spatial cognition. Sohlberg and colleagues [10] recommend to: (1) use landmarks, (2) give short and clear instructions, (3) use written and auditory modalities, (4) link with a caregiver if needed, (5) allow the repetition of the instructions to overcome memory issues and parasite noises in urban environment, and (6) to include user's notes and landmarks personally chosen. These recommendations address two main points: taking into account information coming from the user (behavioral information) as well as from the outside (contextual information); personalization.

Some researchers have further demonstrated the importance of emotion in spatial representations. Indeed, positive emotions will improve spatial information retention [9,11]. According to Delgrange [3], proposing *emotional* routes could therefore improve the performance of people with cognitive disabilities, who are prone to experiencing negative emotions in complex navigation situations.

To our knowledge, few papers in the literature propose NAS for ID people, and ours is the only one to highlight both personalization in various aspects of the system (user profile sensorial modalities, photos for each user's favorite destination, landmarks, and so on) and real-time adaptation to user's behavior and to environment information. For instance, Davies and colleagues [2] propose a step-by-step system allowing ID people to take the bus for the first time on a new route but does not emphasize the learning of these routes. As for the system proposed by Gomez and colleagues [5], we find it somewhat confusing in terms of user interface, and not taking into account users who would not be lateralized (i.e. do not know their left and right). Despite their respective qualities, these systems do not offer any adaptation to ID people's behavior: They do not plan to react to potential changes in the route or in case of unexpected events; They do not reassure users in such cases.

Our proposition follows the work by Lakehal et al. [6,7]. These authors proposed Augmented Reality glasses-based NAS considering different wayfinding states. Our goal is to follow the guidelines expressed in [10], going further in personalization and pushing towards learning new routes.

PROPOSITION

The proposition consists in adaptation principles for a NAS dedicated to people with ID. The system would provide reassurance to such users (but also their entourage), and encourage them to a little more independence by assisting them in two different ways: undirected assistance, and directed assistance [7]. Undirected wayfinding assistance suggests relevant landmarks, depending on the user's preference. By sequencing a route in different stages, marked by theses landmarks, it could help the user to memorize environment information and to remember the route. Directed wayfinding assistance, on the other hand, will be the core of the NAS. The system will guide and assist the users to reach their destination, based on their preferences. It will not require caregivers to assist users in the first steps, as it is the case with the existing processes.

This paper focuses on the two aspects of our proposition that are the most specific, in our opinion, to address the issues meet by people with ID: step by step guided learning process with relevant landmarks selection; personalization. The process is modeled by an UML state-transition diagram (cf. Figure 1). The system will therefore propose a main route (*Route Planning* on Figure 1) going from a starting point to a destination, divided into different sequences. These sequences are determined by various landmarks along the route, which will constitute the stages of the route. Each path is also made up of decision points, where the user will have to make a choice during the trip. A decision point can be a step in the trip. The user knowing or not a sequence will determine the type of guidance. *Learning mode* allows a route/sequence learning process and insists particularly on the learning of remarkable and specific landmarks.

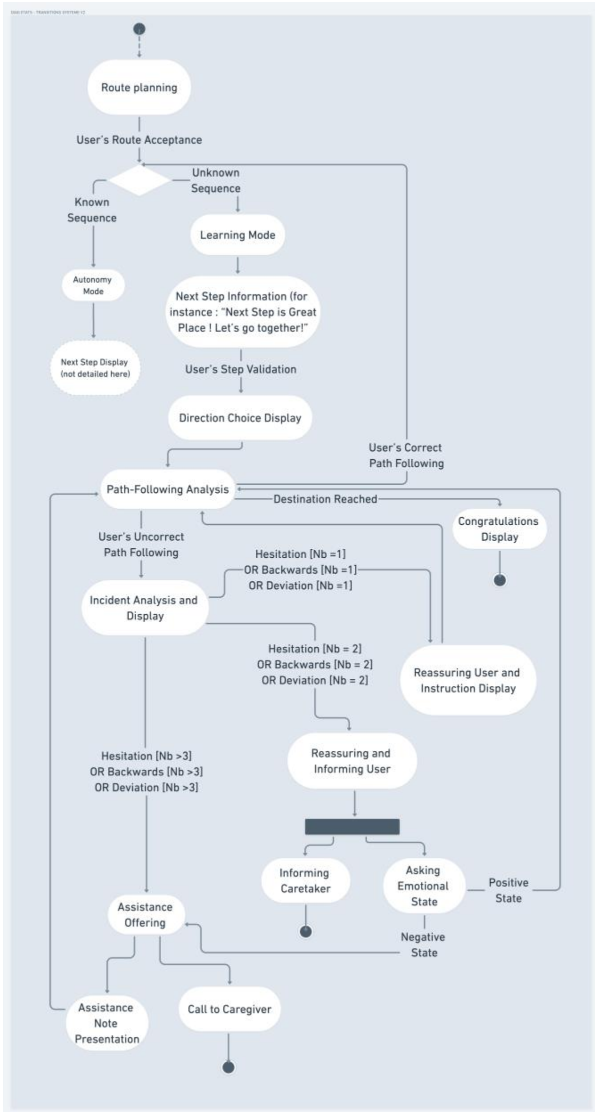

Figure 1. State transition diagram.

Autonomy mode (Figure 1) allows the users to be monitored remotely on a route they already know (which we will not detail further here). The purpose would be to increase the number of route/sequences known by the users and thus, to reinforce their autonomy.

In *Learning mode*, the system will first indicate and show the next step to reach (Figure 1: *Next Step Information*). Once the user has validated the indication, the system will assist them at each decision point, indicating on one hand the direction to follow and on the other hand providing information about relevant landmarks in order to help them memorize the route and reinforce their spatial knowledge. At the same time, the user's path-following is analyzed in order to give them relevant instructions according on their position on the route (Figure 1: *Path Following Analysis*).

The system also anticipates instances where the user may no longer follow a *normal* path, such as hesitating, turning back or deviating from the main route. These behaviors may indicate a mental state that would made them less disposed to continue the journey. The purpose is to keep them informed about the path tracking while reassuring them at the same time through written or auditory messages, in order to encourage them to go on the route (Figure 1: *Reassuring User and Instruction Display*). Another way of encouraging the user will be to display congratulatory messages when they reach a step or the destination. Figure 1 shows that if the destination is reached, then the system's state will be *Congratulations Display*.

In case these behaviors seem to be repeated, the user has the opportunity to decide whether to continue the journey or not, without endangering them. After analyzing the path-following, the system will first self-assess their emotional state (Figure 1: *Asking Emotional State*), represented by a happy face or a sad one. If the self-assessment is positive, the user will then be allowed to continue the journey, and a caregiver will be informed at the same time, as a precaution. If the self-assessment is negative, the system will display some help. The user will be able to choose between an automated form, allowing assistance to explain the situation to a person present in the immediate environment, and a direct call to a caregiver, to whom the GPS location will be shared in order to remotely help the user in need. This help feature will be accessible at any time during the journey.

Furthermore, it will be possible to add positive-evaluated areas or points of interest. On the other hand, to adapt to the user, negative-evaluated areas or points would be automatically avoided when creating routes. In a same way, it would be possible to decide on certain sensory modalities for displaying route instructions (for example, only auditory instructions, or visual with vibrations), The system also plans to allow the user to choose one mean of transport rather than another, and even to directly integrate pictures and photography of well-known and frequently visited places as destination choices. These features address the personalization aspect issues, while including in the NAS the emotional aspect.

To overcome memory and attentional difficulties met by people with ID, the system will regularly ask a first feedback from the user to indicate good reception of a notification, then a second feedback to indicate they understood the instruction or the message displayed.

PROOF OF CONCEPT

From the proposition of adaptive system, modeled by UML diagrams, mock-ups are proposed to allow a better visualization of the system and the possible interactions with the user. We took inspiration from [2,5] concerning (1) the progress bar, (2) the step-by-step process with interaction needed with the user, (3) the always available help function, (4) the simple user interface, (5) the use of precise and street-level pictures and photos, (6) the personalization in the management of landmarks and photos. Figure 2 shows different screens of the prototype. Figure 2a) represents a street-level photography with a textual indication of the direction to take, also indicated by the blue arrow showing the left direction. This will be the kind of instruction provided to the users. If they cannot read, the message will be displayed as an audio message. Figure 2b) shows what happens when the user reaches a step on the route. We can see a photo of the landmark, the library, and a physical description to help memorization.

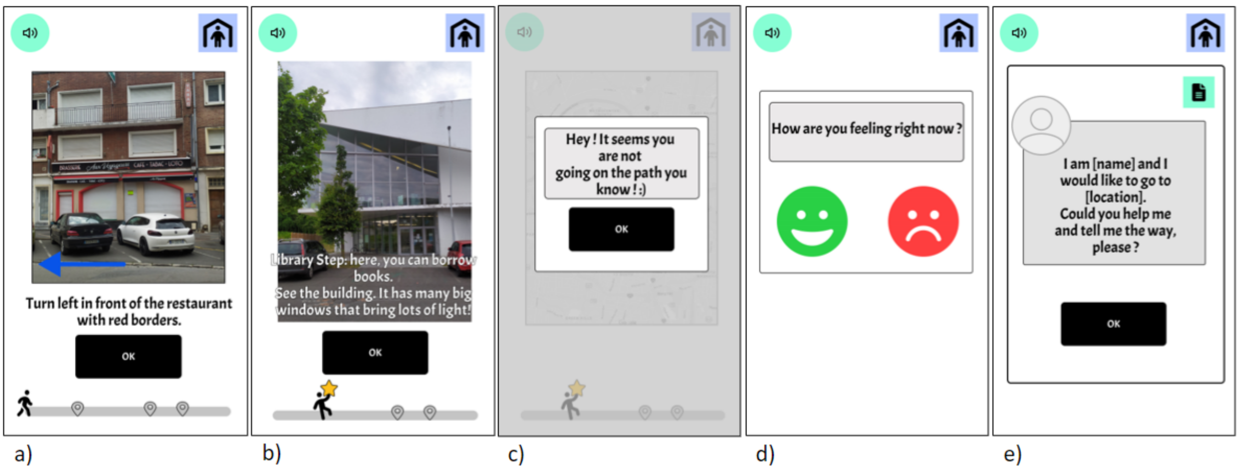

Figure 2: Mock-ups of the system.

A mock-up also shows textual indication explaining what the purpose of the building is. At the bottom of both of figures 2a) and 2b), we can see a progress bar, where the gray pin icons represent the steps not yet reached. On Figure 2b), the first pin has a star shape because the user has just reached it. Once the user has moved forward, the pin will return to its original shape and be colored yellow, to indicate that the step has already been reached.

Figure 2c) shows the kind of message the user might receive when they seem lost or hesitant in learning mode. Figure 2d) shows the screen displayed when the user hesitated or took the wrong path at least twice. The system will then ask their emotional state so that the user can answer by choosing between the two faces. If the user chooses the sad face, the system will propose two ways of getting help: the call to the caregiver or the automated form. Figure 2e) shows a template of this form that the user can display and show to a third-person to ask for help. On top of all frames, we can see on the left a speaker icon, allowing to hear or repeat an instruction or a message, and on the right a shelter icon that give access to the help screen (with the form or the direct call, as mentioned previously).

CONCLUSION

The adaptation principles we propose aim to improve urban mobility for people with intellectual disabilities. Such principles take into consideration guidelines of the literature concerning accessibility through wayfinding and HCI. Our goal is to address the needs and the will of the people with ID to be more independent in mobility contexts. This involves helping the user to learn route (by selecting relevant landmarks and by predicting user's behaviors in order to reassure them) and making it possible to personalize the tool (by including recurrent routes but also places liked by the user). The paper has described our work in progress. We plan to validate our proposition first by showing it to caregivers (psychologists, educators). Their feedback will allow us to refine the system. We also plan to assess the usability and acceptability from our system through different questionnaires (SUS, UTAUT) and user tests, that will be first run with caregivers, then with people with ID.

This first iteration of the project focuses on the adaptation during the journey, but it will be essential to refine and mature the user profile in a future work, especially the autonomy skills. For instance, some users are able to cross a road alone while others will need a reminder to keep them safe. A finer granularity in the personalization of the system could also allow adapting even better to the various behaviors and preferences of the user (for example, means of transports to favor, or obstacles to avoid).

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