IMPROVING PEDESTRIAN NAVIGATION FOR OLDER ADULTS WITH MILD COGNITIVE IMPAIRMENTS THROUGH LANDMARKS

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1. Motivation

Nowadays, ageing is considered a global epidemic due to the rapid growth of the older population throughout the world. It is predicted that, in 2050, for the first time in recorded history, the older population is set to surpass the young population.

This has lead to an increased incidence of age-related physical and mental impairments, which often translate to a decreased mobility and spatial awareness.

In order to overcome this problem, we need to continuously provide ways to improve their quality of life. By doing so, we will also put the patient's caregiver at ease and lessen the inflicted stress. This dissertation focuses on these mobility issues and investigates how can navigation systems best be used to guide older adults and increase their sense of safety when going outdoors.

2. Goals

The main goal of this dissertation is to study possible ways to improve navigation aids targeting an older population. In particular, two distinct methods to guide a user along a path towards his destination were studied: *turn-by-turn* and *landmark-based* navigation. The former, seen in most current navigation systems, instructs the user by providing relevant street names and distance information. The latter, rarely observed in current systems, guides the user through enhanced visual cues about his surroundings.

The second major goal of this dissertation is to investigate how these two methods affect the spatial orientation of older adults with mild cognitive impairments. To this end, a prototype of a pedestrian navigation subsystem capable of using either technique was developed and embedded into AlzNav [1], a pedestrian navigation system for Android smartphones, focused on older adults. Through an empirical approach, experiments were performed on the field with 12 selected participants from this population, from which data was collected and analysed.

3. Literature Review

Current navigation systems adopt a turn-by-turn approach and, so, provide users with information such as distance to the next decision point, the name of the street to turn onto and turn direction. Such examples are Garmin and TomTom.

On the other hand, a landmark-based navigation system offers the user information regarding conceptually and perceptually distinct locations (e.g., "Turn right at the supermarket"). Studies have shown that landmarks are the most important kind of information for a successful navigation task, for both drivers [2] and pedestrians [3]. Additionally, May et al. identified 3 distinct purposes for landmark-based navigation instructions: (1) *preview instructions* give advance warning of upcoming manoeuvres, as in "In 100 meters, turn right after passing a restaurant", (2) *confirmation instructions* assure the user he is on the right track, such as "You should see a church to your left" and (3) *identification instructions* pinpoint a decision point (i.e., where the user should take an action), like "Turn left at the traffic light".

For landmarks to be used effectively, only the most prominent must be chosen. Thus, evaluating landmarks according to their saliency is a task that must be given focus. Raubal and Winter [4] described a set of characteristics that make landmarks visually, semantic or structurally attractive.

4. Prototype development

The developed subsystem, integrated into AlzNav, generates preview, confirmation and identification instructions for any given route. In the settings menu, the user is given the option to enable or disable the landmark-based navigation mode. In its absence, turn-by-turn instructions are generated instead.

The application begins by querying the MapQuest database for a route plan towards the user's destination. This route is made of a sequence of steps, that is, paths linking each consecutive pair of decision points through which the user must pass. The data is sent to the subsystem, which loops through the given steps in order to ascertain which instructions should be generated. For each step, the subsystem performs a cycle where it (1) fetches nearby landmarks data from the OpenStreetMap database and processed this data, (2) filters potentially useful information and (3) generates the necessary instructions. Then, the navigation task *per se* is initiated and the subsystem feeds the user with the generated instructions at appropriate times.

In the first stage of this cycle, the type, name and location of nearby landmarks are extracted. Other information, such as the relative position of the landmark (left or right side of the street), distance to the street and facade width are calculated.

In the second stage, landmarks located far from the route are discarded. Then, the usefulness of each landmark is evaluated. This is done according to three different parameters:

- Recognisability: a measure for prominence or visual attraction, based on the landmark's width and distance to the street;
- Identifiability: a measure for how unique and distinguishable a landmark is, based on the landmark's type uniqueness (e.g., museums are far less common than restaurants) and uniqueness in that particular street.
- Pinpointing precision: a measure for the landmark's ability to accurately pinpoint the location of the manoeuvre, based on its distance to the decision point.

Having assigned a score to all landmarks, a dynamic programming algorithm was developed to select the best possible combination of landmarks. This algorithm follows an approach similar to the solution to the knapsack 0-1 problem.

In the last stage of this cycle, textual descriptions of the selected landmarks are created, such as "a hotel" or "the Megasport bicycle shop". These are then used to build preview, identification and confirmation instructions, using templates for the user's language of choice (english or portuguese). An english confirmation instruction, for instance, would be "Continue on this route. You should see a hotel to your left".

These instructions are then queued according to the order in which they will be delivered. During the navigation task, the system then successively polls the queue for the next instruction that will be shown to the user until he reaches his destination.

5. Evaluation

In order to study the effects that both methods have on older adults' mobility, field experiments were performed using an empirical approach. For these tests, 12 participants with ages ranging from 63 to 80 (and an average of 70.9) years old were recruited.

Participants were asked to follow the given instructions to find their way to an undisclosed destination, using either the landmark-based or the turn-by-turn approach. Therefore, the participants were split into two groups: the landmark-based group and the turn-by-turn group. Participants were evenly assigned to either group so that there would be no significative difference in age, mental status, or previous experience with navigation systems between both groups.

During the test sessions, notes were taken regarding the number of errors made by the participant, number of hesitations (whether vocalised or witnessed), number of times the participant got lost (disoriented and unable to make a decision) and time taken to travel. The results can be seen on Table 1. Following each journey, participants were handed satisfaction questionnaires to evaluate their level of confidence throughout the walk and whether the supplied information was perceived as useful or unsuitable.

Tab. 1 – Summarized results of the landmark-based and turn-by-turn groups

Measures	**Groups**	
	Landmark-based	**Turn-by-turn**
Errors	1	1
Hesitations	2	6
Lost	0	0
Mean Time	5:33	5:50

The collected data led to the conclusion that older adults using a landmark-based navigation system tend to make faster decisions with little hesitancy. Thus, they feel more secure about the path taken. The answers to the questionnaire also indicated that older adults usually have no trouble locating the referenced landmarks, and that these are considered to be more valuable than street addresses.

6. Conclusions

In order to overcome the problems related to older adults' mobility and sense of security, a prototype of a pedestrian navigation system focused on older adults using both a landmark-based and a turn-by-turn approaches was developed.

Employing an empirical methodology, field tests were performed with participants from the target audience. These tests revealed that a landmark-based approach presents key advantages in helping older adults navigate autonomously and with confidence.

References

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