

# Auditory Perceptible Landmarks in Mobile Navigation

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## ABSTRACT

Normally, mobile pedestrian navigation systems use visually perceptible landmarks to guide their users through the environment. In this article we introduce concepts for the use of auditory perceptible landmarks in route descriptions. Such auditory perceptible landmarks complement their visual counterparts and also stand to be beneficial for certain groups like the visually impaired and the elderly.

**ACM Classification:** H.5.2 User Interfaces (D.2.2, H.1.2, I.3.6) - User-centered design

**General terms:** Human factors

**Keywords:** Pedestrian navigation systems, auditory perceptible landmarks, visual impairment

## INTRODUCTION

Nowadays, navigation systems can be seen to have paved their way into our daily lives. Internet-based route planners and in-car navigation systems are widely used and there is an emergence of pedestrian navigation systems reaching the market. Pedestrian navigation systems and their special needs have been investigated in several research systems (e.g. [1, 5, 3, 4]). Research in this area explicitly points out the importance of landmarks, 3D-graphics and multi-modal interaction. Until now, these systems use only landmarks which are visually perceptible from a certain view-point in the environment in their navigational instructions, that are generated based on graphical, textual and/or verbal descriptions of the route. In order to improve future versions of pedestrian navigation systems we looked at the possibilities to use auditory perceptible landmarks in route descriptions, that will hopefully lead to more expressive pedestrian navigation systems, that also benefit the visually impaired and the elderly.

In [2] the authors describe the paradigm of a *chatty environment*, which tries to make some of the visual informa-

tion available to the visually impaired by using the audio channel. They built a prototype of such an environment by tagging objects in the environment with electronic beacons and also representing real-world objects digitally, by linking the objects to information stored on a web-server. The user of the system carries a device, the world explorer, which uses Bluetooth and a WLAN 802.11 to access information about tagged entities in the environment. Whenever the user moves into the aura of a tagged object, the device senses the object and mediates the information exchange between the user and the object.

In contrast to the approach described above we do not want to instrument the environment with tags or any additional communication infrastructure but instead we try to use auditory perceptible landmarks that are already available in the environment.

## AUDITORY PERCEPTIBLE LANDMARKS AND THEIR CLASSIFICATION

In an empirical study we identified 51 different sound sources that might be used as auditory perceptible landmarks during a navigation task [6]. In order to determine their usefulness for navigation, we categorized the sound sources. Categories, and additional attributes which will be assigned to sound sources in order to describe them, are as follows:

### Category:

We discriminate between natural and artificial sounds.

### Natural sounds:

Natural sounds are caused by animals, persons, natural objects, e.g. a river or waterfall, and the weather.

### Artificial sounds:

For artificial sounds we discriminate, e.g. sounds from vehicles, machines, engines, sounds stemming from public buildings or public utilities, and music.

### Scenario:

Information about the situation where these sound sources are perceptible, e.g. within or outside of buildings.

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## Loudness:

Starting from a totally calm environment, labeled with Level 0, where persons are able to understand whispers without problems. We defined five different loudness levels.

**Level 1:** Speaking with normal voices is possible without problems.

**Level 2:** Speaking with a louder voice is necessary, but manageable without problems.

**Level 3:** Speaking with a very loud voice is necessary and possible with great effort.

**Level 4:** Talking to each other is not possible anymore.

**Level 5:** Sounds might be harmful.

## Seasonal dependencies (SD):

Information about whether these sound sources depend on the time of the year, e.g. whether they are most likely to occur in spring, or will not occur in winter. Possible values are: *-sp: not during spring, -su: not during summer -au: not during autumn, -wi: not during winter, sp+: predominantly during spring, su+: predominantly during summer, au+: predominantly during autumn, wi+: predominantly during winter*

## Time dependencies (TD):

Information about whether these sound sources depend on the time of the day, e.g. whether they appear in the morning and whether they will not appear at night. Possible values are: *-n: not during the night, -d: not during the day, n+: predominantly during the night, d+: predominantly during the day*

## Usable as landmark (UaL):

Information about whether these sound sources are usable as auditory landmarks.

Following the aforementioned classification scheme with its attributes table 1 shows an excerpt from our 51 identified sound sources, their resulting categorisation and attributes assigned.

## IMPLEMENTATION

In order to conduct the user study we extended the navigation system described in [4] for the use of auditory perceptible landmarks. The resulting system is able to generate graphical route descriptions using 3D maps and textual/verbal route descriptions which contain information about auditory landmarks perceptible at certain locations on the route. An example of such a route description using an auditory landmarks, is the following segment of a description produced by the system for a route on the campus of the University of Saarbrücken. “*You are on the campus road. Go straight on, in about 180 meters you will reach a crossing. You will pass building 17, 10, and 12. Building 12 is the university’s music hall. You might here music from a concert or the*

*daily rehearsals.*” Textual descriptions like the aforementioned are prepared beforehand and verbalised using the TextAloud system from Nextup ([www.nextup.com](http://www.nextup.com)) or synthesised with the RealSpeak system from Nuance ([www.nuance.com](http://www.nuance.com)) and saved as MP3-files. During the navigation task they are synchronized to be played at the right sections of the road.

## USER STUDY

13 subjects took part in the user study, 5 women and 8 men. The subjects were between 22 and 68 years in age with a mean age of 29,77 years. 9 subjects were students, 3 were employees and 1 person was already retired. 3 from the 13 subjects of the study were visually impaired, which in this case meant they were blind.

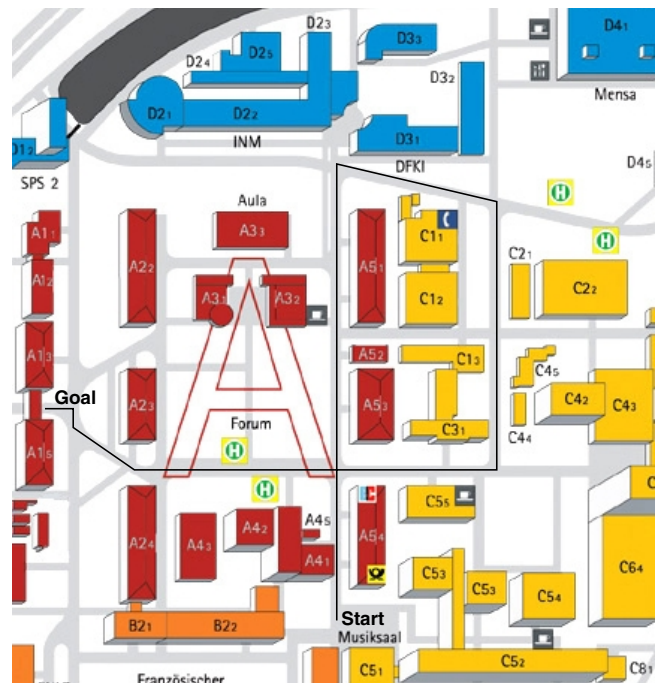


Figure 1: Depiction of the route of the user study

## Method

All subjects of the study were instructed on how to use the navigation system. After that, they had to manage a navigation task following the instructions of the system. For the user study on our university’s campus we prepared descriptions for the route, and subjects of the study had to follow the descriptions containing auditory perceptible landmarks. Figure 1 depicts the route of the user study. After the navigation task, subjects had to fill out a questionnaire with 14 questions. Questions ranged from whether subjects of the study had previously used navigation systems, to questions on whether the system was helpful during the navigation task, and questions about the usage and usefulness of auditory perceptible landmarks.

Sound source	Natural	Artificial	Scenario	Loud.	max. Loud.	SD	TD	UaL
Car		vehicle	outside	2	3	no	d+	no
Pedestrian Traffic Light		public utility	outside	1	1	no	no	yes
Fountain		public utility	outside	1	2	-wi	-n	yes
River	natural object		outside	1	2	no	no	yes
Escalator		machine	inside	1	1	no	no	yes
Music in a Shopping Mall		music	inside	1	2	no	yes	yes

Table 1: Examples of identified sound source and their attributes

## Results

53,85 % of all subjects of the study had used navigation systems before, while 46,15 % had not. On the question whether the navigation system was helpful in managing the navigation task, 7,69 % found the help from the system very good, 53,85 % answered with good and 38,46 % had no clear opinion. But 92,31 % found that using sound sources as auditory perceptible landmarks helped their orientation during the navigation task. All subjects of the study appreciated the use of auditory perceptible landmarks in the prepared verbal descriptions. On the question what kind of sound sources would be useful in route descriptions and what should be included, the following sound sources were mentioned, sorted by frequency:

- Sounds from cafés and restaurants (84,62 %)
- Sounds from pedestrian traffic lights (84,62 %)
- Sounds produced by water, e.g. fountains (84,62 %)
- Sounds from vehicles (69,23 %)
- Sounds stemming from different floor surfaces, e.g. tarmacs vs. cobbled pavement (46,15 %)
- Music (46,15 %).

Last but not least, only 38,46 % of all subjects in the study stated that they would appreciate the inclusion of sounds in the descriptions, that they could expect to hear during the navigation task.

## CONCLUSION AND FUTURE WORK

As a result of our user study, one can say that auditory perceptible landmarks are equally usable as visual perceptible landmarks in route descriptions and that people are able to learn routes using auditory perceptible landmarks (see also [7]). In order to improve future versions of mobile navigation systems we will implement a version of the navigation system described in [4] which will be adaptable to its users. Concerning the research presented in this paper, this means that the system should be adaptable to normally sighted or visually impaired people. Blind or visually impaired users of the system will get route descriptions based mostly on auditory perceptible landmarks in the environment helping them to orient themselves during the navigation task, while normally sighted users will get route descriptions mostly based on visually perceptible landmarks.

Furthermore, the possibility of the system to take speech or sound memos which are associated with GPS-coordinates should be extended such that users are allowed to define their own individual landmarks, e.g. by recording their own comments, hints or sounds. Whenever the

user comes near to the coordinates of such an individual determined landmark during a navigation task, the recorded memo will be played serving as an individual auditory perceptible landmark.

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