"In Fifty Metres Turn Left": Why Turn-by-turn Instructions Fail Pedestrians

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ABSTRACT
As being the offspring of car navigation systems, Smartphone-based pedestrian navigation applications often employ turning instructions such as "in fifty metres turn left". Pedestrians, however, use these devices in a significantly different context than car drivers. In this paper we highlight three issues which make turning instructions unsuitable for pedestrian navigation: coping with inaccurate positioning, the negligence of human navigation skills, and the inappropriateness for typical use cases. We argue that conveying the location of reference points via non-visual feedback can be a suitable approach to overcome these issues.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Haptic I/O; I.3.6 [**Methodology and Techniques**]: Interaction techniques

General Terms
Human Factors, Experimentation

Keywords
Pedestrian Navigation, Spatial Information, Turn-by-turn Instructions, Non-visual Information Presentation

1. TURN-BY-TURN INSTRUCTIONS
Thanks to emerging mobile applications such as Google Navigation for Android phones or the numerous navigation applications for the iPhone, pedestrian navigation support has reached the end-consumer market. The navigation systems we know from our cars that conveniently guide us to any destination are now available in our pocket. Offering special routing modes, these systems promise the same comfort for pedestrians.

However, the design of these systems is still very much influenced by the interaction metaphors use in car navigation systems: the user's location is displayed on an interactive map and the route to the destination is highlighted. Additionally we receive turning instructions, either by speech (e.g. "in 50 metres turn left") or by little arrows and distance figures.

In this paper we bring forward arguments that question if turn-by-turn instructions can work as good for pedestrians as they worked for car drivers. In particular, we discuss the problems of positioning inaccuracy, the problem of denote the turning points in the real world, the negligence of the human navigation skills, and the typical use case of pedestrian navigation systems. We make the point that spatial information presented in a continuous and non-visual way can enable new forms of pedestrian navigation which overcome these problems.

2. ISSUES WITH TURN-BY-TURN
In this section we highlight issues of turn-by-turn navigation that prevents the concept from being successful in any situation. In particular we argue that (1) the available technology's positioning accuracy is still too bad, (2) turn-by-turn instructions underestimate and let wither away the human's inherent navigation skills, and (3) that in many scenarios the high granularity of turn-by-turn instruction is not needed.

Figure 1: If the user wanted to go to the entrance of this building, would s/he really benefit from a turn-by-turn routing algorithm?

2.1 Positioning inaccuracy
Routing algorithm require to know the user's exact position to run properly. Typically, three positioning methods are employed today: (1) a very coarse location estimating

can be made by triangulating the device location via the network cells. (2) Another commonly used mechanism is localisation through WLAN. In this scenario, the device scans for WLAN access point IDs and can retrieve its location through a database. The most well-known and most accurate positioning technology is the use obtaining it via GPS.

Neither of these position technologies can guarantee accurate position estimation at any time. Although the GPS accuracy is improving continuously there are still scenarios where it does not work sufficiently well. For example, being in a building cause GPS to become very inaccurate. But also being urban canyons can cause significant signal reflections [1].

To cope this inaccuracy the typical navigation system employs a technique called map-matching [14]. In principle the user's location is projected to the nearest known street. However, if the user takes an unknown path, such as an open meadow, this method still puts the user on the street next to it and will - in consequence - issue senseless instructions. Also, if the position method gets to inaccurate the user might even be placed on a false street causing false turning instructions. In [10] where we conducted a user study involving GPS navigation systems in a city centre, we deliberately had to avoid certain areas where the GPS quality good routinely too bad. In the best case the user can still use the map to navigate correctly. However, even then the lost of trust might be unfavourable for the further use.

2.2 Negligence of Human Navigation Skills

Turning instructions are very detailed. There is much research investigated in giving even better instructions. Pan et al. [9], for example, have investigated how to include open areas into routing algorithms. This algorithm is intended to be applied to pedestrian navigation in open spaces, such as squares, parks and big halls.

However, while detailed instructions are indispensable in cars where the driver's primary concern is on the traffic participants' safety, pedestrians have much more time to reflect and interpret navigation information. If we e.g. take the situation in Figure 1 as an example: the average user would reach the building's entrance without any problem. Even if s/he was a few dozen metres further away it would not be a problem for the typical person to walk up to the building. Still, a turn-by-turn routing algorithm would calculate the shortest way (across the footpaths or in the case of Pan et al. presumable the direction as the crow flies).

This is an exaggerated example of how turn-by-turn navigation systems take away the responsibility of the user. Several user studies highlight different negative aspects of this. For example, Leshed et al. [6] observed that drivers using navigation systems show signs of getting disengaged from their environment. Thus, it is not surprising that people using navigation system show a decreased understanding of the spatial layout of the environment [2, 5]. Furthermore in our own studies users repeatedly complained to be at the navigation system's mercy and felt "bossed around" [10] when they had to navigate an unknown route by turn-by-turn instructions.

2.3 Non-Applicability to Other Use Cases

Something that is also often neglected is the use case. Turn-by-turn navigation assumes that the user wants to be guided the most effective (fastest or shortest) route to the destination. But, what are the typical scenarios where people need to get from A to B as fast as possible and how often do they really occur?

In many cases alternative scenarios might apply. A typical situation of visiting an unknown place is when being a tourist. However, tourists mostly do not have the intention of getting to some point as fast as possible on foot [3, 12]. Instead they might want to be strolling around and explore the environment. In this scenario the most important aspects are not to get lost.

Also the distances are usually shorter. While car drivers often cross many kilometres of unknown terrain, the pedestrian mostly covers rather short and clear routes. In this case, it is often sufficient to have rather coarse information, e.g. the general direction or information about a few landmarks.

3. NON-VISUAL APPROACHES

In the previous section we have argued that alternative ways of communicating navigation information to pedestrians are needed that can cope with inaccurate positioning, leverage the human's inherent navigation skills, and support alternative use cases.

In this section we argue that conveying spatial information via the auditory and the sense of touch offer the opportunities to realise these alternative ways. One of the biggest prospects lies in communicating the spatial location of reference points, such as a compass or a radar to visually. For example, a system could present the location of the prominent landmarks of an area as reference points. The advantages of non-visual communication here is that it can the reference points locations' continuously, giving the user a much better sense of her/his spatial position and orientation in relation to these points.

In contrast to turning instructions, which must be exact, this kind information presentation will also work if the factual direction is off by a few dozen degrees. A user is still able to navigate into the roughly right direction, even if the destination is shown at 270 degrees instead of 220 degrees. Thus, inaccurate positions can be tolerated to a much greater extend. Conveying the location of reference points also help understanding the own location's and the presented location's interrelationship in space. Using the presented locations as reference points allow users to stay oriented while leveraging the inherent navigation skills to find the actual route. In addition, supporting the user's orientation also helps in other use cases, such as exploring a city centre as a tourist.

In the previous research, many prototypes presenting the location of reference points non-visually have already been built and investigated (see Figure 3). GPSTunes and *feelspace* [13, 8] are two example where spatial audio/vibration is used to point at a point in space, such as a compass. A similar metaphor realised with a tactile display has shown to

Figure 2: (a) GPSTunes [13], an auditory compass (b) SoundCrumbs [7], auditory landmark visualisation, (c) FeelSpace [8], a tactile compass, (d) ***Space Awareness*** **[4] by presenting the location of obstacles by a tactile display.**

improve the navigation with paper maps [11]. Other groups have also shown that it is possible to convey the location of multiple objects through the sense of hearing [7] and the sense of touch [4]. Future work needs to further discuss how these findings can be applied to pedestrian navigation and location-based services in general.

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