

# “I Did It My Way”: Moving Away from the Tyranny of Turn-by-Turn Pedestrian Navigation

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## ABSTRACT

In this article we describe a novel approach to pedestrian navigation using bearing-based haptic feedback. People are guided in the general direction of their destination via vibration, but additional exploratory navigation is stimulated by varying feedback based on the potential for taking alternative routes. We describe two mobile prototypes that were created to examine the possible benefits of the approach. The successful use of this exploratory navigation method is demonstrated in a realistic field trial, and we discuss the results and interesting participant behaviours that were recorded.

## Categories and Subject Descriptors

H.5.2 [User Interfaces]: Haptic I/O; Prototyping; Interaction styles

## General Terms

Design, Experimentation, Human Factors.

## Keywords

Mobile, bearing-based, navigation, vibrotactile, GPS

## 1. INTRODUCTION

Turn-by-turn pedestrian navigation is now widely available in mobile devices. However, we believe these increasingly-ubiquitous mobile systems can often remove the wonder and enchantment of an individual’s exploration, and have an impact on users’ normal behaviour [2]. In this article we present a simpler method for pedestrian navigation that aims to free users from the need to look at a screen or be micro-managed by listening to turn-by-turn instructions. Our goal is to remove the division of attention between a navigation device and the real world it describes; instead we prompt users to fuse their view of a location with the feedback given, allowing a more engaging experience. Our approach removes the complexity of direction following, recognising that pedestrian navigation might often be more exploratory, taking place in semi-familiar places. This approach also has benefits in other scenarios, such as those locations with no defined waypoints for turn-by-turn navigation, or completely unfamiliar places, where context is important, and a person walking alone might take a different route than when walking with friends.

We envisage this approach not as a replacement for, but as a complement to current navigation systems. In situations where quickest

time or shortest path are not particularly important, users might find it more enjoyable to turn off the demands of instruction-following. Instead, we imagine people wandering through and impulsively exploring the interesting places around them, but with occasional reassurance that they’re heading in the right direction. Consider the following scenario, which illustrates the approach:

*John is visiting Rome for the first time, and is looking forward to meeting some friends at a good local restaurant. Taking out his mobile, he sees the arranged meeting place just about 2km away. It’s such a lovely spring day, so, with time to spare, he roams freely in the rough direction of his meet-up, taking in the maze of alleys and quirky shops all around him. After 10 minutes, he scans left to right; the device vibrates to reassure him he’s still on course, and also indicates that there are many routes to his destination. It feels good finding his own way, so he continues to make his own choices, enjoying the area around him. A little later, he comes to a main junction. Should he turn left or right? He’d better get this right, he thinks. Scanning again, the vibration feedback is now more targeted, and he walks on with confidence...*

We built two mobile vibrotactile prototypes to explore this type of spontaneous navigation behaviour. The first of these—*static feedback*—provides directional assistance in the form of fixed size, low-resolution vibrotactile feedback. Pedestrians can casually scan to discover the direction of their destination using a handheld device, but the apparent width of the haptic target remains the same regardless of their surroundings. The second prototype—*dynamic feedback*—uses information about potential path choices in the vicinity of the user’s current location to expand or contract the size of the feedback area, providing some indication of the degree of choice available when route finding.

## 2. BACKGROUND

It is well known that the use of mobile devices while moving can cause problems in situations where visual attention is necessary, and pedestrian navigation is a perfect example of this type of scenario. Seager [12] discusses many of the challenges in screen-based pedestrian navigation. Holland *et al.* [5] describe potential problems and offer a solution in the form of audio cues to guide users toward a destination. A similar approach was taken by Jones *et al.* [7] and Strachan *et al.* [16] by dynamically adapting the music that a user is listening to in order to guide them in a certain direction. While these approaches have shown promise, related early work has found that many users are reluctant to use headphones for this type of task [1], citing concerns about being recognised as tourists, or a feeling of isolation from the environment. Our approach helps

to minimise these effects, using vibrotactile feedback to allow a less-restrictive interaction style.

Previous research has investigated the use of directional vibrotactile feedback as a navigational guide, with vest- or belt-based systems being the most common approach. Van Erp *et al.* [14], for example, studied several combinations of vibrational pulses, and were able to successfully guide users to walk between waypoints. A similar approach was taken by Johnson and Higgins [6], applying the technique to navigation for blind users. Their tactor belt was aimed at helping people avoid obstacles in their surroundings, motivated in part by a desire to lessen the effect of navigation on users' other activities. Our systems have a similar goal: allowing interaction with a navigation device to be thought of as a background task undertaken only when it is necessary or desirable, rather than providing feedback for slight path deviations or upcoming waypoints.

Many haptic navigation systems have used tactors in fairly fixed positions on the user's body, but handheld vibrotactile navigation has only emerged fairly recently. Lin *et al.* [8], for instance, provided navigational assistance via direction-specific tactons, finding that users were quite able to recognise the haptic cues and take appropriate paths through their environment. Our work, however, relates more closely to the bearing-based feedback used in [9], combined with the low-attention feedback aims of [13], and drawing upon previous research showing the benefits of handheld directional vibrotactile feedback while moving [11].

### 3. PROTOTYPE SYSTEMS

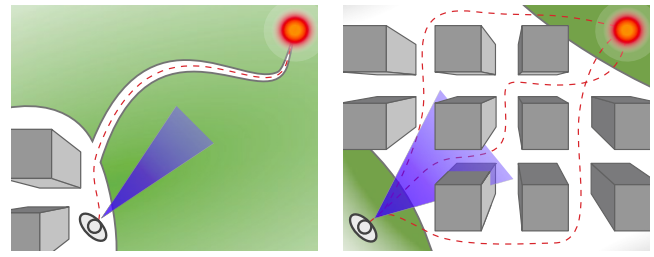
We created two prototypes to investigate this approach to navigation assistance. Our systems use a simple scanning gesture to browse for feedback, with the user holding a mobile device in-hand and feeling for navigation feedback whenever they like.

In our prototypes, the feedback is not given in a turn-by-turn fashion; rather we present directional vibration to indicate the bearing of the destination, and allow the user to make their own path choices. Previous work has investigated the use of a general directional cue for situations such as bike-based tourism [10], but we apply the technique to navigation while walking. We build upon recent work that investigated the use of handheld directional vibration as a casual method for organising group meetups [15], extending this concept to allow users to get a sense of the path choices around them. This approach, we believe, can offer the user more freedom where appropriate, providing opportunities for off-the-beaten-track exploration. Unlike some previous approaches ([16], for example, which provided feedback varying as function of possible paths) we do not give any indication of the distance of the target, focusing instead on the benefits of giving users familiar and always-available reassurance that they are heading in the right direction.

Our first prototype—*static feedback*—uses a fixed angular width for the feedback given, relying on the user to observe potential route options and make appropriate choices. The second prototype—*dynamic feedback*—varies the width of the feedback area to give more information about the user's immediate environment (as illustrated in Fig. 1). By incorporating this extra aspect, pedestrians are able to sense whether alternative routes are available, but are still free to pick their own path at any point.

#### 3.1 Implementation

Our prototype systems were implemented using Nokia N95 mobile phones. For feedback and device movement sensing we used the SHAKE SK6 sensor pack [16]. The SK6 provides three-axis accelerometer, magnetometer and angular rate data, and incorporates a pager motor which we used to produce vibrotactile effects. GPS positioning was provided by the N95's onboard receiver. For



**Figure 1: Dynamic feedback is directly related to path options. When fewer routes are available (left) the feedback area (shown in blue) is small, expanding when there is more choice (right). The centre of the feedback area aims directly at the goal.**

this early prototype the N95 was worn on a lanyard around the neck, and the SK6 was held separately, attached to a dummy mobile phone. This was a design compromise chosen to minimise cross-device sensor interference while still providing a realistically-sized object that users could comfortably hold to feel for feedback.

The feedback used was designed based on previous research that showed that feedback can be a function of possible paths through the environment [16], and that vibrotactile angular widths need not be particularly small—indeed larger angular widths help to minimise user frustration, and have surprisingly minimal effects on user performance [15]. Our systems used the same minimum angular width of  $60^\circ$ , with the static feedback system using this at all times. The dynamic feedback approach altered the target width based on the number of potential alternative paths found. Pathfinding was achieved by precomputing a shortest path matrix using the Floyd-Warshall algorithm [4] on a graph of the study area. During actual usage, potential alternative routes were calculated by testing for paths from points in the area directly in front of the user's GPS trajectory. Routes that added more than 25% to the distance of the shortest path from the user's current location were discarded. The number of paths remaining was used to directly resize the feedback area, but this was limited to a maximum of  $120^\circ$  to avoid the excessively long routes that might result from edge-following behaviour.

### 4. EXPERIMENT

We conducted a field study to investigate the systems' effectiveness in a realistic navigation scenario. Our research questions were:

*Viability:* Can pedestrians navigate to a destination knowing only its general direction?

*Freedom:* Does the dynamic feedback prototype's coupling of feedback size to path variance have an impact on users' exploration of their surroundings while navigating?

After an initial pilot study, 24 participants aged from 18 to 65 were recruited for individual trials to help understand potential usage of the system. 14 participants were female, 10 were male; 13 were members of university staff, 11 were students. None of the participants worked in areas directly related to HCI.

Before the study each participant was randomly assigned to use one of the two prototypes. Fixed start and end points were chosen at the edges of the approximately  $0.5\text{km}^2$  study area, in order to give participants exposure to navigation with the system through both urban and rural areas. The straight-line distance between start and end points was  $0.77\text{km}$ , and the shortest walking route (when keeping to paths) was approximately  $1\text{km}$ . These well-spaced points allowed us to measure participant performance at a much greater distance than that commonly used between turn-by-turn waypoints.



