# Interactively Displaying Maps on a Tactile Graphics Display

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**Abstract.** We present a system that allows blind users to explore both indoor maps and large-scale OpenStreetMap data on a tactile graphics display. Additional information about the map object that is being touched by the user's finger is provided by text-to-speech output. Different styles allow to concentrate on specific aspects of the map. First tests show that the system can help blind users to get an impression of the layout of unknown areas, and even to get a better understanding of areas that are well-known to them.

**Keywords:** Tactile Maps, Tactile Graphics Display, Accessibility

## 1 Introduction

Being able to read maps is an important first step towards successful navigation in unknown areas. While maps are becoming ever more available for sighted persons via smartphones and services such as Google maps, blind users often still have to rely on maps that are provided specifically for them, and are often only available for small areas. At the same time, digital maps are becoming more widely available through initiatives such as OpenStreetMap. What is still missing is the link between those digital maps and the blind users. Screenreaders and Braille devices have adopted the role of this link for digital information in text format, but for spatial information such an accessibility is still missing. In this paper we present a system that is designed to provide this link, and to make maps – especially OpenStreetMap – accessible to blind users.

## 2 Related Work

With the advance of widespread availability of digital maps, making them accessible for all is a logical next step. Accessible maps can be classified according to several criteria, including the sensory channel that they use (e.g. tactile vs. auditory maps). Another important distinction is whether they represent a larger two-dimensional overview of the map or an approach based on a virtual observer, where only information in the immediate vicinity of a freely movable virtual observer (or cursor) is presented to the user.

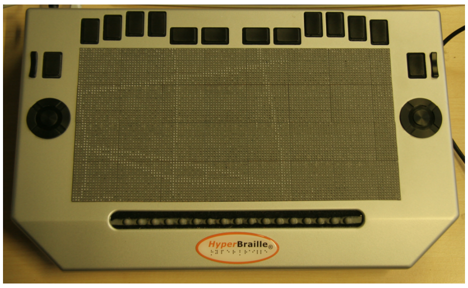



**Fig. 1.** The tactile graphics display, including a braille keyboard on top and two four-way digital crosses.

Purely auditory maps are normally bound to the virtual observer model, such as the auditory torch by Heuten et al. [2, 1]. In contrast to that, the works on tactile or combined tactile and auditory maps vary between those using a virtual observer model and those representing a larger overview at once. Rice et al. combine tactile and auditory feedback in their system that controls the virtual observer by a force feedback mouse [5]. Our own previous work includes a virtual observer controlled by a rumble gamepad [7].

Systems that present a larger overview often require more elaborate hardware and a setup that is tied to desktop use. Wang et al. print out a certain area of the map with a thermal embosser [8]. The printout is then placed on a touchpad, allowing audio feedback upon the touch of the user's finger. A similar approach was used by Paladugu et al. with the goal of evaluating design patterns for the production of tactile maps [4]. The system by Zeng and Weber is most similar to the one presented in this paper, also using a tactile graphics display [9]. The system uses an inbuilt GIS and renders roads as lines and buildings and other points of interest as fixed symbols from a library. Our system aims at greater flexibility by using OpenStreetMap and freely choosable styles.

## 3 The Tactile Graphics Display

Our system displays the maps on a Tactile Graphics Display, the "Stuttgarter Stiftplatte", with a resolution of 120x60 pins and touch-sensitive sensors for feedback about the position of the user's fingers [6] (see Figure 1). However, our system does not specifically build maps for this display, e.g. by directly activating specific pins. Instead, normal graphics output is used, and the driver converts the output for use on the Tactile Graphics Display. With this approach, the system is not limited to a specific Tactile Graphics Display, instead any that can convert on-screen graphics can be used.

Because of this approach some graphical details might be lost during the conversion. This can mostly be avoided by choosing appropriate styles for the graphics display (section 6.1).

## 4 Maps

Our systems displays two different kinds of maps: Highly detailed maps of buildings and small outdoor areas and OpenStreetMap data for an overview of large outdoor environments.

### 4.1 Detailed Maps

The detailed maps are handbuilt and were originally made for the ASBUS project, which among other goals aims at making the University of Stuttgart accessible to disabled and especially blind students by providing a navigation system. The maps show buildings with rooms and even small details like pillars and benches. The maps are stored in XML files based on the CityGML standard, but limited to two dimensions.

### 4.2 OpenStreetMap

For large outdoor areas where no detailed maps are available, OpenStreetMap data is used. A certain area around the current viewport is downloaded. If the user scrolls out of that viewport, new data is downloaded automatically.

OpenStreetMap is a community effort in providing maps that is a viable alternative to commercial data providers, especially regarding pedestrians: In 2011 OpenStreetMap provided a more than 30% larger street network for pedestrian navigation in Germany than the commercial TomTom Multinet 2011 database [3]. OpenStreetMap data consists of three types: Nodes, ways and relations. Nodes are simple points on the map, ways are linestrings that connect the nodes and relations can contain both nodes and ways. All three can have an arbitrary number of key-value string pairs called tags, in which the type of the object, but also any additional information is stored.

## 5 Interactions

As in any common map application, the user may zoom and scroll the map by using the arrow keys or the four-way digital cross of the tactile graphics display. The main additional feature is that the user can click on any object by pressing a button while having the finger on the object. Its name, function or address is then read out by a text-to-speech engine. If a handbuilt map is used, this is straightforward, as all displayed objects are named. However, in a community-based environment, in our case OpenStreetMap, the data is not always present in such a straightforward manner. Therefore, in order to be helpful to the user, the text that is read out has to be chosen more diligently. If the object is tagged with a name tag, the name is read out directly. If no name is given, a combination of the type of the object and (if available) the address is read out. The type of the object is determined by the OpenStreetMap tags in combination with strings from the styles (section 6.1), that also allow a translation into other languages. If several objects are stacked on top of each other in OpenStreetMap, the objects are read out one by one after each consecutive click, beginning with the innermost. For detailed maps, consecutive clicks are equivalent to going up one step in the GML hierarchy, so that e.g. a building's name will be announced after a room number.

Some features of the system can be accessed by a menu. After opening the menu with a keystroke, the user can navigate through the menu with the cursor keys or the digital cross. The individual menu items are read out by the text-to-speech engine. The menu allows access to the various maps (section 4), the different styles (section 6.1), and to the place search (section 6.2).

## 6 Additional Features

While the system as described above is functional, some additional features were implemented in close collaboration with a blind colleague, who currently uses the system most frequently. Those features can greatly enhance the usability of the system.

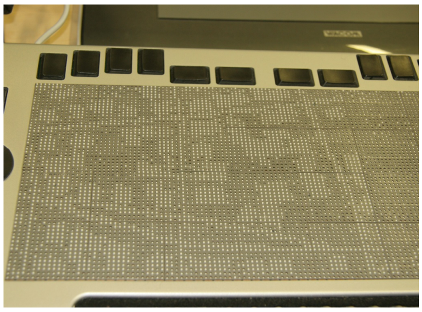
### 6.1 Display Styles

The Display component of our system is completely configurable. This means that for all tags in OpenStreetMap the color and thickness of the lines that are drawn, as well as the color and hatching of polygonal objects can be freely chosen. Objects can also be completely hidden, depending on their tags. Details like color and hatching cannot be reproduced on the tactile graphics display, and are mainly useful for collaboration with sighted users that use a monitor. Line thickness or the hiding of objects can be used to avoid clogging the tactile graphics display with too much information. These style settings can be stored and loaded and also added to a quick styles menu, allowing easy selection of different styles, such as “only buildings” or “only streets”. Figure 2 shows a detail of an area near our University campus, showing both buildings and streets (a, b), only buildings (c, d), and only streets (e, f).

### 6.2 Place Search

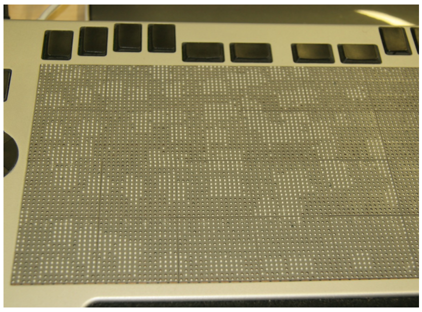
The place search allows entering the name of cities, streets or well-known entities such as landmarks. The search string is forwarded to both GeoNames and OpenStreetMap Nominatim. The places found by both services are presented to the user in an accessible list, that can again be accessed with the cursor keys. Upon selection of an entity, the map is changed to OpenStreetMap (if it is not already the case), and centered on the geographic position of the selected entity. This allows switching fast between different areas of interest.

(a) Buildings and streets (screen)

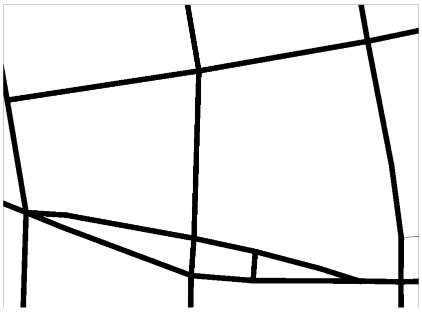


(b) Buildings and streets (tactile graphics display)

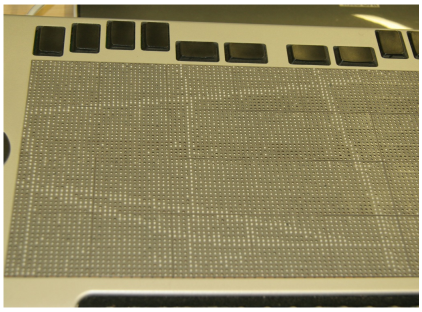
(c) Buildings only (screen)



(d) Buildings only (tactile graphics display)



(e) Streets only (screen)



(f) Streets only (tactile graphics display)

**Fig. 2.** A map shown with three different styles on both the computer screen and the tactile graphics display.

## 7 Results

First tests have shown that the system can greatly enhance the spatial understanding of its users. A blind colleague who uses the system says that she has had to correct her understanding of the street layout even of areas that she has lived in for a long time. The possibility to quickly jump to a desired location was regarded positively, as it enabled the user to go from exploring one area, such as the workplace, to another, e.g. the place of residence. Furthermore, the different styles were regarded as very helpful to reduce information overload depending on specific tasks, e.g. our colleague chose to hide all buildings when exploring the layout of streets. The use of OpenStreetMap has the advantage of providing a worldwide data set. Especially in conjunction with the flexibility achieved by the different styles, this provides a main difference from many of the previous works in this area. The effects of the low resolution can be diminished by using appropriate styles, e.g. by rendering only streets of a certain importance if zoomed out. However, the effects of using different styles for different zoom levels still need to be evaluated.

**Acknowledgments.** This work was funded by the Deutsche Forschungsgemeinschaft (DFG). We would like to thank Andrea Berghammer for her involvement in the design process and her invaluable feedback.

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