box or a dropdown menu where the user can edit (or select from the list) the desired day. For the day's info, specific written or audio content about the day can be assigned and so triggered. In the accessible calendar, the QR codes are placed at the bottom of the page for horoscope and agriculture information related to the moon phases (see Figure 2). The QR code in the top-right corner activates the day mp3 file. The QR code in the top-right corner brings the users in a web page navigable with flick-left and flick-right screen gestures enabling the listening and the navigation of all the month's audio files (one for each day) (see Figure 3).

- Calendar format. The standard format with a single list of days placed one under the other would make available much more space to write information that is more visible even for visually impaired people. The more compact grid format requires an app to enrich content and information not only for the blind but also for the visually impaired (see Figure 2).

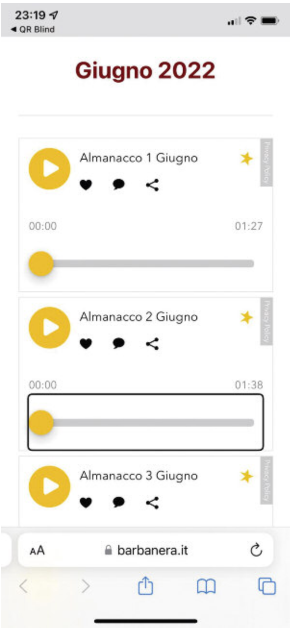

Figure 3: Web page for the audio contents.

Conclusions

In summary, the proposed solution combines tangible references with digital tools (app or web) to make a paper-based object more accessible. The solution proposed here is meant to be an example of how simple tools – if well exploited – can become assistive technologies for a more inclusive society.

Link:
[L1] https://www.barbanera.it/

References:

[1] A. Brown, C. Jay, S. Harper, S.: "Audio access to calendars", in Proc. of the 2010 International Cross Disciplinary Conference on Web Accessibility (W4A) (pp. 1-10), 2010.
[2] Y. Mehta, et al.: "Accessibility of date picker for touchscreens", in Proc. of the 8th Indian Conference on Human Computer Interaction (pp. 64-69), 2016.

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Using Haptic Feedback to Support Cognitive Mapping in Mobile Applications for Orientation and Mobility

by Maria Teresa Paratore (ISTI-CNR) and Barbara Leporini (ISTI-CNR)

The aim of this study, which is currently underway, is to investigate how the haptic channel can be effectively exploited in a mobile app devoted to visually impaired users, for the preliminary exploration of a complex indoor environment, such as a shopping mall.

Navigation apps have proven to be effective assistive solutions for persons with visual impairments, helping them achieve better social inclusion and autonomy [1]. Navigation apps can be used to get real-time information about users' actual position in a physical environment, route planning, and accessibility warnings. A mobile app can also be used to help users build a cognitive map (i.e. a mental representation) of the spatial environment before physically accessing it. An effective cognitive map allows a subject to localise and orient themselves in the space in relation to the landmarks and elaborate a route to reach a given point in the environment [2]. For a visually impaired person, this is particularly useful before physically accessing a complex, unknown or rarely visited environment [1]. The goal of our study is to investigate the potentialities of vibration patterns to enhance the learning rate of a cognitive map. Our idea is to adopt the haptic channel in order to provide not only spatial cognition and directional hints, but also an overview of the functional areas of the environment, also known as Points of Interest (POIs). Almost every public building nowadays provides visitors with aids for navigation (paper maps, digital signage, websites or mobile apps); however these aids are generally not accessible for visually impaired users. In the following, we describe a mobile Android application we designed and developed for testing purposes, with the aid of two experienced visually impaired users.

The Test Application

Our test application provides users with a simple audio-vibration map. Seven functional categories were identified, which are typical of a shopping mall, and each category was associated to a different vibration pattern. The map is composed of two layers, one of which is invisible, and is responsible for the haptic and audio rendering. The hidden layer is formed by a set of coloured areas, each corresponding to a POI. RGB (red, green, and blue) colour encoding was exploited to identify each POI; predefined couples of red and green levels were associated with many functional categories in the building. The blue component, on the other hand, was used to precisely identify each single POI. While the user explores the touchscreen with their finger, the app checks the colour of the underlying coordinates. Whenever a couple of red and green components is detected, which corresponds to a POI category, the matching vibration pattern is triggered, and if the user lifts their finger, the blue component will be considered to announce the matching descriptive label through the TTS engine. Vibration

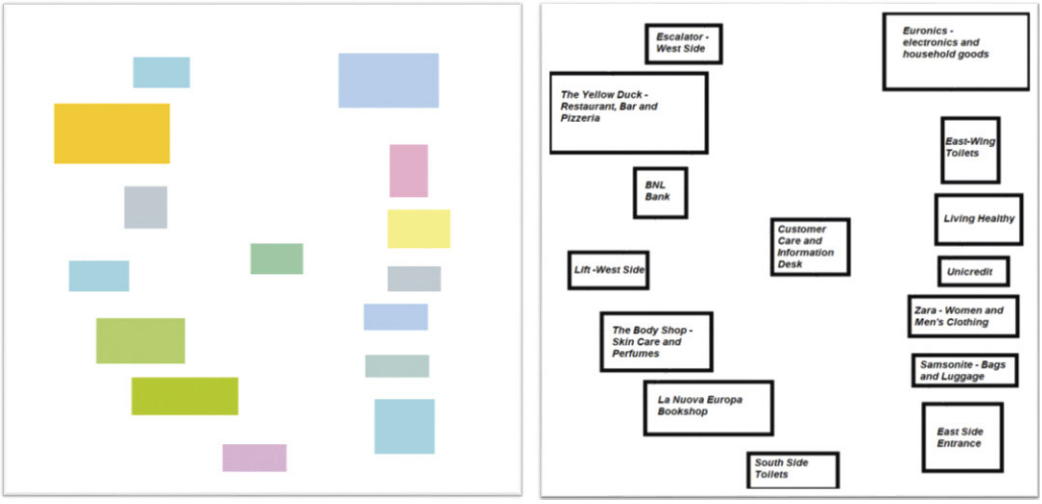

Figure 1: The coloured image used to recognise the different areas on the map, and the visible version of the map.

```
<color name="pharmacy">#FFFF80</color>
<color name="info_box">#80D8A8</color>
<color name="stairs_elevator">#89DAE5</color>
<color name="shop">#ABCCF6</color>
<color name="atm">#BCC8CE</color>
<color name="bar_restaurant">#FFC90E</color>
<color name="toilettes">#F7B0C8</color>
```

```
//POI types
public static final int POI_TYPE_PHARMACY = 0;
public static final int POI_TYPE_INFOBOX = 1;
public static final int POI_TYPE_STAIRSELEVATOR = 2;
public static final int POI_TYPE_SHOP = 3;
public static final int POI_TYPE_TOILETTE = 4;
public static final int POI_TYPE_ATM = 5;
public static final int POI_TYPE_RESTAURANT = 6;

public static final int SHORT_VIB = 100;
public static final int LONG_VIB = 200;
public static final int LONGER_VIB = 300;
public static final int PAUSE = 100;

//pattern values in msecs
public static long[] PATTERN_PHARMACY = new long[]{0,LONG_VIB,PAUSE,SHORT_VIB,PAUSE,SHORT_VIB};
public static long[] PATTERN_INFOBOX = new long[]{0,LONGER_VIB,PAUSE,LONG_VIB,PAUSE,LONGER_VIB};
public static long[] PATTERN_STAIRSELEVATOR = new long[]{0,SHORT_VIB,PAUSE,SHORT_VIB,PAUSE,SHORT_VIB};
public static long[] PATTERN_SHOP = new long[]{0,SHORT_VIB};
public static long[] PATTERN_TOILETTE= new long[]{0,LONGER_VIB,PAUSE,LONG_VIB};
public static long[] PATTERN_ATM = new long[]{0,SHORT_VIB,PAUSE,LONGER_VIB};
public static long[] PATTERN_RESTAURANT = new long[]{0,LONGER_VIB};
```

Figure 2: Colour encoding adopted to identify the different categories of POIs and the associated vibration patterns, as they are encoded according to the Android/Java formalism.

patterns were designed in such a way as to make the POI categories as distinguishable as possible, while keeping a low level of intrusiveness. Concern arose that the cognitive load may become too heavy in certain conditions or for certain categories of users, such as the elderly. A "filter by category" function was therefore introduced.

Experimental Results

The app was provided with three alternative modalities of feedback: audio only, vibration only, audio and vibration. Trials were carried out in which users were asked to build a cognitive map of a shopping mall in each of the three modalities of interaction. We found that, when only haptic feedbacks were enabled, users were able to get an idea of the arrangement of the POIs within the space and had no difficulty in recalling the location of specific POIs, as well as the total number of shops or entrances and stairs. The task of finding a given shop on the map was also successfully accomplished. Worse results were achieved when the exploration

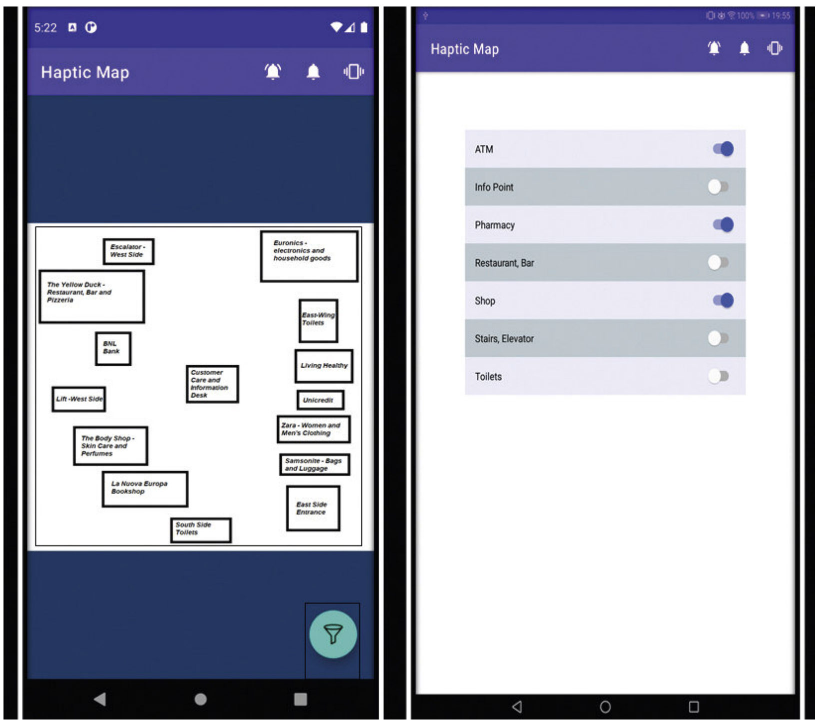

Figure 3: Two screenshots of our test application: the map to be explored with the feedback and filter controls and the filtering switches.

was only supported via auditory feedback. Using both the auditory and the haptic channels to announce the POI category was perceived as overwhelming, even though this modality was appreciated for a training phase, when correspondences between vibration patterns and POI categories had to be learned. Problems were occasionally reported, related to synchronisation of the TTS announcements. We are confident to solve these issues during the next phase of our study, when integration with Android's accessibility service will be better exploited.

Future Work

Our aim is to integrate the described approach into traditional maps provided by services such as GoogleMaps [L1] and OpenStreetMap [L2]. To achieve this goal, further ad hoc trials will be carried out, focusing on specific aspects such as the maximum number of patterns that can be used at the same time and the most effective pause and vibration configurations, also in relation to users' demographic data.

Links:
[L1] https://developers.google.com/maps?hl=en
[L2] https://www.openstreetmap.org/about

References:
[1] A. Khan, S. Khusro: "An insight into smartphone-based assistive solutions for visually impaired and blind people: issues, challenges and opportunities", Universal Access in the Information Society. 1-34 (2020). https://doi.org/10.1007/s10209-020-00733-8
[2] R.A. Epstein, et al.: "The cognitive map in humans: spatial navigation and beyond", Nature Neuroscience, 20, 1504-1513. (2017). https://doi.org/10.1038/nn.4656

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PlayToPickUp: Customisable Serious Games for Children with cognitive disorders

by Letizia Angileri, Marco Manca, Fabio Paternò, Carmen Santoro (ISTI-CNR)

PlayToPickUp is a serious game that stimulates children in the relevant cognitive aspects (attention, planning task and error monitoring) while performing tasks that replicate the activities of daily life, such as preparing the backpack, recognising money or emotions.

Cognitive developmental disorders are common in children and affect the language or attention area, such as attention deficit and hyperactivity. In these cases, the individual is unable to engage and interact effectively with the environment, resulting in difficulties in learning and autonomously carrying out daily activities. For these reasons, this work proposes a solution that aims to stimulate children in the relevant cognitive aspects, which are attention, planning tasks and error monitoring. The proposed solution is PlayToPickUp, a serious game that supports tasks that replicate the activities of daily life, such as preparing the backpack, recognising money or emotions.

Previous work on serious games to cognitively stimulate young people includes a proposal by Fontana et al. [1] who put forward Train Brain, a serious game for selective attention training, based on memorising images in one or more contexts using coloured circles. However, in general, previous work lacks proposals to support children in their daily routines, so we thought it would be interesting to address this aspect in a new solution, which also takes into account emotional-related aspects of the target population.

Design

The serious games design and implementation was driven by aspects and requirements gathered in state-of-the-art analysis, interviews, empathy maps and personas. For example, it was found that these children have low self-esteem as they tend to maximise their weaknesses and minimise their strengths, isolate themselves for fear of rejection and seek attention with cocky attitudes.

The PlayToPickUp game [L2] has been designed to reproduce some scenarios that children may encounter in their daily life: preparing the backpack, recognising money or emotion representations, stimulating sustained attention, planning skills and error monitoring. The objective of this game is to help the main character (a robot) to collect some target objects (school- or money- or emotion-related). The game is a responsive web-based application, therefore available on different platforms (tablet, smartphone, PC) and has four difficulty levels that automatically increase as the game progresses. Each difficulty level has three sub-levels where dynamic objects move, respectively, in the following ways: vertical, horizontal, and vertical with the initial position of the elements set randomly. When objects appear, the user has to collect those elements