Indoor wayfinding app for all

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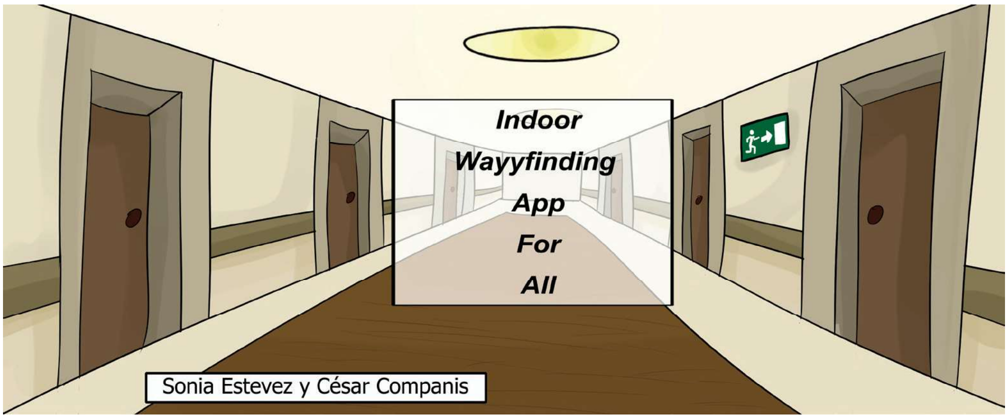


Accessibility
Mobile App
Navigation map
Indoor
Wayfinding App

Accessibilità
App mobile
Mappa di navigazione
Navigazione interna
App wayfinding

Some indoor navigation and wayfinding apps already exist, such as Google Indoor. Still, there are only a limited number of buildings in this system because the building owner must submit the floor plans to Google to be incorporated into Google Maps.
In this work, we present the design of a new indoor navigation application for smartphones. In the design of the app, it has been prioritized that it can be used in any building and that it can be used by people with vision and hearing problems, as well as people with reduced mobility. This new approach describes the route instead of marking it on a map as GPS systems do.
The objective of this app is to show either the shortest path or the different paths that connect two different rooms in the same building. With this objective the requirements of the app are: 1) simplicity, 2) it does not require many memory resources or advanced technology and, 3) that it can be used without an internet connection.
To create this app with these requirements, two stages of work are needed. The first stage deals with the labeling of the entrances to the building and its rooms, and the second stage consists of looking for the possible paths between two rooms. The first stage only needs to be done once per building. In the second stage, after each search, each path found can be detailed using the different sensors incorporated in almost all smartphones. As a result, a new app will be developed following this design.

Esistono già alcune applicazioni per la navigazione interna e il *wayfinding*, come Google Indoor. Tuttavia, il numero di edifici presenti in questo sistema è limitato, poichè il proprietario dell'edificio deve inviare le planimetrie a Google per poterle inserire in Google Maps.
In questo lavoro presentiamo il progetto di una nuova applicazione di navigazione *indoor* per *smartphone*. Nella progettazione dell'applicazione è stata data priorità al fatto che possa essere utilizzata in qualsiasi edificio e che possa essere utilizzata da persone con problemi di vista e di udito, oltre che da persone con mobilità ridotta. Questo nuovo approccio descrive il percorso invece di segnarlo su una mappa come fanno i sistemi GPS.
L'obiettivo di questa applicazione è mostrare il percorso più breve o i diversi percorsi che collegano due stanze diverse dello stesso edificio. Con questo obiettivo i requisiti dell'app sono: 1) semplicità, 2) non richiedere molte risorse di memoria o tecnologie avanzate e 3) poter essere utilizzata senza una connessione a Internet.
Per creare questa *app* con questi requisiti, sono necessarie due fasi di lavoro. La prima fase riguarda l'etichettatura degli ingressi all'edificio e delle sue stanze, mentre la seconda consiste nel cercare i possibili percorsi tra due stanze. La prima fase deve essere eseguita una sola volta per ogni edificio. Nella seconda fase, dopo ogni ricerca, ogni percorso trovato può essere dettagliato utilizzando i diversi sensori incorporati in quasi tutti gli *smartphone*. Di conseguenza, verrà sviluppata una nuova app seguendo questo progetto.

Introduction

Today it is common to use mobile apps that show us the way to go to a specific place, such as *Google Maps* or *Bing Maps*, *Here WeGo*, or *OsmAnd*, among others. Outdoor navigation apps make use of GPS systems to locate users. But this technique is not reliable for indoor orientation. So, is it possible to navigate inside a building where the GPS doesn't work? There are some indoor positioning systems, but they are based on technologies such as *Ultra Wide Band* (UWB) that only some buildings have. There are also apps for navigating inside buildings, which are detailed in the state of the art section. The problem with these apps is that they can only be used in very specific buildings that have already been labeled.

Bearing in mind the apps that already exist, we believe that a simple indoor wayfinding app that can be used in any building and, that can be used by almost everyone is necessary. Therefore, our app design is valid for people with reduced mobility or with vision or hearing problems. Besides to find the shorter path, the app has the option to show all paths that connect two different rooms in the same building.

The idea underlying this app is based on a previous work that is presented in section Research Methodology Applied. But before we present the State of the Art.

State of the Art

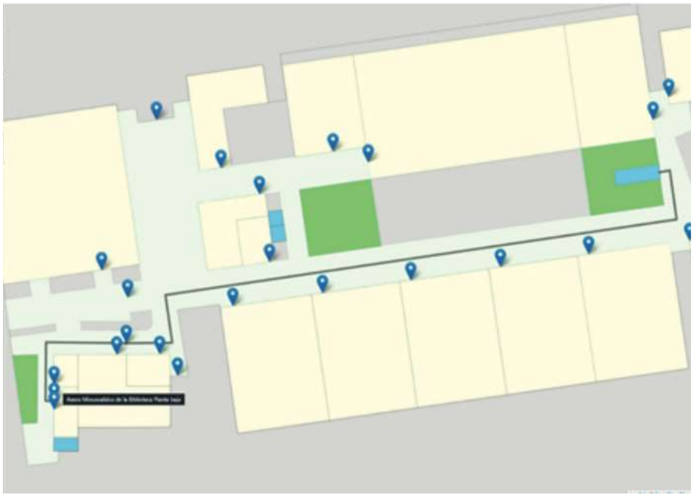
Indoor navigation apps help us move to our desired location within the building quickly and easily. These apps access to certain sensors in our phones as accelerometers, gyroscopes, or barometers to create a map. These technologies are continually improving. Some indoor navigation apps are detailed below.

Google Indoors uses the same interface as *Google Maps* and is accessed through it. If you zoom in on a building, you can see parts of the interior of it. This effect has been built with photographs and it is possible to 'walk'. But it's limited and relies on businesses uploading floor plans of their interior spaces on *Google Maps*. That is, *Google Indoors* only works for certain types of buildings that are part of this system, such as airports, shopping malls, or stadiums [1].

Cover Image
Indoor wayfinding app for all

Fig. 1.
Path on floor 0.

Fig. 2.
Path on floor 2.



Path Guide is an indoor navigation app developed by Microsoft that does not use GPS. The mapping is done on the mobile when we walk inside the building, with the barometer and the magnetometer the distances are calculated and maps are created. In essence, it guides users to destinations based on a path compiled by one or more previous travelers. For example, you can record a route from a parking spot in a garage to the elevator and later follow it in reverse to find your car [2].

Situm's mapping tool gives you the ability to map your own buildings and then share the maps with the people who need the information. It uses your phone's gyroscope, Bluetooth and Wi-Fi to create the maps. Record paths between locations within the building and create a path that actually guides your visitors through your structure [3].

Mally is an app designed for the Weston Favell shopping center in Northhampton (UK). Using machine vision and 3D technology, *Mally* creates 3D maps of the mall for users. The app allows you to trace your shopping route [4]. Other app that uses 3D maps is *Visioglobe* app allows to create and edit maps and analyze and the behavior of its user. It also has a wayfinding software [5]. Other apps focus on improving the productivity of manufacturing and warehouse operations as indoorway [6].

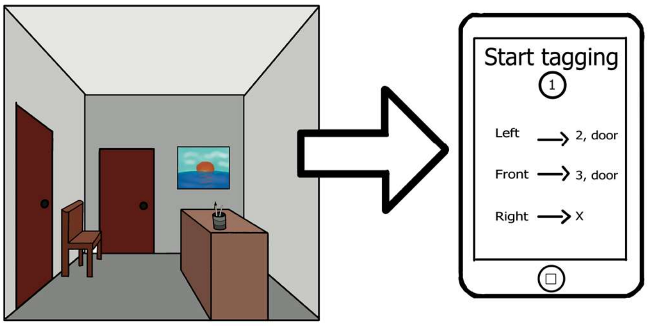
Research Methodology Applied

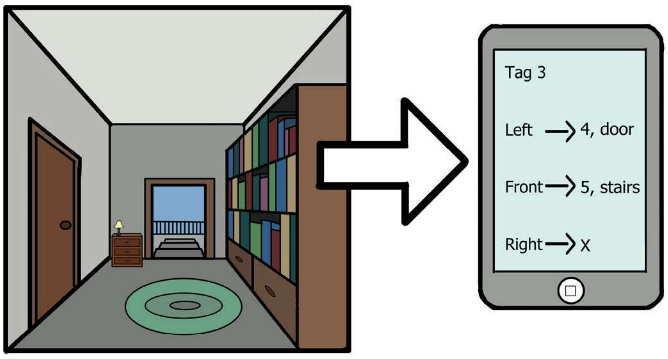
In a first approximation, we developed an application that allows users to know in advance the shortest path between two points within a certain building [Palma 2020]. This project is parte of the result of the RiseWise EU project [7]. For the development of this web application, a mapping of a specific building was made in *Open Street Map*. Specifically, rooms, doors, elevators, stairs, ramps, etc. were labeled. From this labeling, a graph was generated and applying the mathematical theory of graphs, the shortest path between two points of a building was obtained. The points can be on different floors, and even if two buildings are connected by a bridge or tunnel, the shortest path between two points located on different connected buildings can be calculated. For example, Figure 1 and 2 shows the shortest path between two points located on different floors.

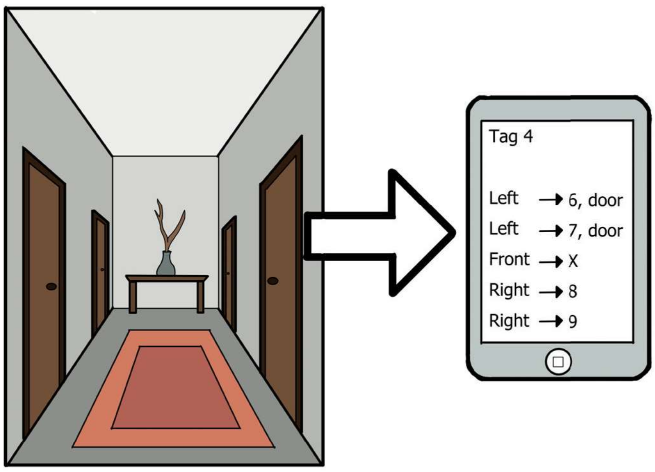
Fig. 3.
The entrance to the office and its corresponding labels on the app.

Fig. 4.
Labeling next room from 3.

Fig. 5.
Labeling next room from 4.


Start tagging
1
Left → 2, door
Front → 3, door
Right → X


Tag 3
Left → 4, door
Front → 5, stairs
Right → X


Tag 4
Left → 6, door
Left → 7, door
Front → X
Right → 8
Right → 9

The problem with this approach was that the labeling is 'bolted' to a specific building. For this reason, the goal of the new application is to make it a system that can be adapted to any building and is easy to use.

New app Design

The fundamental idea of this new app is that the labeling will be done on a graph instead of on a map. To do this, the user who is going to label a new building walks through the building and labels the type of access: stairs, ramps, doors, or elevators. The user must also label the connections to other rooms with numbers. As information is incorporated, the app expands the graph structure. This idea is shown below with an example of the labeling process for an office.

Example: We want to incorporate an office into this app. We start with the first stage, the labeling of the entrances to the building and its rooms. This stage only needs to be done once.

Labeling

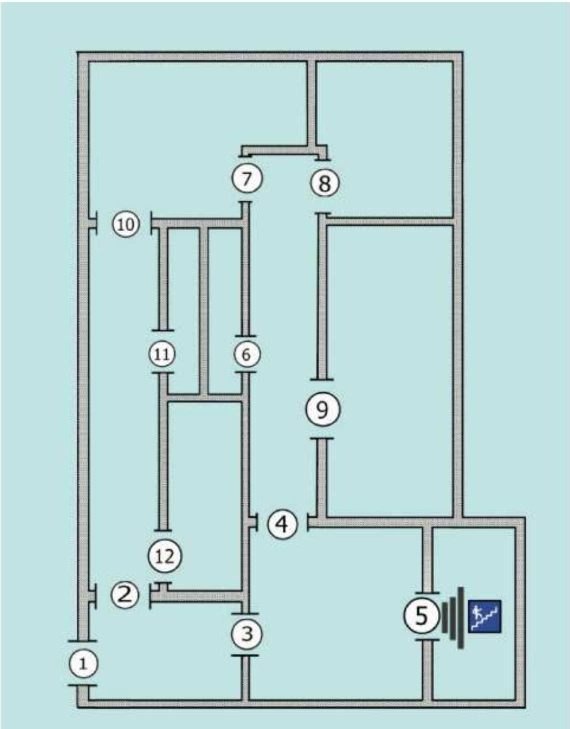
The entrance to the office is labeled with the number 1 and the accesses to other rooms (left, front, and right) are listed (fig. 3). Once the process is finished in a room, the user moves to a point with a label and repeats the process.

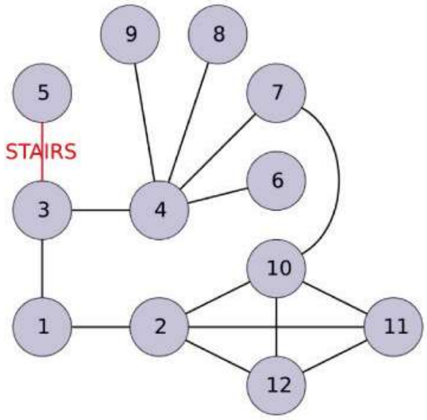
In Figure 4, the user has moved to label 3 and works with the new room. Note that label 5 corresponds to stairs.

Next, the user moves to label 4 (fig. 5) where there are different doors on the same wall, these are labeled with different numbers. The process ends when all points have been visited. Note that walls that do not communicate with other rooms are labeled with the symbol 'x'.

In addition, while the user is labeling the entrances and stairs, the mobile sensors create the map shown in Figure 6. In concrete the compass is used to mark the direction; the accelerometer and gyroscope help us to know the position and movement of the device and the pedometer indicates the number of steps. In addition, as it is labeled, a data structure called a

Fig. 6. Architectural plan of the office to be labeled and the corresponding graph to be created.


7
8
10
11
6
9
12
2
4
3
5
1


9
8
5
7
STAIRS
6
3
4
10
1
2
11
12

graph is created and represents the connections between labels. On this graph we can apply the Dijkstra's shortest path algorithm [Chen 2003] or the backtracking mechanism to find all paths joining two points [Palanque, Paternò 1998]. Additionally the graphs can be downloaded and any user can use the app locally without the need for an internet connection.

The second stage: find all paths connecting two rooms.

Once the graph is created, two points can be chosen, and it is possible to choose either the shortest path or all the paths that join those two points. Since the shortest path is contained in all the paths that join those two points, we will continue with all the paths of the example. For this second stage, rooms are numbered with characters (a, b, c, …) (fig. 7).

Before displaying the route, the user can specify if they have any disabilities (fig. 8). If the user is blind, then the mobile voice must be activated; if the user is deaf then he reads the mobile messages and if he has mobility problems, then the paths with stairs are not shown.

Of the possible routes that connect rooms C and H (fig. 9), the user chooses the first one and it is displayed on the screen (fig. 10) and detailed by voice. Note that if the user checks the mobility problems option, then only routes free of physical impediments such as stairs are shown.

Conclusions

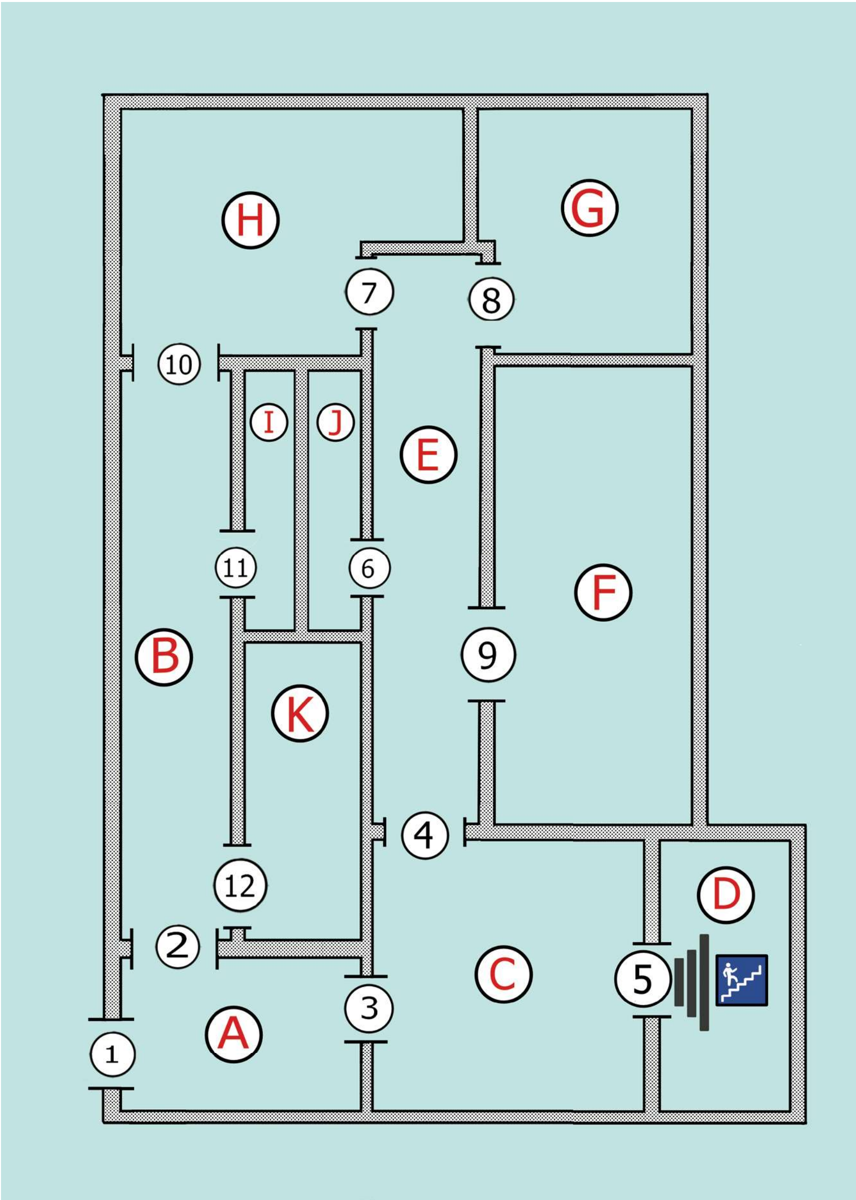
In this work, we present the design of a new indoor navigation app that can be used in any building and that can be used by people with vision and hearing disabilities, as well as people with reduced mobility. This app shows either the shortest path or the different paths that connect two different rooms in the same building.

The design is simple and is intended for programming an app that does not require many memory resources or advanced technology and that can be used offline. Thus, our app can be used by people who do not have state-of-the-art mobiles and even people who do not have advanced knowledge of technology.

The advantage of this application is that anyone can record the data of any building and anyone can use it. That is,

Fig. 7.
Rooms with chars labels.

Fig. 8.
Disabilities symbols.


H
G
7
8
10
I
J
E
11
6
F
B
9
K
4
12
D
2
C
5
3
A
1

the building plans are not necessary, nor is a mobile phone with a lot of memory necessary. In other words, our goal is to design in an accessible and inclusive wayfinding app.

Notes

[1] https://www.google.com/maps/about/partners/indoormaps/ accessed September 2022

[2] https://www.microsoft.com/en-us/research/project/path-guide-plug-play- indoor-navigation/ accessed September 2022

[3] https://situm.com/en/solutions/indoor-mapping/ accessed September 2022

[4] https://en.wikipedia.org/wiki/Geniusmatcher accessed September 2022

[5] https://visioglobe.com/ accessed September 2022

[6] https://en.indoorway.com/ accessed September 2022

[7] *Risewise. Rise women with disabilities in social engagement, Horizon 2020. Research and innovation programme*. Marie Sklodowska Curie grant agreement n. 690874. <https://cordis.europa.eu/project/id/690874> (accessed 26 August 2022).

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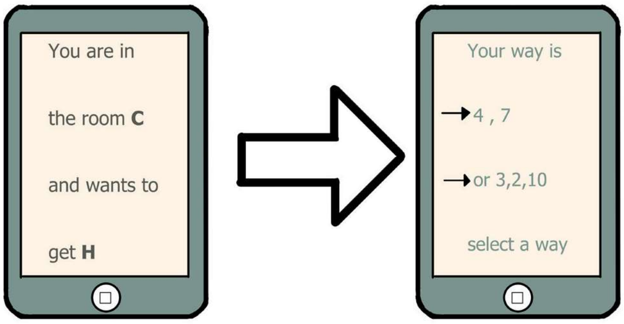
Domínguez, T., Alén, E., Fraiz, J. (2013). International Accessibility: A Proposal for a System of Symbols for People with Disabilities. In *International Journal on Disability and Human Development*, n. 12(3), pp. 235-243.

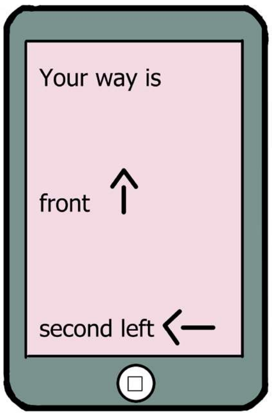
Palanque, P., Paternò, F. (1998). Specifying history and backtracking mechanisms. In *Formal methods in human-computer interaction*, pp. 1-23. London: Springer.

Palma Moreno, A., De La Oliva Sánchez-Valladares, J. (2020) *Aplicación que determine si existen restricciones de accesibilidad entre dos puntos dentro de un edificio*. Final Degree Project directed by Sonia Estévez-Martín.

Fig. 9.
Possible routes connecting rooms C and H.

Fig. 10.
The first route.


You are in
the room **C**
and wants to
get **H**
Your way is
4 , 7
or 3,2,10
select a way


Your way is
front
second left