Inclusive indoor mapping

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***Abstract*—New students, as well as Erasmus or disabled students feel often challenged in their first weeks of classes, when they cannot find the way to their classrooms or the easiest way to do it. InDoor Mapping is an application that similar to a GPS navigation application allows users to navigate through buildings while being able to see their current location, the desired location, and the connection path. With this assistive technology, students have a much easier time walking around the campus in the beginning of their journey. Also, the ability to adapt paths for disabled people, makes this tool a more inclusive and pro-accessibility initiative.**

Keywords—Assistive technology; Geolocation; Indoor Mapping

I. Introduction

The Indoor Mapping application can be explained as a web and mobile application with the purpose to guide and assist its users in navigating within an indoor environment. This allows the user to see the path from his current to his desired location. To be possible for the user to navigate through the facilities, beacons are placed in selected points, like the building entrances, for example, and then, the beacon can deliver the information to the application which allows the application to locate the user in the facilities and with that information it can generate and deliver a path.

This initiative, first designed and planned for the Superior Institute of Engineering of Porto (ISEP), falls within the need to welcome and assist its students, whether they are incoming students that struggle to move around the premises, Erasmus students that do not speak the language and not always find a person who can help them or even disabled students, that can benefit from this application by simply having access to the mapping information and the easiest path to take.

Finding their way to the classroom, when struggling to communicate, for instance, can be a challenge. Providing new, welcoming and inclusive tools, offers all students the chance to have an easier journey [1] [2] [3] [4].

II. Related Research

In the past years, research is being made regarding localization science and engineering, that enables the development of several applications [5].

These applications found geolocation useful for mapping, important for our project and technology that is based on this concept. In simple terms, "geolocation denotes the position of an object in a geographical context" [6].

Geolocation

Not a new concept in the world of software location, geolocation consists of tracking the position of a given individual or object [5] [6] [7]. In the world of software development, it is used in very different ways such as in AirTags. Developed by Apple, AirTags are small circular devices, designed to be attached to items like keys and wallets, so the user can track them via Bluetooth using Find My App. Its' hardware can help specify the location of the AirTag, overcoming difficulties that Bluetooth usually presents when the location has different obstacles. These devices work by sending a secure Bluetooth signal along nearby devices (from Apple), so they can send anonymously the location of AirTag to iCloud. It is important to note that the other users don't realize they are sending the location of AirTag to its owner. In "lost mode", an AirTag user will receive a notification from the moment AirTag enters the Bluetooth network.

Indoor mapping

Navigation techniques in outdoor settings have been developed and allows users to move around locations on foot, by car or even by public transports. However, indoor navigation and consequently indoor mapping are still underdeveloped, despite its high potential.

Similar to outdoor mapping, indoor mapping allows individuals to access navigation information. To do so, new technologies are necessary:

> In general, providing accurate location and navigation indoors will require extensive infrastructure or the implementation of multiple, complementary technologies (....). In fact, the trend in indoor geolocation research seems to point towards the integration of hybrid sensor technologies. The effectiveness of different sensors can vary based on the environment of operation and the tracked subjects' motion [7].

In the case of the InDoor Mapping application, we are using use beacons, a sensor technology, to detect the user's location within the complex of the building.

III. Methods and Materials

A. Concept

The purpose of the project is to help new students or ERASMUS students to navigate within the schools' buildings more easily. This project can also be described as a new navigation technology with features that help deaf, blind, and physical impaired people to easily access information about their location and destination.

An application was developed to allow the users to select their destination, showing them the correct path to take, as well as the forms of access to each building. In this application, there are only two types of users- the consumer and the administrator. The difference falls within the extra features of adding, editing, and removing beacons for the administrator. Also, the administrator is able to create, edit and remove users and also get back to the feedback given by the user/consumer.

The consumers are able to check the path to their destinations, create, edit their account, and give feedback to the administrator by text, voice, and images. The consumers can also check the floors layouts.

The most important feature of this new tool is its assistive features; this application provides a better experience for new, Erasmus or disabled students. In case they are in a wheelchair, the application provides the most convenient and adapted path; in case they are blind, in the future, the application will provide them with audio information. Even in cases where the students are blind, the application can be an asset when faculty staff do not know how to use sign language.

Also, for non-disabled students, like incoming or Erasmus students, this assistive technology can provide them with the help they need to become more easily familiar with the facilities.

B. Methodology

The methodology used on the course of the project was Scrum, which consists of five comprised values - commitment, courage, focus, openness, and respect. The main goal is to develop, deliver and sustain simple to complex products through collaboration, accountability, and iterative progress.

C. Development

Following the Scrum methodology, the project research, deliverables planning, and implementation can be sorted in four groups:

1) Design, Marketing, Audio & Video

Right after all deliverables were planned, the design department started working on the application visual mockup, logo, and first low fidelity mockups. Examples of the last can be seen below (figure 1).

Fig. 1. Splash screen (left) and homepage (right) mock-ups.

4The low fidelity mockups were a priority with the purpose of removing any initial bottleneck issues from the frontend team. After that, the mockups continued to be developed as well as the map svg and a demo building interior with all floors and rooms as can be seen below on figure 2.

Fig. 2. Building B - Floor 1 SVG.

2) Backend

Backend development by deciding the technologies to be used. As soon as they were selected, the database design started.

During the life cycle of the product implementation, there were times were the database suffered minimal alteration to fully satisfy the frontend team needs, which were previously reported. With the database created and posteriorly deployed, it was time to develop the API and its endpoints.

The API was then deployed and given access to the rest of the team to test it and update it to meet any frontend requirement. To make the frontend work easier, documentation of all endpoints was created.

3) Frontend

The frontend team started working even without the mockups being first released. The team discussed which technologies would be used to develop the application and discussed the application structure and layout.

Since the technologies chosen for the project are based on separated components, some of them were shared across different pages, so, after identifying those shared components, they were implemented dynamically so that every page could be accessed easily.

Data collection process

The first data needed to develop the application was ISEPs plant as well as all the plants of the buildings. The beginning of this project focused only on the plants of building B. This was done by getting pictures of the buildings, which are scattered across ISEP. On the runtime of the application, there is also data collection processes, namely:

- Registration - When a user first enters the application, he is required to register, saving its name, email, and password to the platform.

- Feedback - When a user wants to send feedback or entry to the platform, he uploads image, video, or audio files, which are converted and save on x64 format. This feedback is only visible to the user who owns it and administrates it.

According to the requirements engineering framework, one methodology is to interview or distribute questionnaires. These were used to evaluate the performance and usability off the final application.

Data analysis

The data gathered on the questionnaires was critical to evaluate and situate the prototype developed. One example of the questionnaires' application can be seen below on figure 3, which relates the ease of use of the web application, from a score of 1 to 5.

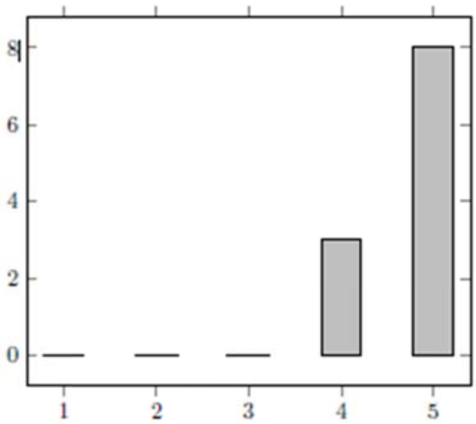

Fig. 3. *Answers on "How easy it is to use the web application?".*

On this particular question we got 72,7% replying 5 and 27,3% replying 4. This showed us that the application is on the right direction but can still be enhanced to facilitate all user actions.

Another example, with a more negative evaluation, can be seen on figure 4, rating the navigation system and its instruction accessibility.

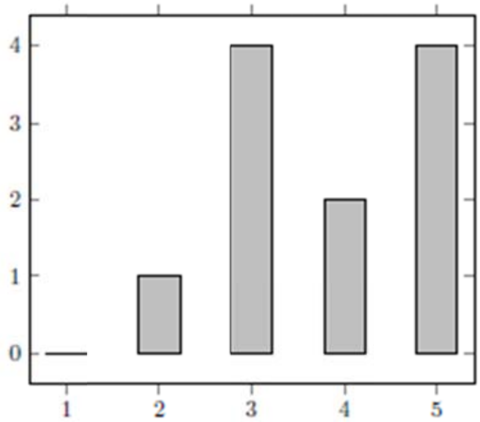

Fig. 4. *Answers on "Were the navigation system and the instructions easy to understand?".*

Analyzing these results gave the team an overview on the underdeveloped navigation system, making it hard for its users to understand the instructions.

IV. RESULTS

To evaluate the results, the best approach is using the Quantitative Evaluation Framework (QEF) sheet [8]. An extraction of the full sheet can be seen below on table I.

TABLE I. QEF SHEET

Qi	Dimension	Qj	Wij	Factor
59,61%	Functionality	16,67%	0,143	Information Provision
		62,5%	0,524	Services/Facilities
		100%	0,065	Security
		100%	0,048	User Guidance or Support
		71,43%	0,143	Customizability
95,96%	Reliability	90,91%	0,444	Navigation
		100%	0,222	Maintenance
		100%	0,333	Programing Practices
49,61%	Usability	35,19%	0,261	Assets
		55%	0,261	Engaging
		100%	0,043	Error Tolerance
		50%	0,435	User Feedback

As can be seen, the three existing dimensions got a delivery percentage to a result of 74%. The reliability dimension was by far the most developed. The others were around 50% developed.

Some examples of the final application can be seen on the figure below.

Fig. 5. *Login screen (left) and homepage (right).*

The login grants access to the user after authentication, as well as an overview about the application itself. The screen on the right is the homepage, the main purpose of the application which is showing the user a path from a point A to point B. The user can select both this points and a dotted flashing path will appear, suitable to the user needs. The user can also zoom in and out and drag the map. On the developed prototype version, the user can also "open" the building and see its floors, being able to change them to view every room within the building.

The other two pages developed were the settings and feedback pages, illustrated on figure 6.

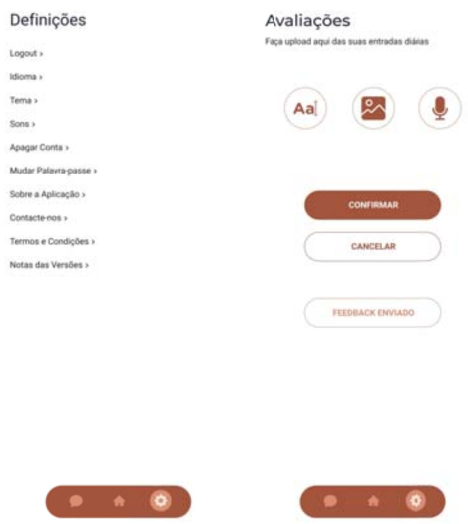

Fig. 6. *Settings (left) and feedback (right) pages.*

The first is general application settings such as theme, sounds, languages, and user actions (change password, delete accounts). The second is the whole feedback process, which can be sent on the form of text, image/video, or audio file.

V. Discussion

Following an action-research model, the team managed to produce all the written documentation before the development phase, organizing itself among the different groups created and attending the established meetings. In addition, difficulties were always overcome, which was also due to the team's method of organization, taking into account the skills of each member

VI. Conclusion

With all the research, organization and commitment from the team, the resulting prototype met most of the requirements. This is made evident by the QEF review, having 74% of the use cases and the final prototype examples showed on figure 5 and figure 6. Additionally, working methodologies used were a major factor on the pushing the project to near company environment.

VII. Future Work

In the future, it is expected that this project can be extended to other facilities than ISEP. The project is doable, innovative and shows social concerns, such as inclusion and accessibility.

Notwithstanding, the project team intends to improve this application, by making it more user friendly and simpler to use. So, we gathered some possible future improvements that we believe could be added to the project that would make it not only a more user-friendly experience, but also would turn this application into a more premium and interesting experience for the users.

First, we would like to add the possibility for the user to select a teacher's office, accessing the teacher's schedule and the way to its office. Also, the user would also be capable to select a room and access its occupancy.

Second, we would like to evolve the application to a navigation system supported by a voice guide, necessary for blind students.

Finally, we intend to develop a new feature that allows users to save their favorite locations. By selecting one of these favorite locations, the user would get the path to that location from its current location in that moment, in a more instant way.

The project team also believes that this is an opportunity for other indoor environments, other than faculties or schools; it can also be adapted to other settings, such as companies.

VIII. Acknowledgments

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