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Navigation with Augmented Reality in a Hospital

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Abstract. To improve wayfinding in hospitals or other complex buildings a prototype of an indoor navigation app was implemented that uses Augmented Reality for positioning and guiding users. The iOS and Android app allow the navigation from anywhere inside an area of 690 m². In a usability test 8 from 12 users preferred using the app over a map or verbal directions. Along with the proposed improvements this approach allows covering areas as large as 100'000 m².

Keywords. indoor navigation, wayfinding, positioning, augmented reality, mobile application

1. Introduction

Wayfinding inside large and complex buildings like hospitals is difficult due to multiple buildings, floors and insufficient aids like signage or maps [1, 2]. Complicated wayfinding can lead to patients frequently asking staff for directions, treatments being started late, etc. Most existing indoor navigation apps for smartphones rely on Wi-Fi or Bluetooth for which the acquisition and maintenance often are associated with high costs [3]. These apps mostly show information as a 2D map or text instruction, which some people find difficult to understand. Augmented Reality (AR) promises to present directions in a more understandable way by embedding 3D objects as an overlay in a live video feed of the surroundings captured by the rear camera [4, 5]. Until now, AR on smartphones was limited to showing 3D content on small surfaces. Recent advances in computer graphics algorithms and better calibrated smartphone cameras (vSLAM and viSLAM) enable complex AR experiences in a larger environment such as an entire building [6]. Such AR experiences require point clouds, a set of image data describing unique points in the environment. These functionalities became available for the public in the most known AR-frameworks in September 2020, when this project was started.

2. Methods

2.1. Implementation of the app

Requirements and mockups were defined in cooperation with the Hospital Centre located in Biel, Switzerland. Different AR frameworks were evaluated. Criteria included: the

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capabilities of the framework (the size of point clouds, the creation methods, the deployment for Android and iOS), easiness of using the functionalities and the ability to use the framework in the game engine Unity.

To create point clouds, the authors used the *Matterport Pro2* camera and the *Area Target Creator* app on an Apple iPad Pro 11 (2020). For route calculation the *NavMesh system* and the extension *NavMeshComponents* of Unity was used.

Due to COVID-19 restrictions the prototype app was only implemented and tested at the Bern University of Applied Sciences in Biel and not at the hospital.

2.2. Usability tests

The first test was carried out during the implementation phase when the app included one point cloud. Following tasks were performed: read and explain the onboarding, navigate to two destinations, and complete a guided tour. The second test was conducted after the main implementation phase and included three point clouds. The probands were randomly assigned to navigate on three different routes, overlapping multiple point clouds, by using three wayfinding aids: the app, a map created by the authors and verbal directions. For both tests a guide observed the proband and observed the behavior and how the tasks were solved. After the tests the probands filled out a questionnaire.

3. Results

3.1. Indoor navigation app

The framework Vuforia (version 9.6.4) was chosen because of its easy-to-use functionality to manage point clouds. The framework is known to support many devices and is able to manage up to 255 *Area Targets* (an optimized point cloud) of which one can have a maximum size of 450 m² when using a 3D capturing camera like *Matterport Pro2* [7]. During the project seven *Area Targets* of the total size of 850 m² were created. In the final app three *Area Targets* with the total size of 690 m² were used. The file size of the *Area Targets* used in the app is 46.8 MB and the automatically generated mesh used for occlusion is 144.3 MB. One *Area Target* that included a long corridor generated with the *Matterport Pro2* had to be discarded because of an error while postprocessing. Three *Area Targets* were used for testing purposes only. For 100 m² it took about one hour for scanning with the *Matterport Pro2* and five minutes with the *Area Target creator* app. For postprocessing it took the *Matterport* service between two and ten hours and less than a minute with the *Area Target creator* app.

The app was deployed for iOS and Android and consists of two main functions: navigation and a guided tour. A navigation or tour can be started from any position inside the area where *Area Targets* previously have been created.

Before starting a navigation or tour the user is asked to select the current floor. This activates the respective *Area Targets* needed for positioning. The user is asked to point the device's rear camera continuously at the environment so the app can find its exact position. As soon as the device position is found a green line and arrows show the fastest route to the destination (Figure 1). At the destination a green pin and an orange board is visible. On the bottom of the screen an estimated arrival time and the remaining distance is shown.

Figure 1. Screenshot of the navigation mode on a tablet. A video is available on YouTube [8].

Figure 2. A test person using the app on a smartphone.

3.2. Usability test results

All the eight probands that participated in the first test were able to navigate with the app while facing some issues: not knowing the ideal way of holding the device for optimal positioning, insufficient instruction when the position was lost and overseeing obstacles.

Table 1 shows the results of the second test were twelve probands participated. The additional app time indicates positioning at the starting point. Encountered issues included: positioning at the starting point took a lot longer than previously (brackets) due to an algorithm trying to automatically detect the floor (was deactivated later) and the green line was partially visible through the wall which distracted some probands from completing the navigation task.

Table 1. Characteristics and results of wayfinding on three routes by using three wayfinding aids.

Distance	Turns	Change of floor	App	Map	Verbal
61.8 m	7	-	2.2 (+ 1.2) min	1.6 min	1.4 min
50.9 m	6	+ 1	2.1 (+ 0.6) min	1.8 min	0.7 min
59.5 m	10	- 1	1.3 (+ 0.6) min	3.5 min	1 min

8 out of 12 probands indicated they would prefer to use the app in a hospital. 5 of 12 probands were over 55 years old. The constant holding of the device in front of the eyes sometimes led to fatigue or obstacles were overlooked. Some probands indicated that an additional 2D map would be helpful.

4. Discussion

This project shows that an AR indoor navigation app is technically realizable for large buildings and was preferred by probands over maps and verbal directions. However, the usefulness and acceptance in a hospital environment could not be conclusively investigated, considering the more stressful circumstances and floors and walls being very look alike. The technology stack has proven to be a good combination. Based on the chosen approach and considering some improvements, a surface of about 100’000 m² can be covered.

4.1. Usability

Navigation with the app was only faster than with the map on one of three routes, nevertheless with ten turns and change of one floor it is the most complex one. To navigate with verbal directions was faster as expected because the test environment was relatively small and simple.

Most of the test persons found it intuitive to follow the displayed path and would prefer using the app over a map or verbal directions. Some of the encountered issues during the tests are software issue which can be solved by updates, and some depend on the digital literacy of the user which can be improved by better instruction. It was observed that the 5 of 12 probands older than 55 years old had most difficulties to concentrate to follow the line or overseeing obstacles. Furthermore, to navigate with the app the user is required to point the smartphone camera constantly at the environment. Stable localization therefore requires active action on the part of the user.

4.2. Recommendations

Scaling the app from 690 m^2 to 100’000 m^2 could lead to saturation of device storage or impact WLAN performance at a hospital. To overcome these difficulties different approaches are possible: download data dynamically, provide pre-installed devices and the use of low polygon objects for occlusion instead of the generated mesh. The authors recommend using the *Matterport Pro2* because *Area Targets* can be four times larger than with the *Area Target creator* app.

An inaccurate *Area Target* created with the *Matterport Pro2* revealed that the current software has difficulties to cope with similar looking environments. To improve positioning under such conditions the app can be provided with the approximate position of the user, by using GPS, using QR codes or let the user select the current floor.

To the authors it is unknown how robust *Area Targets* are to changes in the environment. This should be investigated further, but is not considered a concern due to the assumption that areas relevant for navigation won’t change the appearance much.

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