

Adaptive Indoor Navigation for the Blind

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Abstract: In this paper, we describe a prototype of an adaptive indoor navigation system which is based on mobile devices and navigates visually impaired people through an unknown building. The system determines the users position inside the building on the basis of a map of the building with the help of Bluetooth-beacons. Since an exact navigation is necessary for navigating visually impaired people, we show how the system uses landmarks for gaining a higher precision for the navigation instructions for the users. We show how the system is able to determine the maximal achievable accuracy in localizing users in the given infrastructure and how the system adapts the navigation to the accuracy.

1 Introduction and Related Work

Visually impaired people often encounter difficulties to orient themselves and to find a destination in an unknown building. Current indoor navigation systems are not intended to be used by visually impaired users since the systems extensively use visual components which are not appropriate for visual impaired users. In this paper, we describe an practicable indoor navigation system for visually impaired people for area-wide use. It achieves a high precision, secure navigation at low infrastructure costs.

Indoor navigation is a challenging topic. At the moment, there are dozens of GPS based navigation systems for outdoor use available. For indoor use, there are only a few solutions. When considering visually impaired people, it becomes even worse. For visually impaired people, there are only prototypes of navigation solutions available[1, 2]. The system described in [1] navigates the users based on a 3D model of the navigated building. In [2], RFID technology is used to localize the users inside a building. The technology, used in the mentioned systems leads to very high costs for installing and using the systems. Hence, they are not appropriate for area-wide use.

2 System Description

The developed system is dedicated to visually impaired people and their needs. The system can be used on common smartphones in order to allow the users to use their own smartphone, which they are familiar with. In contrast to common navigation systems, it works without visual components. It uses Bluetooth localization techniques on the basis

of a 2D map together with an extended navigation graph of the building for navigating the users. The navigation graph represents the geography of the navigated area. It consists of three different layers. The first layer represents a network of beacons identifying floors. The second layer consists of the beacons for localizing the users and the third one consists of the additional landmarks used for navigation. For navigating visually impaired people, the localization of the users must be done with high accuracy. Technical limitations of the infrastructure like insufficient sensitivity of the Bluetooth-receivers in the mobile devices lead to variations of the localization of the users. The navigation instructions must be very precise and they must contain additional information in order to navigate visually impaired users safely to their destination. Hence, additional information like landmarks are integrated into the navigation. A navigation instruction with landmarks could be *'Please enter the room left of the sculpture'*. When visually impaired users navigate through an unknown building, they might lose orientation. In that case, they can request a ping, which is an audio signal from an acoustic landmark, as an orientation help. Technical restrictions of the infrastructure can decrease the quality of the localization and therefore also the quality of the navigation. Hence, the system uses a layered localization approach, based on the three layers of the extended navigation graph. The approach uses fingerprints to calculate the current position, which means for every point on the map we store a list of beacons that should be visible at that point. The number of beacons available for localizing the users has direct influence on the localization accuracy. The more beacons are available, the more precise the users can be localized. Depending on the provision with beacons, the system adjusts the navigation instructions and extends them if necessary with additional information and landmarks. Hence, the system can guarantee a precise navigation which is independent of infrastructural limitations. The system is at the moment in an early development stage. We implemented a localization prototype which already delivers promising results but still needs improvement.

3 Discussion and Future Outlook

Using low cost technologies like Bluetooth and landmarks leads to a cheap infrastructure with adaptive high precision navigation at the same time. This makes the system applicable for area-wide use in public buildings.

References

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