Simultaneous Localization and Mapping for Visually Impaired People for Outdoor Environment

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Abstract Today, mobile phones are equipped with at least half a dozen sensors such as accelerometer, gyroscope, proximity, and ambient light sensor. Mobile phone is increasingly being used to address various challenges on part of information dissemination, navigation, guidance, and short-range device-to-device communication. With the availability of sensors, there is a growing focus on the development of localization and mapping algorithms using mobile. In this paper, we focus on the simultaneous localization and mapping algorithm (SLAM) for visually impaired people. We have conducted an initial study on a visually impaired person for outdoor navigation in our University campus.

Keywords Augmented reality (AR) · Simultaneous localization and mapping (SLAM)

1 Introduction

Today, mobile phones are equipped with at least half a dozen sensors such as accelerometer, gyroscope, proximity, and ambient light sensor. Mobile phone is increasingly being used to address various challenges on part of information dissemination, navigation, guidance, and short-range device-to-device communication. With the availability of sensors, there is a growing focus on the development of localization and mapping algorithms using mobile. SLAM deals with the problem

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of building a map of unknown environment and at the same time navigating the environment using a particular map. Location mapping can be done for Indoor as well as outdoor application. Mobile device being an integral part of life, we plan to use it to assist the visually impaired using SLAM. Considering both indoor and outdoor situations, GPS is more reliable in outdoor environment as it performs poorly in indoor and rural areas [1]. Meanwhile, for location-related incidents, like freezing of gait [2], location tracking applications can assist the end-user by creating a user awareness while crossing peril zones. There is wide literature available on SLAM algorithms. Exploring an unidentified environment of a robot involves simultaneous localization and mapping (SLAM), as it is a requisite for many real-world applications. Visual SLAM [3, 4] is the methodology which resolves problems like converting visual information such as images or audio. Visual SLAM is nowadays used in wearable devices like Google glass and smart phones. However, due to various obstacles within defined range, indoor slam is different from outdoor ones, as due to fast movement of human and inadequate indoor illumination. One such solution is to use SLAM in mobile devices which not only record the surroundings but also play an important role in helping blind or visually impaired person, by detecting the dangerous surrounding issues such as potholes or even staircases. Moreover, SLAM based on global localization is formulated as disjoint problems [5]. In practical terms though, these are not disjointed, especially when the given map is insufficient—an imperfect map has minute errors between the applied map and the real environment which results to either a lack or an excess of landmarks in the former. In contrast to this, a perfect map fully describes every landmark in the target environment. Although floor plan is an imperfect mapping system, many localization solutions utilize it. The following paper deals with the idea of achieving global localization even when only an imperfect map is given with no initial state. Taking in concern both the pros and cons, we determined that in the following mentioned situation, both global localization and SLAM problem have to be solved simultaneously and dependently.

In this paper, we present our study for outdoor navigation. Location can be detected using GPS sensor. Localization using GPS is an important challenge in Indoor environment, as GPS has a lot of blind spots. In the context of localization and mapping, the fundamental problems are characterized as below:

- A local localization problem which occurs when both the map of the environment and prior state information is provided.
- A global localization problem which occurs when only the map is provided.
- SLAM [6] which occurs when only a prior state is given and both states of the map and pose are estimated simultaneously is provided.

This paper is organized as follows. The next section describes the problem statement. Section 3 shows the proposed system explaining the schematic of application. In Sect. 4, we describe the experimental results carried out on the application followed by Sect. 5 describing the implementation. Finally, in Sect. 6, results are shown.

2 Problem Statement

Person who is visually impaired or blind lose their way while walking. However, they use stick or smart stick which can resolve their problem for detecting the obstacles. So to provide a better solution, use of smart phones is an alternative to assist them, as not to follow the wrong path. This can be resolved through Dead Reckoning algorithm as shown in Algorithm 1. We have noticed that the central reason behind this complicacy is that they are not aware of their stream location and as a result of which they sometimes keep heading toward the wrong direction.

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Algorithm 1:

Input: Mapping M1, Walk W
Two Position: P1, P2
Output: f: W→M, Matching

1) Start
2) Begin←Address of P1 in W
3) S←Find possible path through P2
4) a←begin +1;
5) While a<=n do
6) P←(X1, Y1)
7) Rectify the routes(S, P)
8) a←a+1
9) reverse the direction of routes in S;
10) a←begin -1;
11) While a<=n do
12) P(X1, Y1)
13) Rectify routes (S, P)
14) a←a-1;
15) f←Pick one route from(S)
16) End
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3 Proposed System

We propose to build a system, which assists the blind people with the help of smart phones that can assist them in a similar way how a smart stick supports, thus providing accurate location information which, when combined with a digital map, offers guidance vibrations to the user. Hence, it substantially solves the localization problem by designing an accurate outdoor pedestrian tracking system that can be a reliable guidance measure for reaching their destination. Flowchart shows how the application works for both sighted user as well as for blind one. A sample use case of our application involves following steps. Figure 1 shows a flow for sighted user, and the application will work in the manner described in the flowchart. First, the user has to open the application on his device followed by starting the GPS connection. The moment GPS is on, device will track the user location through inbuilt

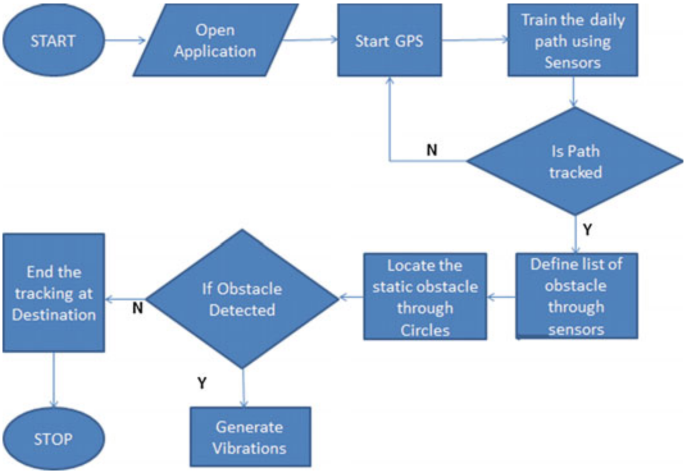

Fig. 1 Flowchart for sighted user

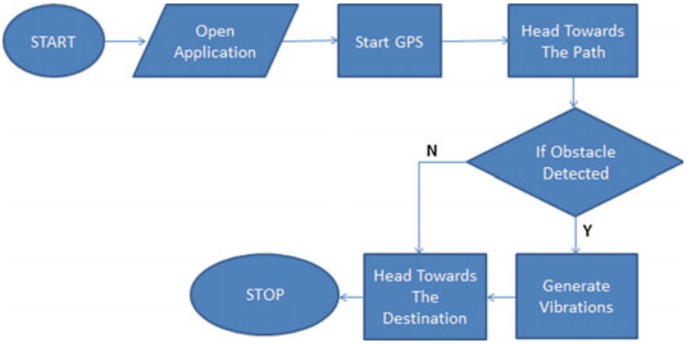

Fig. 2 Flowchart for a blind person

sensors. Now, the next step is to walk on a desired path and mark the obstacles as shown in Fig. 7. This process continues till the source reaches to its destination. Similarly, Fig. 2 shows the flow for physically impaired person. The same process is taken into consideration except that now there is no need of marking the obstacles as co-ordinates are fixed. As a result, whenever the user is in the obstacle range, the device will vibrate and hence the user can follow the proper path to reach the destination.

4 Experimental Results

We conduct our experiment in the area shown in Figs. 3, 4, 5, and 6.

5 Implementation

The application was tested using MicromaxA210 smart phone. The outdoor navigation smart phone application processed the sensor data from accelerometer, proximity sensor, and ambient light sensor which is inbuilt in the above-mentioned device used. During the prototype phase of the experiment, a user is asked to follow a particular path, from a source position to multiple known destinations. The first obstacle encountered by the user was a barricade. As soon as the latter came across the obstacle, the device vibrated thus alerting him. This way, the user can avoid that particular obstacle and move forward along the scheduled path (Fig. 7).

Figure 8 describes the user taking a turn while entering into the mess premises. Now, the final obstacle that the user comes across is a staircase. The device vibrates to inform the user about the hindrance.

Fig. 3 Hostel–mess

Fig. 4 Barricade as obstacle

Fig. 5 Mess area

Fig. 6 Stairs as obstacle

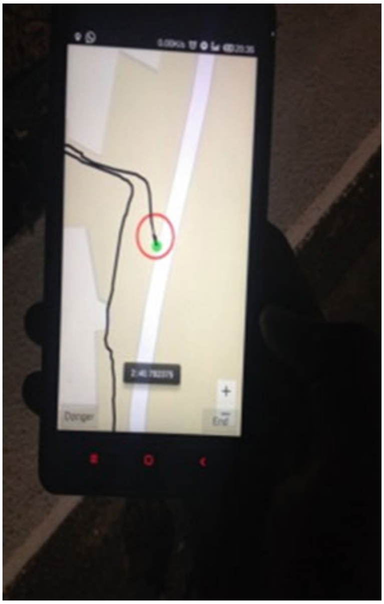

Fig. 7 Obstacle 1

Fig. 8 Obstacle 2

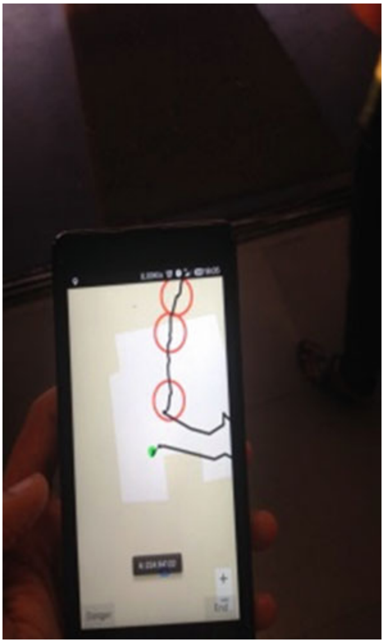

Fig. 9 Obstacle 3

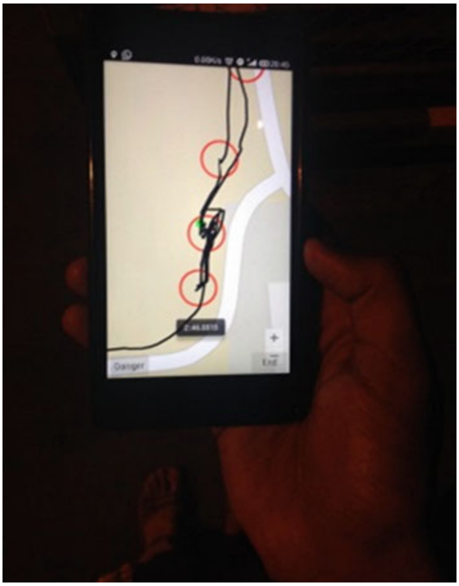

Fig. 10 Obstacle 4

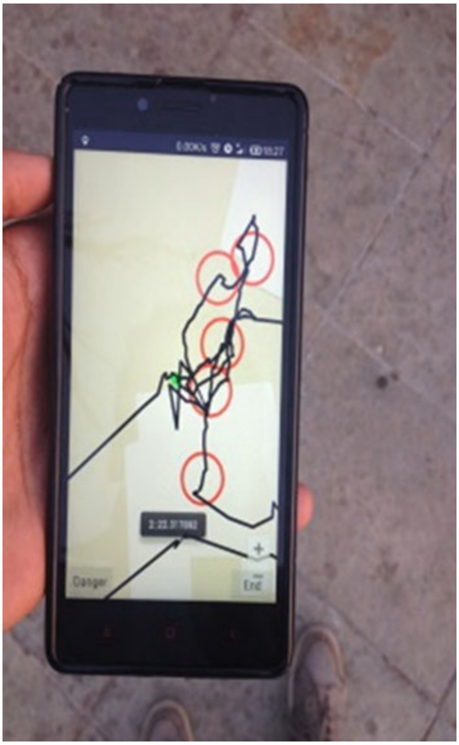

Figure 9 describes the entire premises of the campus (Hostel–Mess, Mess–College) and vice versa. The obstacles present through the scheduled path are marked by red circles as shown in Fig. 10. So as to check the accuracy in various conditions of the pathway, multiple readings were compiled and are presented in a nutshell.

6 Conclusion

In this paper, we provide some initial experiments using dead reckoning-based SLAM algorithm. We have tested on an android phone for outdoor navigation. The developed application can track the path and setup points where there are stationary obstacles and alert the user successfully. This could be a good use case for a blind person to alert him about fixed obstacles. So far, this application works statically, so our next task is to make it work on run-time basis as well. This can be done through mounting the sensors which should be integrated from exterior. In addition to this, we can also replace alert from vibration mode to audio signals which will assist the blind persons to follow the appropriate path.

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