METHOD FOR IMPROVING ACCURACY OF MOBILE AR NAVIGATORS

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Abstract: *The development of augmented reality (AR) technologies and the capabilities of modern mobile devices has led to the emergence of a new class of AR mobile navigation systems. One of the basic requirement of such applications is device localization and precise mapping of the route and other visual objects to observed environment, which requires high accuracy of positioning and orientation.*

This paper addresses the problem of localization precision in AR navigators and proposes general concept of improving accuracy of basic GPS-based methods by augmenting them with local device information about its position. Some algorithms and experimental results are provided to demonstrate benefits of the proposed method.

Keywords: AR NAVIGATION, AUGMENTED REALITY

1. Introduction

Basic GPS navigator is essential application for is available in almost every modern pocket gadget. However, there are scenarios in which the quality (accuracy) of GPS-based systems is insufficient. Depending on the manufacturer and model of the smartphone, its built-in GPS module under certain circumstances can determine the position with an error in 5 to 50m range, which is actually not enough for city navigation especially in AR solutions.

The most common and easiest way of positioning is to navigate solely based on GPS coordinates. However, this method has rather low accuracy and cannot satisfy minimum requirements of AR navigators especially for precise mapping of routes to video from camera in real-time. The following approaches are available to minimize positioning errors [1]:

1. Using recursive filters or probabilistic algorithms, i.e. Kalman filtering, based on processing sequences of noisy or uncertain measurements over time in order to enhance them to statistically optimal values.
2. Alternative positioning methods based on Wi-Fi, Bluetooth or radio frequency (RF) localization. The main idea is to determine current coordinates as a superposition of signals from the Wi-Fi/Bluetooth/RF beacons. These methods demonstrate good results in indoor and special scenarios with homogeneous networks, high quality signal and little noise. However, in outdoor scenarios they usually perform worse compared to enchanted GPS-based algorithms.
3. Augmenting GPS-data with extra sources of information available in mobile devices.

Advanced sensor systems of modern smartphones provide information about local displacements including changes of orientation and acceleration. This data adds extra degrees of freedom to positioning systems and can be used to increase localization accuracy. It is important to notice that output values of embedded gyroscope, accelerometer, magnetometer and other sensory devices have their own errors [2] that should be taken into account.

Moreover, AR applications use embedded camera enabling video-based simultaneous localization and mapping. This challenging task especially in outdoor scenarios requires effective algorithms and high performance devices or network services to process real-time video stream but is very promising.

Some existing AR-navigators ask the user to adjust starting position or mapping manually by dragging and rotating initial visualization in order to reduce positioning errors. Manual tuning can be avoided by correction of local displacements in correspondence with horizontal and vertical surfaces of the real world observed by camera of a gadget. In this case, local displacements can be determined by comparing images at different points in time [3]. This functionality is already available in Apple ARKit and Goggle ARCore services [4]. As the navigation speed increases, an object tracker [5] should complement image recognition from the camera.

2. Proposed method of positioning enhancement

Proposed method (Figure 1) utilizes both concepts. Video-based localization contributes to local displacement accuracy. In addition, evaluation of coordinates of the device on each step consider both global positioning data and local displacements:

$$POS_{i+1} = LOC_i + (GPS_{i+1} - LOC_i)*BIAS$$

where POS_i, GPS_i, LOC_i - are actual, GPS and local coordinates respectively. If video-based localization (AR) is used it is included in *LOC.*

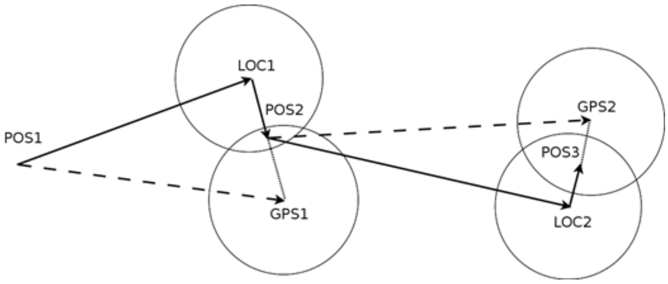

Fig. 1. ***Visualization of the described algorithm of refined positioning***

Variable *BIAS* describes the distribution of confidence between data from GPS module and local devices and determines relational reliability of each source:

$$BIAS = R_{LOC} / (R_{LOC} + R_{GPS})$$

where R_{GPS}, R_{LOC} - are confidence radii of GPS and local positioning respectively. Adjusting the value of the BIAS parameter to proper values depending on environment and device parameters allows to increase resulting accurace and makes the algorithm more flexible.

This general method is implemented in developed AR-navigator as SIMPLE and LERP algorithms [1], where LERP algorithm additionally corrects rotation angle of local coordinate system on each step.

AR navigation system

AR navigation application was developed for testing proposed algorithms. Visual appearance is presented on Figure 2. Target platform – iOS 12, development framework – d C# 6.0, .NetFramework 4.7.1, platform – Unity v.2018.2.12, xCode v.10.1. Apple ARKit was used to improve local displacements and map routes on real-time video stream from camera. Mapbox toolkit was used for 3D map visualization.

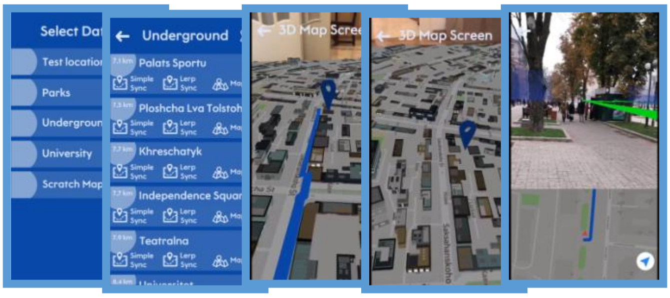

Fig. 2. ***Screens of developed solution***

Simulation results

Proposed solution was tested on iPhone 8 Plus smartphone in specially developed simulation mode allowing to study the impact of both typical embedded device errors and special cases with modified accuracies. Fig. 3 demonstrates algorithms visualization. Default GPS accuracy was around 20 m; gyroscope accuracy was close to 100%; accelerometer – around 80 compass – in range 95% –99%.

After running a series of over 200 simulations, we received following results: average deviation from actual coordinates for SIMPLE algorithm was 4,3m and 4m for LERP that is up to 50% more accurate compared to GPS. In most cases BIAS value around 0,4-0,5 provided best results making influence of local and global data equal. SIMPLE algorithm has higher tolerance to GPS errors but is more influenced by compass errors. In scenarios with compass accuracy close to 100%, SIMPLE algorithm outperforms LERP, but in all other cases, LERP shows better results.

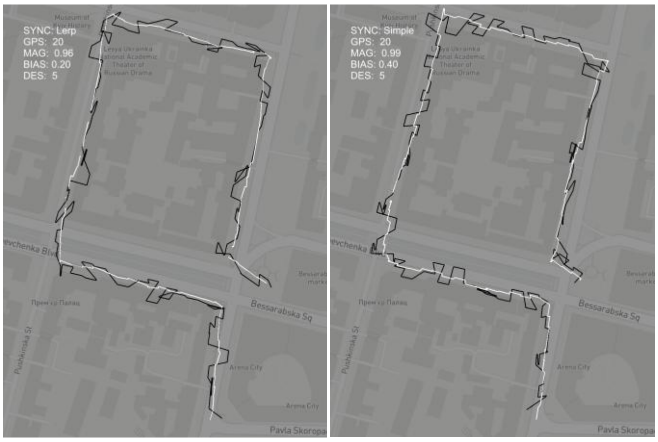

Fig. 3. ***Visual comparison of algorithms: dark trajectory - GPS coordinates, light – developed algorithms.***

Conclusions

The proposed method for augmenting classical GPS-based localization with additional data from local devices allows significant increase of positioning accuracy. Rather simple algorithms designed for typical smartphone demonstrate good results and are especially useful in AR scenarios. Application in mobile robotics[6] looks promising as well.

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