**Vision based indoor navigation system for Shopping complexes**

**Abstract**

Navigating in unknown big indoor environments with static 2D maps is a challenge, especially when time is a critical factor. In order to provide a mobile assistant, capable of supporting people while navigating in indoor locations, an accurate and reliable localization system is required in almost every corner of the building. We present a solution to this problem through a hybrid tracking system speciﬁcally designed for complex indoor spaces, which runs on mobile devices like smartphones or tablets**.**

The developed algorithm only uses the available sensors built into standard mobile devices. State-of-the-art indoor tracking approaches use mainly radio-frequency signals like Wi-Fi or Bluetooth for localizing a user. In contrast to these approaches, themainadvantageofthedevelopedsystemisthecapabilityofdeliveringacontinuous3Dposition and orientation of the mobile device with centimeter accuracy. This makes it usable for localization and 3D augmentation purposes, e.g. navigation tasks or location-based information visualization

**Introduction**

Specially in big indoor environments such as shopping malls, people are usually not familiar with the ﬂoor plan of the building and ﬁnd it therefore difﬁcult to get to a desired destination in time. For a mobile assistant, capable of supporting people while navigating in indoor locations, an accurate and reliable position of the user is required in almost every corner of the building. For a cell assistant, succesful on supporting humans while navigating in indoor locations, to provide a herbal navigation experience a virtual navigation application, which is augmenting the actual world video move together with location-based visual facts would stand at all helpful. For exhibiting location-based records or the unerring wrap on the cell dignity an exact place (position yet orientation) must stay computed in real-time over a mobile device. This enables the provision after guide position-dependent augmented fact (AR) capabilities no longer only for navigation however additionally because of games, 3D review or education.

Global Positioning System (GPS) is oft back among out of doors scenarios, but does now not labor reliably indoors. Competing state of the art indoor localization processes uses and known as beacons, which are devices distributed all over the building that broadcast a unique identiﬁer. This technology, generally primarily based on Bluetooth yet sordid radio frequency (RF) technologies, only operates at a brief distance and needs a complex infrastructure. Localization via Wi-Fi requires adense network of access points, which leads to excessive renovation costs, but solely affords positional truth on 1–3 m including solely iii tiers over freedom.

This paper presents the design and the development of a full mapping, tracking and visualization pipeline for large indoor environments. In a ﬁrst stage clearly recognizable area like advertisements, company logos or posters are used as visual descriptors for detecting the initial position and for continuous tracking. The second level of the hybrid solution is using an adapted visual simultaneous localization and mapping (SLAM) algorithm to achieve continuous tracking in almost all areas of the environment if none of the afore mentioned descriptors is available

**Background and Related works**

1.Simultaneous Localization and Mapping

The SLAM mapping process tries to extract spatial information (signal strength, 3D points ... ) of the real world environment in order to store it in a global reference map while at the same time keeping track of the agent’s position. When using smartphones as a base platform [1] low computational power, limited battery life and low-quality sensors pose additional requirements on a SLAM algorithm. There are already different approaches and a broad number of concepts based on different hardware such as Bluetooth, Wi-Fi or visual features. All of these technologies can be used for implementing a SLAM system for localization.

1.1. Wi-Fi SLAM

Wi-Fi SLAM is frequently used for localization since many buildings are already equipped with numerous access points. For the mapping process the mobile device has to be moved through the whole environment in order to periodically measure the signal strength of all surrounding access points. The accuracy that can be achieved with Wi-Fi SLAM is below one meter in the best case.

Some researchers have combined Wi-Fi with Bluetooth beacons in order to improve the accuracy in interesting areas. In any of these cases, the result of the tracking is a 2D position in a 2D map.

1.2. Vision-Based SLAM

Vision-based SLAM algorithms relying on point features are able to estimate a position as well as an orientation of a stereo setup. Spatial information in terms of point features like the Scale In variant Feature Transform (SIFT), the Features from Accelerated Segment Test (FAST) , the Oriented FAST and Rotated BRIEF(ORB),etc. is extracted from sequent frames in order to simulate stereovision. The baseline between two frames has to be high enough in order to estimate the distance of the features [9]. This data is stored in a global map representation. Over time, a certain area can be mapped and used for tracking.

2.Marker-Based Tracking

Another possibility of creating a visual indoor localization system was developed by Wagner et al. They presented a solution based on ﬁducial markers, which were manually placed in an indoor environment.

3. Complementary Tracking Technologies

Beacons are small devices, which are distributed in the tracking area with high density. These beacons can use different signals in order to be detected by mobile devices. Usually Bluetooth, Wi-Fi or even a combination of multiple signals is used in order to estimate the approximate position of the user’s device. The accuracy depends on the amount of devices spread over the environment.

**Advantages and challenges**

**Advantages**

First, it only relies on a camera (and thus only has requirements in the visual domain) and suﬃcient processing power, which is both given in up-to-date smartphones

vision-based localization can be combined with inertial sensors [1] such as accelerometers, which are likewise built into state-of-the art phones

It reduces costs and is feasible in arbitrary surroundings. Augmentation (e.g. with beacons) is not possible everywhere due to constructional challenging environments, energy consumption (power supply is not given everywhere), vandalism, costs or legal problems. Moreover, vision-based localization is suited, in principle, for indoor and outdoor environments and a seamless transition between them.

**Challengers**

First, it requires reference data, i.e. the environment must be known in order to localize the device within the environment. Reference images must be gathered in the ﬁrst place and the exact location must be assigned to each image. Since the environment could be subject to change (e.g. when shop window displays, adverts or posters are replaced), a way to update the reference material must be foreseen. This can be done centralized or in a collaborative approach, where query material is tagged with a location manually by users and eventually becomes part of the new reference dataset.

A second challenge is the quality and distinctiveness of the query images, which impact the location estimate

vision-based localization requires the camera to point at ‘interesting’ regions in the environment. The ideal pose therefore would be as if taking a photo. Permanently maintaining this pose is inconvenient for the user. We thus need to ensure that location accuracy remains suﬃcient for providing correct navigation instructions

**Evaluation**

**Research questions**

1. Which concept (AR or VR) is preferable in terms of perceived accuracy?
2. Which concept (AR or VR) is preferred by users?
3. What information should be presented?
4. Which visualizations could be appropriate to acquire suﬃcient visual features?
5. Can object highlighting be improved with a soft border visualization?

**Research methods and Approaches**

Envisaging an iterative design process, we wanted to collect feedback from a large number of users before we will implement our proposed concepts or revise them according to our ﬁndings. The evaluation was conducted based on mock-up images and videos, illustrating the operation of the system, and a corresponding online questionnaire**.**

**Participants**

Participants were recruited using the Mobile works in shopping complexes, aged between 18 and 59 years (average age: 28, standard deviation = 8.7), participated in the study; 39 thereof were female, 42 were male.

**Discussion**

Our proposed navigation interface concepts, Augmented Reality and Virtual Reality, show their strengths in diﬀerent domains. In case of incorrect location and orientation estimates, VR was perceived as more reliable, since it was less inﬂuenced by inaccuracies.

We believe that a combination of AR and VR is indeed adequate for indoor navigation, and for the particularities of vision-based localization