A Distributed and Collaborative vSLAM Framework for Real-Time Localisation in Huge Environments for Mobile Devices

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Abstract

This poster proposes a collaborative vSLAM system for mobile Augmented Reality applications in huge environments. The system combines the efficiency of local vSLAM methods with the accuracy of large-scale mapping techniques. In order to overcome the efficiency problems of large-scale algorithms,a distributed architecture in the Cloud that keeps the consistency of the map is proposed. To achieve it, the data coming from multi-user local vSLAM algorithms is fused with the large-scale map stored in the Cloud.

Categories and Subject Descriptors (according to ACM CCS): I.3.0 [Computer Graphics]: General—

1. Introduction

Augmented Reality for mobile devices is becoming very popular thanks to the emergence of the new generations of smart phones. These applications show to users geolocated information overlaid with the images that the camera captures. In general, the information shown consists of 2D tags taken from public databases. Information is overlaid using the position and orientation information given by the GPS, compass and accelerometers of the device. However, the accuracy of the readings of these sensors is not enough to insert 3D content properly aligned with images.

Nevertheless, having some 3D knowledge of the environment allows applying computer vision algorithms that can accurately estimate the position and the orientation of the device. With this regard visual SLAM (vSLAM) [DRMS07] has shown to be a very precise localisation technique, especially in unknown environments. This technique recursively builds a map as the device explores new areas. The main problem of these maps is that they need to be extended and continuously updated. Although this problem has been widely studied in small and controlled scenarios, the process of upkeeping and extending a map in large outdoor environments is very complex.

Considering the mentioned problem, a new localisation system in which users act as data supplier is being evaluated. Our approach proposes a local vSLAM system that uses a low precision but efficient map to perform the localisation in real-time. In parallel this map is used to extend the large-scale one in the Cloud by means of accurate 3D reconstruction techniques. This method opens new research lines in the field of collaborative vSLAM where many users can contribute simultaneously in the building process of the huge map.

Hence, the main goal of the research that is introduced in this poster is to perform outdoor localisation of mobile devices using a real time dense 3D reconstruction based on collaborative vSLAM.

2. Related Work

vSLAM techniques are used by many applications, like robot navigation, augmented reality or driver-less cars. The main challenge of the large-scale vSLAM techniques is scalability and loop closure. Strasdat [SDMK11] suggested an optimization algorithm that combines pose-point constraints in the local area of the current pose with frame-frame constraints in the periphery.

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On the other hand, the use of vSLAM techniques in mobile devices has been succesfully addressed in reduced and controlled workspaces in works like [KM09].

Some recent works like [ZT13] have already proposed collaborative vSLAM as the solution to highly dynamic scenarios using multiple cameras that are mounted and moved independently. Each camera generates individual maps that are merged in a large one that is used to detect moving objects.

3. Proposed Method

Based on the results obtained in [SDMK11] the system proposed in this research is divided into two main parts. On the one hand, vSLAM is applied locally to small environments. On the other hand, the map obtained locally is used to extend and update the map in the Cloud using dense 3D reconstruction techniques. This accurate map is recursively used to update the local maps. For the initial map multi-view reconstruction techniques are used [HZ04] . The Figure 1 shows the overview of proposed system.

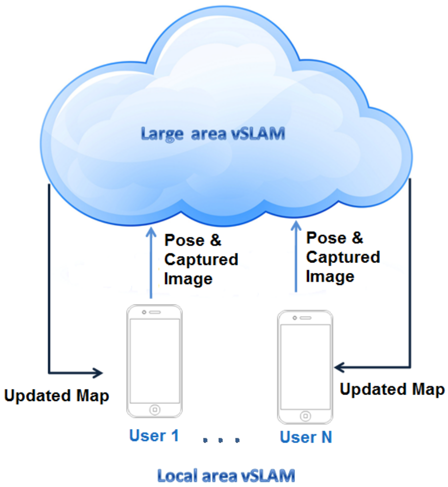

Figure 1: *Proposed System*

3.1. Local Area vSLAM

This part of the localisation process is executed in the mobile device, i.e. in small and controlled environments.

The map stored in the Cloud is used as the initial reconstruction. Then as in [KM09] the strategy is focused in the application of Bundle Adjustment (BA) algorithm [TMHF00] only to a set of input frames or *keyframes*. Within this framework the pose and the structure are recursively updated with every new *keyframe*.

At the same time, each *keyframe* k_t is sent to the Cloud with its corresponding pose information that is used by large area strategy.

3.2. Large Area vSLAM

In this part of the system, the collaborative vSLAM concept and the roll of users acting like data providers arise.

As real-time response is not needed in this stage, more accurate mapping algorithms can be used. In this way dense 3D reconstruction methods are used to extend the huge map similar to *Building Rome in a Day* [ASS*09] in which the 3D reconstruction of the city was done using a large collection of photographs that were found on Internet photo sharing sites.

Taking into account that the Cloud uses images and poses coming at the same time from different sources new synchronization and coherence problems have to be solved.

As the map is updated at the Cloud, it is sent back to the mobile devices improving their local maps. So, we are talking about a feedback system.

4. Conclusions

This poster presents a novel collaborative vSLAM system for mobile devices. In this system the efficiency of local vSLAM methods is combined with the accuracy of large-scale mapping techniques. In comparison with [SDMK11] that is focused in relative large environments, the algorithm presented in this work can handle huge areas like entire cities. In addition, while the algorithm presented in this poster aims at running in mobile devices, the work presented by Strasdat uses a desktop computer with much more computational power.

In conclusion, this research line poses very ambitious challenges that suppose an important contribution to the field of augmented reality.

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