3D Real-Time Reconstruction using the Cloud

L. Riazuelo, J. Civera, J. M. M. Montiel

RoPeRT (Robotics, Perception and Real Time Group).
Instituto de Investigación en Ingeniería de Aragón (I3A).
Universidadde Zaragoza, Mariano Esquillor s/n, 50018, Zaragoza, Spain.
Tel. +34-976762707, Fax +34-976762043, e-mail: riazuelo@unizar.es

Abstract

This work presents a 3D real-time reconstruction based on a visual SLAM (Simultaneous Localization and Mapping) approach using a RGBD camera. The proposed system aims to create a 3D model of an environment using a low-power computer and Amazon EC2 (Elastic Compute Cloud) server for computation offloading.

Introduction

Cloud computing is an emerging technology in the last years. The ability to use this technology in robotics opens a new line of reseach called Cloud Robotics [1]. This approach to robotics allows robots to benefit from the massively computational and storage resources of cloud data centers. In addition, the increment of network bandwidth will reduce the transport delays and hence make possible the computation offloading.

During the last years some robotic frameworks had addressed the cloud computing paradigm. Rapyuta [2] presents an open source platforms-as-a-Service (PaaS) cloud framework for robotics applications that enables to offload heavy computation in the cloud. The DAvinCi project [3] proposes a frameworks based on Hadoop cluster with ROS (Robotic Operating System) that provides the scalability and parallelism advantages of cloud computing.

Regarding the 3D reconstruction field, the incipient development of new low-cost sensors, such as Microsoft Kinect or Asus Xtion, has led to the development of new tools to build 3D models of the environment. These sensors are capable of adding the depth information of a scene together with the RGB image that the camera provides. Thus, the sensor provides complete information of the environment. Several approaches like Kinect Fusion, RGBDSlam, C^{2}TAM [4] have been developed in the last years. The goal of theses applications is to provide a continuous localization of the camera sensor while a 3D map of the environment is built. In particular, C^{2}TAM provides a distributed framework for cooperative tracking and mapping.

System overview

The presented work in based on an open source technology developed under the European project Roboearth [5]. Figure 1 shows a scheme of the 3D reconstruction method presented. The system is mainly composed by 3 pieces: a tracking client, a map builder server and a 3D visualizer. For the visual slam implementation we have used the C^{2}TAM framework, developed by the author of this contribution. As we mention before this framework has been developed for a distributed execution an fits very well with the cloud approach. For the execution of a component in a cloud server we use the Rapyutaframework that enables the execution of a software component in a cloud server. In this work, we use Amazon EC2 [6] servers for computing offloading.

Client-side

The tracking component provides a continuously localization of the camera position estimating its position using local descriptors based on salient FAST features on the camera image and the map provided by the server after the optimization in the cloud. Tracking component works at 30 fps and itis placed on the local computer (see figure 1) where the camera is pluged. The tracking is a light-power process that can be run on a low-power computer, in our case a laptop.It is in charge of select the keyframes of the video stream that will be sent to the server in order to build the map. It is essential to correctly choose the frequency in which these frames are sended to the server because the system must to take into account the network bandwidth and deal with the network delay to avoid a bad performance of the system.

Server-side

The mapping component creates a 3D model of the environment using the data provided by the tracking client (a collection of several keyframes composed by a RGB image and depth information). As we can see on figure 1, the mapping component runs on an Amazon EC2 server. Rapyuta Cloud Engine provides the execution ofthis component in a cloud server. The estimation of the 3D map is the most demanding computation of this approach because it requires an optimization process. Due to this process does not require a strong real-time constraints it can be executed in the cloud.

3D model visualizer

The visualizerprovides a real-time representation of the 3D model of the environment that is being built and the location of the camera (see figure 2 for a real experiment visualization). The main advantage of this component is that is able to run both the server side and the client, minimizing data traffic in the network to reduce the bandwidth consumed.

Experimental results

On this section we present a 3D reconstruction of a real environment using the proposed system. We use a Microsoft Kinect camera that provides RGBD images with a resolution of 640x480 at a frequency of 30Hz, a low-power laptop (AMD Fusion, Asus EeePC 1600.0 MHz) and a Amazon EC2 instance (m1.medium, Intel Xeon). According to the schema proposed on the figure 1, the tracking process is allocated on the laptop and the map builder runs in the cloud server. For communication issues we use a standard wireless network.

We perform a real time map of a hospital room (see figure 2 left). The tracking estimates continuously the position of the camera during the experiment and the mapping process builds a map using the keyframes. As a result, figure 3 right shows the 3D model of this environment generated. A video of the full experiment, and the 3D model generated can be found at [7].

Conclusions

This contribution presents a 3D reconstruction of an environment using a low-power computer. We believe that this result opens a new research line in the field of low-cost devices and computation offloading. Using a cloud server for allocating the most expensive tasks, enables the execution 3D reconstruction in real time.

References

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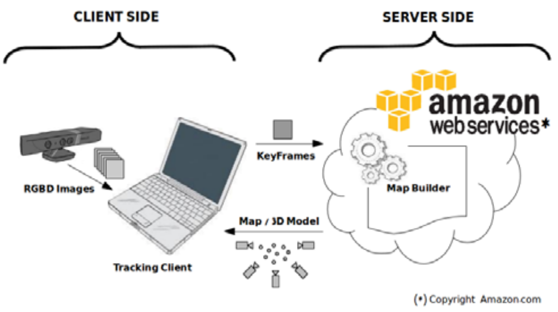

Figure 1: System overview of the proposed method.

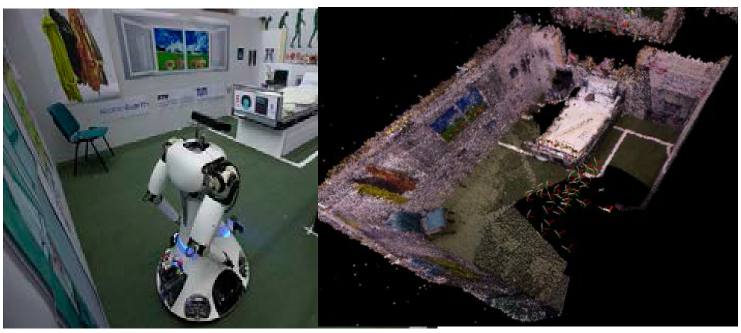

Figure 2: Experimental environment and 3D reconstruction.