Chapter 97
Cloud Robotics:
Robot Rides on the Cloud – Architecture, Applications, and Challenges

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ABSTRACT

Cloud robotics is an emerging field which enables the web enabled robots to access the cloud services on the fly. Cloud Robotics was born by merging robotics with the cloud technologies. The robot intelligence is no more in the robot itself but remotely executed on the cloud. Robot acts as thin-client. There are several frameworks already in development and still growing. With the help of high speed networks using 4G/5G technologies, offloading of computation and storage in cloud is the further step in robotic evolution. This chapter deals the exploration of cloud robotics with its architecture, applications and existing frameworks. Also, existing research carried out is summarized in this chapter. The future challenges are discussed to foresee the opportunities in cloud robotics. It aims for the complete study on how robots leverages the cloud computing.

INTRODUCTION

Cloud offers on-demand services to the pooled users and devices. These services may range from Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). All these services are hosted in the cloud provider's servers and instances are launched in the client devices when they are in need of those services (Saravanan, K., & Rajaram, M. 2015). The key benefits of cloud computing is listed below: Quick deployment and integration of services which help the consumer's business agility. It allows setup a virtual office anywhere and anytime without investing hard infrastructure requirements. In the present competent IT industry environment, it is inevitable to focus on cost-cutting technologies in procurement and maintenance of expensive systems. Thus, adapting to cloud services reduces the operation costs and the maintenance costs in an effective way. Cloud is emerged from its predecessor models such as grid computing, Web 2.0, distributed and pervasive computing, virtualization and many more. It is fine-grained to current trends of business and technology evolvement.

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Cloud services can be paid only for how much they consume and when they consume, which in fact reduces the carbon footprint, thus make it environmental-friendly for giant IT industries. Scalable in nature, cloud storage can be stretched to any level depending on the business requirement. Cloud suits well for the volatile trends (peak vs. low) in trading. Cloud adopts multi-tenant model through which the provider's physical resources are sliced into virtual machines that can be assigned to multiple consumers through virtualization. Effective utilization of resources helps the cloud providers to achieve economies of scale.

Today, robotics plays important roles to automate and to perform the day-to-day activities of the human. Robots are equipped with lot of sensors and decision making capabilities to complete the jobs in efficient manner. With the advent of sophisticated technologies, these robotic controls provides more number of services such as Global Position System (GPS), Thermal and atmospheric sensors, bio-metric sensors for identification and security, semantic natural language processing, analytical services, artificial intelligence and so on. The in-built memory in robots can store and process these data, which will make the robots as a large carrying unit apart from the external devices attached to it.

To overcome these issues, cloud computing offers on-demand services to robotic devices thus make robot as a light-weight smart device. Cloud Robotics is a subset and emerging field in robotics that deals with the cloud services used in robots (Kamei, K., Nishio, S., Hagita, N., & Sato, M. 2012). Not only getting the services from the cloud, but these robots also shares the data in the cloud, which is helpful for other robots using the cloud services. For example, consider the scenario of robots employed in medical assistance. They can upload the processed medical knowledge into the cloud for the use of similar robots. Cloud enables synergy among the robots for sharing and accessing the knowledge and services. i.e., cloud enabled robots can perceive, understand, share and react.

Cloud robotics aims for placing the intelligence in the cloud and simplified robotics on the ground. When the computing task is offloaded to the high computing performance cloud systems, the computational load of robots is reduced to a great extent (Wan, J., Tang, S., & Yan, H., 2016). Without the cloud connected network, each new robot introduced to the system has to duplicate again the experiences and learning of its predecessors on their own, which makes the system inefficient. But when the robots are interconnected in cloud space, learning can be reused.

The benefits of using the cloud in robotics are identified: 1) Big Data: access to updated streaming data in diversified forms such as images, audio/video, text, maps, and object/product data, 2) Cloud Computing: access to computational and storage services on demand for knowledge accumulation &real time analysis, experience sharing, and location tracking in motion, 3) Collective Learning: robots can share their knowledge, behavior outcomes and learned skills on trajectories, control policies and sensory outputs to the peer robots, 4) Human Computation: use of crowd sourcing to tap human skills for analyzing images and video, classification, learning, and error recovery (Wikipedia,2016). Cloud Robot can be broadly defined (Kehoe, B., Patil, S., Abbeel, P., & Goldberg, K. 2015) as follows: "Any robot or automation system that relies on either data or code from a network to support its operation, i.e., where not all sensing, computation, and memory is integrated into a single standalone system". The motivation behind cloud robotics is summarized as below:

Off-the-shelf software and hardware provides low-cost, affordable robot, thus increases the usage of robots in different fields. Scalable in terms of computation and memory of the robots. Also, no need for maintenance and up gradation required on individual robots since it can be managed by cloud. Shared knowledge among robots improves the efficiency of the tasks completion and decision making. Energy saving which leads to long battery life of the robots. Cloud makes robot as light-weighted smart device.