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A Study on Cloud Robotics and Automation

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Abstract: Robotic systems have made their impact on human life in unexpected ways. Earlier robotics systems were thought as units which work independently of each other then came the idea of connecting them through a network. Later it has been identified that rather than connecting the robots through a network it will be more powerful when they are connected through the Cloud. With this the learning from one robot can be processed remotely and mixed with information from other robots. Since the cloud can have all the computation and memory stored remotely, all of the endpoints can be lightweight, and there is a huge collective benefit. These robots can address billions of behaviors and learn how to do important things quickly. This study aims at learning the architecture of cloud robotics and the potential benefits of the Cloud offered to the cloud robotics. The paper also discusses the challenges and direction of future work in the field of cloud robotics.

Keywords: Robotics, network, Cloud, automation.

I. INTRODUCTION

Robotic systems have brought significant changes to human lives over the past few decades. For example to do tedious, repetitive, or dangerous tasks, such as assembly, painting, packaging, and welding in factories, industrial robots have been widely deployed. These robots have been very successful in industrial applications due to their high speed, and precision in structured factory environments.

To extend the functional range of robots or to deploy them in unstructured environments, robotic technologies are integrated with network technologies to foster the emergence of networked robotics. A networked robotic system refers to a group of robotic devices that are connected via a wired and/or wireless communication network. Networked robotics applications can be classified as either teleoperated robots or multi-robot systems. In the former case, a human operator controls or manipulates a robot at a distance by sending commands and receiving measurements via the communication network. Application examples include remote control of a planetary rover and remote medical surgery. In the latter case, a team of networked robots complete a task cooperatively in a distributed fashion by exchanging sensing data and information via the communication network. Examples include cooperative robot manipulators, a team of networked robots performing search and rescue missions, and a group of micro satellites working cooperatively in a desired formation. The National Institute of Standards and Technology (NIST) defines the Cloud as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable resources (e.g., servers, storage, networks, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". An example for cloud is the online word processing capabilities offered by Google Docs. Google Docs allows documents to be shared and modified online. Here the document and software does not reside locally. The data and code is stored in the Cloud using remote servers with shared processors and memory. The Cloud also provides economies of scale and facilitates sharing of data across applications and users. Networked robotics faces inherent physical constraints as all computations are conducted onboard the robots, which have limited computing capabilities. Information access is also restricted to the collective storage of the network. With the rapid advancement of wireless communications and recent innovations in cloud computing technologies, some of these constraints can be overcome through the concept of cloud robotics, leading to more intelligent, efficient and yet cheaper robotic networks. Networked robotics distributes the workload of sensing, actuating, communication, and computation among a group of participating robots. Cloud Robot and Automation systems can be broadly defined 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". Cloud Robot and Automation systems often include some capacity for local processing for low-latency responses and during periods where network access is unavailable or unreliable. The Google self-driving car exemplifies the idea. It indexes maps and images collected and updated by satellite, Streetview, and crowdsourcing from the Cloud to facilitate accurate localization. Another example is the Kiva Systems pallet robot for warehouse logistics. These robots communicate wirelessly with a local central server to coordinate routing and share updates on detected changes in the environment.

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II. ARCHITECTURE OF CLOUD ROBOTICS

According to Guoqiang Hu, Wee Peng Tay, and Yonggang Wen the architecture of cloud robotics is organized into two complementary tiers: a machine-to-machine (M2M) level and a machine-to-cloud (M2C) level. On the M2M level, a group of robots communicate via wireless links to form a collaborative computing fabric (i.e., an ad-hoc cloud). The benefits of forming a collaborative computing fabric are multi-fold. First, the computing capability from individual robots can be pooled together to form a virtual ad-hoc cloud infrastructure. Second, among the collaborative computing units, information can be exchanged for collaborative decision making in various robot-related applications. Finally, it allows robots that are not within communication range of a cloud access point to access information stored in the cloud infrastructure or send computational requests to the cloud. On the M2C level, the infrastructure cloud provides a pool of shared computation and storage resources that can be allocated elastically for real-time demand.

III.BENEFITS FROM THE CLOUD FOR THE CLOUD ROBOTICS

According to Ben Kehoe, Sachin Patil, Pieter Abbeel, and Ken Goldberg the potential benefits of Cloud include 1. Big Data: access to remote libraries of images, maps, trajectories, and object data; 2) Cloud Computing: access to parallel grid computing on demand for statistical analysis, learning, and motion planning; 3) Collective Robot Learning: robots sharing trajectories, control policies, and outcomes; and 4) Human computation: using crowd sourcing access to remote human expertise for analyzing images, classification, learning, and error recovery.

Big Data:- Big data describes data that exceeds the processing capacity of conventional database systems, including images, video, maps, real-time network and financial transactions, and vast networks of sensors.
Cloud Computing: -Cloud Computing has potential to speed up many computationally- intensive robotics and automation systems applications such as robot navigation.
Collective Robot Learning:- The Cloud facilitates sharing of data for robot learning by collecting data from many instances of physical trials and environments. For example, robots and automation systems can share initial and desired conditions, associated control policies and trajectories, and importantly: data on the resulting performance and outcomes.
Human computation: crowd sourcing and call centers: Human skill, experience, and intuition is being tapped to solve a number of problems such as image labeling for computer vision, learning associations between object labels and locations, and gathering data. In future there can be systems where errors and exceptions are detected by robots and automation systems which then contact humans at remote call centers for guidance.

IV. CHALLENGES IN CLOUD ROBOTICS AND AUTOMATION

Robotics and automation systems using the Cloud for better performance introduces many new challenges. The connectivity inherent in the Cloud raises a range of privacy and security concerns. These concerns include data generated by Cloud-connected robots and sensors, especially as they may include images or video or data from private homes or corporate trade secrets.
Another concern that Cloud Robotics and automation systems raise is the potential of robots and systems to be attacked remotely: a hacker could take over a robot and use it to disrupt functionality or cause damage.

V. CONCLUSION

New algorithms and methods are required to cope with time-varying network latency and Quality-of-Service. Nowadays with faster data connections, both wired Internet connections and wireless standards the problem of latency is solved up to an extent. But algorithms must be designed for the graceful degradation when the Cloud resources are very slow, noisy, or unavailable. The Big data often contains unwanted data that needs to be filtered out effectively. So the new algorithms are needed to scale to the size of big data. When the Cloud is used for parallel-processing, the failure of some remote processors or their delay in returning the result also needs to be handled.

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