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Cloud Robotics: An Evolving Research Field

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Abstract:

There are several sectors, applications and disciplines where the robotic system technology is used such as hospitals, airport defense sectors, hotels etc. The infrastructure of cloud and the extensive set of accessible internet resources which has a potential to provide important benefits to robots and automation system. The robot and automation system depends on the data or code provided from a network to support their operation. This paper discusses about the four benefits of the cloud which are big data, cloud computing, collective robot learning and human computation. This system of cloud can improve the robots and automation system that provides access to a data base publication, models, open competition for designs and systems and the open source software.

Keywords: *Cloud Computing, Automation system, Cloud Robotic system*

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Introduction

As the research on Robotics has completed a long way since the engineers and scientists demonstrated one of the type of human that looks like robot in 1939 and 1940.The weight of robot is approximately 265 pounds and seven feet in height and named it Elektro. Elektro has the ability to walk using commands of voice, speaks about 700 words and move his arm and head. The process of Robotics is majorly affecting or impacting the human lives for example, Robot manipulators in industrial robots are deploying in factories to do monotonous or hazardous tasks such as painting, packaging and welding. In Industries, preprogrammed robots have been successful because of their high strength, speed and accuracy in the surroundings of structured factory. In unstructured environments, for the purpose to enlarge the robots functional range or to deploy them, the technologies of robots are integrated with network technologies (Hu, Tay and Wen, 2012). The cloud in Cloud Robotics has the possible potential to enhance a wide range of robots and automation system. According to National Institute of Standards and Technology (NIST), the cloud is defined as the "a model that enables ubiquitous, convenient and on demand network access to a configurable resources such as servers, storage, applications of network that is released rapidly with efforts of minimal management or service provide interaction".

As according to Patil and Goldberg 2014, the cloud robot and the automation system is defined as "Any kind of robot or automation system that depends on data or code generated from a network to supper its appropriate operation". This automation system includes the future systems, network teleoperation, and networked groups of mobile robots. Because of the network latency and variability in the quality of service, the cloud robot and automation systems sometimes also includes the ability of processing for low-latency responses.

In various sectors, fields and disciplines, robotics as a technology is used such as in hospitals, airport, historic places, defense and army sectors etc. (Bhardwaj and Saxena, 2016).The functions of three Robotic services are sensation , actuation and control. Intelligent artificial activities provide supports to robotic services through socially conscious behavior that should be interactive to support daily human activities (Miratabzadeh et al, 2016). A group of robotic devices that are connected with wired or wireless communication network is referred to networked robotic system.

Cloud Robotics

This technology produces models of new generation of robots in which some resources such as the computing power, memory and storage is provided by the data centers which are external for e.g., the Cloud. Most of the systems of robot are basically equipped with more and more sensing units to be increasing autonomously. Actually the cloud is ubiquitous and is accessible from everywhere. The operation starts on demand and according to the requests of robot, it also provides scale economies and data sharing across users and systems (Botta et al, 2017).

As stated by Dr. Kleinrock in 2000, the computer networks are still exists in infancy but as they grow up they become more sophisticated. Through these techniques the computer services that are based on the model of service provisioning has evolved and then dominated by two significant concepts of architecture. One of them is Service oriented architecture i.e., SOA and other is Cloud Computing. These services are expanded that includes more services as a part of their offerings and the whole computing industry has undergone a major transformation that makes services readily available on demand. Consumers are required to pay for all these services according to the usage in case they access these services.

Technologies of Cloud Computing

The process of cloud computing comprises of three important models as Software as a Service (SaaS), Platform as a Service (PaaS) and infrastructure as a Service (IaaS).The applications of software as a service (SaaS) are server over the entire network which therefore eliminates the requirement to install and run the application on the system, of user. The access is done remotely using a web browser and are managed from a centralized location. The most widely used SaaS application suit is Google Apps. PaaS refers to a platform of the computing system that is served beyond any infrastructure and it offers developers to get a system hold of every systems and environments that is required to complete the lifecycle of software whether it is developing, testing, deploying and web application hosting. IaaS provides the infrastructure that is required as a service.

The services of cloud computing are used to enhance capabilities of robot and these technologies provide number of advantages that can be useful for the purpose of determining composition and running robot services (Das, Saikiran and Ramana, 2016).

According to Henry Schaffer, X as a service (XaaS) includes cloud computing, when X can be denoted as anything for example,

- Hardware as a service (Haas)
- Communication as a service (Caas)
- Database as a service (Daas)
- Software as a service (Saas)
- Storage as a service (Saas)
- Cloud Functionality and the Robots' tasks

The robots have basically small computer architecture for the purpose of mobile that leads to insufficient capability of computing. The access of data is constrained to the distinct network storage. Some of the technologies such as wireless communication and cloud computing technologies helps in overcome all the restrictions by cloud robotics.

The tasks of robot are classified on the basis of types of cloud resources and some of the robots tasks are obstacle avoidance, vision processing, localization, path planning and mapping of environment. All the unnecessary and inefficient concerns can overcomes by the cloud environment that is done by paradigm shifting of computer resources. The tasks are categorized as follows,

- The resources of computing devices that is allocated for each agent.
- The resources of storage for the research activities of data analytic.
- The resources of network for swarm performing cooperative missions.

Proposed Software Architecture

The system of architecture comprises of three systems which are:

- Middleware subsystem which is the platform's main carrier.
- Background task subsystem includes the batch processing.
- Control subsystem is the platform's brain.

All the subsystems are ordered horizontally and the computation, storage and networking tasks are vertically processed.

As According to the Miratabzadeh et al, Implementation includes,

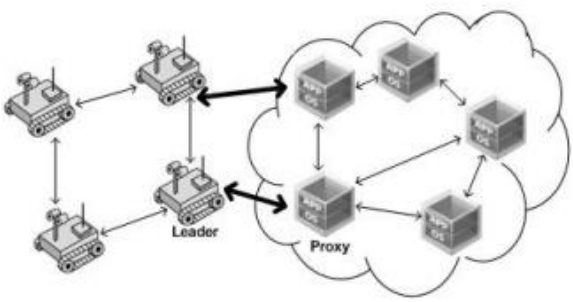
Connection of multiple agents - Robot Operating System (ROS) is basically an open source software for any type of robotic system that includes powerful packages that are accessible for free and legal for the purpose of usage. The used packages output the topics of data that pertains to the agents such as angular velocities, linear velocities and camera data, control topics. This developed data is then used to perform various tasks. Then the next is, connecting each agent to the cloud using ROS.

Cloud Seeding and Cloud Architecture

As stated by Chifamba 2015, in his paper "A study on Cloud Robotics", that the individual field robots have their own resources i.e., computer, memory and storage. All these factors extends the capacity to the cloud using a process called offloading. As according to the Guoqiang Hu et al, three architecture systems are proposed for the purpose of construction of a cloud robotics system that includes Proxy based Model, Peer based model and Clone based model.

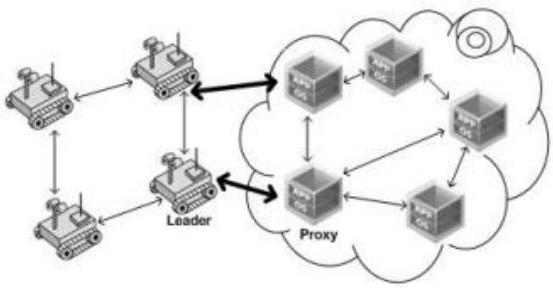
Proxy Based cloud Robotics model

In this process, a proxy is deployed that is directly communicated with a robot leader that forms a bridge between the cloud and the network of robot.



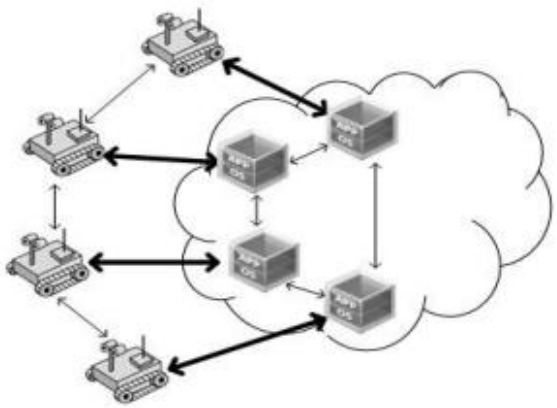
Peer Based Model

This is the connection that is a full mesh where the robot and systems made a network.



Clone Based Model

Each robot has a corresponding clone in the cloud system which has a greater relationship between each pair (Chifamba, 2015).



Network Construct for Cloud Seeding

Every robot has the ability to directly communicate with other utilizing standards such as WiFi, Zigbee and Bluetooth for the purpose of short ranges. There is a need for procedures that relies and adapts fast in the environment. The availability of high protocols having low latency and low communication load in the network that is considered as the network center.

There are some heddles and challenges in cloud seeding which are computational, communication, power, application and operational challenges that can be overcome using different techniques.

Review of Literature

Hu, Tay and Wen 2012 discussed in his paper about the Architecture, challenges and applications of cloud robotics. The communication protocols and various elastic models of computing are proposed to handle the different type of applications. The technical challenges in communication and computation are discusses in this paper.

Burski and Garbacz 2014 stated the use of cloud computing in mobile robotics and also explained about the capability of popular platform of cloud robotics. This paper also discusses about the short descriptions of a number having cloud based platforms that includes the DAvinCi project, Cloud Based Robot Grasping Project and RoboEarth. Kinect sensor and RoboEarth object recognition software are the simple tests which are performed in this paper.

Kehoe and Abbeel 2014, performed a survey of research on Cloud Robotics and Automation and stated that the systems of robots and automation that depends on data or code from a network that supports the operation. This survey is organized and having four potential benefits of the cloud which are big data, cloud computing, collective robot learning and human computation. 150 references are included in this survey that works on results and open challenges.

Chifamba 2015 studied on cloud computing: the Ad-Hoc Cloud that the researcher explores on how cloud seeing can be done properly which involves the security implications as well the networking concerns.

Koken 2015 described that the cloud system provides computation power that is unlimited, memory, and storage. These cloud enabled robots which are divided into two major classification as standalone and networked robots. The survey is performed in this article for cloud robotic platforms and on works of networked robotic.

Bhardwaj and Saxena 2016, discusses about the cloud robotics in which they identified the analog signal through cloud facilitating robots. This paper explained that how analog signals can facilitate robotics system and this approach somewhat not only allow machine to cloud communication (M2C) but also allows machine to machine communication (M2M).M2M performs task faster in different areas at the same time.

He et al. 2016 stated in his research paper about the cloud based real time multi robot collision Avoidance for Swarm Robotics. This paper discovers about the cloud based real time control availability of complex robots that are massive is performed by complicated technique and the performed by local collision avoidance algorithm. All the characteristics developed from these applications verifies that the environment of cloud computing is considered as a new platform for studying the complex robots in swarm robotics.

Manzi et al 2016 explained the cloud robotic system design for the purpose to support senior citizens and this paper explores about the process that is solely based on the robot called KuBo. This system depends on the resources of cloud that helps in the capability extension for the purpose of human interaction and environmental sensing to provide services for independent living.

Miratabzadeh et al. 2016, explained the software architecture of the cloud robotics system that includes three subsystems which are Middleware subsystem, background task and control subsystem. In this paper, the computing, storage and networking are the three major tasks handled by the proposed software architecture.

As according to **Quintas, Menezesb and Dias,** an approach was .proposed for the purpose of an automated system using mobile robots and a smart room that follows architecture that is service oriented and aims to undertake any kind of complex and heavy

computational tasks. This approach uses the principles of service oriented architecture that relies solely on cloud computing to provide a degree of scalability to the system.

Conclusion

As discussed the architecture of software in the cloud environment consists of three types of subsystems which has been implemented on an IaaS platform by OpenStack that supplements the scalability to the particular system. Using the ROS Multimaster FKIE, the platform that is distributed correctly serves the heterogeneous large scale autonomous robots which having critical problems in case when one robot loses communication. When any type of robot is installed that entails the installation of related packages onto the robot and its related network. Hadoop is used for storing the data in a series of packages that allows the processing of the large amount of data that is received from the software which are robotic agents.

At the end, the software which are discussed for the purpose of cooperative robotics which is having an authentic shared data center for the purpose of communication and a platform that is required.

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