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Abstract. With the upcoming of cloud computing technology, the robots doesn't have to act anymore on their own but they can learn from the experiences of other robots. The main idea of this proposal is how to share knowledge between heterogeneous robots and how to move the processing power from robots to the cloud via cloud computing. A demonstration is thought to be realized using clean robots and the services of cloud computing platform RoboEarth. The orientation and position coordinates of the cleaner robot can easily be calculated by using the encoder and electronic compass. The ultrasonic distance sensor will scan the environment for obstacles and for the borders of the unknown environment. All this information will be transferred to the cloud platform which then uses the path planning algorithm for the coverage of the complete environment for cleaning task. The processing power of the cloud technology enables the low cost production of the cleaner robot. The path planning algorithm based on small area segmentation will be used to control the robot motion and to cover the complete environment.

Keywords: autonomous robots, cloud robot, share knowledge, path planning algorithms

1 Introduction

Cleo robot is design to handle all kind of the requests to finish the job description, his task is to clean the surface and keeps clean the environment, using intelligent algorithms and working hard into artificial intelligent to calculate paths, Cleo should be enough intelligent to handle his operation. Cleo special feature is to create its own world how he sees it through its sensors, and operate starting from decisions and movements independent from human support. Meantime to improve its features a services Cleo will be able to connect to Cloud services and interact with it to solve processing power versus cost of Cleo implementation.

The Internet gave advantages of sharing knowledge between people but this opportunity didn't have the robots until now. The idea of having a remote brain for robots is not something new [1], but the amount of computer power that robots have when connecting to the cloud is something that came together with the new technology generation.

While humanoid robots needed to carry heavy computers and large batteries instead of powering them, with the new cloud computing technology the processing power is moving into the cloud which makes robots even lighter, cheaper and smarter [2]. In cloud robots have the ability to access large amount of data while processing them without problem. The advantage of Cloud robotics is that robots could off-load the Compute-intensive jobs and even download new skills that are required while operating in a real-time manner. For the start the robot can possess locally the basic skills and if in any case the robot faces any new object that doesn't have locally or even never faced it before, the robot for the start can identify the new object as an obstacle and by the aid of ultrasonic distance sensor the robot can send the dimensions of the unknown object to the cloud, where cloud uses the intelligent algorithms to recognize and store the object in the database and responds the necessary commands to the robot in order to interact with the environment. In traditional robots instead of providing one task they needed previously to be reprogrammed, so this drives us to the idea that we previously needed to know what the robot was supposed to do. Nowadays, the robots has the opportunity to offload CPU heavy tasks to remote servers so the robots requires less processing power in onboard computers[6,7]. So, robots could communicate with cloud in case of

recognizing new objects and navigating the environment. The continues advantage of cloud is that it is not limited only to one kind of robot, so instead of robots to share their knowledge they should follow standards no matter if it is a large or small robot, humanoid or not[8].

2 Related Work

2.1 RoboEarth

One of the most successfully projects on cloud robots, RoboEarth [3,4], is a repository of information where different robots could share the information of their experiences. "The goal of RoboEarth is to allow robotic systems to benefit from the experience of other robots, paving the way for rapid advances in machine cognition and behavior, and ultimately, for more subtle and sophisticated human-machine interaction."[3]. Roboearth has three different databases which has information about action, object and environment. Data i these databases are stored in OWL ontology language.

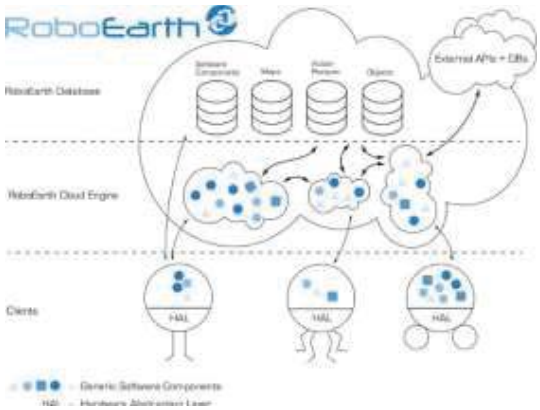

Fig. 1. Architecture of RoboEarth [roboearth]

In figure 1 is presented how a robot could learn new action. In RoboEarth robots could learn new action through teleportation. Human operator controls the robot whereas the signals from sensors and motors are received through ROS, which has a RoboEarth component.

2.2 DaVinci Framework

DaVinci is a platform as a service which provides a framework for providing parallel processing and scalability. In Figure 2 is presented the architecture of DaVinci showing the communication from the machines until the backend of the framework. DaVinci framework it is a UML based Toolkit for modeling DaVinci applications [5].

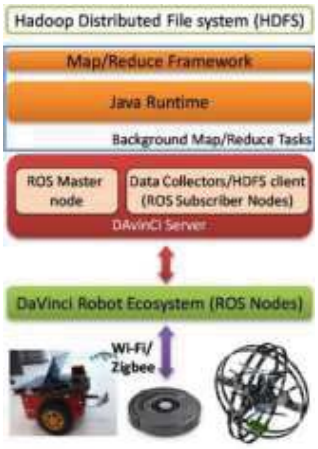

Fig. 2. Architecture of DaVinci Framework [5]

2.3 A proposed Framework

Instead of creating this remote brain the communication is done through machine to cloud and vice versa.

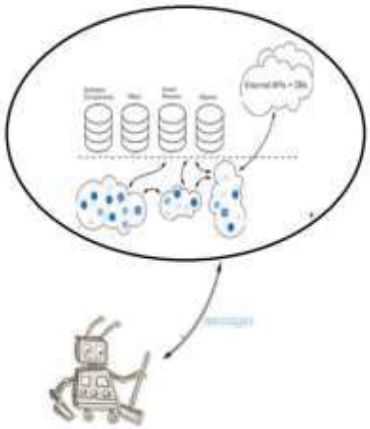

Fig. 3. The communication between CLEO and the RoboEarth framework

So our robot Cleo, will have the initial software which will provide the basic information to the cloud.
We selected RoboEarth framework for communicating in the cloud. So the initial software will be part of RoboEarth Cloud Engine layer which acts between RoboEarth Databse and our cleaner robot.

3 Decision system handling

There are cloud and local intelligent decision making mechanism.

3.1 Decision making mechanism

- Decision making mechanism
- Could
    - Storage information
    - Behavior analyses of the tasks done

    - Prediction
    - Analyses of movement obstacles
- Local Intelligent
    - Intelligent to avoid obstacles
    - Battery life
    - Communication unit

3.2 Graphical User Interface features and System developing technology

Cloud Service offers some features through User Interface for robot owners. In case when we need to monitor or to handle certain propose of the robot than we can use Graphical User Interface (GUI). Those features includes in itself monitoring the robot behavior and giving some basic commands to robot like: Start cleaning Job, stop cleaning, redefine the cleaning map, new cleaning location, monitoring batteries, monitoring cleaning paths and shows all improvements during the time on path optimization, monitoring working hours ect. Those information makes able to manage better the service and robot owner is closer to its robot and know all necessary data for behavior of the robot in its house, merchant, trade center etc.
User Interface is developed in Asp.NET and .NET technology mainly in Visual Studio C# using MCV technology. GUI architecture handle all security issues starting from user level in meaning that each user in system has certain level of user rights where are predefined all access policy. And second step of security is securing the communication from user devices to cloud servers and database.
Cloud database is combination between private Cloud and Public Cloud, in order to increase security, reliability and efficiency. Development technology of database is in MS SQL server 2012 for Private Cloud and MS SQL Azure in Windows Azure for Public Cloud. In database we make all high level of the intelligent transactions and calculation, starting form data collection to data mining, and Business Intelligent.

The population of the data in database is in two ways:

1. Manually (Users put data in system, especially in cases for parameterization and new users and robots in system) and
2. Robot through its sensor gathering data sends to Cloud through Arduino Microcontroller using WiFi communication.

4 Design of the environment

- Detect the position of the Cleo
    - Encoder
    - Angle sensor
- Detect obstacles
    - Ultrasound
- Define the environment for cleaning
    - intelligent algorithms
- Interaction with systemcenter
    - Control Unit

4.1 Detect obstacles and position of the Cleo

- Ultrasonic distance sensor connected to stepper motor for 180 degree obstacle scanning.
- Encoder is used to take information for robot displacement.
- Angle sensor for orientation.
- RF Transceiver for robot computer communication.

- Control Unit (uC) for transferring the sensory information to the system database, and for receiving the necessary commands to control the robot movement.

4.2 Define the environment for cleaning

Main advantages of the Cleo robot is offering the feature to create its own environment not by putting the cleaning map as input information necessary but, it will create the map by using artificial intelligent and input information from its sensors.
We will receive from Cleo three variables from which we are able to construct the cleaning area. First variable is angle of the Ultrasonic sensor, then it is distance measurement from Ultrasonic sensors and last information data is robot movement distance. Through these three information we are able to construct cleaning surface area. This information for our Cloud is in real time interaction even in cases when Cleo have done for one time cleaning the surface and knows the area through Cloud Storage, it updates the obstacles positions.

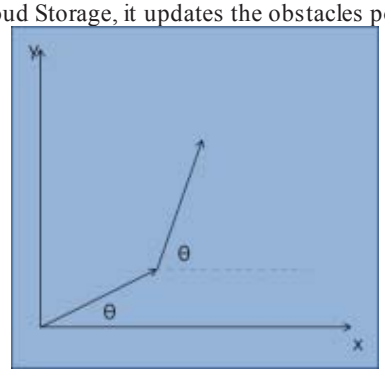

Fig. 5. Coordinate system

Definition of the surface will be in square parts $4m^2$ and all analyses will be handle on this subsurface.

4.3 Interaction with system center

- Control Unit Arduino base
- RF transmitter and receiver

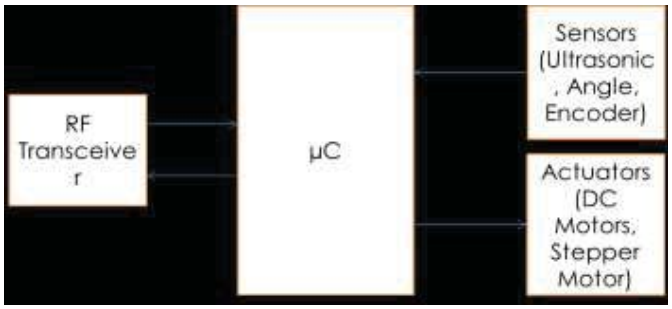

Fig. 6. Hardware design and control system

5 Surface cleaning algorithms

Information that we are gathering from sensors which are putted in robot, we are able to creating area that should be cleaned. This area is created within creating obstacles in environment, creating so called movement obstacles. And on top of these creations we need some kind of algorithms for optimization,

which algorithms will support us to be more efficiency and save battery energy and cleaning process to be shorter and better. Path optimization handle also the process of cleaning entire area without forget any part of surface, object or place where should be cleaned.

5.1 Cleaning defined area and recreating obstacles within environment

To clean the surface in proper way, we should make able to

- Know the obstacles
- Construct surface (area) to clean
- Know which area has been cleaned

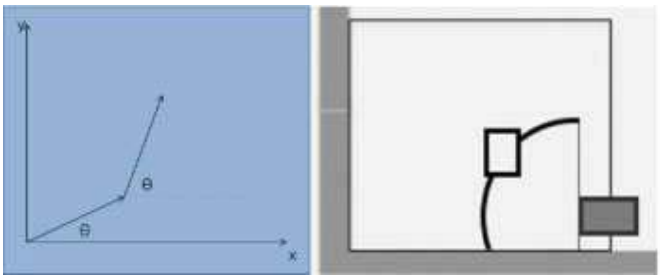

Fig. 7. Coordinate system and Obstacle definition

In this case Cleo will start from left part and going in right direction when finishes the line or when it have any obstacles in front of it. Since Ultrasonic sensor moves in 1800 we have all in front information, this data will gives us better and faster construction of the surface and know obstacles before we are stuck on it.

5.2 Path optimization

The cleaning subsurface is divided to smaller parts for better analyses and optimization behavior of the robot. The algorithm working like:

- These parts are divided in other smaller part in order to be able to check which parts are cleaned,
- Robot goes from current part to part in right side, then left part this way until it is finished all closed area of the current floor
- Second cleaner time compare detected real time parts with information that is stored in database (Cloud task)

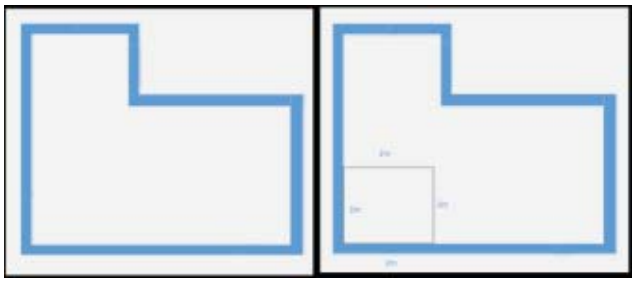

Fig. 8. Surface analyses and subsurface definition

Cleaning process within the subsurface place will be manage through two dimensional vectors that makes able to know each subsurface and each small area
with an ID. On top of this information we will have some kind of flag status for each of them and if robot finishes with any of them then Cloud updates the flag and we will have necessary information

for statement of the surface.

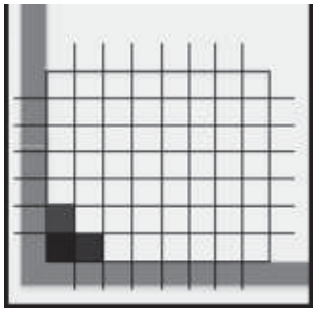

Fig. 9. Path optimization and dividing subsurface into smaller area parts

6 Conclusion

In order to be able to gain enough processing power to handle different types of algorithms for artificial intelligent and makes our robot cost cheap and intelligent enough for its own features we solution of moving the processing power from the robot to Cloud. In this case we engage lots of benefits, like:

Cheaper cleaner robot for market

- If we have cheaper robot than it makes able to produce robots for wide area of market, meaningful financial aspect as well as geographical one
- Cloud Cleaner service analyses, offers analyses for broad families or business even the robot producers from single point to manage and collaborate.

Since we have Could service in place then intelligent development are easier achievement for complex algorithms to Cloud rather than to Robot system itself. Storage issues are near to infinite in Cloud which makes possible to evolve the behavior of the robot and optimizations algorithms. Through Data Mining development in Cloud which is in higher level, we avoid the bottle neck of hardware in robot and are able to plug and play our robot in all spaces needed.
Due these benefits and features that our robot has, it is easier to create the robot world even that is so private for current robot or are some robots that collaborate with each other in same place, Cloud will take care for creating the surface area for these group of robots and exchange the data between. This is what makes system intelligent and robot behavior on it.

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