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A Study on Computer Vision systems in Cloud Computing Environment with GIS

Kondapalli Beulah [1], Penmetsa V Krishna Raja [2], Gudikandhula Narasimha Rao [3], Vijaya Raju Motru [4]

[1,2] Dept. of Computer Science & Engineering

[3] Department of Geo Engineering & Centre for Remote Sensing.

[4] Department of Information Technology.

[1] GVP College of Engineering (A), Visakhapatnam

[2] Sri Vatsavai Krishnam Raju College of Engineering& Technology, Bhimavaram

[3] Andhra University College of Engineering (A), Visakhapatnam

[4] UshaRama College of Engineering & Technology , Vijayawada, Andhra Pradesh, India.

Email: **kondapalli.beulah@gmail.com [1], drpvkraja@gmail.com [2], narasimha.geo@cea.auvsp.edu.in [3], vijayaraju.m@gmail.com [4]**

***Abstract*—** Cloud computing provides a vital role in now a days with big data. We consider robots and automation systems that rely on data or code from a network to support their operation, i.e., where not all sensing, computation, and memory is integrated into a standalone system. This survey is organized around four potential benefits of the Cloud: 1) Big Data: access to libraries of images, maps, trajectories, and descriptive 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: use of crowd sourcing to tap human skills for analyzing images and video, classification, learning, and error recovery. The Cloud can also improve robots and automation systems by providing access to: a) datasets, publications, models, benchmarks, and simulation tools; b) open competitions for designs and systems; and c) open-source software. This survey includes over 150 references on results and open challenges.

Index Terms— Cloud computing, Big data, Cloud automation, Cloud robotics, crowd sourcing, open source, GPS, GIS.

1. INTRODUCTION

Building scalable and consistent data management have been the vision of database researchers for the last few years. With the emerging popularity of the internet, many applications are deployed on the internet and have faced the challenge of serving thousands of customers [1]. Therefore scalability of e-commerce web applications has become an important issue. These modern web applications generate huge amount of data. The database management system plays an important role in managing large amount of data [2]. In order to maintain consistent and reasonable performance, the DBMS must scale out to low cost commodity hardware. Traditional, relational databases could not be scaled out to low cost commodity servers. This gives birth to the No SQL data stores [3]. The key-value stores include properties such as scalability, availability, and elasticity. Scalability is achieved using data partitioning [4]. Data partitioning is a commonly used technique for performing scale out operation. In an e-commerce application, when the customer places any order, the order is fulfilled by a warehouse [5].

Mobile cloud computing becomes an emerging field with high expectation by massive users [8]. We aim to support mobile devices (smart phones, tablets. Etc.) to access cloud services via Wi-Fi or mobile networks. Cloudlets have been proposed as wireless gateways to access remote clouds. Cloudlets and Wi-Fi access points (wireless routers) are integrated to form Wi-Fi-enabled cloudlets. Classification of data bases is one of the biggest issue in cloud data systems [7] [9].

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. This definition is intended to include future systems and many existing systems that involve networked teleportation or networked groups of mobile robots such as UAVs or warehouse robots as well as advanced assembly lines, processing plants, and home automation systems, and systems with computation performed by humans. Due to network latency, variable quality of service, and downtime, 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. This is not a binary definition; there are degrees to which any system will fit under this definition [10].

2. ROBOTICS ROLE IN DIFFERENT FIELDS

2.1 BIG DATA ROLE IN ROBOTICS

The Cloud can provide robots and automation systems with access to vast resources of data that are not possible to maintain in onboard memory. “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. A recent U.S. National Academy of Engineering Report summarizes many research opportunities and challenges created by Big Data and other challenges are summarized. For example, sampling algorithms can provide reasonable approximations to queries on large datasets to keep running times manageable, but these approximations can be seriously affected by “dirty data” [11].

Grasping is a persistent challenge in robotics: determining the optimal way to grasp a newly encountered object. Cloud resources can facilitate incremental learning of grasp strategies. The Robo Earth project stores data related to objects and maps for applications ranging from object recognition to mobile navigation to grasping and manipulation. The Columbia Grasp dataset, the MIT KIT object dataset, and the Willow Garage Household Objects Database are available online and have been used to evaluate different aspects of grasping algorithms, including grasp stability. Large datasets collected from distributed sources are often “dirty” with erroneous, duplicated, or corrupted data such as 3D position data collected during robot calibration. New approaches are required that are robust to dirty data.

Large datasets can facilitate machine learning, as has been demonstrated in the context of computer vision. Large-scale image datasets such as Image Net, PASCAL visual object Classes dataset, and others have been used for object and scene recognition. By leveraging Trimble's Sketch Up 3D warehouse, Lai *et al.* reduced the need for manually labelled training data using community photo collections, Gammeter *et al.* created an augmented reality application with processing in the cloud [12].

2.2 CLOUD COMPUTING ROLE IN ROBOTICS

Uncertainty in sensing, models, and control is a central issue in robotics and automation. Such uncertainty can be modelled as perturbations in position, orientation, shape, and control. Cloud Computing is ideal for sample-based Monte-Carlo analysis. For example, parallel Cloud Computing can be used to compute the outcomes of the cross-product of many possible

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perturbations in object and environment pose, shape, and robot response to sensors and commands. This idea is being explored in medicine and particle physics [13]. Cloud-based sampling can be used to compute robust grasps in the presence of shape uncertainty. This grasp planning algorithm accepts as input a nominal polygonal outline with Gaussian uncertainty around each vertex and the centre of mass and uses parallel-sampling to compute a grasp quality metric based on a lower bound on the probability of achieving force closure. It is important to acknowledge that the Cloud is prone to varying network latency and quality of service.

Some applications are not time sensitive, such as decluttering a room or pre computing grasp strategies or offline optimization of machine scheduling, but many applications have real-time demands and this is an active area of research. The Cloud also facilitates video and image analysis and mapping. Image processing in the Cloud has been used for assistive technology for the visually impaired and for senior citizens. Bekris *et al.* propose an architecture for efficiently planning the motion of new robot manipulators designed for flexible manufacturing floors in which the computation is split between the robot and the Cloud.

2.3 ROBOTIC 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. The Robo Earth and Robo Brain databases are designed to be updated with new information from connected robots. The Robo Brain project "learns from publicly available Internet resources, computer simulations, and real-life robot trials."

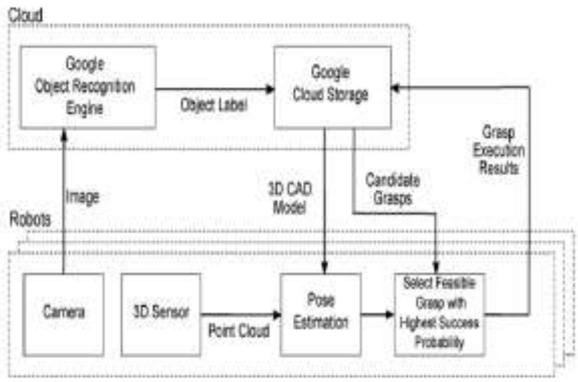

Figure.1. System Architecture for Cloud-based object recognition for grasping

Human skill, experience, and intuition is being tapped to solve a number of problems such as image labelling for computer vision learning associations between object labels and locations and gathering data. Amazon's Mechanical Turk is pioneering on-demand crowd sourcing" with a marketplace where tasks that exceed the capabilities of computers can be performed by human workers. In contrast to automated telephone reservation systems, consider a future scenario where errors and exceptions are detected by robots and automation systems which then contact humans at remote call centres for guidance [14].

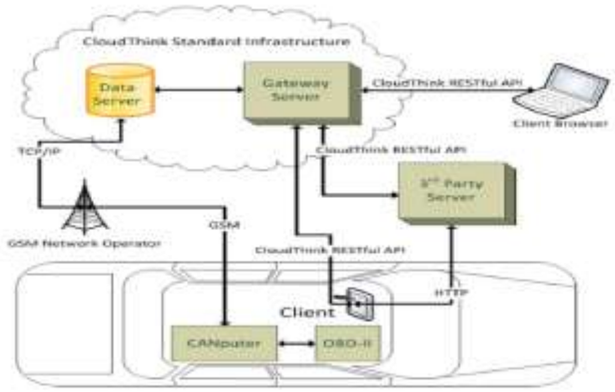

Figure.2. Schematic architecture of Cloud Think

The success of open source software is now widely accepted in the robotics and automation community. A

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primary example is ROS, the Robot Operating System, which provides libraries and tools to help software developers create robot applications. ROS has also been ported to Android devices. ROS has become a standard akin to Linux and is now used by almost all robot developers in research and many in industry, with the ROS Industrial project created to support these users [15].

3. APPLICATIONS OF ROBOTICS

Cloud Robotics and Automation also introduces 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. For instance, researchers at University of Texas at Austin demonstrated that it is possible to hack into and remotely control UAV drones via inexpensive GPS spoofing systems in an evaluation study for the Department of Homeland Security (DHS) and the Federal Aviation Administration (FAA) [16] [19]. These concerns raise new regulatory, accountability and legal issues related to safety, control, and transparency. The “We Robot” conference is an annual forum for ethics and policy research. Faster data connections, both wired Internet connections and wireless standards such as LTE, are reducing latency, but algorithms must be designed to degrade gracefully when the Cloud resources are very slow, noisy, or unavailable. For example, “anytime” load balancing algorithms for speech recognition on smart phones send the speech signal to the Cloud for analysis and simultaneously process it internally and then use the best results available after a reasonable delay.

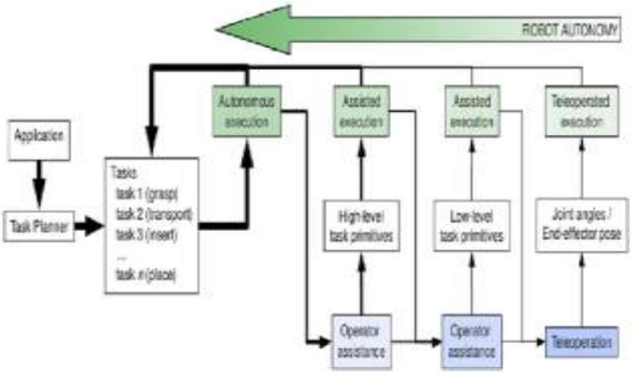

Figure.3. Tiered human assistance using Cloud-based resources for tele operation

When the cloud is used for parallel-processing, it is vital that algorithms over sample to take into account that some remote processors may fail or experience long delays in returning results. When human computation is used, algorithms are needed to filter unreliable input and balance the costs of human intervention with the cost of robot failure. Moving robotics and automation algorithms into the Cloud requires frameworks that facilitate this transition. The positive impact of the instructional program in increasing youths’ self-efficacy in performing robotics and GPS/GIS tasks complements study results showing that the robotics program positively impacted youth STEM learning. While the cognitive results showed differences in male and female scores, the attitudinal research showed no statistically significant gender differences in their relative confidence in performing robotics and GPS/GIS tasks.

4. RESULTS AND DISCUSSION

There's a new tool in your arsenal of GIS data collection instruments. Sitting on the shelf between your GPS and your survey station, one day soon you might find an unusual face staring back at you, a spatially intelligent robot.
Beyond the effective reach of GPS, surveyors have

traditionally used hand laser range finders with Tablet PCs to collect interior space data. This process is very effective for capturing room geometries, but can be very time consuming and especially difficult in non-traditional architectures. The repetitive nature of hand measuring can leave you feeling like a machine by the end of the day. The solution: Don't be a robot, use one Robotic platforms provide a tremendous tool for collecting data. The robotic approach uses onboard laser range finders and odometer to scan buildings as it is driven through a space. Onboard sensor arrays can be set to capture multiple datasets during a single survey, including pictures or video. The process is fluid, and the survey feels more like a brisk walk through the space rather than a survey engagement.

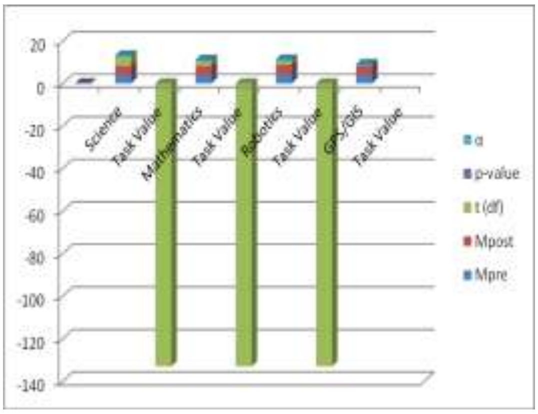

Figure.4. Motivation for Robotics in different problems.

The raw product of the robotic survey is a high resolution map that defines the interior space down to millimetre accuracy. These high resolution floor plans provide a bird's eye view of the interior spaces in a building, including what is actually in them. These data are then processed and attributed by the survey team on tablet PCs in the field, capturing information about room use and occupancy [17].

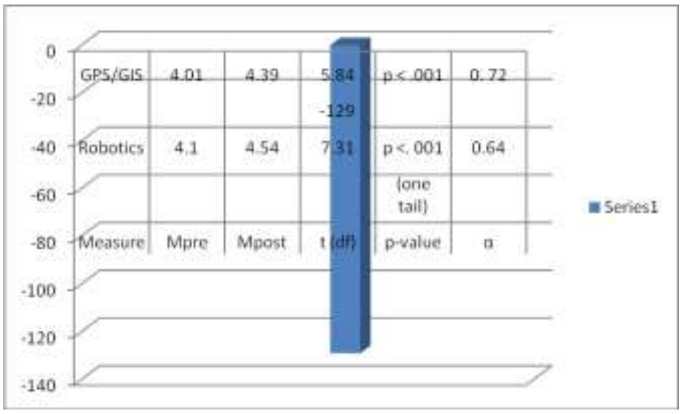

Figure.5. Self Efficiency of Robotics in Cloud Computing

The final product is a high quality map of the interior space data of the facility that is ready to integrate into a GIS. "We are continually looking for new and innovative ways to gather data in order to help base personnel make better decisions through GIS,". "In this case, our search took us to the cutting edge of the robotics world."

The technology through its paces recently during a pilot survey at Langley. During the survey, the robot was able to capture data for over 100,000 ft2 of office space per day, including cubicles and other non traditional features. That may be fast compared to traditional surveys, but you have to look deeper at the real value of this interior space data to fully understand the benefits. "There is immense value in this data," said David Berez, a principal at Post Office Editorial. "With this method, you can get a real-time snapshot of all your facility interests in a fraction of the time. You can also use it to validate existing CAD/GIS data to look for holes or discrepancies [18]."

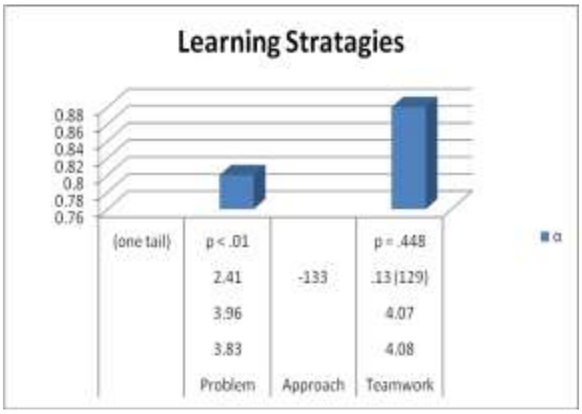

Figure.3. Learning Strategies for Robotics in Big Data and Cloud Computing

Robotic data can also be used to visualize interior space in 3D for applications that require volume or proximity analysis. This extrusion capability provides decision makers with the ability to make more efficient matches between available space and those who need the space. So if the robotic platform is smart enough to map its environment, what happens when it can recognize where it is on the map? The term "Spatially Intelligent" defines a robotic entity which can determine its location by comparing the spatial data it has in memory to those which it sees in real-time through a combination of onboard sensors. Once localized, it understands the space and can dynamically navigate its surroundings. Adding specialized sensors enables the creation of focused missions for the autonomous agent, capable of patrolling the building while sending back sampling data about the environment. Web services allow the robot to query a GIS based on location, and establish a two-way flow of information. The result: a spatially intelligent field agent that can collect, consume and relay information in real-time. While the true potential for these systems unfolds, some GIS industry veterans are willing to wager a guess at what the future holds [20]. Visionary geospatial icon Terry Martin of ESRI explains: "GIS aware robotic systems can form the basis for a virtual neural network of sensors around the world. Further, those robotic systems can be coordinated with GIS to act on information."

4. CONCLUSION

This paper describes RoboEarth includes a Cloud Computing platform. Which is a Platform as a Service (PaaS) framework for moving computation off of robots and into the Cloud. It also connects to the RoboEarth knowledge repository, integrating the Big Data aspect. We believe that this PaaS approach can be extended to use the Software as a Service (SaaS) paradigm, which offers many potential advantages for robots and automation systems robot begins sending up data in the form of point clouds from the Kinect. The robot receives and executes motion plans and grasps, reporting back outcomes to the Cloud-based pipeline, which are combined with feedback from other robots to improve the Cloud-based software parameters over time. We are excited about the potential of such a system and actively working with others on developing its components. More and more Society is demanding new robotic applications in which robot performance is closer and closer for humans to understand.

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