Design of Cloud Based Robots using Big Data Analytics and Neuromorphic Computing

Yu-Wen Chen, Janusz Kusyk, Ashwin Satyanarayana

Department of Computer Systems Technology

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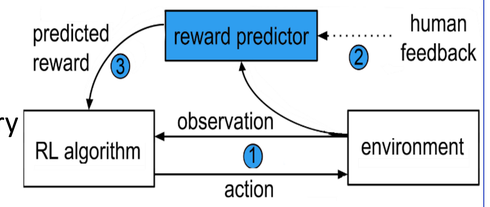
Abstract

Understanding the brain is perhaps one of the greatest challenges facing twenty-first century science. While a traditional computer excels in precision and unbiased logic, its abilities to interact socially lags behind those of biological neural systems. Recent technologies, such as neuromorphic engineering, cloud infrastructure, and big data analytics, have emerged that can narrow the gap between traditional robots and human intelligence. Neuromorphic robotics mimicking brain functions can contribute in developing intelligent machines capable of learning and making autonomous decisions. Cloud-based robotics take advantage of remote resources for parallel computation and sharing large amounts of information while benefiting from analysis of massive sensor data from robots. This poster presents the paper [1] that survey recent advances in neuromorphic computing, cloud-based robotics, and big data analytics and list the most important challenges faced by robot architects. A novel dual system architecture is also proposed for robots where they have a brain-centered cloud with access to big data analytics.

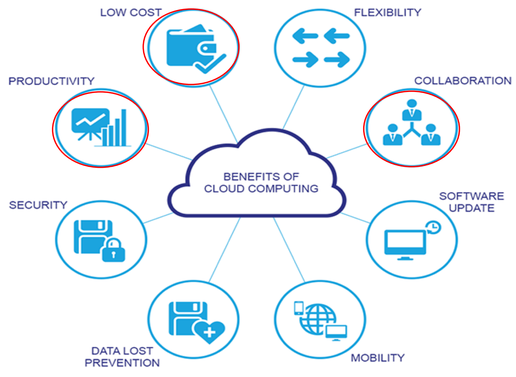
Neuromorphic Computing

- Robot circuits imitating the behavior of a brain
  - Learn via training and feedback while operating in real-life environment
- "Neuromorphic engineering is a new emerging interdisciplinary field which takes inspiration from biology, physics, mathematics, computer science and engineering to design hardware/physical models of neural and sensory systems."

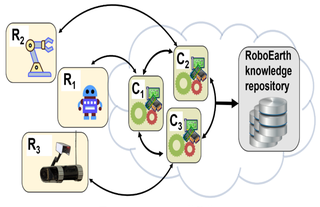


Zeroth processor [2]

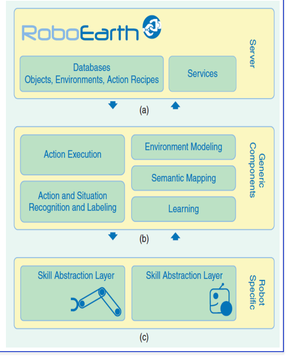
Cloud-based Robotics



A brain centered cloud for robots:

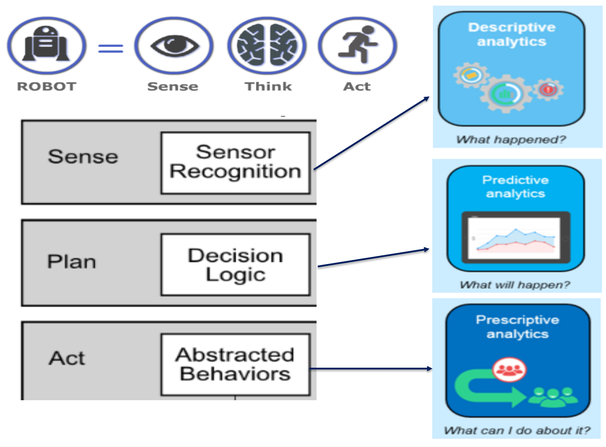


Rapyuta [3]



RoboEarth [4]

Big Data Robotics



Challenges

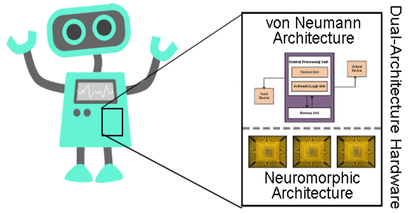
In a modern robotics infrastructure, robots should be able to:

- Operate in a complex adaptive environment
- Handle continuous influx of massive sensory data
- Share information (knowledge and experience) between robots

Proposed Dual System Architecture and Infrastructure

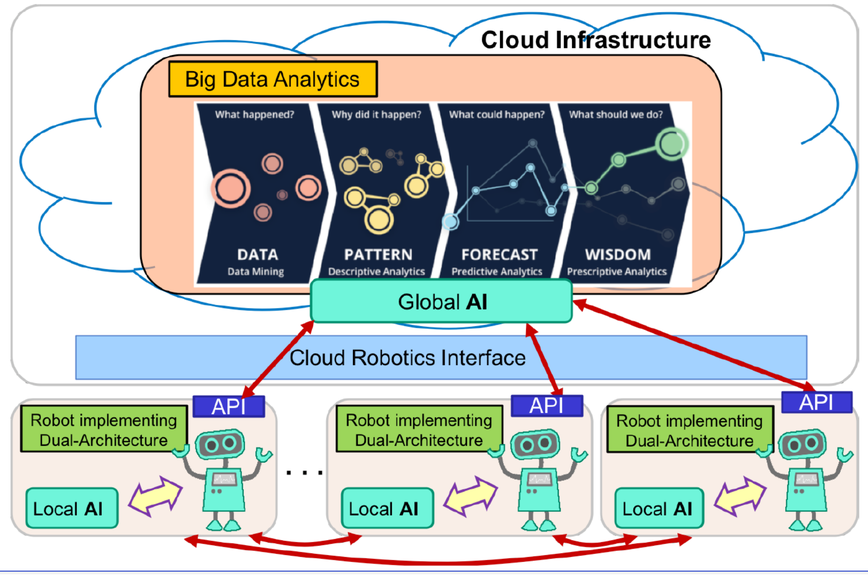
Traditional Chip

- Global AI, which is distributed to all participating robots.
- Access to Cloud Infrastructure (which collects and stores variegated sensory data from all participating robots) and Access to precise big data analytics



Neuromorphic Chip

- Local AI, which helps the robot function even in areas of limited network connectivity.
- Enhance vision and motion computations while providing real-time decisions
- Energy efficient performance



Conclusion

This work is an attempt to cover cloud computing, neuromorphic computing and big data analytics to improve the control architecture of robotics. This work introduces the recent advances in the field of neuromorphic engineering that imitate the human brain by simulating neurons and synapses. Modern robotics is an increasingly interdisciplinary field that could use cloud and big data analytics to facilitate efficient and effective decision making in robots. To address the existed three main challenges in the design of robotics infrastructure, this work proposed a novel dual system architecture (which houses both traditional and neuromorphic chips) where robots have a brain centered cloud with access to big data with analytics. The robots can not only learn from one another by sharing their observation data, experience and knowledge, but can also gain information from cloud-based big data analytics.

Reference

[1] A. Satyanarayana, J. Kusyk, Y-W. Chen, "Design of Cloud Based Robots using Big Data Analytics and Neuromorphic Computing," 31st IEEE Canadian Conference on Electrical and Computer Engineering (CCECE 2018), May. 2018.

[2] Kumar, Samir. "Introducing qualcomm zeroth processors: Brain-inspired computing." (2013).

[3] D. Hunziker, M. Gajamohan, and R. D'Andrea, "Rapyuta: the roboearth cloud engine," in IEEE Int. Conf. on Robotics and Automation (ICRA), 2013, pp. 438–444.

[4] M. Waibel and et al., "RoboEarth: A world wide web for robots," IEEE Robotics & Automation Magazine, 2011.