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Internet of Robotic Things

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Abstract **- Internet of Robotic Things (IoRT) is a new concept introduced for the first time by ABI Research. IoRT provides a dynamic actuation and is considered as the new evolution of IoT. This new concept will bring new opportunities and challenges, while providing new business ideas for IoT and robotics' entrepreneurs. In this work, we will focus particularly on two issues: (i) connectivity maintenance among multiple IoRT robots, and (ii) their collective coverage. Since robots can sense and interact with their environment. Therefore, integrate robots as a device in IoT is obvious. It was the need as an intelligent set of devices that can monitor events, fuse sensor data from a variety of sources, use local and distributed intelligence to determine a best course of action, and then act to control or manipulate objects in the physical world.**

Keywords: Internet, Robotic, Things, IoT, IoRT.

I. Introduction

The Internet of Robotic Things (IoRT) is a new concept that significantly leverages AI. The premise is intelligent technology can be used to monitor and then manipulate events by combining robots’ sensor data and IoT device data to decide on a calculated course of action that could control objects in the physical world.

In a perfect world, IoRT takes advantage of the vast amounts of AI algorithms from an array of IoT sources to enhance the robot’s sensing capabilities above and beyond their current embedded sensors.

II. Overview of Internet of Robotics Things

`This section presents a general overview of Internet of Robotic Things. First, concept behind Internet of Things is presented. Later, Cloud Robotics is merged with IoT as Internet of Robotic Things including its novel definition.

Definition

The main idea behind the Internet of Things or IoT is not a new one. The idea of IoT was conceived by Mark Weiserin his Scientific American article on ubiquitous computing called ‘‘The Computer for the 21stCentury’’. Later, in the year of 1999, Internet of Things term was coined by Kevin Ashton, the then executive director of the Auto-ID Center. As per Giustoet al., IoT combines people, process, device and technology with sensors and actuators. This overall integration of IoT with human being in respect to communications collaboration and technical analytics enables to pursue real-time decision. The concept behind this idea is the ubiquitous presence around human being and its socio-economical culture with a variety of smart objects enabled by radio tags, sensors, actuators, smart devices which are disseminated through unique addressing schemes, secure communication channels and standardized architectural frameworks that per-form interaction and bridges the cooperation with their neighbors to reach specific goals. Smith describes IoT as a dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual ‘‘things’’ have identities, physical attributes, and virtual personalities and use intelligent interfaces, and are seamlessly integrated into the information network; often communicate data associate with users and their environments.

III. Literature Survey

IOT Based Approach: We present an IoT-based approach which is capable of maintaining desired wireless communication coverage among neighboring robots. The proposed approach uses a Central Object (CO) with high computation capability to compute and monitor the connectivity of the overall multi-robot system. We assume that each IoRT robot knows its own position by using GPS or other localization system.

ANN Based Approach: As we mentioned before, the connection to the central object is not always possible. For example, a rescue operation may be difficult after a disaster when the access to the central node is not available. An approach which easily adapts to any type of situation and environment is more than necessary. To meet this need, we provide an ANN-based technique which can perfectly mimic the behavior of IoT-based approach. The ANN-based approaches completely distributed and are trained from a set of data. The data set is obtained by using the IoT-based approach and we use back propagation algorithm to train ANN.

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IV. Characteristics of IoRT Architecture

A) Composability

Since the proposed IoRT architecture uses Web Service Description Language (WSDL) interface, it strives to standardize several communication interfaces deployed for the I RT architecture

B) Context Awareness

Based on the sensed information about the physical and environmental parameters, the sensor nodes attached with IORT ecosystem gain knowledge about the surrounding context. The decisions that the robotic systems take thereafter are context-aware.

C) Virtualized Diversification

The proposed IORT architecture uses a dedicated infrastructure component comprising location identification-based mapping layer responsible for mapping virtual robot objects to physical robots

D) Extensibility

The way complete IORT architecture is designed it the extension of existing robotic services either by adding new forms of robots i.e., drone, butler-robot etc., inM2M2A cloud unit or by updating new services in the IoRT enabled system and which would be easily published as well as subscribed through the developed web interface.

E) Automation in Robotics

Automation is a system or technology that automates some work that was previously done by humans. Parasuraman and Riley (1997, p. 2) defined automation as “the execution by a machine agent (usually a computer) of a function that has previously been carried out by a human”. According to their analysis, automation changes over time and once automation is completely realized, it will be considered a machine. In another word, today’s automation could be tomorrow’s machine.

V. Internet of Robotic Things Architecture

The architecture of Internet of Robotic Things can be divided into 5 layers such as:

(1) the hardware/robotic things layer, (2) the network layer, (3) the internet layer, (4) infrastructure layer, and (5) the application layer. Each of these is described in following section:

A) The Hardware Layer

This is the bottom most layer comprising of various robots and things such as vehicles, sensors, smart phone, defense equipment’s, under water equipment’s, weather sensors, per-sonar equipments, home appliances, and industrial sensors. Technically speaking, physical things (real-life components)do cover up this layer of abstraction to leverage information about its periphery to the above layer i.e., the network layer.

B) The Network Layer

This layer includes modules, controllers, local and cloud data storage, as well as communication and control protocols. BLE, Wi-Fi, and NFC – integrate for facilitating smooth connectivity between nearby robotic things. For the purpose of processing and storing data gather by sensors and actuators both, local and cloud storage are utilizing.

C) The Internet Layer

Internet connectivity is the central part of the whole communication in the IoRT architecture. Due to its own virtue, IoT specific communication protocols have been selectively added into this layer for energy efficient resource constraint and light weight information processing in robotic systems. MQTT CoAP XMPP IPv6 UDP UIP DTLS AMQP LLAP and DDS protocols pave the following tasks respectively.

D) The Infrastructure Layer

IoT based robotic cloud stack revamps this part of architecture to be the most valuable (service centric approaches of cloud, middleware, business process, and big data altogether) layer of all. Truly speaking, this layer is conglomerate of 5different but related compositions such as, robotic cloud plat-form, M2M2A cloud platform support, IoT business cloud services, Big Data services, and IoT cloud robotics infrastructure. Let discuss each as below: Robotic platform support provides robot specific service technologies such as, RT (Robot Technology) middle-ware Robot Operating System (ROS) Robot Service Network Protocol (RSNP) Open Robot/Resource interface for the Network (ORiN) CAN Open and open source ubiquitous network robot platform(UNR-PF) etc.

D) The Application Layer

This is the top most layer of IoRT architecture which is designed to disseminate the user experience through exploring the presented sample of applications that can be per-formed over using robotics. Robots bound with IoT can take active participation while solving numerous problem fields such as

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health care, infrastructural maintenance, EC sites departmental stores, life critical situations, data centers, business shows, WSDL [40] interface, and many more. The possibilities are countless and ever growing, hence its importance and existence.

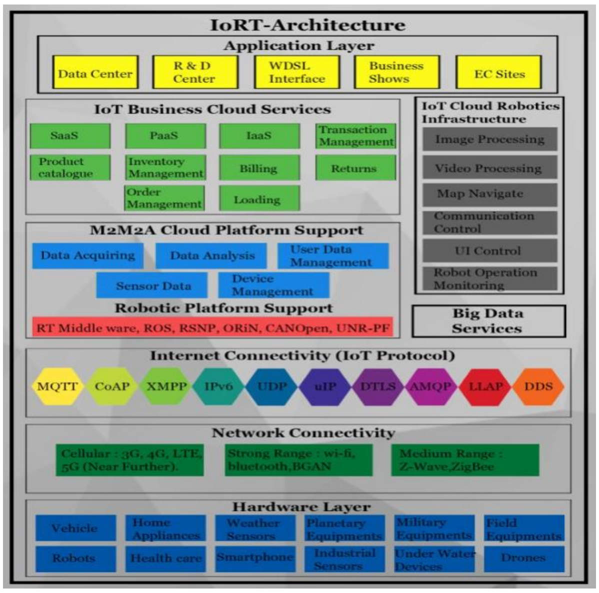

Figure 1: Architecture of IoRT

VI. Application of IoRT

The IoRT enables the transition to a digital, hyper connected society in which every "thing" can sense its surroundings and environment, exchange information, provide feedback, or initiate actions. This is implemented using sensing, processing, cognitive, connectivity, and AI analytics processes at the edge of the network integrated as part of a distributed architecture. In this context, the main benefits of IoRT systems are connected to the network effects that arise when different heterogeneous autonomous systems are integrated, fleets of IoRT devices are interacting and used in different application areas to provide new services.

The novelty of the concept of IoRT extends to multiple application areas that demonstrate the convergence of various technologies integrating collaborative, heterogeneous intelligent robotic things, and autonomous devices into a distributed reference architecture of knowledge-centered platforms that operate over a computing continuum from edge to cloud and to high-performance computing infrastructure.

IoRT uses the convergence of IoT/IIoT technologies and robotics to enhance robotic capabilities, enabling the aggregation of advanced IoT/IIoT functionalities into novel applications and the development of new business models that increase the investment opportunities. AI techniques enable IoRT cognitive systems to be integrated with IoT/IIoT applications to create optimized solutions and fleet-based services and applications.

There are numerous applications for IoRT fleets, and the major benefit of digitalization is the ability to analyse and optimize machine performance in real-time, using data generated by embedded sensors. An example of an application for the IoRT fleets is the concept of self-maintenance of the fleet based on the real-time information, using predictive maintenance models, digital simulation, and identification of trends to provide maintenance information based on actual usage and wear characteristics of the IoRT devices. Companies such as ABB have already developed and deployed solutions like Fleet Assessment to benchmark the connected robots provide preventive care and condition monitoring/diagnostics.

The IoRT applications integrate different types of devices such as collaborative robotic things mobile robotic things (e.g., automated guided vehicles—AGVs), lightweight mobile platforms, used as fleets in warehouses and distribution centers, manufacturing intralogistics, agriculture, and specific environments in logistics in hospitals or retail.

The fleets of robotic things (service and humanoid robots) are used for logistics and delivery as well as for moving objects, such as boxes, pallets, or tools, in industrial settings between machinery, transfer points, or storage areas.

The IoRT applications are expanding in the field of professional service robotic things, personal service healthcare, defense, rescue, security, logistics, construction, agriculture, professional cleaning, inspection, and maintenance, domestic, entertainment and leisure.

The current pandemic crisis has shown the need to accelerate the developments of IoRT technologies and applications for deploying fleets of robotic things for healthcare assistants, logistics, and delivery of goods using autonomous robotic things.

IoRT technologies and applications can be deployed in various industries including healthcare, defence, security, agriculture, forestry, logistics, construction, professional cleaning, domestic, and entertainment.

VII. Conclusion

Internet of robotic things is an emerging field in the 21st century. Detailed study of the field of IORT is given in this paper. In this paper, we described various IORT related definitions and phases of IORT Various architecture layer of the IORT have been discussed and each layer explored with their respective tools. Moreover, we mentioned different tools

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that are utilized in IORT. Finally, we had shown the current research trends in this new era of IORT; it still evolves and will remain a hot topic.

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