Internet of Robotic Things: current technologies, applications, challenges and future directions

**Abstract**—Nowadays, the Internet of Things (IoT) concept is gaining more and more notoriety bringing the number of connected devices to reach the order of billion units. Its smart technology is influencing the research and developments of advanced solutions in many areas. This paper focuses on the merger between the IoT and robotics named the Internet of Robotic Things (IoRT). Allowing robotic systems to communicate over the internet at a minimal cost is an important technological opportunity. Robots can use the cloud to improve the overall performance and for offloading demanding tasks. Since communicating to the cloud results in latency, data loss, and energy loss, finding efficient techniques is a concern that can be addressed with current machine learning methodologies. The aim of this paper is to provide a better understanding and awareness of the new concept of IoRT with its benefits and limitations, as well as guidelines and directions for future research and studies.

**Index Terms**—Internet of Things (IoT), autonomous systems, network communication, Internet of Robotics Things (IoRT), cloud computing, machine learning.

# Summary

## Introduction

Initial introduction with a general speech regarding the current world trend of technologies. We would like to briefly talk about the IoT and the IoRT. If the paragraph is too long, we might want to divide it also between: IoT, Robotics and IoRT. (n\* 3,5,6 for general IoRT and 14,15 for IoT).

## IoT

## IoRT

## Robotics

## IoRT Architecture

Section focused on the architecture of the Internet of Robotic Things. After an initial overview and introduction, we might want to go a bit more in detail dividing the speech between different layers. It’s not the proper ISO-OSI, but just another type of division that is usually accepted when talking about IoRT: physical, network and control, and service and applications. (n\* 3-4-7)

## Physical

Talk about what are the hardware components of the IoRT architecture, i.e. talk about robots, sensors and actuators, their types and main features.

## Network and control

This paragraph explains how the various components are interconnected between each other, so how they can communicate (wireless, wired), what are the main protocols used, and also the control processes of the system (i.e. Robot to robot interactions).

## Service and applications

Finally this third layer talks about the implementation and execution of the previous mechanisms together with the algorithms and technologies used to provide several services and applications to the end users (n\* 5). Here we should include all the talk regarding the machine learning and AI techniques, and also the data cloud computation (n\* 12). If this paragraph becomes too long, we might want to add different subsections talking about AI or cloud computation.

I: End users

* Robot to human interaction

II: Cloud computation

III: Use of machine learning techniques and AI in robotics and IoT

* Classification and clustering
* Deep reinforcement learning and applications

## Application domains

Here we can present some real use case examples to show some actual applications of the concepts that we have presented before. A brief high-level overview of some existing solutions together with our comments and emphasis of their key concepts are analyzed. There is a nice paper on the agriculture field (n\* 16) or also a couple of papers that talk about fire monitoring and disaster prevention (n\* 23,25), or other regarding coexistence of human and robots. These might result in some short subsections based on their length if necessary.

## Regulations and future directions

Here we can briefly discuss what can be the directions of the IoRT, what are the challenges that should be addressed and how they are currently tried to be solved. Then a discussion of where the IoRT can arrive and the general future of it. In addition we could include the regulations and human factor that involve the use of robots in the everyday life (n\* 7D,11). We might divide the speech into two subsections if needed.

## Regulations

## Future directions

## Conclusion

Wrap-up of the paper (n\* 2,3,4…). Final thoughts on what we have discussed before, with some conclusive comments and starting points/inspirations, for some future research and ideas towards the Internet of Robotics Things field.