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Review Article

Advancements in Robotics – A Review

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Index Terms

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Abstract

The paper gives an overview of the applications of robots and the advancements that have taken place in the field of robotics. Artificial Intelligence is the key to developing such applications and lot of research is being conducted around the world in various research laboratories leading to technological growth in the field. Research is on, either to build upon old technologies or develop new intelligent ways of doing things more effectively. Robots have entered every sphere of human activity like manufacturing, surgery, driving, etc. An insight into some of the new revolutionary applications for which robots have been built is given in the paper.

ABBREVIATIONS

AI: Artificial Intelligence; BSR: Building Service Robots

INTRODUCTION

Robotics is a developing field that is opening up a vast array of applications. It uses Artificial Intelligence (AI) that attempts to mimic human behavior. The algorithms that are built into the robot are developed for particular applications, and that makes it functionally equivalent to humans. The most important capability of human being is learning, analysis and development. This intelligent behavior has to be built into the algorithms so that autonomous functioning is possible without human intervention.

AI can be applied to a large number of problems that is routine and monotonous, or the location is inaccessible or dangerous to humans. Some of the problems for which robotics and automation are suitable are production lines in manufacturing industries, military, assisting disabled people, household chores, firefighting operations, earthquake rescue missions, mining, planetary explorations, etc. Nowadays, robots are assisting in performing precision surgeries and in industries that require precise and accurate positioning and / or movements. The difference between an automated operation and an intelligent operation is the human interface. Robots have an interactive and friendly interface with humans and able to perform in a real time environment.

The first instance of a programmable robot was invented by George Devol in 1954 and was called *Unimate* (Universal Automation). This was the foundation on which the entire robot industry was built and today it has attained far reaching heights. From a simple mechanical arm to an efficient humanoid that can perform precise surgeries, robots have grown by leaps and bounds. They have various sensors like camera (machine vision), proximity, temperature, pressure, etc. to sense the environment. They can have movements with the aid of artificial hands and legs that are controlled by actuators and the in-built programmed intelligence.

The brain behind a robot is artificial intelligence integrated with mechanical parts for other coordinated movements. This paper gives an insight into some of the latest advancements in the technological development and applications of robotics. Some of the latest trends in the robot industry are also discussed in the following sections.

Brain behind the robot

There is a concerted effort to fill factories with advanced robots for manufacturing and testing operations. The move is expected to make production more advanced, efficient and cost-effective [1]. Robots are becoming smarter wherein the intelligence of learning and knowledge sharing is incorporated. New techniques are being explored to make a robot adaptable and smart. Robots can even be made to teach each other [2]. This transfer of knowledge from one robot to another will be a big breakthrough if successful. Robots are also getting more personal where they can be home companions with a human touch. The convergence of technologies and cheaper hardware is making possible things that are amazing. New generation of robots are being introduced that can perform feats once considered 'impossible'. Extracting information from data is quite a challenging task. Information extraction and analysis is a major topic of current research in AI.

Applications

Stereotactic neurosurgery [3] enables surgeons to treat deep brain diseases, which is quite complicated involving hundreds of steps that might result in sub-optimal outcomes. The procedure requires accurate tool placement that is hampered by shift of the

brain. It also requires pre-operative MRI, CT and intra-operative MRI intervention. The operation is done through a burr hole in the skull that is operationally 'blind'. MRI guided, robotically activated neurosurgery improves accuracy, safety and reduces the time consumed.

One of the most important human activities is anticipation based on past activities [4]. For example, if a person is holding a glass of water in his hand, the future activity will be moving the glass to the mouth and drinking from it. If a person is carrying a bottle and walking towards the refrigerator, the future activity will be to open the fridge and place the bottle inside. Detection accuracy of past activities can also be improved by anticipation. The context for modeling the activities has to be captured and the large space of future human activities has to be anticipated. An assistive robot can anticipate and plan for reactive responses. An algorithm based on dividing an activity into sub-activities by segmentation in time and object affordances (object functionality) have been proposed. By incorporating reactive responses, the robot can better assist humans in their activities.

Building Service Robots [5] are robots that guide blind people in large buildings such as hotels, departmental stores and office complexes in an effective manner. Based on interactions with visually impaired persons, the primary features of the proposed design are: (i) summoning the robot with a mobile app, (ii) choice of three modes - sighted guide, escort, information kiosk (iii) receive information from robot about the layout of the building. These robots must be around 3 feet tall, autonomous and must be able to find their way around. These features have been arrived at by a participatory design process wherein target users and designers together finalize the design. The robot should interact with the user during the entire process.

Autonomous car is a self driving vehicle that navigates itself without human intervention [6]. It must be able to perceive the environment using sensors, and control itself with actuators. The algorithm that runs on a computer is quite complex and can be divided into several functional units. Distributed system architecture has been proposed in the paper [6] by Kichun Jo et al., for the development of the platform for the autonomous driving system. Distributed architecture is preferable because it has reduced complexity, fault tolerance and modularity. The proposed architecture can be adopted for other driverless units like submarines, airplanes, etc.

Domino's Pizza Delivery Drones [7] get to work in New Zealand - DRU Drone autonomously flew pizzas to customers in New Zealand, the country's first commercial delivery of pizza by drone. The flight lasted less than five minutes. In a partnership, Domino's and Flirtey successfully delivered pizzas to customers in New Zealand where the DRU Drone autonomously flew the pizzas to the backyard of customers.

Latest Developments

A few of the proposed advancements in the field of robotics and automation that are under research and yet to take off have been briefly discussed.

Robot-plant biohybrids growing in european laboratories [8]: Flora Robotica is a project funded by the European Union whose goal is "to develop and investigate closely linked symbiotic relationships between robots and natural plants and to explore the potentials of a plant-robot society able to produce architectural artifacts and living spaces" [cited from IEEE Spectrum]. The basic idea is to support plants in such a way that plants are healthier and robust and react to stimulus from robots. This makes them easier to be incorporated into immovable structures like walls and furniture. The plants support the robots and guide them through growth and the robots in turn control the plants. An artificial growth can be implemented that keeps pace with the natural growth.

Cockroach robot flips itself with insect-inspired wings [8]: Research is going on at UC Berkeley on developing robot cockroaches. Robots are better able to break obstacles with a cockroach like shell. Chen Li presented a paper in 2016 demonstrating flipping over of the robot on its wings like a real insect. If a cockroach falls upside down, it can set itself right by moving its wings, but a similar exercise requires higher power and a specifically designed wing shape on the part of the robot to right itself.

Ucla's humanoid blimp (buoyancy assisted lightweight legged unit) robot [8]: BLIMP is a humanoid robot that has a light weight body and thin legs. BLIMP can walk, hop and perform other activities. BLIMP is stable with all its activities. Research is on to make BLIMP jump or climb tall structures.

Pilot robot (pibot) can fly a plane from takeoff to landing [8]: The pilot robot can fly an aircraft just like a human pilot. At KAIST in South Korea, researchers are developing a humanoid robot that can operate a regular aircraft by sitting in the pilot's seat and using the controls in a manner similar to a human pilot. It relies on a flight simulator and is still under development.

Infographic: future of autonomous underwater vehicles [9]: Autonomous cars and drones have been developed and tested but, autonomous underwater vehicles are lagging behind. Underwater exploration is a challenging task because the environment is vastly different from normal environment. Developing a vehicle for undersea exploration of cables or other military purposes is a fertile research area with vast potential for applications.

Seabed-mining robots [10]: Nautilus Minerals plans to employ deep sea mining robot to dig for valuable minerals in the bottom of Bismarck Sea in 2016. The mining robot is built by Soil Machine Dynamics of UK. The main robots are a pair of tractor-trailer-size excavators. One uses counter rotating heads studded with tungsten carbide picks to chew through the metal-rich chimneys that form around superhot water spewing from sulfurous vents in the seafloor. Its partner adds brute strength, using a studded drum to pulverize rock walls. Dredge pumps built into these machines will push the smashed ore back to a central pile on the seafloor, where a third Nautilus robot will feed slurry of crushed rock and water up a pipe dangling from the production vessel. There the water will be wrung out from the ore and later processed.

DISCUSSION AND CONCLUSION

Robots are reliable and can reduce production costs. They

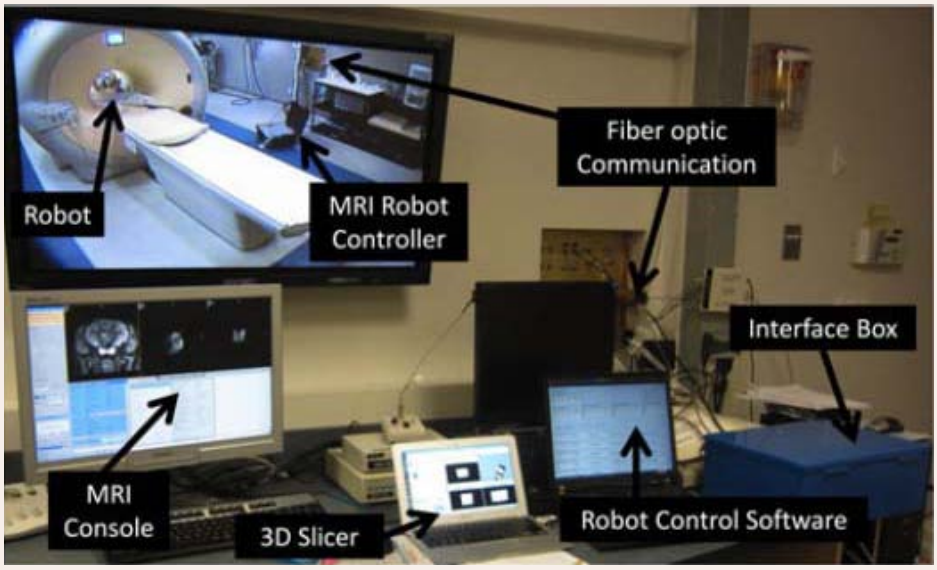

Figure 1 Configuration of MRI-guided robotic neurosurgery system [3].

produce good quality repeatedly and can work tirelessly in any environment even if it is hazardous. Automation and artificial intelligence are the two key aspects in development of robot technology. The artificial intelligence integrated into the robot controls and actuates the other mechanical parts that are built into it. Depending on the application, the size, arms and legs (basic structure) and the movements are determined. Research is growing by leaps and bounds and robot technology is all set to take off in the next decade.

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