

Development in the Deployment of Robots in Various Industrial Sectors

Sumedha Atul Karanjkar¹, Atul V. Karanjkar^{2*}

¹MVPS's Sharadchandraji Pawar College of Architecture, Nashik., MS, India

²Chhatrapati Shivaji Maharaj University, Panvel, MS, India

*corresponding author: Atul Vasant Karanjkar

Abstract- Over the last few decades, the robot market has experienced a significant transformation, with robots growing beyond the workhorses of various types of industries and also beginning to adopt innovative roles among each one. This growth is un-identical for the industries and governed by its profile. This paper introduces the basics of robots. The various fields of industrial robot applications that existed to date are identified. Data on the rise of robot use in the relevant field year over year has been gathered from multiple sources. The polynomial curves are determined to analyze the growth rate. Industry-wise growth rates are compared and their curve characteristics are interpreted with justifications.

Keywords- Robots, Application data, MS Excel, Growth Analysis.

Introduction

The word robot was coined by Czech novelist Karel Capek [1] in a 1920 play titled Rossum's Universal Robots (RUR) [2]. The term could evoke images of a humanoid or a basic material-handling gadget, depending on how sophisticated the technology is. Diverse viewpoints exist regarding robotics among researchers, engineers, and robot manufacturers. However, most people agree that George C. Devol's invention of a programmed material handling device is responsible for today's industrial robots [3]. In 1954, Devol filed a patent application for a new system for part transfer, stating that the device would be operated on the fundamental principle of the teach-in/playback approach is presently commonly used in the majority of industrial robots.

There is profound and ever-expanding development in robotics to address needs of modern industries. J.J. Craig [4] has explained the simple manipulator which is complex enough to demonstrate nearly all the principles of general manipulators without bogging down in too much complexity. An entire library of manipulator software available has been provided. The technology of mechanical manipulation has also been introduced. Industrial robot control and analysis, as well as the foundations of robotics, has been presented by Robert J. Schilling [5]. Rachid Manseur [6] has provided an introduction to robotics and discussed the modeling and kinematics of robot manipulators. Extensive software support in terms of visualization, symbolic equation generation, and computation is also provided. A much more realistic rendition of three-dimensional systems in motion is shown to have a clear idea Vikram Sharma [7] has provided a straightforward explanation of robotics, including its history, benefits of employing robots in industry, key characteristics, types of robots,

economics of robots, applications of robots, programming techniques, artificial intelligence, etc. An overview of automation and robotics as they relate to industry automation activities has been provided by A K Gupta and S K Arora [8].

Numerous writers have gone into great length about the many kinds of robots and how they are used in the various industries of the modern world. This paper has considered the variation in the role played by the robot in the respective industry. This has had an impact on both the rate of its introduction into use and growth within these businesses. So year-wise robot application data is collected and analyzed. The results are interpreted to predict the potential of robot application in the future.

Basics of robotics

By definition Robots can be stated as a programmable machine consisting of memory as well as a mechanism intended to execute various assigned functions automatically, thereby substituting for human manpower. The major components of a robot [9] are the body or frame made up of plastic or metal, control system, manipulators or actuators, and drive systems like electric motors or hydraulic and pneumatic systems or a combination of all these systems. There mainly are three types of robots [10] as mentioned below.

Manipulator robots: A manipulator is a device used to manipulate materials without direct physical contact by the operator [11]. This type of robot deals with biohazardous or radioactive materials using robotic arms. A robotic arm is mostly used in industrial manufacturing sectors. Manipulators are composed of an assembly of links and joints. A manipulator is a device used to manipulate materials without direct physical contact by the operator.

Legged or wheeled robots: Legged robots or wheeled robots [12] are designed for locomotion on rough terrain and require maintaining balance, to determine the direction and speed of the moment. Legged robots can be categorized by the number of limbs they use, which determines the gaits available. The 4 main types are one-legged, two-legged, four-legged, eight-legged, and hybrid. The robots mainly used are ASIMO, BigDog, HUBO2, BoeBot, Cosmobot, RB5X, etc.

Autonomous underwater vehicle or unmanned aerial vehicles: An autonomous underwater vehicle (AUV) is a robot [13] that travels underwater without requiring input from an operator. In military applications, an AUV is more often referred to as an unmanned undersea vehicle (UUV) [14]. These are special-purpose underwater research vehicles. The use of these robots is Intelligence, surveillance, reconnaissance, mine countermeasures, Anti-submarine warfare, Inspection/identification, Oceanography, Communication/navigation network nodes, Payload delivery, Information operations, and Time-critical strikes. An unmanned aerial vehicle (UAV) (also famous as a drone) is an aircraft that operates without any human pilot on board. The drone consists of two major systems such as a ground-based controller and a communications system, along with some automatic functional devices.

Recently, Cobots, or collaborative robots used for direct human-robot interaction. Cobots [15] are of two types 1) Industrial robots used in automation and 2) Services robots for domestic and professional use. Cobots can have many uses examples of services robots, robots that transport material within a building, use for household purposes, etc. Robots are used in logistics, machine tending, packaging and place, quality inspection, palletizing, process automation, material handling, industrial cleaning, fruits picking, space exploration, etc.

Robots in various industries

There are various applications of robots [16] such as labeling and packaging, pick and place for printed circuit boards, assembly and disassembly, painting, welding, product inspection, testing, palletizing and material handling etc.. These all application are done with high precision, speed and endurance also. According to International Federation of Robotics, about 1.64 million industrial robots estimated to be in operation across the world in the year 2020.

The various industries of robot use are mentioned in the Table 1. The different functions, those are needed to carry out by the robot in each of these industries are also identified and mentioned along with their approximate costing incurred for the same.

Table 1 Different types of industries, uses and types of robots and their costing.

Types of Industries	Uses and Types	Costing
1. Food industry	Pick and place of fruits and veggies, cutting and slicing, cake decoration.	Approximately (\$4906) 59,147,76 won
2. Space industry	Remotely operated vehicle (ROV) and remote manipulator system (RMS).	Approximately (\$50,000 to \$80,000) 5,98,72,500 won to 9,57,96,000 won
3. Automobile industry	Painting, welding, to assemble parts, part transfer, machine tending.	Approximately (\$3,00,000 to \$4,00,000) 35,92,35,000 won to 47,98,80,000 won
4. Agro industry	Ecorobotix-To spray weeds, Energid citrus picking system-To pick a fruit, Agro bot E series-To pick only strawberries, Blue river lettuce Bot2-To lettuce the field, Agrirobotix-To collect crop data.	Approximately (\$11.58 billion) 1,38,64,95,56,00 won
5. Transport industry	Driveless vehicle, automated trains, shipping and logistics, etc.	Approximately (\$20,000 to \$50,000) 5,98,72,5000 won
6. Computer industry	Pre programmed robots for simple motonomous tasks, humanoid robots to look alike and mimic like humans, autonomous robots to carry out tasks without humans supervision, teleoperated robots to work in extreme geographical conditions.	Approximately (\$25,000 to \$40,000) 2,99,28,250 won to 4,78,85,200 won
7. Construction industry	Offsite prefabrication system, onsite prefabrication system, drones and autonomous robots for inspection, monitoring and maintenance, exoskeleton to improve construction activities.	Approximately (\$50,000) 5,98,72,500 won
8. Education industry	Nao, pepper, Tiro, IROBI and robovie are primarily used to teach english. Also use for work like taking attendance, correcting answers, etc.	Approximately (\$50,000 to \$80,000) 5,98,72,500 won to 9,57,96,000 won
9. Telecommunication industry	Clouding of computers, network functions virtulization, software defined networking, fibre to home, automation (RPA)	Approximately (\$5,00,000) 59,84,85,000 won
10. Health care industry	Surgical robots for surgeries, exoskeleton to assist surgery and aid, care robots to provide care and support to elderly and disabled patients, hospital robots like Aethons TUG to diliver medication or laboratory specimens.	Approximately (\$2,700) 32,31,819 won
11. Entertainment industry	Teksta, Poo-Chi, etc. For creating spectacles of colors and light in venuse, to control orchestra.	Approximately (\$25,000 to \$40,000)
12. Manufacturing industry	Cartesian, SCARA, Delta, Polar are used for packaging, shifting, carrying the stuffs.	Approximately (\$50,000 to \$80,000)

13. Mining industry	Automated load haul dump trucks and many other robots are used for drilling, bolting mine, underground navigation, mapping.	Approximately (\$903) 10,81,784 won
14. Energy industry	Silicon ingot, silicon modules, solar cell and silicon wafer robots are used in solar energy, Robots painting wind turbine blades, used in automized turbines.	Approximately (\$3,000,000) 3,59,17,20,000 won
15. Hospitality/ Hotel industry	Connie, the Hilton robot used to interact with guests to respond their questions, Travelmate-A robot suitcase used for luggage purposes. Has 360 degree turning capability 1A-TA, Robot travel agent.	Approximately (\$15,080) 1,80,53,474 won.

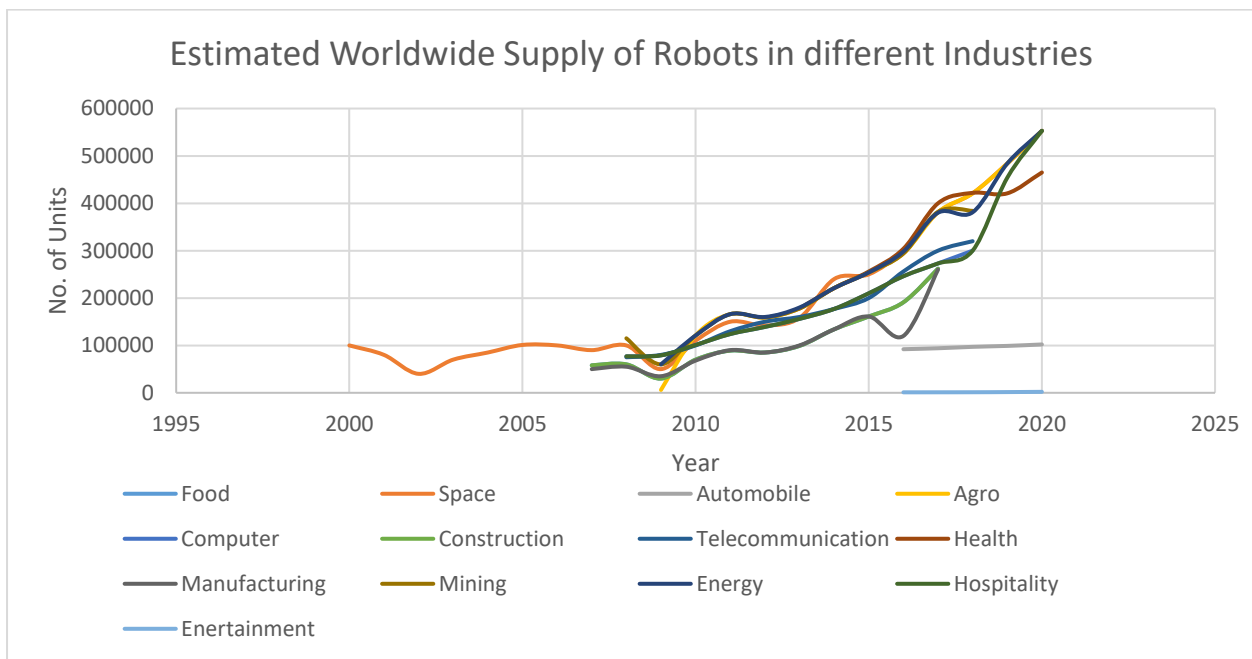


Figure 1: Growth curves for robot use in various industries

Curves are fitted to this data using its chart tool [17] as shown in the Figure 1.

A data about the number of robot unit used in last two decades is collected and segregated according to the industry. This data is tabulated in Microsoft Excel.

Table 2 Industry wise growth trend equation

Sr. No.	Industries	Growth Trend Equation	Growth Rate
1.	Space industry	$y=21265x-4E+07$	Medium
2.	Manufacturing industry	$y=16636x-3E07$	Medium
3.	Construction industry	$y=18864x-4E+07$	Medium
4.	Energy industry	$y=40846x-8E+07$	Very High
5.	Agro industry	$y=43916x-9E+07$	High
6.	Health industry	$y=42893x-9E+07$	High
7.	Food industry	$y = 18864x - 4E+07$	Medium

8.	Computer industry	$y = 23055x - 5E+07$	Medium
9.	Entertainment industry	$y=245x-493069$	Very low
10.	Mining industry	$y=30818x-6E+07$	Medium
11.	Automobile industry	$y=2500x-5E+06$	Low
12.	Telecommunication industry	$y=24909x-5E+07$	Medium
13.	Hospitality industry	$y=34297x-7E+07$	Medium

The maximum sales of robots is seen in energy industry, [18] as the slope of linear curve is 404846. . The use of robots in energy industry started from the year 2009 and now it has taken a quite good grip of growth among all industries. The energy sector is frequently in carrying out industrial operations and challenging maintenance. In the energy industry use of robots across the sites like analyzing data that prevent robots from steering into a dangerous obstacle, making logical decisions, and carrying out tasks that are harmful to humans. In the energy industry lot of work is related to or carried out in hazardous places where it is difficult for human beings to work, therefore robots are used a lot in such places. Robots are used to work in hazardous places such as carrying out radiation detection for the uranium rich nuclear plant. Robots also play a key role in the setting up and installation of technologies such as offshore and wind panels. Using robots in a hazardous environment helps in preventing accidents that can cause severe threats to the life of the operator, co-workers, equipment, and the environment. Hence, the use and sales of robots in the Energy industry is more. The growth of robots use is the in all sectors with the non-uniform rate in descending manner these sectors can be mentioned as shown in Figure 2.

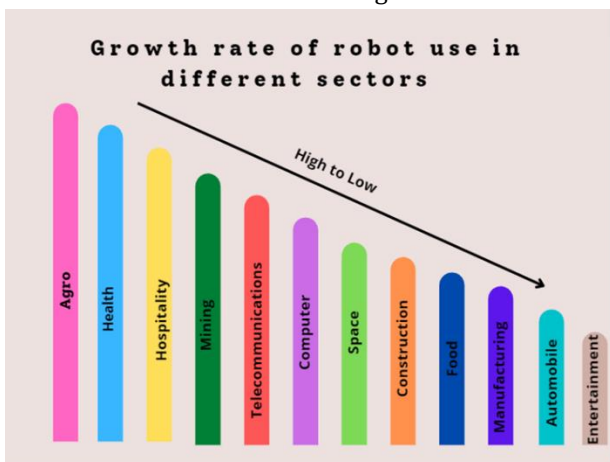


Figure 2 Growth rate of robot use in various industries

The minimum sales of robots is seen in entertainment industry [19], as the slope of linear curve is 245. The use of robots in entertainment industry started in the year 2016. In the entertainment industry, working is easy and can be carried out by humans. In the entertainment industry more of the work is needed to be carried out by humans and cannot be taken over by robots. Hence the use of robots in entertainment industry is quite low.

Use of robots started first in space industry [20]. The robots entered in the space industry in the year 2000 to the above study. Hazardous problems such as radiation, isolation and confinement, distance from earth, hostile environment, lack of oxygen and pressure, etc. are there in space. We can send robots to explore space without having to worry so much about their safety because even if a robotic mission fails, the humans involved with the mission stay safe. Sending robots to space is even much cheaper than sending a human. Robots don't need to eat or sleep or go to the bathroom. They can survive in space for many years and can be left out there. In order to do difficult or rote tasks such as repairs in dangerous environments or working in radioactive places in space robots are used. Hence, due to more environmental use of robots started earlier in the space industry.

The above graph tells us about the increasing sales of robots in different industries and the rate of growth.

Conclusion

Robots are programmed to perform dangerous, dirty and/ or repetitive tasks with consistent precision and accuracy. This is why they are increasingly used in a variety of industries and applications. A basic details of the robots are studied. The major industries, in last two decades, which has initiated and extended the use of robots are identified. The role of robot in each of these industries along with the approximate investment is also explored. A data of number of robot units used yearly in the respective industry is mentioned. Curves are fitted to these data points.

These curves are then analyzed using their trend lines to identify the robot growth rate in that specific industry. This growth rates are compared to identify the high potential industries for robot application. A justification is been provided in support of this identified potentials.

References

- [1] Christensen, A. G. (2007). Karel Čapek. The Literary Encyclopaedia.
- [2] Moran, M. E. (2007). Rossum's universal robots: Not the machines. *Journal of endourology*, 21(12), 1399-1402.
- [3] Miller, R. K. (1989). Robots in industry. In *Industrial Robot Handbook* (pp. 1-9). Springer, Boston, MA.
- [4] John J. Craig (2005) *Introduction to Robotics: Mechanics and Control*, Pearson Education, Inc., Upper Saddle River, New Jersey, e3.
- [5] Robert J. Schilling (2007) *Fundamentals of Robotics*, Pearson Prentice Hall.
- [6] Rachid Manseur (2007) *Robot Modeling and Kinematics*, Firewall Media, New Delhi.
- [7] A. K Gupta, S.K. Arora (2007) *Industrial Automation and Robotics*, Laxmi Publications Pvt. Ltd., New Delhi, ed.1.
- [8] Vikram Sharma (2010) *Fundamentals of CAD/CAM/CIM*, S.K. Kararia & Sons, New Delhi.
- [9] Shoham, M. (1984). Components of Robotic Systems. In: *A Textbook of Robotics 2*. Springer, Boston, MA. https://doi.org/10.1007/978-1-4615-9888-6_1
- [10] Ben-Ari, M., & Mondada, F. (2018). Robots and their applications. In *Elements of robotics* (pp. 1-20). Springer, Cham.
- [11] Hunt, V.D. (1985). *Robot Manipulators*. In: *Smart Robots*. Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-2533-8_6
- [12] Nuryanto, Mr & Widiyanto, Andi & Raliby, Oesman & Widaryanto, Rochim & Ariyanto, Mochammad. (2019). The Concept of Wheeled-Legged Robot Transformation. *Journal of Physics: Conference Series*. 1196. 012036. 10.1088/1742-6596/1196/1/012036.
- [13] Hyakudome, T. (2011). Design of autonomous underwater vehicle. *International Journal of Advanced Robotic Systems*, 8(1), 9.
- [14] Nuryanto, Mr & Widiyanto, Andi & Raliby, Oesman & Widaryanto, Rochim & Ariyanto, Mochammad. (2019). The Concept of Wheeled-Legged Robot Transformation. *Journal of Physics: Conference Series*. 1196. 012036. 10.1088/1742-6596/1196/1/012036.
- [15] Bergman, M., Joode, E.D., Geus, M.D., & Sturm, J. (2019). Human-cobot Teams: Exploring Design Principles and Behaviour Models to Facilitate the Understanding of Non-verbal Communication from Cobots, CHIRA.
- [16] Shanmugavel, B., Kumar, T. R., & Karrthik, R. (2018). Applications and Future scope of Robotics—A Review. *Int. J. Robot. Auton. Syst*, 3, 12-26.
- [17] <https://web.ece.ucsb.edu/Faculty/rodwell/Classes/ece2c/labs/CurveFittinginExcel.pdf>
- [18] Berry Mulder, Ross Doak, Adam Serblowski (2021) *The Road Travelled So Far to Ground Surveillance Robots*, Shell TechXplorer Digest, Shell, pp. 36-41.
- [19] Sabe, K. (2005, June). Development of entertainment robot and its future. *Int. Digest of Technical Papers. 2005 Symposium on VLSI Circuits*, IEEE, pp. 2-5.
- [20] Yoshida K, Wilcox B. (2008) *Space Robots and Systems*. In: Siciliano B., Khatib O. (eds) *Springer Handbook of Robotics*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-30301-5_46.