STM JOURNALS

Journal of
Instrumentation Technology & Innovations

ISSN: 2249-4731 (Online)
ISSN: 2347-7261 (Print)
Volume 14, Issue 1, 2024
January—April
DOI (Journal): 10.37591/JoITI

https://journals.stmjournals.com/joiti

Review JoITI

Implementation of Robotics in Pharmacy System

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Abstract

Implementation of robotics is the essential aspect for development of the pharmacy sector. This replaces the medication (or) industrial process with new technology which results in significance of accurate and quality results. This technology aims to detect and ensure quality of finished products with new methodology which increases the productivity, and it also identifies potential problems and rectifies them which leaves a great impact on pharmacy system. The main purpose of implementing robotic system is to reduce human time and cost of labour, and safety from potential hazards. Robotic system minimizes the errors in process and works continuously without any break. This technology will save money as it will have quick return on the investment which leads in more profit; and also, by implementing this technology, pharmacists' life will become easier and more comfortable regarding work. The rise of robots is also having negative impact such as decreasing of employment levels because certain jobs which are done by humans are now done by robots, which creates jobless future. This technique facilitates the pharmaceutical industry to perform tests and trials and allows research and development department to proceed their job faster. Making Use of ROBOTS Technologies employed in a range of industries, including medical, distribution, services, and industrial applications, are what drive the development of the pharmacy sector. Additionally, the management of requirements, efficiencies, and infrastructure aids in the development of the pharmacy system.

Keywords: Robotic systems, pharmaceutical industries, articulated robots, cartesian robots

INTRODUCTION

Nowadays, robotics play an important role in pharmaceutical field. These are computer-based systems, which involve multiple functions to be performed in technical way. In pharmaceutical manufacturing, robots play essential role by working faster and more consistently. Robot is designed as a multifunctional system for measuring, mixing, counting, and packaging of the products without any errors. The works which cannot be done by humans are performed by robots [1–8]. Errors which might occur during packaging, manufacturing etc. are totally avoided by the usage of robotic system in the pharmacy field. The main purpose of implementing robotic system is to reduce human time and the cost of labour, and safety from potential hazards. The key of robotic system is automatic process with safety and efficacy. Application of robotic system in this field results in development and qualification in the process and pharmaceutical industry. Robotics help in delivery of latest drugs. Robotics systems help to speedup the process and help in performing the tasks which are difficult for humans. Manufacturing, packaging, inspection, and production of new drugs all become easy all thanks to robots [9–18].

Some robots are remote controlled, semi-autonomous or fully automatic robots which have been implemented for developing the pharmaceutical

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Received Date: April 22, 2024
Accepted Date: May 10, 2024
Published Date: May 20, 2024

Citation: Afra Saniya, Sravanthi Gandu. Implementation of Robotics in Pharmacy System. Journal of Instrumentation Technology & Innovations. 2024; 14(1): 1–15p.

systems. High quality products are produced by implementation of robotic technology. By implementing this technology, pharmacists' life became easier and more comfortable regarding work. This technology consists of enormous (or) vast number of advantages. Robotic technology has improved performance, decreased costs, and increased consumer satisfaction in today's market, particularly in the pharmacy sector. Pharmacy robots had made the daily work of pharmacists easier. This technique facilitates pharmaceutical industry to perform test and trials and allow research and development department to proceed their job faster. By applying these technologies to pharmaceutical, distribution, service, and industrial applications, the pharmacy sector grows. This technology manages efficiencies, requirements and infrastructure which help in developing the pharmacy system [18–35].

History

- Pharmacy automation was invented by *Frank Kirby* and his associate *Rodney Laster* in the year *1967*. He invented the *Digital Tablet Counter* which helps to count Tablets with new technology.
- Pharmacy Robotic System had begun in the late *1960s* with machines designed to count tablets (or) other pharmaceutical products. The first *Digital Pill Counter* was invented between *1967 and 1970 by John and Frank Kirby* at *Manchester* [36].
- *Automated Dispensing Cabinets* were introduced in late *1980s*. These facilitate medication, distribution, storage and dispensing of the products.
- Future of pharmacy robotic system in market was observed at *5.60* billion dollar in *2022* and expected to grow *8.02%* from *2022–2023* [37].
- The first *Pharmaceutical Blister Machine* was developed by *Karl Klein* in *Germany* in the year *1964*. Fully automatic forming, filling and sealing machine was developed in *1911* [38].
- Filling, sealing glass ampoules were invented in France by Pharmacist *Stanislaus Limousin.*
- *Punch card Tabulation Machine* was invented by *Herman Hollerith* in the year *1950*. First, *Barcode Scanner* was invented by *Norman Joseph Woodl* and *Bernard Silver* in the year *1952* to read the information of pharmaceutical products [39].
- First *Robotic Arm* was invented by *George Devol and Joseph Engelberger* in the *year 1963* which was used for Packaging, Grinding, Pelletizing, Material handling etc. *Loading Drawers* were also invented which were used in wide range of *storage and transportation* functions in Pharmacy Field [41].

Scope and Importance

- Robotics and automation offer the facility round the clock which help in development of the sector. The main point of view is demand for new drugs' development and its productivity with new technology. Implementation of robotics is a greater opportunity for manufacturers and distributors to increase their productivity, efficiency, quality of products in industry [40–45].
- Implementation of this technology increases production flexibility. Industry becomes more dependent on robotics which helps to speedup of tasks without any errors and with accuracy.
- Robotic technology not only improves delivery system but also boosts the enhancement of testing and analysing samples accurately. Its implementation increases the commercial and financial pressures within a short period of time which is a great advantage. The aim is to perform the operations with efficiency and accuracy with new technology.
- Robotics' implementation helps (or) save workers from performing dangerous (or) hazardous tasks which also saves workers' life from dangerous environmental conditions [46–55].

The Laws of Robotics

There are three laws of robotics:

1. A robot must not injure a human being through its action.
2. A robot must obey orders which are given by a human being but, it should follow 1st law.
3. A robot must protect its own existence.

TYPES OF ROBOTS (STRUCTURE)

There are four types of robots:

1. Articulated Robots:
   a. 6-axis Articulated robot;
   b. 4-axis Articulated robot; and
   c. 7-axis Articulated robot.
2. Scara Robots.
3. Delta Robots.
4. Cartesian Robots.

Articulated Robots

- These contain both horizontal and vertical joints with increased movements. With their greater flexibility they can perform any task that is harmful to humans, as shown in Figure 1 [56].
- Six axes are most commonly used Articulated robots in which first link rotates in horizontal plane and second two links rotate in vertical plane. It also contains vertically rotating wrist and also rotating fore arm which allows increased movements.
- The wrist joint and forearm of robot which works as similar to human hand allows them to *pick up* any material (or) objects such as packaged boxes and placing it at any required angle.

Scara Robots (Selective Compliance Assembly Robotic Arm)

- Scara robots are the most popular and are easy to use (Figure 2). These are mostly used for manufacturing and assembly applications. The name SCARA stands for Selective Compliance Assembly Robotic Arm which refers to the ability of robot to move freely and maintain stiffness in work.
- These move in versatile motion in XY plane like the combination of rigid and dynamic axes [57].
- These robots are perfect for both rapid and labor-intensive material handling activities, like packing and semiconductor handling for biomedical applications.
- The advantage of Scara Robots is that they are less expensive than other types of industrial robots because of their simpler design which can be an advantage of cost saving [58].
- Scara Robots are kings of small parts assembly applications which consist of high speed and accuracy. A Scara work envelope is cylindrical in manner which helps to work easier and faster [59].
- Scara Robot is controlled by various controlling systems such as Robust control, Fuzzy logic control, adaptive control and sliding mode control which help the Scara robot to handle the works with consistency [60].

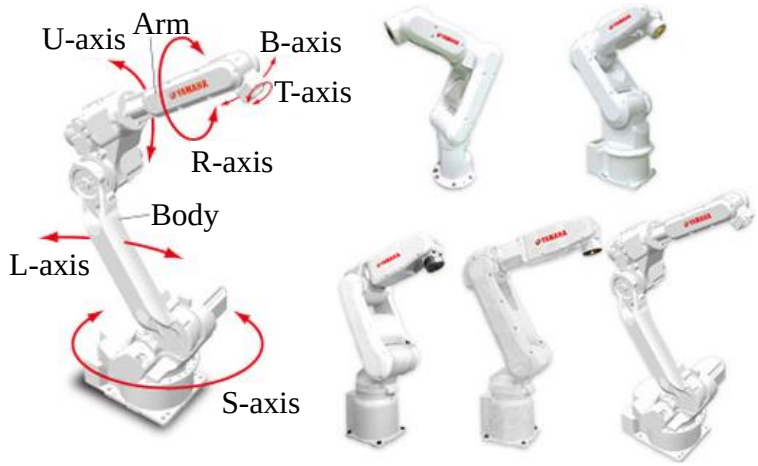

Figure 1. Articulated Robots.

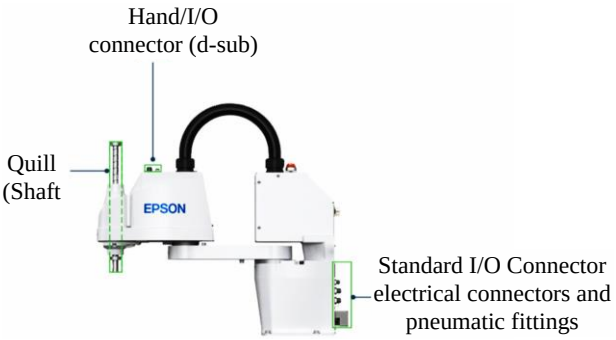

Figure 2. Scara Robots.

Limitations of Scara Robots

1. Because of their configuration they are only capable of carrying light weight up to *2* (or) *10 kg* maximum.
2. It is circular which cannot suit all applications and this robot is having lower flexibility compared to the other types of robots.

Delta Robots

- These were created in *1980s* which are also known as Parallel-link Robots because they are having Parallelogram Arm Design. Their arms are joined in the middle so they are bent. And they are connected to a motor and end effector which are connected with in the robot body [61].
- These robots are used in picking and packaging in factories. They are very fast (around 300 picks per minute). The advantage of Delta robots is high speed which are used in packaging industry, medical and pharmaceutical industry [62].
- Delta Robot consists of multiple kinematic chains which connects base with end effector (Figure 3). This robot is known as the four-bar linkage's spatial generalization[63].
- Its applications include high precision in the operations in cleaning room, dispensing, packing industry, medical operations, cosmetics, etc. The Delta robot's lightweight structure and rapid speed make it an excellent choice for picking and placing tasks requiring a high degree of rigidity.

Limitations of Delta Robots

- It contains low load capacity.
- It has small working volume because its robotic arms are connected with end effector.
- This can handle only light weight parts.

Cartesian Robots

- A Cartesian robot is also called Linear robot whose principal axes of control are Linear which move in straight line and consist of right angles at each other (Figure 4).
- The robot has high precision when operating in three-dimensional space because robot is in coordinate system with the rigid links connected to each other by joints.
- The application of this robot is in filling machines and plotters. They consist of high-speed performance and high accuracy and used in many automation systems.
- There are many applications of Cartesian robots in the industry because of its easier operation, and lower cost and it is completely versatile. These robots give high level of accuracy and precision compared to others due to their linear motion and these robots are having capability to carry heavy load.

Advantages

- Easy to customize and maintain.
- No need of a particular controller.

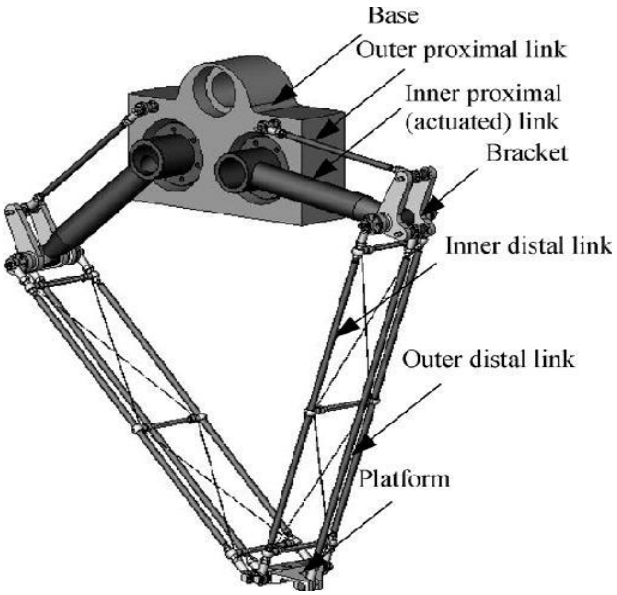

Figure 3. Delta Robots.

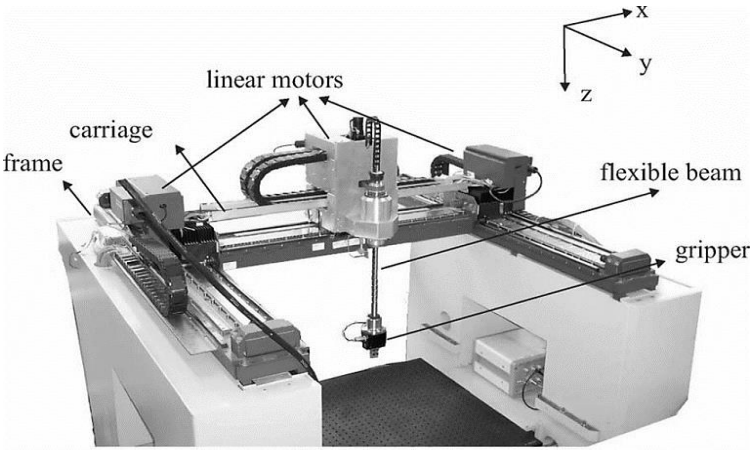

Figure 4. Cartesian Robots.

ROBOTS USED IN PHARMACEUTICAL INDUSTRY

Robots used for Filling, Inspection and Packaging

- Robotics are mainly used for vial-filling applications in which robotic vial manipulation is used in both before and after filling vials and pack-off vials; and this new technology is also used in handling plastic and glass syringes buffering and their packaging. 2D models of robots used in packaging are shown in Figure 5.
- The advantage of this is reduction of contamination and productivity is also increased because of accuracy and efficiency of robots.

Robotic capsule Filler

- This machine is expensive and used for filling capsule, spray-dried, pure API, blended, freeze-dried and biological powders. Different and infinite dose weight is accepted in this machine which helps to fill the capsule. Robotic capsule Filler is shown in Figure 6.

Robots in the Laboratory

- Laboratory robotics are able to work in such environments that are not safe for humans such as dangerous chemicals etc. These robots are having same speed and consistency throughout work without any tiredness. Work of robots in laboratory is shown in Figure 7.

- These robots perform the tasks same as humans but, in shorter time as compared to humans by producing less wastage.
- The robotic system in laboratory helps to ease the sample delivery, processing, analysing and reporting of the procedures.
- This technology also improves labware transportation, cleaning, error detection and handling of the laboratory.

Robotics in Pelletizing

- At the end of production process, the finished products need to be packed which are done automatically by making them into cartoons, boxes and keeping them into pellets as a task of robots as shown in Figure 8.
- This can arrange number of boxes and wrapping process is also done by these robots, which increases stability.

Figure 5. Robots used for Packaging.

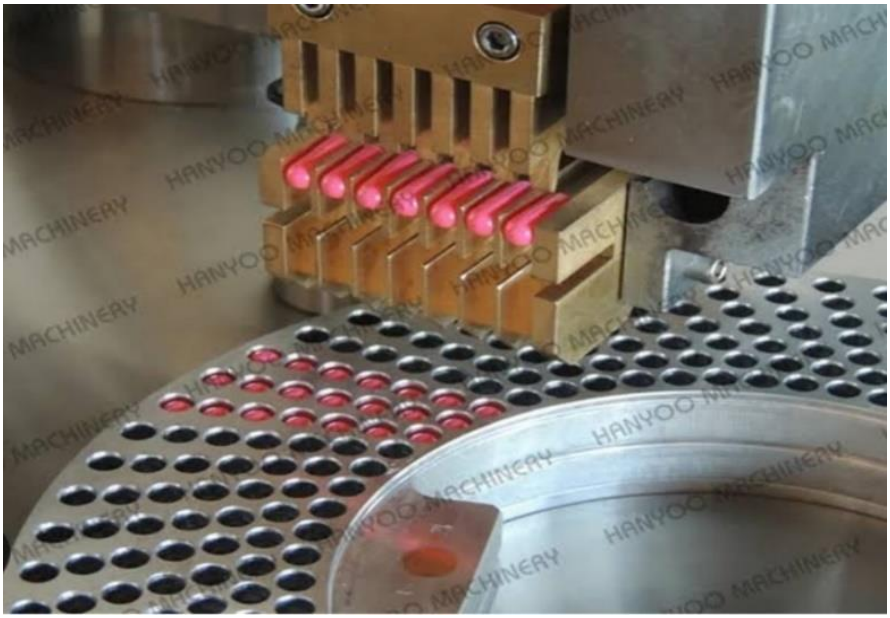

Figure 6. Robotic capsule Filler.

Figure 7. Laboratory robotics.

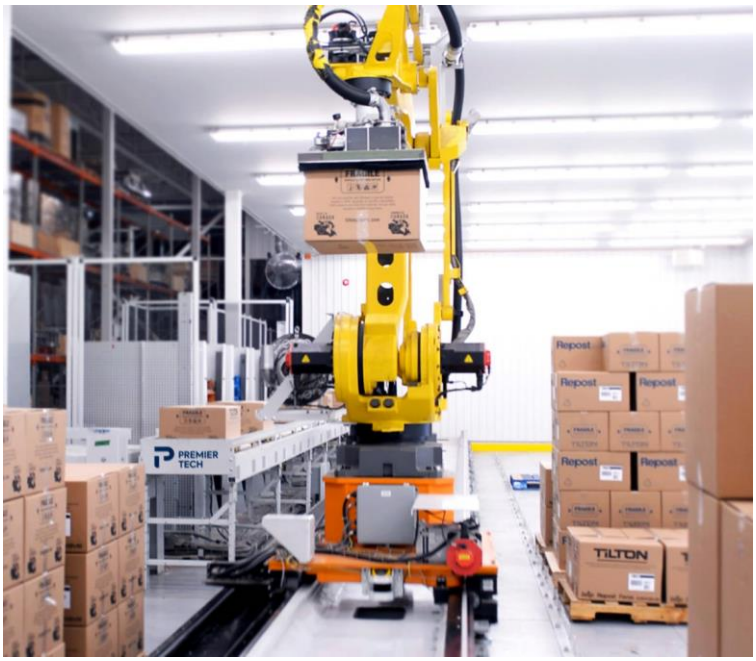

Figure 8. Robotics in pelletizing.

Robotics in Dosing and Closing of Bottles

- Dosing in correct amount of material in the bottles, syringes (or) vials is a difficult task. Sometimes, humans make mistakes in dosing accurate amount. But, using of robotic dosing machine helps to fill correct amount of dose as required.
- Closing of the bottles, vials, syringes contain caps which are sometimes not tightly packed and it is the most difficult task for workers to tight caps which sometimes cause leakage of the material; using robotic machines for closing bottles helps them to seal and pack conveniently without any leakage, as shown in Figure 9.

Robotic in Labelling

- After packing, labelling the products is next process for finished products which is inefficient process in which workers spend hours in just sticking labels and it also leads to errors that causes major issues.
- Robotic machine labelling, as shown in Figure 10, can improve efficiency which saves labour costs, avoid mistakes in label placements and less wastage and also reduce the issues from incorrectly placarding labels.

Figure 9. Robotics in closing of bottles.

Figure 10. Robotic in Labelling.

Robotic Mass Comparators

It is a high-performance comparator which consist of a robotic arm which helps in calibration of a large number of weights in automatic process without human help. Robotic Mass Comparator is shown in Figure 11.

- This achieves high accuracy in mass calibration of the pharmaceutical products and all the data is stored automatically by software.
- These comparators are having ability to handle large number of weights for high-throughput which contains high accuracy weight calibration.
- These comparators help to weigh all the samples, such as test, standard (or) other finished products accurately without errors.

Robotics in Quality Control of Products

- This involves automated quality control in which robots automatically inspect, test (or) measure manufactured products as shown in Figure 12.

- They contain, high resolution cameras etc. which conduct inspection of the pharmaceutical products.
- They detect many defects such as contamination, change in size, shape, colour, consistency, of the products with an automated process and finally ensure the quality of each product automatically.

THE MAJOR CHALLENGES ASSOCIATED WITH USE OF ROBOTICS IN PHARMACEUTICAL MANUFACTURING

Robotics is a technology used to increase efficiency, reduce errors and improve overall productivity, but this technology also faces challenges and opportunities during implementation. Such as:

High Cost

One of the main challenges in increase of robotics in pharmaceutical manufacturing is the cost of implementation which is most expensive to purchase, install and maintain. This also requires significant (or) special modifications which leads to additional expenses.

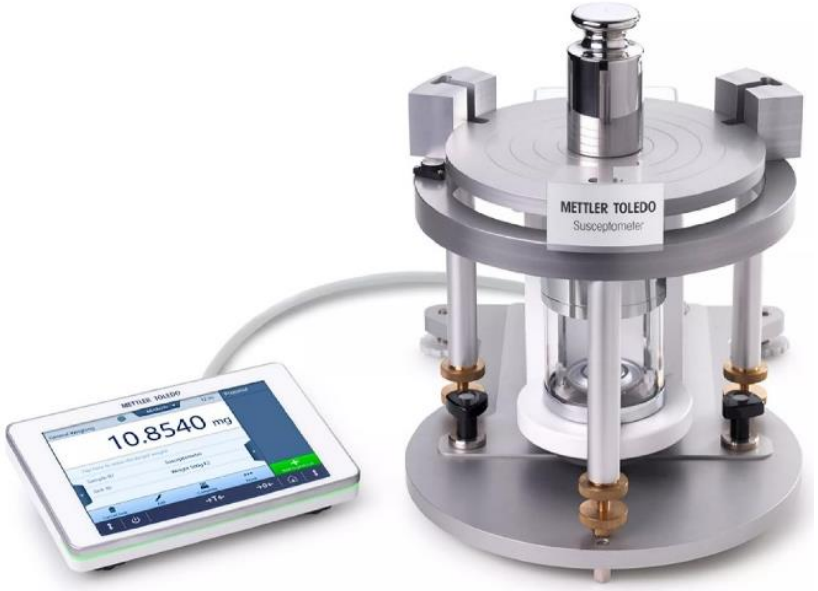

Figure 11. Robotic Mass Comparator.

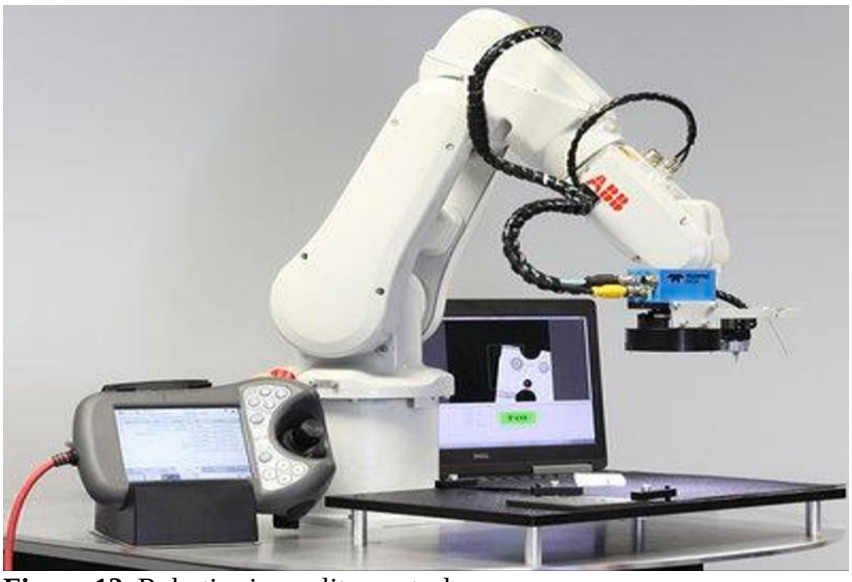

Figure 12. Robotics in quality control.

Specialized Skills

Other main challenge is need of technical experts to design and operate these systems because this technology improves efficiency and reduces errors. So, they require high degree of technical knowledge for proper functioning. For training personnel with technical expert can be time-consuming and expensive.

Job Displacement

When robots are used, more jobs are lost because human workers are replaced by more capable medications. But it creates new job opportunities such as development and also operation of these systems.

Compatibility

There is a different compatibility of different machines present in the industry maintaining heavy records. It is a significant task which requires additional investment in technologies.

Security Risks

As more manufacturing processes become automated, there is a risk of security threats increasing. Robots and other connected devices can be attacked through cyber hacks which leads to the financial losses in the company.

THE IMPACT OF ROBOTICS IMPLEMENTATION ON HUMANS

- As field of robotics increases continuously it is clear that it will have a significant impact on future of humanity such as, increasing use of robotics in various industries in manufacturing, transport and packaging free up the human workers from dangerous tasks.
- The rise of robots is also having negative impact such as decreasing of employment levels because certain jobs which are done by humans are now done by robots, which creates jobless future.
- Robotics technology leads to increased productivity and reduced production costs in companies which helps in saving money on wages on human labour; this increases profits for shareholders but also results in job displacement.
- Robotics reduce the need of workers to lift or carry heavy objects which results in back injuries for employees and significant savings for health insurance and compensation cost.
- Another advantage for humans is that its implementation saves time because robots can work for extended periods of time without any break. The work is completed accurately, consistently on time. Additionally, the work is completed in less time with a better outcome, saving human labor.
- In data analysis, robotic technology gives accurate output as compared to humans which leads to accuracy of the analysed samples. Many industries use robotics to make production line more efficient and time saving which a great advantage for humans.
- The implementation of robotics minimizes the errors in the process and work continuously without any break. This technology will save money as they have quick return on their investment which leads in more profit.
- Using robotics helps manufacturers improve quality of their products and meet customers' demands more efficiently. This technology increases productivity and gives more yield to manufacturers and saves labour wages which is also profit.
- The robotics in laboratories help the workers from the dangerous and hazardous chemicals in lab with which they save their lives. By using this robotics technology, there is no need of costly equipment in the industry. Because a robot is having an ability to perform different tasks with which manufacturers get big change in market demand with quality and efficiency.

OBSTACLES DURING IMPLEMENTING THE ROBOTICS SYSTEM

Implementation of robotics in industry is a challenging process and there are also technical challenges included or faced during the successful implementation. Such as:

1. Employees fear of robotics' implementation is the biggest challenge because employees are worried about losing their jobs.

2. Another is lack of knowledge among implementers on how to involve processes such as mixing the solutions with other solutions etc.
3. An important obstacle is inability to manage the robots and also their services which are sometimes unable to be controlled.
4. The majority of workers struggle to determine which robotics procedure is best for a given task, even if these abilities are crucial. So, lack of knowledge is also considered as an obstacle.
5. Poor knowledge regarding ownership and responsibility of the process make a big difference financially.
6. Difficulties in measuring the rate of return in investment.
7. Problems in clearly understanding operation, service or goals of implementation which run the robotic technology.

ADVANTAGES AND DISADVANTAGES

Advantages

- Robots produce quality results consistently.
- Reduces the costs.
- They can be trusted to work safely and effectively.
- They save the time as they work round the clock.
- As long as we maintain the robotic programme correctly, we get precision and reliable results.
- Manufacturing robots offer maximum productivity in low time management.
- These robots function faster than humans and also reduce labour cost.
- When the manual work is replaced with robotics, we can avoid the risk of danger or harm to employees especially in the hazardous environments.
- This technology gives the production with assured quality which ensures the consistency and possible human errors threat will be removed.
- Minimize potential legal liabilities.
- Unskilled workers will be replaced.
- Robots do not need rest, break or shift changes as they work 24/7 with a constant speed.
- Robots can work in any environment, they do not need particular environment as humans need, such as air conditioning, lighting, or noise protection.

Disadvantages

- Before we gather the benefits by robotic technology, we need to invest. Price can be different costs based on level of complexities. Depending upon completion of your robotics, this requires a specialist operation, programming and maintenance which gives a great impact.
- Joblessness is the most significant disadvantage because the robots are performing activities which are done by humans.
- We also need to invest on ongoing costs such as robots and its related connected devices etc. which is additional investment.
- Robots only do what they are told to do; they cannot improvise.
- They are sometimes hard to operate which also leads in failure of robots which need a greater skill.
- Installation of robotics may sometimes cause serious attacks such as cyber-attacks etc. which leads to company losses financially.

APPLICATIONS

Materials Handling

The robots are utilized to move, pack and select the products. Their function is to automate involving transferring of parts from one piece of equipment to another.

Assembly

Robots assemble products, eliminating hard tasks. They increase output and reduce operational costs.

Painting

Robotic painting is used in automatic production which increases quality and consistency of product. Cost savings are realized through less work.

Mechanical Cutting, Grinding and Polishing

These processes are difficult to automate. They take 45–50 min with human performance but, same function is done by robot in just a few minutes.

Sealing and Spraying Materials

Sealer robots are built with many robotic arm configurations. The primary benefit of these applications is, increased quality consistency and speed of a finalized product.

Machining and Cutting

These robots insert work pieces into machine tools and remove after operation is completed which is a hard task and time-consuming process for a human. Cutting the products is hard sometimes which can injure employees but, robotic machines help in easy cutting with desired length.

Finishing

Robots remove undesired material left behind from many processes, including drilling, casting, and welding, to produce sharp edges and produce the desired final product.

Palletizing

The robots can pack boxes and containers onto a pallet in an optimized way. Heavier containers are placed in bottom by robots. The boxes are adjusted in such a way that number of boxes fit into the pallet

Inspection and Quality control

Human inspection is 80% accurate but, inspection done by a robot is 100% accurate.

Sorting

Workers perform task of sorting which is typical task. For example, they may separate items by size, type or under number which is a difficult process. Therefore, robots relieve humans from such pressure. Now, you can programme robot even with simple sensor for variety of sorting tasks.

Casting and Moulding

Injecting a liquid metal in a cavity shape of the object in which, liquid is sometimes lost by humans. But robotic machines can inject a liquid in desired amount and shapes. Moulding of different shapes is needed. Therefore, injection moulding robots are used in the industry.

CONCLUSION

Implementation of robots in pharmaceutical domain decreased the human effort and time. Increase in the technology of robots mainly drawn for pharmaceutical domain, especially with Artificial Intelligence and Machine learning algorithm will bring a new era in the world of robotics especially made for pharmaceutical domain. More research should be performed for improving the intelligence of robot especially for pharmaceutical domain.

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