THE IMPLEMENTATION OF INDUSTRIAL ROBOTS

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ABSTRACT: Progress is nothing new, especially from a scientific point of view. Many would argue that we are now in Industry 4.0, the fourth Industrial Revolution, due to the rapid digitalization of the world. We covered the historical context that justifies our current need for industrial robots, arguing about the benefits and disadvantages of their implementation. After a short discussion about 'Smart Factories', we classified the industrial robots, choosing to detail the industrial robot SCARA, drawing and explaining the advantages of its kinematic scheme.

KEYWORDS: industrial robot, Smart Factories, SCARA robot, kinematic structure.

1. Introduction

In the paper the subject is debated at length, focusing on the remarkable progress of technology, showing that mankind has always invented better and better means to meet their needs. All that is presented leaves room for the question "what will happen next?"

2. Current status of industrial robots

Presentation of the history behind industrial robots and the advantages and disadvantages of large-scale implementation. What is a "Smart Factory" and the classification of industrial robots.

2.1 The historical context of robot deployment

In many ways, throughout history, humans have created various ingenious solutions to simplify their daily tasks. This simple but remarkably human fact has caused significant changes in our lifestyle, and we can say that it has directly helped our evolution as a species.

A first change of this kind, and the first time man used anything but his own hands and physical exertion was more than 10,000 years ago, when man transitioned from hunting / searching for food to raising it in a farm. Slowly, the quality of human life increased, no longer needing to lead a nomadic lifestyle, pursuing food - cities and settlements were formed, all through human ambition and insight.

With the Second Industrial Revolution, which began in the 19th century and ended in the early 20th century, mass production in factories became possible thanks to electricity, the scientific progress of that period, and the invention of the assembly line. The assembly line was invented by Henry Ford in 1913, and once installed, it was able to reduce the assembly time of a machine from 12 hours to one hour and 33 minutes. The third Industrial Revolution, also called the Digital Revolution, began in 1960 and was characterized by the construction of the first computers and later, in 1990, the Internet.

Since 1980, the interest of large manufacturing companies for robots has begun to grow exponentially. Yaskawa America Inc. introduced the Motoman ERC control system in 1988 to work in one of their assembly plants. It had the power to control up to 12 axes, which was the largest possible number at the time. In 1994, the Motorman ERC system was upgraded to support up to 21 axles, and in 1998, 27 axles. The controller could also operate up to 7 robots, used in form cutting (laser cutting or high pressure water cutting) the task considered by Yaskawa America to be far too dangerous for humans.

In December 2008, Linatex, a Danish supplier of plastics and technical rubber for industrial applications, purchased a new UR5 robot (made by Universal Robots) to automate the operation of CNC machines, which they installed next to the company's employees, without using a safety grille, as usual. Instead of bringing in an external programmer with complex programming skills, Linatex programmed the robot themselves, using a touch screen, with no programming experience. With the launch of UR5, Universal Robots became a major player in industrial automation, paving the way for new frontiers, with a particular focus on small and medium-sized businesses, where the use of robots was usually too expensive and complex. With more than 8,400 robots now installed in more than 55 countries, the company has successfully entered markets that require flexible and easy-to-use robots that can work with employees safely.

We consider, therefore. that we are in the 4th Industrial Revolution, due to robots and the rapid advancement of technology, and that the implementation of industrial robots will have as much significance for humanity as the invention of the train rails of the first industrial revolution.

2.2 Smart factories

The term 'Smart Factory' was first used at the Hannover Fair in Germany, 2011. A Smart Factory is a unit based on intelligent/automated production and although this concept is still in its infancy, it is considered the result of the Fourth Industrial Revolution, known as Industry 4.0. Smart factories use the latest technologies in areas such as artificial intelligence, robotics, analytical tools and IoT - 'Internet of Things', a term that refers to billions of devices around the world connected to the Internet and permanently stored in a collection process. and data exchange. This type of factory is designed to operate autonomously with minimal human intervention, requiring people only for maintenance and inventory, and, of course, in managerial positions. In conclusion, the implementation of robots in factories to such a high degree could positively influence the quality of human life, replacing people in hazardous areas or with unfavorable conditions, performing repetitive tasks and actively preventing their exploitation.

2.3 The advantages and disadvantages of implementing industrial robots

Advantages:

1. increased quality consistently: Like other technologies such as the above-mentioned "Internet of Things", industrial robots are able to provide a better quality of production, through precision. A great benefit to this is the ability to monitor robots in real time, effectively preventing any mistakes.

2. Increased productivity: An industrial robot greatly increases production speed, in part due to the fact that it works non-stop, requiring no breaks or shift

3. Provide human safety: We consider this to be the most important advantage - using robots for repetitive tasks means less risk of injury to workers, especially if manufacturing takes place in a hostile environment.

4. Lowering wage costs: Paying a person often costs more than a robot and maintaining it. The base can guide them to parts of the business where their unique skills can be better used, such as in engineering, programming and maintenance.

Disadvantages:

1. Requires a large initial investment: Industrial robots usually need a generous initial investment to cover installation and configuration costs, since many current industrial robots are no longer as simple as UR5.

2. Permanent costs: Robots need maintenance, but not only. In addition, the protection of robots and associated devices through the "Internet of Things" from cyberthreats also imposes a cost.

3. Leaving the middle class out of work: This aspect is also important to consider (although this paper is not, per se, about this theory): If the jobs to which workers are heading are not as well paid or require education at which they did not have the privilege of taking part? We cannot be convinced that the company he works for will provide them with courses or opportunities that will provide him with at least as beneficial a job.

2.4 Classification of industrial robots

Depending on the type of movement, industrial robots can be:

1) **Cartesian robot**: also called rectilinear, its arm operates in a space defined by Cartesian coordinates (x, y, z), which means that it moves in straight lines, translation on 3 different axes. Cartesian robots have very flexible configuration models and are a popular choice for building CNC and 3D printing machines.

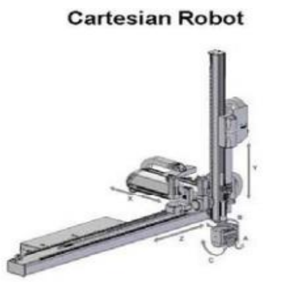

Fig. 1. The Cartezian robot

2) **SCARA robot**: SCARA = Selective Compliance Assembly Robot Arm. Similar to the Cartesian ones, SCARA robots operate on the x, y and z axes but also have rotational motion. SCARA robots are excellent for lateral movements and are used in assembly and biomedicine.

Fig. 2. SCARA robot

3) **Cylindrical robot**: Cylindrical robots have a rotating joint at the base and a prismatic one for connecting the arm that moves in translation. Due to their compact design, they are most often used in painting or repairing cars.

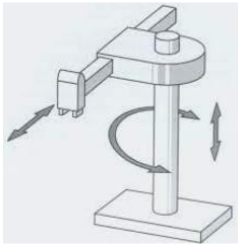

Fig. 3. The cylindrical robot

4) **Delta robot**: also called the parallel robot, it has 3 arms fixed to the same base mounted above the workspace, each arm having a joint between the effector that allows it to work precisely, delicately, but also incredibly fast. Delta robots are predominantly used in the pharmaceutical and electronics industries.

Fig. 4. Delta robot

5) **Polar robot**: nicknamed the spherical robot, they have an arm with 2 rotating joints and a translation arm, connected to a twisting base. The robot's axes together form polar coordinates, allowing the robot to work anywhere in its sphere. They are usually used in metal welding and injection molding.

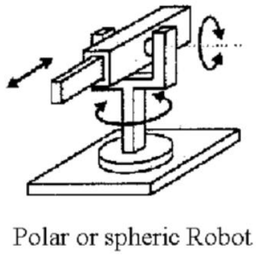

Fig. 5. The spherical robot

3. The SCARA robotic arm

Next, we will deepen the subject of the robotic arm of SCARA type robots.

YAMAHA - a multinational company of Japanese origin known as one of the largest motorcycle manufacturers in the world - attributes part of its success to the market of the SCARA type robots they use: YK-XG Series. Their robotic arm can operate at lengths between 120mm and 1200mm and can support weights between 1 kg and 50 kg. This robot is used in a wide variety of processes and applications, such as production equipment for electrical and electronic components and small precision machine components that require precise assembly and assembly, handling and transfer of large automotive components.

Fig. 6. Operating principle

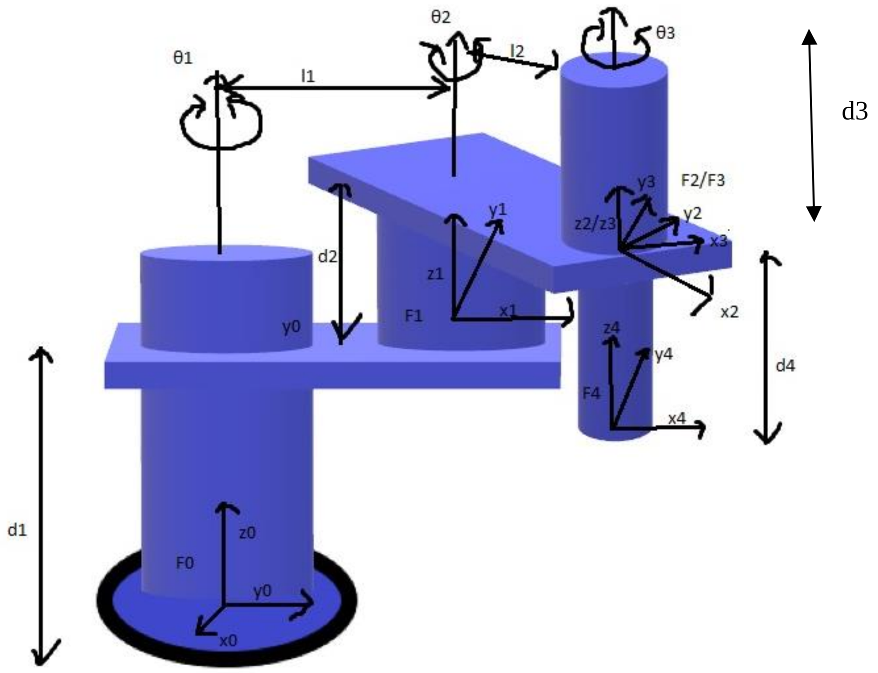

Fig. 7. Kinematic structure of the SCARA robot

We can see that the SCARA robot has 3 rotating joints, rotating at angles Θ1,2,3 and can perform 3 independent rotational movements with respect to each other (RRR), having 4 degrees of freedom.

We can analyze the movements of the robot knowing the movements of each coupling of the SCARA robot. For this we will use the Denavit-Hartenberg (DH) parameters entered in MATLAB. Knowing these parameters we can determine the position of the end-effector.

"Li" is the distance between the z-axes measured along x ; "αi" is the angle at which the system i-1 must be rotated in respect of x so that day-1 reaches z ; "di" is the distance between the x-axes measured by z.

Tabel 1. The SCARA robot parameters

	Variable arms	**αi**	**αi**	**di di**	**αi -d3**	**sin θ1**
1	θ2	0	L1	0	1	0
2	L2	0	θ3	0	1	0
3	d3	0	0	-d4	1	0
4	0	0	0	ai	1	:

DH matrix has the following forms:

$$\begin{pmatrix} \cos(\theta 1) & -\sin(\theta 1) & 0 & L1\cdot\cos(\theta 1) \\ \sin(\theta 1) & \cos(\theta 1) & 0 & L1\cdot\sin(\theta 1) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \cos(\theta 2) & -\sin(\theta 2) & 0 & L2\cdot\cos(\theta 2) \\ \sin(\theta 2) & \cos(\theta 2) & 0 & L2\cdot\sin(\theta 2) \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & -d3 \\ 0 & 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} \cos(\theta 3) & -\sin(\theta 3) & 0 & 0 \\ \sin(\theta 3) & \cos(\theta 3) & 0 & 0 \\ 0 & 0 & 1 & -d4 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (1)$$

$$\begin{pmatrix} \cos(\theta 1 + \theta 2 + \theta 3) & \sin(\theta 1 + \theta 2 + \theta 3) & 0 & L2\cdot\cos(\theta 1 + \theta 2) + L1\cdot\cos(\theta 1) \\ \sin(\theta 1 + \theta 2 + \theta 3) & \cos(\theta 1 + \theta 2 + \theta 3) & 0 & L2\cdot\sin(\theta 1 + \theta 2) + L1\cdot\sin(\theta 1) \\ 0 & 0 & 1 & -d3 - d4 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (2)$$

4. Conclusions

- We explained the historical context of people's need for industrial robots.
- We have exemplified the advantages and disadvantages of their implementation in factories, mentioning smart factories.
- We classified, according to the type of movement, the industrial robots, choosing the SCARA robot for detailing.
- Making a kinematic structure of a SCARA robotic arm, we detailed the robot main parameters and gave the final form of the Denavit-Hartenberg matrix.

5. References

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