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Chapter 1

The fundamental ideas behind robots

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Abstract: According to the Robot Institute of America, a robot is said to be a reprogrammable, multi-tasking machine. A functional manipulator that is designed to transfer materials, components, tools, or specialised devices through a specialised device. There are several motions that have been coded in order to carry out a wide range of jobs. The combination of numerical control and remote manipulation not only resulted in the creation of a new area of engineering, but it also brought about the emergence of a number of scientific concerns in design and control that are significantly distinct from those that were associated with the technologies that were initially developed. This chapter illustrates robots main concepts, Components of robots, robots' classification, robots' controls, and robots and automation influence on industry sectors and jobs.

Keywords: Robots concepts, classification, controls, automation, industry, jobs.

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1.1 Introduction

Robots are expected to possess a level of movement and dexterity that is far higher than that of conventional machine tools. A vast accessible range, the ability to enter busy locations, the ability to handle a variety of workpieces, and the ability to do flexible duties are all abilities that they need to possess. The peculiar mechanical structure of robots, which is similar to the structure of the human arm, is the result of the high mobility and dexterity requirements that are placed on them. This structure, on the other hand, is somewhat different from the conventional machine design. Cantilevered beams, which are used to build a series of arm links that are joined by hinged joints, are the fundamental components that make up the mechanical framework of a robot. The mechanical rigidity and accuracy of such a structure are intrinsically low, and as a result, it is not suitable for the high-precision, heavy-duty applications that are needed of machine tools. In addition to this, it suggests that there is a sequential succession of servoed joints, the mistakes of which gradually accrue along the linkage. It is necessary to overcome these challenges through the use of sophisticated design and control strategies in order to take advantage of the high mobility and dexterity that are distinctive characteristics of the serial connection. Complex equations that are nonlinear in nature are used to explain the serial linkage geometry of manipulator arms.

For a comprehensive understanding of the geometric and kinematic behaviour of the manipulator, which is commonly referred to as the manipulator kinematics, it is required to have analytical tools that are effective. Due to the fact that research in kinematics and design has traditionally concentrated on single-input mechanisms with single actuators moving at constant speeds, this represents a significant and one-of-a-kind area of robotics research. Robots, on the other hand, are multi-input spatial mechanisms that require more sophisticated analytical tools.

1.2 Literature review

David Marr's research on computational theories of vision, which he conducted at the Massachusetts Institute of Technology (MIT) (Marr, 1982) from the 1960s to the 1980s, is frequently seen as a significant step in the development of computational neuroscience. The work of Marr had a great influence on the field of computer vision research and made a substantial contribution to the creation of functional technologies for applications in everyday life. While Marr's primary focus was on issues pertaining to vision, he also had a comparable interest in computational theories that were established for issues pertaining to motor control. This interest has also predominantly been centred at MIT.

John Hollerbach, who was Marr's first Ph.D. student, and Neville Hogan were among the early faculty members at MIT who developed computational theories and algorithms of human motor control. They were joined by a subsequent generation of scientists, such as Tamar Flash, Christopher Atkeson, Ferdinando Mussa-Ivaldi, and Michael Jordan. The experts in question had extensive knowledge in the fields of physics, mathematics, biomedical engineering, and control theory. They proposed rigorous formulations of computational theories of neuromotor control that could also be validated in actual robots. This group has made a number of significant contributions, some of which include the following: optimal control of motion planning (Brady et al., 1982; Flash, and Hogan, 1985; Hogan , 1984), model-based control (An et al., 1987), learning control (Aboaf et al., 1988), learning of internal models (Jordan and Rumelhart, 1992; Schaal and Atkeson, 1994), and general planning and trajectory construction with dynamic systems theories (Ivaldi and Giszter, 1992). Around the same period, that is, roughly in the 1980s and early 1990s, a number of very talented roboticists began conducting research at the

Massachusetts Institute of Technology (MIT) on animal-like and anthropomorphic robot systems.

For instance, Marc Raibert's Leg Lab was focussing on legged locomotion with dynamic gait patterns and most impressive experimental accomplishments from single legged to four-legged robots (Raibert, 1986). Jean-Jacque Slotine developed theories and experimental evaluations in nonlinear control (Slotine and Li, 1991) that were tested on high performance robot arms. Stephen Jacobsen, a professor at the University of Utah who had previously trained in biomedical engineering at the Massachusetts Institute of Technology, collaborated with colleagues from MIT to build the Utah/MIT Dexterous Hand, a high-performance hand that resembles a human hand and has five fingers. A line of study on skill development in robotics was initiated by Christopher Atkeson's group (Schaal and Atkeson, 1994), which is also closely related to the research that is currently being conducted by Daniel Koditschek's research group at Yale University on the analysis of dynamic motor skills for robots (Bühler and Koditschek, 1988; Bühler and Koditschek, 1990; Rizzi and Koditschek, 1992).The dynamic behaviour of robot manipulators is also complicated due to the fact that the dynamics of multi-input spatial connections are strongly coupled and nonlinear. The movements of all of the other joints have a major impact on the activities that take place in each individual joint. It is important to note that the arrangement of the manipulator arm has a significant impact on the inertial stress that is introduced at each joint. In situations when the manipulator arm is moving at high speeds, the effects of Coriolis and centrifugal forces become more noticeable. Effective control system design is a major issue in robotics because of the kinematic and dynamic complexity that produce unique control difficulties that are not sufficiently addressed by typical linear control approaches. As a result, effectively designing control systems is a critical issue.

Last but not least, in comparison to conventional numerically-controlled machine tools, robots are expected to interact with peripheral equipment in a far more significant manner. In their most basic form, machine tools are self-contained devices that are designed to handle workpieces in very specific areas. In contrast, the environment in which robots are employed is frequently poorly organised. Therefore, it is necessary to design efficient methods in order to detect the positions of the workpieces and to connect with peripheral devices and other machines in a coordinated manner. A further significant distinction between robots and master-slave manipulators is that robots are autonomous systems, in contrast to the latter. Master-slave manipulators are essentially systems that are controlled manually, with the human operator being the one who makes decisions and implements control actions. An operator is responsible for interpreting a job that has been provided to them, determining a suitable strategy to complete the work, and planning the method of operations. On the basis of his or her prior experience and understanding of the activity, he or she comes up with an efficient method of accomplishing the objective. After then, the slave manipulator receives his or her decisions through the joystick through which they are conveyed. The operator is responsible for monitoring the motion that is produced by the slave manipulator, and then making any required changes or alterations to the control actions in the event that the motion produced by the slave manipulator is insufficient or when unexpected occurrences take place while the operation is being carried out. In light of this, the human operator constitutes an essential component of the control loop. If the operator is removed from the control system, then the machine itself will be responsible for generating all of the planning and control orders. To ensure that the robot is able to correctly comprehend and carry out the motion command, it is necessary to first establish the complete sequence of operations in advance. Additionally, each step of the motion command must be prepared and programmed in an acceptable manner. In addition, there is a requirement for efficient methods of storing the commands and managing the data file. Programming and command generation are therefore extremely important concerns in the field of robotics. Furthermore, the robot must be able to thoroughly monitor its own movements in order to function properly. The robot needs a variety of sensors in order to acquire information about the environment (through the use of external sensors, such as cameras or touch sensors) as well as information about itself (through the use of internal sensors, such as joint encoders or joint torque sensors). This allows the robot to adapt to disturbances and changes in the work environment that are unpredictable. It is necessary to have sophisticated control algorithms in order to have effective sensor-based methods that incorporate this information. On the other hand, there is a need to suggest a comprehensive comprehension of the work at hand.

1.3 The Constituent Parts of a Robot

When we talk about mechanical platforms or hardware bases, we are referring to a mechanical device like a wheeled. A construction that is capable of interacting with its surroundings, such as a platform, arm, fixed frame, or other structure as well as any other mechanism that is affected by his skills and applications.

- ***Sensors systems*** are unique components that are located on or around the robot. You could use this equipment to equip with the ability to offer the controller with judgement based on pertinent facts on the surroundings and provide the robot with input that is helpful.
- ***Joints;*** The robot itself benefits from increased adaptability thanks to joints, which are more than just a point that unites two moving parts. any linkages or components

that are capable of flexing, rotating, rotating, and translating. The joints are extremely important components of the robot. The capability of the robot to move in a variety of directions, which brings about an increased degree of freedom.

- ***The Controller*** is the "brain" of the robot and performs its duties. The controls that are used in modern robots are run by programs, which are collections of instructions expressed in code. To put it another way, it is a computer that is utilised and exert control over the robot's memory and reasoning. So that it, be able to work without supervision, and automatically take place.
- ***Power Source*** is the primary source of energy that is used to satisfy all of the requirements of the robots. Potentially, it is a source.
- ***Direct current***, such as that produced by a battery, or alternating current, such as that produced by a power plant, solar energy, or hydraulics or gas itself.

The term "artificial intelligence" refers to the capacity of computers to "think" in fashions that are analogous to those of humans beings. It is true that modern "AI" enables robots to imitate certain basic human cognitive processes, but they are not even close to being able to compete with the speed and complexity of the brain. To the contrary, on the other hand, not every robot is equipped with this kind of capabilities. It requires a significant amount of programming for the robot to be able to achieve this level, sophisticated controls and sensory capabilities are required. The muscles of a robot are referred to as actuators. A mechanism that helps activate process control is referred to as an actuator. There is a wide variety of them. Types of actuators used in robotic arms, include brush-based synchronous actuators and brushless DC servo controllers, stepper motor and asynchronous actuator, including traction motor, pneumatic, and alternating current (AC) servo motors hydraulic in nature. Fig. 1.1 illustrates a robot that mimic humans.

1.3.1. Robots, Controls and Their Classification

These are the several ways that a robot can be classified:

In accordance with the structural capabilities of the robot, the robot can be classified as either mobile or stationary. The term "mobile robot" refers to a machine that is capable of moving around on its own and functioning automatically. For example, a robot that spies. ***Mobile robots*** are able to move around in their surroundings and are able to move around their environment, not restricted to a single geographical area on earth. It is possible for mobile robots to be "autonomous" (AMR stands for autonomous mobile robot).

It indicates that they are able to navigate an environment that is not under their control without the need for physical manipulation. or gadgets that incorporate electromechanical guiding. There is also the possibility of mobile robots relying on navigation systems that let them go along a predetermined navigation route in a space that is substantially under their control (AGV stands for autonomous vehicle).

Fig.1.1. Robot picture

Stationary robots; Industrial robots, on the other hand, are often more or less fixed and comprise of a jointed structure. The arm, which is a multi-linked manipulator, and the gripper assembly, also known as the end effector, are permanently connected to a surface.

The majority of industrial robots have a fixed base, although the arms are able to move about. Joint motions are required for an industrial robot to be able to function in accordance with the software instructions. Precise control may be exercised. In order to operate the robots, controllers that are based on microprocessors are utilised.

The following is a list of the several forms of control that are now being utilised in the field of robotics.

1. Sequence Control That Is Restricted

In terms of control, it is a fundamental kind. For straightforward motion cycles, such as pick-and-place, it is utilised in carry out operations. That is accomplished by establishing limits or mechanical stops for every joint, and it is executed. In order to complete the surgery, the movement of the joints must be sequenced. It is possible to employ feedback loops to it. It is necessary to tell the controller that the action has been completed in order for the program to proceed to the next step. This type of control system has a reduction in precision. Its most common application is in pneumatically powered systems.

2. Point-to-point control is supported for playback

In order to capture motion sequences in a work, playback control makes use of a controller that is equipped with memory. In addition to linked locations and other characteristics, it continues to play back the work cycle when the software is being executed. Through the use of point-to-point control, the locations of each individual robot are recorded within the recollection. Not only do these places provide mechanical stops for every joint, but they also include the set of values in which the places within the range of each joint are shown. Utilising feedback control allows for the verification of the Individual joints that are able to reach the regions that have been defined in the software.

3. Iteration of playback with continuous path control

The term "continuous path control" refers to a control system that is able to perform simultaneous operations continuously, and control of two or more axes simultaneously. With regard to this particular form of playback, the following benefits are observed: increased storage capacity—the number of places that can be stored is bigger than in the previous situation, interpolation computations, particularly linear and circular ones, may be utilised in addition to point-to-point calculations, and interpolations are used.

4. Control that is Intelligent

When a robot displays behaviour that gives the impression that it is intelligent, we say that it is intelligent. Just one example: There is a possibility that it possesses the ability to interact with its surrounding environment; the capacity to make decisions; capability of interacting with human beings; capability of performing computational analysis while on the job reactivity to sophisticated sensor inputs, as well as cycle response. It's also possible that they have the playback and available facilities. Nevertheless, it necessitates a rather high level of computer control as well as sophisticated programming. The process of storing language for decision-making reasoning and other forms of intelligence into the memory is required. Fig.1.2. illustrates stationary and mobile robots. Fig.1.3. illustrates types of robots' controls.

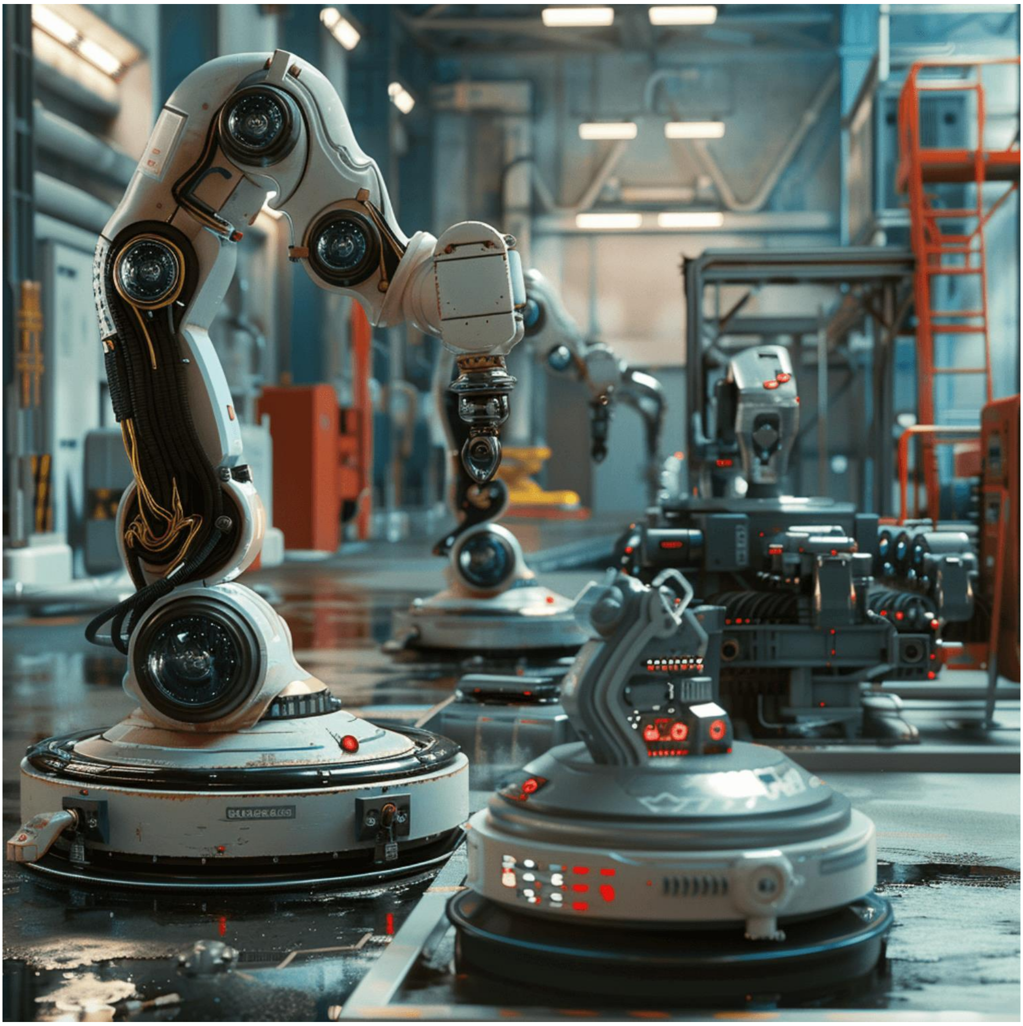

Fig. 1.2. Stationary and Mobile Robots

Fig. 1.3. Types of Robots’ Controls

1.4 The Impact of Robots, Automation on Industry Sectors and Jobs

The overall effect of automation, and robotics in particular, is a net benefit for the labour market. The situation, however, is not uniform among industries, occupations, or levels of expertise. The public is understandably worried that automation will lead to the total elimination of some occupations (Frey and Osborne, 2013). Recent research has taken a more complex approach, focussing on tasks rather than the automation of jobs (Arntz et al., 2016; McKinsey Global Institute, 2017). Depending on the profession and industry, the amount of possible automation of tasks within a job varies widely, and this data indicates that less than 10% of jobs are completely automatable. More jobs will evolve than be replaced by robots, according to McKinsey (McKinsey Global Institute, 2017). The IFR's experience supports this important differentiation, which depicts a future where humans and robots collaborate, each doing their best work. This will have positive effects on the firm's competitiveness, which in turn affects employees, and on the quality of work that people do. The value of the remaining human links in the production chain improves when automation or computerisation makes some phases in a labour process more reliable, cheaper, or faster, according to economist David Autor (Autor, 2015). Economist James Bessen notes that, contrary to popular belief, the number of bank tellers was not reduced when automated teller machines were introduced in the 1990s. The number of tellers per branch did decrease, but banks expanded their network to stay competitive, and tellers' responsibilities shifted to include more valuable customer interactions (Bessen, 2015). Although some studies have shown that automation lowers employment and the proportion of workers' income going to the national economy, others have shown that the creation of more complicated jobs has the reverse impact, and that innovations of both kinds lead to economic progress. There is a steady balanced growth path where the two kinds of inventions go hand in hand under suitable conditions (Acemoglu and Restrepo, 2015). Keep in mind that just because the workforce in one industry is contracting doesn't mean that all jobs will be lost. What matters is whether or not other industries or job types are adding to the total. For instance, according to (Bessen, 2016), the agricultural sector has seen a precipitous decline in employment, going from employing a considerable number of people of the US labour force in 1900 to fewer than 5% now. However, this decline has been more than offset by the creation of new jobs in industries like manufacturing and services. In a similar vein, a World Economic Forum study predicting member companies' employment growth in the Architecture and Engineering job family indicated that robotics will play a significant role (World Economic Forum, 2016).

Conclusions

The field of technology known as robotics is concerned with the creation of robots, as well as their operation, utilisation, and operation. A robot is a machine that can be taught to perform a broad variety of tasks, ranging from the most fundamental to the most complex. This is what we mean when we say that it is feasible to teach a machine to perform these tasks. Recent technical breakthroughs, on the other hand, have made it possible to deploy robots in a wide variety of diverse businesses. For a substantial amount of time, robotics has been extensively employed in the manufacturing and industrial activities of various industries. Robots are one of the technologies that have been responsible for the most significant and widespread upheaval in the business sector in recent years. Robots are rapidly transforming the manner in which we work and live. These robots are having an impact on a wide range of industries, including healthcare, education, and manufacturing, as well as logistical operations.

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