A BRIEF ANALYSIS ON ROBOT ANATOMY

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Abstract: The paper describes an anatomy of robots and performance of robot anatomy. A robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. Today, there is vast advancement in the field of technology; a robot is a real example for this. The robot looks like a normal human being who performs similar activities such as walking, talking and perform various tasks that has been asked to do. The analysis and synthesis of construction and operation of the robots will be termed as robotics. In this paper, the anatomy describes the whole requirements for the manufacturing of a robot. It deals with the physical construction of a manipulator structure (robot). The manipulator of an industrial robot is constructed of a series of joints and links. Robot anatomy deals with the types and sizes of these joints and links and other aspects of the manipulator's physical construction which is described in this paper.
KEY WORDS: Robot, Robotics, Robot Anatomy

I. INTRODUCTION

An industrial robot is an automatically controlled, reprogrammable, multipurpose manipulator programmable in three or more axes. The field of robotics may be more practically defined as the study, design and use of robot systems for manufacturing (a top-level definition relying on the prior definition of robot). Typical applications of robots include welding, painting, assembly, pick and place (such as packaging, palletizing and SMT), product inspection, and testing; all accomplished with high endurance, speed, and precision.

There are various types of the robot depending upon the purpose of need and physical structure. Some robots are programmed to faithfully carry out specific actions over and over again (repetitive actions) without variation and with a high degree of accuracy. These actions are determined by programmed routines that specify the direction, acceleration, velocity, deceleration, and distance of a series of coordinated motions.

Other robots are much more flexible as to the orientation of the object on which they are operating or even the task that has to be performed on the object itself, which the robot may even need to identify. For example, for more precise guidance, robots often contain machine vision sub-systems acting as their "eyes", linked to powerful computers or controllers. Artificial intelligence, or what passes for it, is becoming an increasingly important factor in the modern industrial robot.

Fig 1 Robot

II. ANATOMY OF A ROBOT

The term robot stems from the Czech word robota, which translates roughly as 'dull, repetitive labour'. Although robots are indeed often associated with performing highly repetitive, routine applications, today's flexible automation technology lends itself to much more than that, undertaking sophisticated precision tasks that a human cannot hope to emulate. But to understand quite what applications the technology is capable of and where it might be integrated into your own production processes, it is important to appreciate the anatomy of a robot, or more accurately an industrial robot, since that governs its functionality.

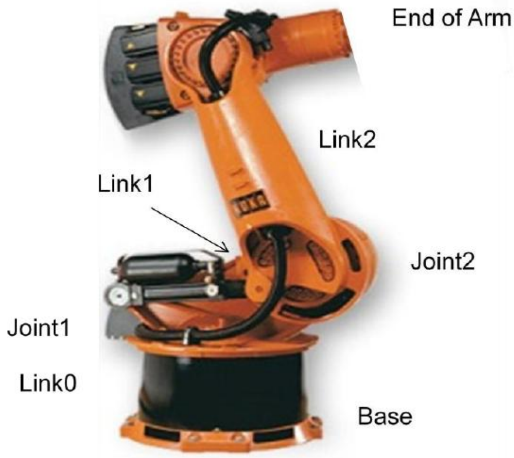

Fig 2 Anatomy of robot

The manipulator or robotic arm has many similarities to the human body. The mechanical structure of a robot is like the skelton in the human body. The robot anatomy is, therefore the study of skelton of a robot, i.e. the physical construction of the manipulator structure. The mechanical structure of the manipulator that consists of the rigid bodies (links) connected by means of articulations (joints), is segmented into an arm that ensures the mobility and reachability, a wrist that confers orientation, and an end-effector that performs the required task. Most manipulators are mounted on a base fastened to the floor or on the mobile platform of an autonomous guided vechile (AGV).

A. Defining Parameters

- Numbers of axes – two axes are required to reach any point in a plane; three axes are required to reach any point in space. To fully control the orientation of the end of the arm (i.e. the wrist) three more axes (yaw, pitch, and roll) are required. Some designs trade limitations in motion possibilities for cost, speed, and accuracy.
- Kinematics the actual arrangement of rigid members and joints in the robot, which determines the robot's possible motions. Classes of robot kinematics include articulated, Cartesian, parallel and SCARA.
- Carrying capacity or payload – how much weight a robot can lift.
- Speed – how fast the robot can position the end of its arm. This may be defined in terms of the angular or linear speed of each axis or as a compound speed i.e. the speed of the end of the arm when all axes are moving.
- Acceleration - how quickly an axis can accelerate. Since this is a limiting factor a robot may not be able to reach its specified maximum speed for movements over a short distance or a complex path requiring frequent changes of direction.
- Accuracy – how closely a robot can reach a commanded position. When the absolute position of the robot is measured and compared to the commanded position the error is a measure of accuracy. Accuracy can be improved with external sensing for example a vision system or Infra-Red. See robot calibration. Accuracy can vary with speed and position within the working envelope and with payload (see compliance).
- Repeatability - how well the robot will return to a programmed position. This is not the same as accuracy. It may be that when told to go to a certain X-Y-Z position that it gets only to within 1 mm of that position. This would be its accuracy which may be improved by calibration. But if that position is taught into controller memory and each time it is sent there it returns to within 0.1mm of the taught position then the repeatability will be within 0.1mm.
- Motion control – for some applications, such as simple pick-and-place assembly, the robot need merely return repeatedly to a limited number of pre-taught positions. For more sophisticated applications, such as welding and finishing (spray painting), motion must be continuously controlled to follow a path in space, with controlled orientation and velocity.
- Power source – some robots use electric motors, others use hydraulic actuators. The former are faster, the latter are stronger and advantageous in applications such as spray painting, where a spark could set off an explosion; however, low internal air-pressurization of the arm can prevent ingress of flammable vapours as well as other contaminants.
- Drive – some robots connect electric motors to the joints via gears; others connect the motor to the joint directly (direct drive). Using gears results in measurable 'backlash' which is free movement in an axis. Smaller robot arms frequently employ high speed, low torque DC motors, which generally require high gearing ratios; this has the disadvantage of backlash. In such cases the harmonic drive is often used.
- Compliance - this is a measure of the amount in angle or distance that a robot axis will move when a force is applied to it. Because of compliance when a robot goes to a position carrying its maximum payload it will be at a position slightly lower than when it is carrying no payload. Compliance can also be responsible for overshoot when carrying high payloads in which case acceleration would need to be reduced.

III. JOINTS & LINKS

A joint in the robot is similar to the joint in the human body; it provides relative motion between two parts of the body. Many types of joints can be made between two links however, only two basic types are commonly used in the industrial robots, first one is Revolute (R) and second one is Prismatic (P).The relative motion of the adjoining links of a joint is either rotary or linear depending upon the type of the joint. Revolute Joint: The two links are joined by a pin (pivot) about the axis of which the links can rotate with respect to each other. Prismatic Joint: The two links are so jointed that these can slide (linearly move) with respect to each other. Screw and nut (slow linear motion of the nut), rack and pinion are ways to implement prismatic joints. At a joint, links are connected such that they can be made to move relative to each other by the actuators. A rotary joint allows a pure rotation of one link relative to the connecting link and prismatic joint allows a pure translation of one link relative to the connecting link. The kinematic chain formed by joining two links is extended by connecting more links. To form a manipulator, one end of the chain is connected to the base or ground with a joint. Such a manipulator is an open kinematic chain. The end-effectors are connected to the free end of the last link. Closed kinematic chains are used in special purpose manipulators, such as parallel manipulators, to create certain kind of motion of the end-effectors. The kinematic chain of the manipulator is characterized by the degree of freedom it has, and the space its end-effectors can sweep. The mechanical structure of a robotic manipulator is a mechanism, whose members are rigid links or bars. A rigid link that can be connected, at most, with two other links is referred to as a binary link. Two links are connected together by a joint. The joint formed is called a pin joint also known as a revolute or rotary joint. Relative rotary motion between links is possible and the two links are said to be paired.

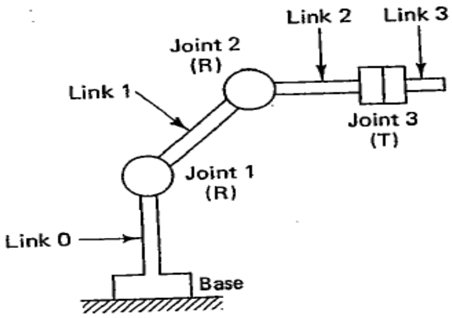

Fig 3 Diagram of robot construction showing how robot is made up of series of joints and links combinations

IV. DEGREES OF FREEDOM (DOF)

The number of independent movements that an object can perform in a 3-D space is called the number of degrees of freedom (DOF). Thus, a rigid body free in space has six degrees of freedom – three for position and three for orientation. The degree of freedom is also equal to the number of links in an open kinematic chain. For example, the open kinematic chain manipulator with two degree of freedom has two links and two joints. The variable defining the motion of a link at a joint is called a joint-link variable. Thus, for an n DOF manipulator n independent joint- link variables are required to completely specify the location (position and orientation) of each link (and joint), specifying the location of the end-effectors in space. Thus, for the two links in turn 2 DOF manipulator, two variables are required to define location of end point. The DOF of a manipulator are distributed into subassemblies of arm and wrist. The arm is used for positioning the end-effectors in space and, hence, the three positional DOF are provided to the arm. The remaining 3 DOF are provided in the wrist, whose task is to orient the end-effectors. The type and arrangement of joints in the arm and wrist can very considerably.

V. END EFFECTORS

The end- effectors are external to the manipulator and its DOF do not combine with the manipulator's DOF, as they do not contribute to manipulatability. Different end- effectors can be attached to the end of the wrist according to the task to be executed. These can be grouped into two major categories:

Grippers – to grasp and manipulate objects (e.g., parts) during work cycle.
Tools – to perform a process, e.g., spot welding, spray painting.

The grippers are end –effectors to grasp or hold the work piece during the work cycle. The applications include material handling, machine loading- unloading, palletizing, and other similar operations. Grippers employ mechanical grasping or other alternative ways such as magnetic, vacuum, bellows, or others for holding objects. The proper shape and size of the gripper and method of holding are determined by the object to be grasped and the task to be performed.

For many tasks to be performed by the manipulator, the end-effectors is a tool rather than a gripper. For example, a cutting tool, a drill, a welding torch, a spray gun, or a screwdriver is the end-effectors for machining, welding, painting, or assembly task, mounted at the wrist endpoint. The tool is usually directly attached to the end of the wrist. Sometimes, a gripper may be used to hold the tool instead of the work piece. Tool changer devices can also be attached to the wrist end for multi-tool operations in a work cycle.

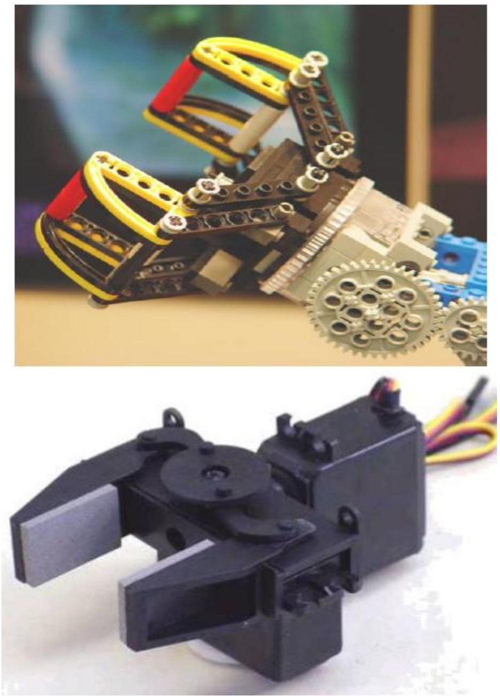

Fig 4 End effectors of a pick and place robot

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