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Review on Intelligent Controller Path Planning of Scorbot Robot

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Abstract
Robotics is spanning as a prominent component of manufacturing industries tending to affect human being at all levels, from managers of production to shop floor unskilled workers. A programmable robot with number of degrees of freedom and different configuration can perform diverse tasks with the help of associated verity of grippers. This article deals with "Intelligent Controller for Path Planning of Scorbot Robot". Modelling and design analysis are primary requirements for manufacturing a robot. Kinematic express knowledge about performance and actions of a mechanical system and it take part in greater role for development and software management. In the first part of the article, kinematic behavior has been analyzed for scorbot-er 4u robot. On each link frame is assigned which gives spatial position by mapping and positions of gripper with respect to base is found or vice versa. Direct kinematics is the finding the position and orientations of the gripper with respect to a known reference frame for an n DOF manipulator. In the next part of the thesis an intelligent controller has been proposed using fuzzy logic technique to perform desired task of scorbot. The proposed methodology has been analyzed by simulation result and verified experimental result which is good agreement & its effectiveness of the proposed methodology.
Keywords- Intelligent controller, Scorbot 4 u, path planning, robot

Review Article

1. INTRODUCTION

A robot is a machine designed to execute one or more tasks repeatedly, with speed and precision. There are as many different types of robots as there are tasks for them to perform. A robot can be controlled by a human operator, sometimes from a great distance. But most robots are controlled by computer. There is no one definition of robot which satisfies everyone and many people have their own [1]. Joseph Engelberger, a pioneer in industrial robotics once remarked: "I can't define a robot, but I know one when I see one."[2]. According to the Encyclopedia Britannica a robot is "any automatically operated machine that replaces human effort, though it may not resemble human beings in appearance or perform functions in a humanlike manner"[3]. Merriam-Webster describes a robot as a "machine that looks like a human being and performs various complex acts (as walking or talking) of a human being", or a "device that automatically performs complicated often repetitive tasks", or a "mechanism guided by automatic controls"[4]. At its most basic a robot is a machine that senses the world, processes the sensor information with a computer and then does something in response to that information (such as moving or turning). A robot isn't just a computer. A desktop computer can "sense" that you are typing or moving the mouse, but the computer itself doesn't move or act in the physical world [5]. The Robotic Industries Association (RIA) defines "A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks." Recently, however, the industry's current working definition of a robot has come to be understood as any piece of equipment that has three or more degrees of movement or freedom. An industrial robot is defined by ISO [6] as 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. 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.

1.1 Overview

The word robot can refer to both physical robots and virtual software agents, but the latter are usually referred to as bots. There is no consensus on which machines qualify as robots but there is general agreement among experts, and the public, that robots tend to do some or all of the following: move around, operate a mechanical limb, sense and manipulate their environment, and exhibit intelligent behavior — especially behavior which mimics humans or other animals [7-11]. There is no one definition of robot which satisfies everyone and many people have their own [12-13].

1.2 Kinematic Analysis

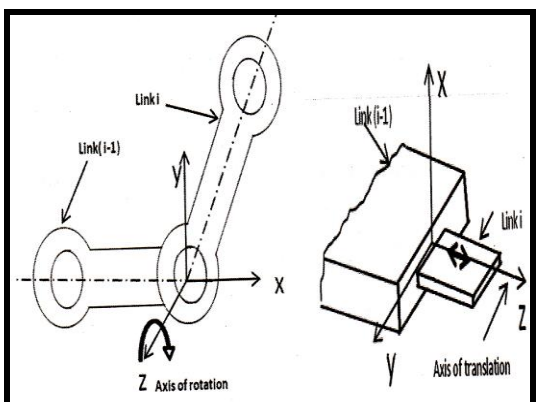
Kinematics is the most basic study of how mechanical systems behave. It is necessary to understand the mechanical behavior of the robot both in order to design appropriate robots for tasks and to understand how to create control software of robot hardware. This article provides a detailed kinematic analysis of a 6DOF robot manipulator.

2. ABOUT ROBOT KINEMATICS

A robotic manipulator is designed to perform a task in 3-D space. The tool or end-effector is required to follow planed trajectory to manipulate objects or carry out the task in workspace. The kinematic model describes the spatial positions of joints and links, and the position and orientation of end effector, the relationship between the motions & forces or toques that cause them in dynamic problem. The differential kinematics of manipulator refers to differential motion that is velocity acceleration and all higher order derivatives of position variables.

2.1 Mechanism Structure and Notations

A manipulator consists of a chain of rigid bodies called 'links' connected to each other by joints, which allow linear or revolute motion between connected links each of which exhibit just one degree of freedom, Joints with more than one degree of freedom is not common. A joint with m degree of freedom can be modeled as m joint with one degree of freedom each connected with (m-1) links of zero length. The number of degrees of freedom a manipulator possess is the number of independent parameters required to completely specify its position and orientations in space. Because each joint has only one degree of freedom, the degree of freedom of a manipulator is equal to number of joints. Single DOF joints between links of a manipulator can be classified as revolute or prismatic. A revolute joint denoted as R-joint, allows rotational motion between connected links.



(a) Revolute joint (b) Prismatic (sliding) joint

Fig 1 Two common types of joints and axis of motion (joint axis)

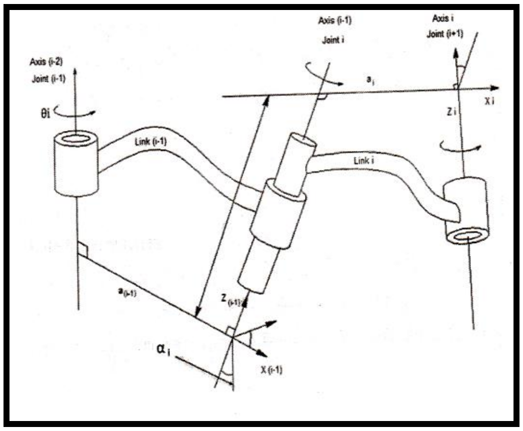


Fig 2 Setting up coordinated frames for an arbitrary manipulator

A prismatic joint denoted as P-joint also known as sliding or rectilinear joints, permits translational motion between the connected links. Each joint has a joint axis with respect to which the motion of the joint is described as shown in fig (1). In case of revolute joints, the axis of relative rotation is the joint axis. For the prismatic joint the axis of relative translational motion is the joint axis. By convention the Z-axis of co-ordinate frame is aligned with the joint axis (Fig 2).

2.2 D-H parameters.

The definition of a manipulator with four joints link parameters for each links and a systematic procedure for assigning right-handed orthogonal coordinate frames, one to each link in an open kinematic chain, was proposed by Denavit and Hartnberg (1995) and is known as DH parameters [21].

Table 1 Excalibur link parameter

Link	θ_i	α_i	a_i	d_i	$\cos\alpha_i$	$\sin\alpha_i$
1	θ_1	-90	0	0	-1	1
2	θ_2	0	L_2	0	1	0
3	θ_3	90	0	0	0	1
4	θ_4	-90	0	L_{34}	0	-1
5	θ_5	90	0	0	0	-1
6	θ	0	0	0	1	0

$$^{i+1}T_i = \begin{matrix} C\theta_i & -S\theta_i C\alpha_i & S\theta_i S\alpha_i & a_i C\theta_i \\ S\theta_i & C\theta_i C\alpha_i & -C\theta_i S\alpha_i & a_i S\theta_i \\ 0 & S\alpha_i & C\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{matrix}$$

The matrices which will give the position of end-effectors with respect to base frame can be calculated by multiplying the joint matrices as given below.

$$^0T_6 = {}^0T_1\ {}^1T_2\ {}^2T_3\ {}^3T_4\ {}^4T_5\ {}^5T_6$$

3. INTELLIGENT CONTROLLER FOR ROBOT

In order to exhibit the effectiveness of the proposed fuzzy controller for robot, the simulation results are verified with experimental results, comparison is also made between the results from Adaptive fuzzy logic-based controller by Das et al. [22] and neuro-fuzzy based approach by Zhu et al [23] [14-15]. The comparison of controllers with the current developed controller, demonstrate the feasibility of the current approach. It is found that the developed fuzzy controller can negotiate the obstacles efficiently. Moreover, the developed controller can be used for several robots [16-17]. A series of simulations and experiments are conducted using the SCORBOT-ER 4u robot to show the effectiveness of the proposed algorithm. Image of a Scorbot robot is presented in Fig 3.

3.1 Application

Robots have a wide range of applications in industries, hospitals, offices, and even in the military section, due to their superior and intelligence. They are also useful in emergencies, for example, for fire extinguishing and rescue operations [18-20].

Table 2 gives some examples for formulation of robot.

Fig 3 SCORBOT ROBOT

Table 2 Formulation for obstacle and target located in the right side of the robot

Sl. No	RIGHT-OBSTACLE (millimeter)	TARGET ANGLE (degree)	ARM ANGLE (degree)
1	100	165	65
2	100	155	104
3	100	135	130
4	100	125	150
5	100	115	160
6	100	95	165
7	150	70	105
8	100	65	75
9	100	0	45

Combined with manipulation abilities, their capabilities and efficiency will increase and can be used for dangerous tasks such as security guard, exposition processing, as well as undersea, underground and even space exploration.

4. SCOPE

Robot path planning is about finding a clash- free motion from one location to another location. Navigating the path and detect the obstacles to change its path. Automobile assembly industries required path planning of robot.

Conclusions

To design the robot manipulator, kinematic analysis plays a vital role to design control soft-ware and to analyze dynamic forces. The kinematics model gives relation between the position and orientation of the end effectors spatial position of the joint-link.in this project a 6 DOF manipulator has been developed and modeled using CATIA. A matrix has been formulated for each joint and D-H parameter has been analyzed in this report. After theoretical and numerical analysis, the following conclusion has been drawn.

i. The matrix formulation is helpful and it is easy to implement to control software for 6 DOF manipulator.
ii. The developed matrix is also helpful for force analysis to each joint as well as link of manipulator.
iii. The entire joint matrix has been hybridized in homogeneous transformation matrix.
iv. The 6 DOF manipulator has been modeled using CATIA which will helpful to analyze the stress and strain during movement of joint and link.

The conclusion drawn based on the theoretical; simulations and experimental analysis are depicted below. Both in simulation and experimental modes the developed controller worked efficiently. The simulation results are also compared with the other results obtained from the other investigations and they show a very good agreement. Some features of the intelligent controller cannot be added by using a single technique like fuzzy logic.

Conflict of interest

The author declares no conflict of interest.

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