Modeling and Dynamic Analysis of Puma Robot Manipulator

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Abstract: Current industrial robots are made very heavy to achieve high stiffness which increases the accuracy of their motion. However, this heaviness limits the robot speed and in mass the required energy to move the system. The requirement for higher speed and better system performance makes it necessary to consider a new generation of light weight manipulators as an alternative to today’s massive inefficient ones. Light weight manipulators require less energy to move and they have larger payload abilities and more maneuverability. However, due to the dynamic effects of structural flexibility, their control is much more difficult. Therefore, there is a need to develop accurate dynamic models for design and control of such systems. This project presents the flexibility and dynamic analysis for three degree of freedom (3DOF) of robot manipulator considering deflection. Based on the distributed parameter method, the generalized motion equations of robot manipulator with flexible links are derived. The final formulation of the motion equations is used to model general complex elastic manipulators with nonlinear rigid-body and elastic motion in dynamics and it can be used in the flexibility analysis of robot manipulators and spatial mechanisms. Manipulator end-effector path trajectory, velocity and accelerations are plotted. Joint torques is to be determined for each joint trajectory (Dynamics). Using the PRO ENGINEERING software to draw all the modeling also using joint torques, static loading due to link’s masses, masses at joints, and payload, the robot arms elastic deformations are to be found by using ADAMS software package, and we used the MATLAB software to calculating the value of the velocity and accelerations to the robot question. Elastic compensation is inserted in coordinates of robotic programming to get exact end-effectors path. A comparison of paths trajectory of the end-effector is to be plotted. Also variation of torques is plotted after considering elastic compensation. These torque variations are included in the robotic programming for getting the accurate end-effect or’s path trajectory. One fundamental issue in today’s Online Social Networks (OSNs) is to give users the ability to control the messages posted on their own private space to avoid that unwanted content is displayed. Up to now, OSNs provide little support to this requirement. To fill the gap, in this paper, we propose a system allowing OSN users to have a direct control on the messages posted on their walls. This is achieved through a flexible rule-based system that allows users to customize the filtering criteria to be applied to their walls, and a Machine Learning-based soft classifier automatically labeling messages in support of content-based filtering.

Keywords: Robot, End Effectors, Dynamic Robot, Kinematic Robot, Stress Analysis, Displacement, Velocity And Acceleration.

I. INTRODUCTION

Computer algorithms are designed to calculate an appropriate reference signal based on the desired task path and time-related limits (such as speed and acceleration). This reference signal is the trajectory, and can be defined as a locus of points in operational or joint space on which a time-law has been specified. The generation of an appropriate trajectory is the problem that is being investigated in this thesis. The path along which the trajectory is defined can be point-to-point; namely, the machine is required to move between the two points but is not given any fixed intermediate path. This type of path is useful in manipulator pick-and-place operations. A path can also be completely specified through use of geometric functions. This type of path is commonly used in CNC machining applications or in manipulator applications when obstacles are present, or when it is necessary to ensure that the end effector follows as specific path\cite{2} \cite{4} \cite{7}.

II. INDUSTRIAL MOTIVATION

Increased productivity is an important industrial consideration. Machine limits the task speed, decreasing the machine’s overall motion time will increase productivity. In addition improving the tracking accuracy of the machine is always desirable since it results in more repeatable products or operations. Tracking a purely time-optimal trajectory with a simple controller will saturate the actuators resulting in poor tracking, vibrations in the machine and increased machine wear. Specialized controllers have been developed in order to provide better tracking of time-optimal trajectories. However, it is unlikely that they will be widely implemented in industry due to their complicated form. Purely time-optimal trajectories have been modified to take into account further limitations of the actuators, for example jerk or torque rate limits, thereby avoiding controller saturation and resulting in improved tracking. Herein, trajectories that are planned with jerk or torque rate
limitations are termed smooth trajectories. There exists a need for a smooth trajectory generation algorithm that can easily be integrated into existing industrial systems, that is, be implemented using a typical industrial controller. Such an algorithm should be applicable on-line, provide adequate dynamic limitations, and allow the specification of the speeds at all the way-points. [2] [4] [7]

A. Research Objectives
The objective of this work is to provide a method of generating smooth bath near time-optimal trajectories on-line. The trajectory generation algorithm must be computationally simple.

B. Work Aims
Produce a trajectory that will improve the motion time and the trajectory tracking of a standard industrial machine whether it is applied to the machine through a simplified controller or a more complex controller.

C. Dynamics of a robot
The dynamics control problem is, given the desired trajectory of the end-effectors, what torque pattern (as a function of time) should be applied by the actuators to achieve the desired motion. Having a geometric model of the manipulator, the computer is able to transform the required path from world coordinate to machine coordinate, and having a dynamics model, which relates torques to position, velocity and acceleration of machine coordinates, allows the computer to predict the required torque patterns. [1] [2] [6] [7]

III. BASIC, MANIPULATOR GEOMETRIES
In this section, I looks at some basic arm geometries. As I said before, a robot arm or manipulator is composed of a set of joints, links, grappers and base part. The joints are where the motion in the arms occurs, while the links are of fixed construction. Thus the links maintain a fixed relationship between the joints. The joints may be actuated by motors or hydraulic actuators. There are two sorts of robot joints, involving two sorts of motion. A revolute joint is one that allows rotary motion about an axis of rotation. An example is the human elbow. A prismatic joint is one that allows extentions orteseoscopic motion. An example is a telescoping automobile antenna. There are some types of manipulator kinematics below. [3] [5]

A. Open Chain Manipulator Kinematics [2]
In this types of the arm, mechanics of a manipulator can be represented as a kinematics chain of rigid bodies (links) connected by revolute or prismatic joints. One end of the chain is constrained to a base, while an end effector is mounted to the other end of the chain. In the open chain robot arm, The resulting motion is obtained by composition of the elementary motions of each link with respect to the previous one. The joints must be controlled individually.

B. Closed Chain Manipulator Kinematics
Closed Chain Manipulator is much more difficult than open chain manipulator. Even analysis has to take into account statics, constraints from other links, etc. Parallel robot is a closed chain. For this type of robots, the best example is the Stewart platform.

IV. LITERATURE REVIEW
Laura Celentano in 2009 discussed about a simple method to obtain the analytical model of a flexible robot is presented, which turns out to be more efficient, from a computational point of view, than the classic assumed modes method. The presented method consists of using appropriate linear combinations of the modes of each link as basis functions to evaluate the deflection, in such a way as to minimize the dependency of the position of the generic link on the Lagrangian variables of the previous links. Gerasimos G in 2008 discussed about a comparative study on representative methods for model-based and model-free control, of flexible-link robots. Model-based techniques for the control of flexible-link robots can come up against limitations when an accurate model is unavailable, due to parameters. In this paper two model-free approaches of flexible-link-robot control are examined: (i) energy-based control, and (ii) neural adaptive control. The performance of the aforementioned methods is compared to the inverse dynamics model-based control, in a simulation case study for planar 2-DOF manipulators. S.Kemal Ider in 2006 discussed about Inverse dynamics control of flexible joint robot is addressed. It is shown that, in a flexible joint robot, the acceleration level inverse dynamic equations are singular because the control torques do not have an instantaneous effect on the end-effector accelerations due to the elastic media.

A. Proposition Work
In this thesis discuss about modeling by using ALUMINUM (Density=2.74E-006 kg/mm^2 , Young’s modulus = 7.1705 E+004 N/mm^2, poisons ratio = 0.33) because it Cheaper and lighter than steel, also used dynamics analysis to 3DOF to the shape to calculat the acceleration, velocity, displacement and torque. By using MATLAB to calculat the value by insert the robot equation to create all the part of the shape and get the value of the stesses to each part. 

International Journal of Scientific Engineering and Technology Research, Volume.03, IssueNo.20, September-2014, Pages: 4152-4155
modeling from rigid body to flexible body and used ADAMS software to get the deformation in each part and each joint.

V. DYNAMIC ANALYSIS

The dynamic analysis to the rigid body before the FEA to check the translational displacement, velocity, acceleration and element torque as shown in Figs. 1, 2 and 3. [7]

A. The Stresses Values After Make the Body Flexibil

<table>
<thead>
<tr>
<th>Rank</th>
<th>Stress (N/mm^2)</th>
<th>Node</th>
<th>Time (sec)</th>
<th>Location (mm)</th>
</tr>
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<td>1</td>
<td>240.632</td>
<td>1</td>
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<td>289.458</td>
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<tr>
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<td>1</td>
<td>1.7</td>
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<tr>
<td>3</td>
<td>256.63</td>
<td>2</td>
<td>1.7</td>
<td>-15</td>
</tr>
</tbody>
</table>

B. The Deformation

Table 1: Stress Analysis at part 4 and RPM = 30

The Deformation is meaning that the change in the shape of a body caused by the application of a force (stress) also it is proportional to the stress applied within the elastic limits of the material as shown in Figs. 4, 5, 6 and 7. [1]
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VI. CONCLUSION

This project presented the dynamic analysis of puma robot manipulator. Dynamic analysis is performed to find the velocities, accelerations and joint torques for moving the end-effector in the considered path trajectory with the help of MATLAB-2008 software. Using joint torques, static loading due to link’s masses, masses at joints, and payload, and the deformations are found by using ADAMS 2013 software package. Taking into consideration the deformation and inserted it in the co-ordinates of robotic programming to get exact end-effectors path. A comparison of path trajectories and variation of torques is plotted after considering elastic compensation. It is suggested that by compensating the joints torque variations in the robotic programming, the trajectory path of the end-effector will be accurate than the specified repeatability at max ±0.1 mm in the more puma robot.

VII. FUTURE SCOPE OF WORK

- The robotic programming language can be modified and that can be incorporated and tested with puma robot for getting accurate path trajectory of the end effector according to the result obtained in this theses work.
- This analysis may be further extended by considering the inertia effect due to the speed increased in the robot arm.
- Feed back control for position can be incorporated in the analysis, and also used more weight in the end effector.

VIII. REFERENCES


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