Mian Muhammad Kamal et al. International Journal of Institutional & Industrial Research ISSN: 2456-1274, Vol. 1, Issue 2, May-August 2016, pp.25-27

Stability Analysis and Trajectory Tracking Control of Robot for Industrial Application of Wielding

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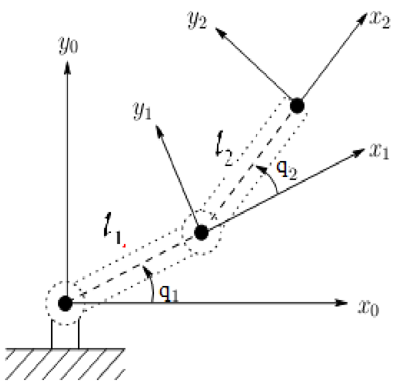
Abstract: **This research work is aimed at presenting kinematic and dynamic model of robot manipulators and designing optimal control law for the purpose of motion and trajectory control of the end effector. The main theme of this research is to control and stabilize two link robot manipulator end effector's motion to track the desired trajectory. For this purpose, LQR controller is designed. An iterative procedure is adopted to obtain optimal solution. The open loop robot manipulator model is checked for stability and its roots. a feedback optimal controller is designed. For the motion control and trajectory tracking, a feedback PID controller is used. A reference trajectory with a continuous varying periodic signal such as a sine wave is given as a reference to the robot manipulator and the desired response is plotted showing that the robot manipulator provides the desired trajectory tracking. The simulations results showed negligible deviation of actual trajectory from the desired. In the same way, the response of the actual angular velocity of each joint is plotted along with the desired response of the angular velocity; the results show negligible deviations. The 2R robot manipulator is used as an automatic wielding machine for industrial application. At the end effecter, a gripper is used which is to hold a wielding machine. The desired shape is provided by user to the robot manipulator and the robot keeping the workspace i.e. the coordinates in memory carry out the desired trajectory. The results show that the manipulator cuts the object in the same defined.**

Keyword: **Microcontroller, Motors, Sensors, Gripper, LQR controller.**

1. Introduction:

Robotic manipulators consist of a chain of links (it may have one to n-links). The links of manipulator are connected by joints. A joint may be revolute joint or it may be a prismatic joint. A revolute joint is capable of carrying out rotational motion and a prismatic joint is capable of carrying out a translational motion. A revolute joint is usually represented by R and a prismatic joint is represented by P. One end of the chain of the robotic manipulator is normally fixed to a rigid support also known as base of the robot manipulator while the other end of the chain is free. At the free end of the chain of robotic manipulator there is an end effector. Depending on the application for which the robot manipulator is being used, end effector may assume different kinds of shapes; for example, if a robot manipulator is to hold a laser at the end effector then in such a case the end effector might be a gripper. For the designing of robotic manipulators, information about its kinematic and dynamic model is very important. Kinematic model of a robot manipulator creates relationship between the spatial position of the end effector and position and orientation of the joints. The differential motion of the manipulator that is velocity, acceleration and other higher order derivatives of the position variables are modeled by differential kinematics. During the work cycle, a robotic manipulator is initially at rest, it accelerates to a specific speed and then move with a constant speed, and then decelerate. During this motion, the position of the manipulator and its orientation changes with time. This change of position and orientation with time is known as dynamic behavior of robot manipulator and is characterized by the dynamic model of the manipulator. This motion is basically caused by time varying torques that are applied at the joint using DC motors in order to balance the internal and external forces. The internal forces consist of Coriolis, inertia and frictional forces and are caused by the motion of links of manipulator. The external forces include forces due to gravity, inertia and load are causedby the environment. The main goal of the controlling of a robotic manipulator in many applications is to command the manipulator's end effector to move to a desired location i.e. to achieve a desired response**.**

2. Kinematic and Dynamic Model of Robot Manipulator:

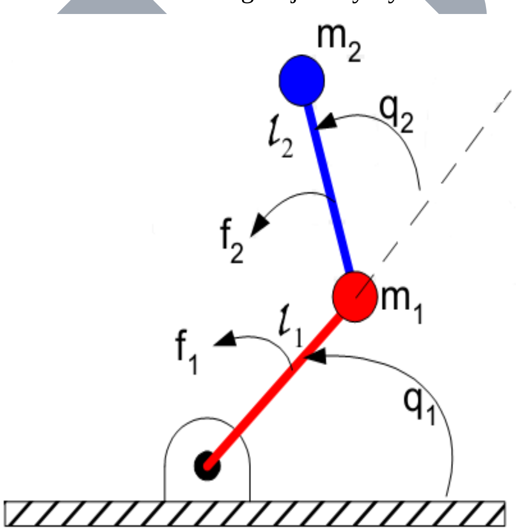


2.1. Methodology:

Initially the project was divided in three sections, the mechanical structure, Electronic Hardware section and Software coding The work done will be elaborated in the above-mentioned three main streams as mechanical structure, hardware and software, separately because all these things are different fields of work. So the software section deals with the choice of programming language, so the language chosen by us for the programming is assembly language because of low level language and easy to use.

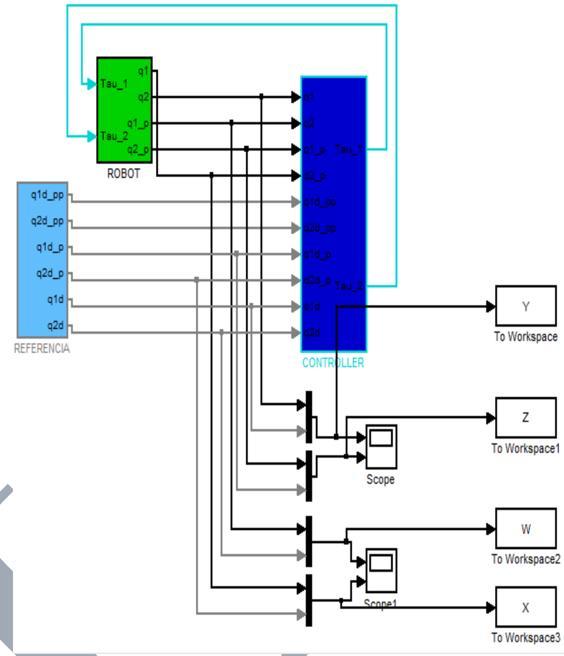
2.2. Working:

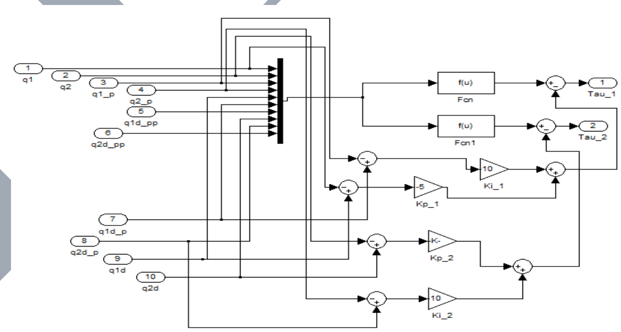
The working phenomena is that to give the desired trajectory points to the manipulator 2R Robot in the kinematic model either in forward direction or in reverse direction. After following trajectory by the robot and to



stabilize the robot we use dynamic model for controlling. Dynamic model stabilizes the robot manipulator by Eigen values that is LQR controller.

3. Simulink Model of the Trajectory Tracking Controller:





4. Application:

6.1. Some of the useful applications of Robot Manipulator are as follow

Robot manipulators are widely used in industrial applications. For example, for wielding purposes and for manipulating harmful material like radioactive substances etc. In this research work, after analyzing the results of simulations, the 2R manipulator is used for industrial applications that is as wielding machine. A gripper is connected at the end effector of the robot manipulator. The job of the gripper is to hold a wielding machine. The object that is to be wield is placed in front of the robot manipulator. The user will define the shape or trajectory in which the object needs to be wield. The manipulator end effector and hence the gripper will track the desired trajectory and the object will be wielding in the desired shape. One such industrial application of robot manipulator is given in Figure

5. Conclusion:

- The modeling of Robot Manipulator system is done in state space with model.
- Open loop response simulated in MATLAB showed that the system was unstable.
- An LQR controller was designed to stabilize the system.
- A controller was designed for trajectory tracking of end gripper.
- Simulink Models are obtained for open and closed loops.
- The manipulator was used as an automatic wielding machine with addition of gripper at the end effector.

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