ENPM 662
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Simulation of 6 DOF Robotic Arm on Linear Rail

PROJECT PROPOSAL

University of Maryland, College Park

M.Eng. Robotics Program

1. Summary

The goal of this project is to create a moderately simplified simulation model of 6 DOF robotic arm mounted on a linear rail. This simulation will serve as a proof of concept towards developing a rail mounted robotic arm suitable to operate continuously over relatively long distance e.g. ship hull welding, aircraft exterior painting, etc. The project will encompass not only the 3D CAD design of the Robotic arm but also the position and trajectory control of the end effector and all the necessary intermediate steps. A comprehensive interface will be developed to visualize and command the robotic arm to follow user desired trajectories and positions.

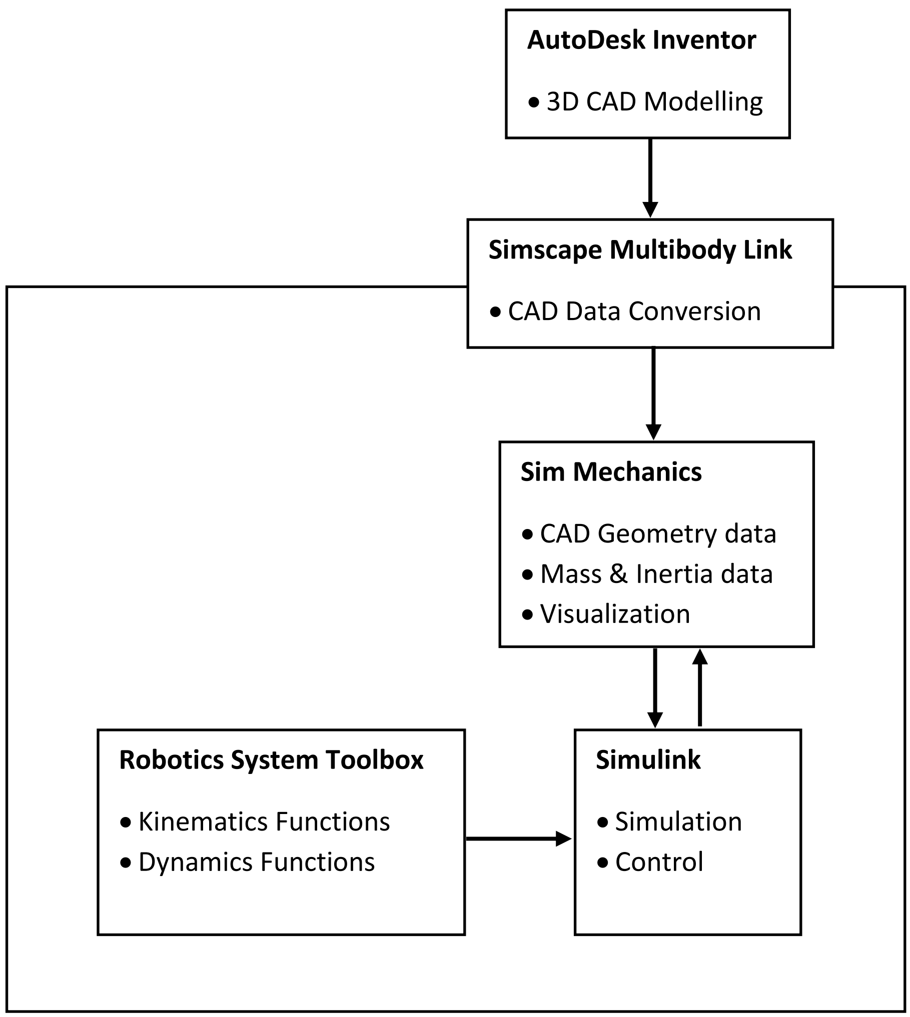
2. Motivation

Robotic arms have become the industry standard alternative to laborious and monotonous jobs disliked by human workers. Along with cost savings, deployment of robotic arms dramatically increases the quality of work done. Some industrial sectors still lack the desired level of automation due to unavailability of feasible robotic configurations. One such example is of the ship industry. Currently, the ships metallic hulls are welded manually by laborers since the welding spans long continuous contours. Deploying a fixed robotic arm in such cases would be fruitless. A robotic arm mounted on a linear rail, however, will solve this problem.

3. Scope of Work

• 3D Cad Modelling

3D CAD model of the robotic arm will be designed using Autodesk Inventor CAD software. Primary reason to select this software is due to the support for conversion of CAD data to MATLAB compatible format. To keep this robotic arm relevant to the industrial context, its workspace dimensions are desired to be approximately 3 meters, comparable to medium to heavy duty robotic arms. To simplify the simulation process, the manipulator joint will be designed as a spherical wrist joint.



- ### DH Parameters & Forward Kinematics

Defining Joint Frames, DH parameters and subsequently computing the Transformation matrices for each joint is a fairly straight forward procedure and comparatively requires very little effort.

- ### Inverse Kinematics

Due to selecting a spherical manipulator wrist joint. The inverse kinematics can be decoupled hence be solved.

- ### Quintic Polynomial Trajectory planning

To obtain a continuous smooth path trajectory free of jerks, Quintic Polynomial trajectory planning technique will be implemented due to its ability to control starting and ending accelerations and thus avoid jerks when a continuous motion consisting of individual position points is desired.

- ### Newton Euler Formulation

Formulate the Newton Euler equations representing the arm dynamics which will aid us in the independent joint control.

- ### Independent PID Joint Control

Each joint of the robotic arm will be modelled as being actuated by a simple geared DC motors. A feedback control system with PID compensator will be implemented on each motor.

4. Desired Specifications

The desired specifications are outlined in order to maintain a competitive edge when compared to other commercially available options in the market. The 3D CAD design process will be carried out while keeping the following desired specifications in mind:

Robotic Arm Vertical Reach:	2.5~3m
Robotic Arm Horizontal Reach:	3~3.5m
Linear Rail Travel:	20m
Maximum Payload Capacity:	30~50kg
Repeatability:	0.2~0.5mm
Robotic Arm Weight:	<500kg

5. Validation Plan

After computing the forward & Inverse Kinematic equations, Dynamic equations and implementing the independent joint controller, a complete simulation of the robotic arm will be setup. The output will consist of an animation depicting the exact movement of robotic arm in an intuitive 3D manner.

A second 3-dimensional figure will illustrate the difference between reference trajectory and actual trajectory traversed giving a good estimate of the accuracy of the controller implementation and the simulation technique. This will be implemented using the Simulink and Sim Mechanics programming frameworks.

A GUI input application will be created in a MATLAB programming language to allow for a repetitive and hassle-free way to input desired trajectories or create random but smooth trajectory for the robotic arm to follow.

6. Assumptions

As mentioned earlier, the goal of the project is to create these simulations with moderate simplifications to achieve the objectives in given time. For this purpose, the following assumptions will be made:

- The robotic arm linkages are assumed to be entirely rigid with no flexibility
- The Motor joint friction is assumed to be zero
- Gear backlash and other non-linearity inducing factors are ignored.

Commonly used Industrial robots are actuated by advanced AC Servo motors, but for our case we make use of the permanent magnet geared DC motor. It is also assumed that the electrical time constant of this motor is much smaller as compared to the mechanical time constant.