Robot Dynamics
&
Control

Assignment 2

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Preface

The work is based on " Recursive Inverse Dynamics " using the Newton-Euler algorithm. Our aim is to create an algorithm meaning that works on any parameter related to the specific robot or the input trajectory should be defined from the outside and also irrespective of the joint type.

Acknowledgements

Under the supervision of Prof.Giorgio Cannata, Francesco Grella and Giulia Baldini, I learned a lot about the proposed work.Hence, I thank them for their continuous support.

Abstract

The assignment is about the calculation of inverse dynamics of manipulators using Recursive Newton-Euler Algorithm.Recursive is used as it is an efficient process i.e it takes less computations and CPU time. We make a generic algorithm that calculates the inverse dynamics by above-mentioned method. We also focus on the calculations of inverse dynamics joint torques along a certain axis for the three manipulators (2R,RP and 3R).Using all the given parameters, we calculate the problems on MATLAB.

Keywords

Recursive Newton-Euler Algorithm; Inverse Dynamics; Forward Recursion; Backward Recursion

Contents

1 Introduction

Inverse dynamics is the problem of calculating the forces required to produce a given acceleration.Given the configuration,velocity and acceleration, it amounts to finding the joint torques and contact forces such that the constrained equations of motion are satisfied.The algorithm works in two ways: a forward recursion which is mostly a second-order forward kinematics,followed by a backward recursion that computes forces and joint torques.At each step of recursion, we have two vector equations at the joint providing the torques which also contains the reaction forces/torques at joint axis.We also take into account that they should be projected next along/around the axis.

The algorithm also takes into account that irrespective of the number of links and joint-types (Rotational/prismatic), it calculates the joint torques.

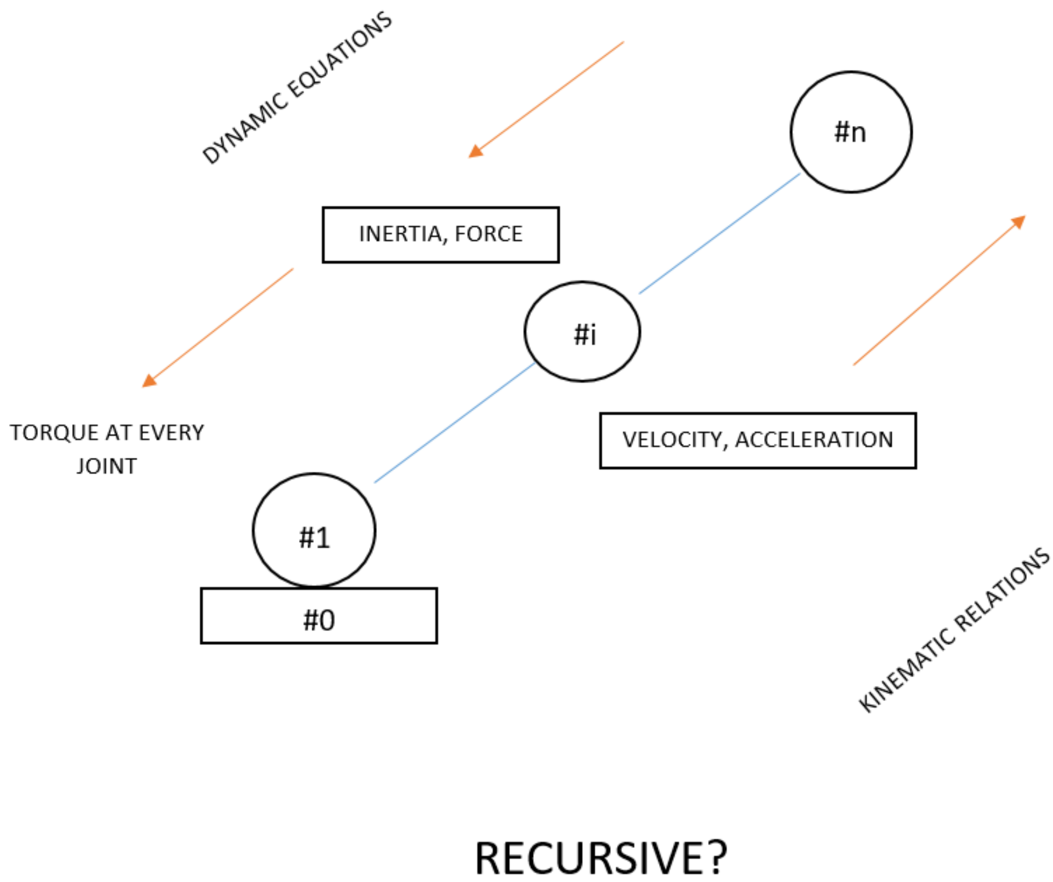

Figure 1: What is Recursion ?

2 Methodology

The resultant acceleration vectors at center of mass of each link was calculated. Then, equate the external forces and moments applied to every link. Then the system of equations have to be solved for the forces and torques in the given axes in the problems.

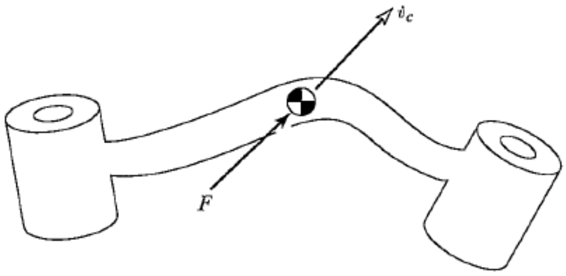

Figure 2: Newton's Equation

The Newton's Equation acts at the center of mass and causes the acceleration.Calculation procedure: sum of forces = variation of linear momentum

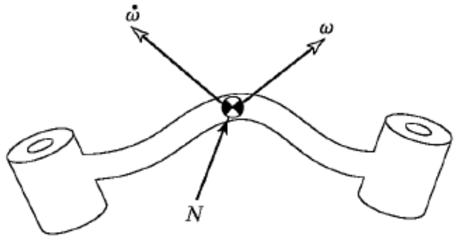

Figure 3: Euler's Equation

The Euler's equation deals with the body rotating with angular velocity and with angular acceleration. In such a situation, the moment, which must be acting on the body to cause this motion, is given by Euler's equation.Calculation procedure: sum of torques = variation of angular momentum

2.1 Matlab Script

2.1.1 Datafile

The script contains the data file of a specific robot which contains the number and types of joints (revolute/prismatic) , D-H kinematic parameters and also the list of dynamic parameters of the links.

2.1.2 Inputs

The inputs are all the data given in the questions which also includes the joint position, velocity, acceleration values.For each robot there are two values hence there would be two torque values in each case.

2.1.3 Outputs

The outputs are the generalized force for complete inverse dynamics and the joint torque values.

3 Results and Discussion

Given below are the following calculations

3.1 Data tables

The data tables given below compares the equivalent torques calculated according to the axes mentioned in the questions. The second exercise focuses on the 2R planar manipulator, the third exercise focuses on RP planar manipulator while the fourth exercise focuses on 3R planar manipulator.

Our Calculations		
SerialNo.	without gravity	Gravity ()
1	4.36	318.19
	1.89	38.67
2	-12.37	-61.09
	0.29	-51.43

Table 1: Result : Exercise 2

Calculations		
SerialNo.	without gravity	Gravity ()
1	1.22	113.69
	0.0139	18.24
2	-1.70	-73.31
	-1.796	42.49

Table 2: Result : Exercise 3

The units are in "Nm"

Our Calculations		
SerialNo.	without gravity	Gravity ()
	5.11	5.11
	1.37	104.18
	0.15	6.77

Table 3: Result: Exercise 4

4 Conclusion

We have calculated the inverse dynamics using the Recursive Newton-Euler approach. Since it is a time-efficient approach , it is highly used nowadays.The various equations and algorithm are designed to use this data in their calculations. The class of robots considered were having revolute and prismatic.The solution is best for synthesis of model based control schemes.

5 References

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