Assignment 1

FMN110: Numerical Methods in Multibody Dynamics

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The purpose of this assignment is to experiment with the material from Chapter 1 numerically and to test an algorithm for reduction to state space form.

The assignment has 6 tasks. You should hand in results electronically latest on February 08, 2012.

Task 1

Formula (1.3.10) in the course bookdefines the matrix $Z(\alpha, \beta, \gamma)$ which establishes the relation between the derivatives of rotation angles and angular velocities for an Kardan angle parametrization. The inverse matrix is given by

$$Z^{-1} = \begin{pmatrix} \cos\beta\cos\gamma & \sin\gamma & 0 \\ \sin\gamma\cos\beta & -\cos\beta & 0 \\ \sin\beta & 0 & 1 \end{pmatrix}$$

Show that this matrix is singular for $\beta = \pi/2$. Then, fix α and γ to some values of your choice and compute the condition number of this matrix as a function of $\beta \in [0, \pi]$. The log of the condition numbers can be used to estimate how many digits of accuracy are lost in the worst case, when using this matrix to solve a linear system of the type $Zx = b$. Make a plot and determine graphical the interval around $\pi/2$ in which more then 6 digits are lost. Explain the relevance of this test.

Task 2

Download from the webpage `http://www.maths.lth.se/na/staff/claus/NMMD2/` the MATLAB files for the constrained truck.

Task 3

Linearize the equations numerically about a nominal configuration (given also as an M-file on the web) and compute the mass, stiffness, damping, constraint and excitation matrices M, K, D, G, B.

Task 4

Reduce the system to its state space form numerically and compute the reduction matrix V.

Task 5

Compute the system's eigenvalues and discuss stability.

Task 6

Perform a simulation of the linearized truck with zero initial conditions and u being a step function of $10cm$ height. Use for this task the analytical formulation of the exact solution with the matrix exponential function (transistion matrix).

Lycka till!