TOGAC51_AMBF_R_CartesianSystemIdentification.docx

Identifying all the Cartesian Directions of the Galen robot in the AMBF Simulation.

This work follows after the report of TOGAC34_AMBF_R_LumpedSystemIdentification.docx

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Contents

System Identification

The system was identified for each degree of freedom the same as in TOGAC34_AMBF_R_LumpedSystemIdentification.docx of the lumped system data, but this was done from the cartesian perspective. The Jacobian of the AMBF Galen robot was used to convert velocity references from the cartesian space to the joint space. Each DOF of the robot was assigned a chirp input from 0.001 Hz to 5 Hz over a 60 second period.

The systems were then each Identified with a second order Tfest estimate with the MATLAB systems identification toolbox.

The following transfer functions were obtained.

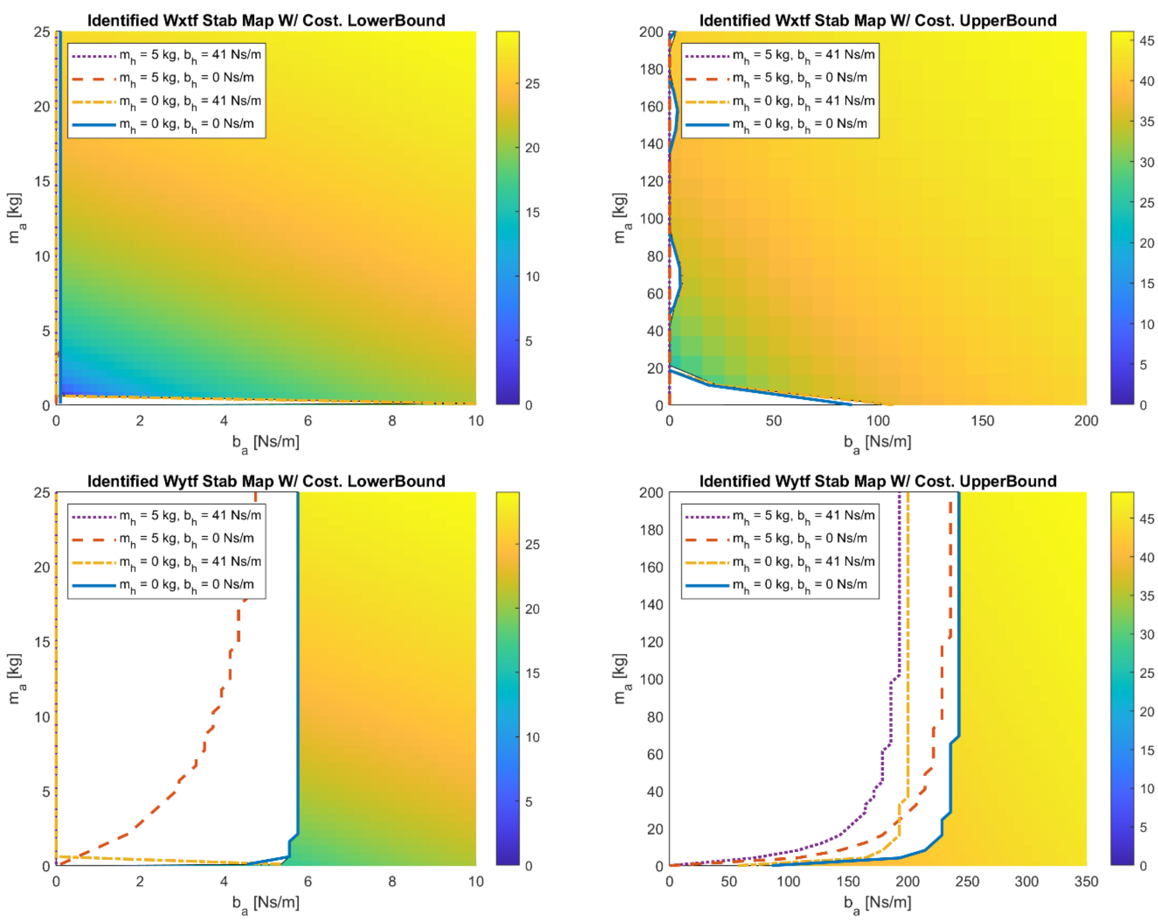
Velocity Component	Transfer Function	Quality of Match
Vx	132.8/(s + 145.8)	77.93%
Vy	131.8/(s + 132.4)	92.15%
Vz	$1.973e06/(s^2 + 1.558e04s + 1.975e06)$	92.58%
Wx	$2.542e05/(s^2 + 153.1s + 2.561e05)$	89.39%
Wy	$1.587e04/(s^2 + 230.7s + 1.584e04)$	91.03%

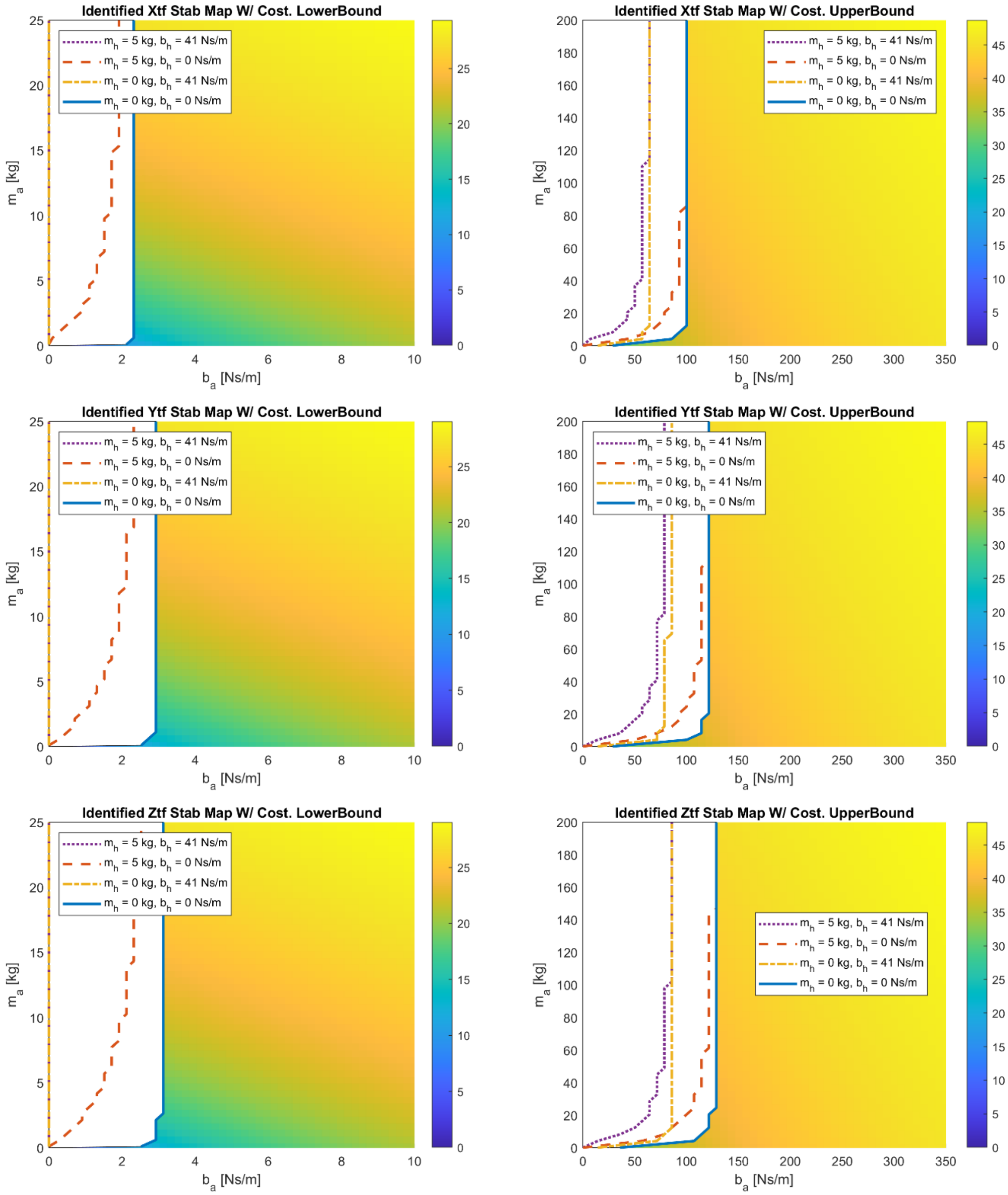
Stability Analysis of the Identified System

The closed loop poles of the transfer function were observed and a stability map for different desired admittance mass and damping values was made.

The figures below descirbe regions where the robot is garunteed to perform with a stable response given a human force is interacting with the robot moving it up or down. The human force also imposes an impedance on the robot that will slow it and change the system dynamics. These human factors are modeled by the upper and lower extreme bounds of the human interaction. Contact with the environment is also taken into account, such that any contact is assumed to take on a maximum stiffness value that impedes that robot similar to the human. These bounded values are as follows. Human and environment impedance: Upper bound, mass mh = 5 damping bh = 41 stiffness kh = 401 Environment ke = 16599; Lower bound, mass mh = 0 damping bh = 0 stiffness kh = 401 Environment ke = 0;

The output for the case with high envrionmnet impedance (16599) is on the left. The case on the right has no environment impedance. Thus, Any value in the shaded yellow/green region in the left figure will result in addmittance controller values acceptable for all human environment interactions. The more blue/green the acceptable values are, the more transparent the controller will feel.





Simulated Admittance Application

An admittance controller was applied to the identified TF with different admittance mass m_ad and damping b_ad values that were in the stable region and unstable region. The expected output of the control follows suit to the stability map. Stable values result in stable outputs. Unstable values result in unstable outputs. Different input cases were used. First a step input of constant 10 newtons was applied. Then a sine force of amplitude 5 was applied. This simulation was done assuming that both human and environmental impedance were present at their worst-case values.

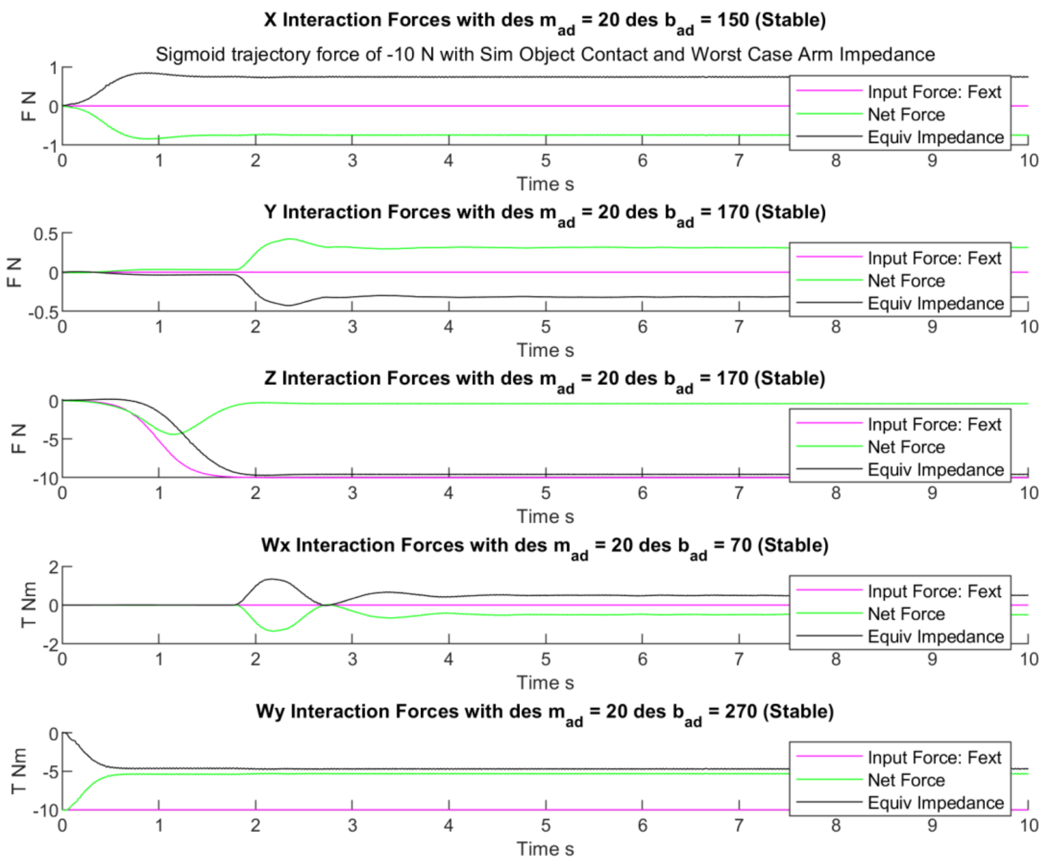


Figure 1 Output results for the stable impedance values

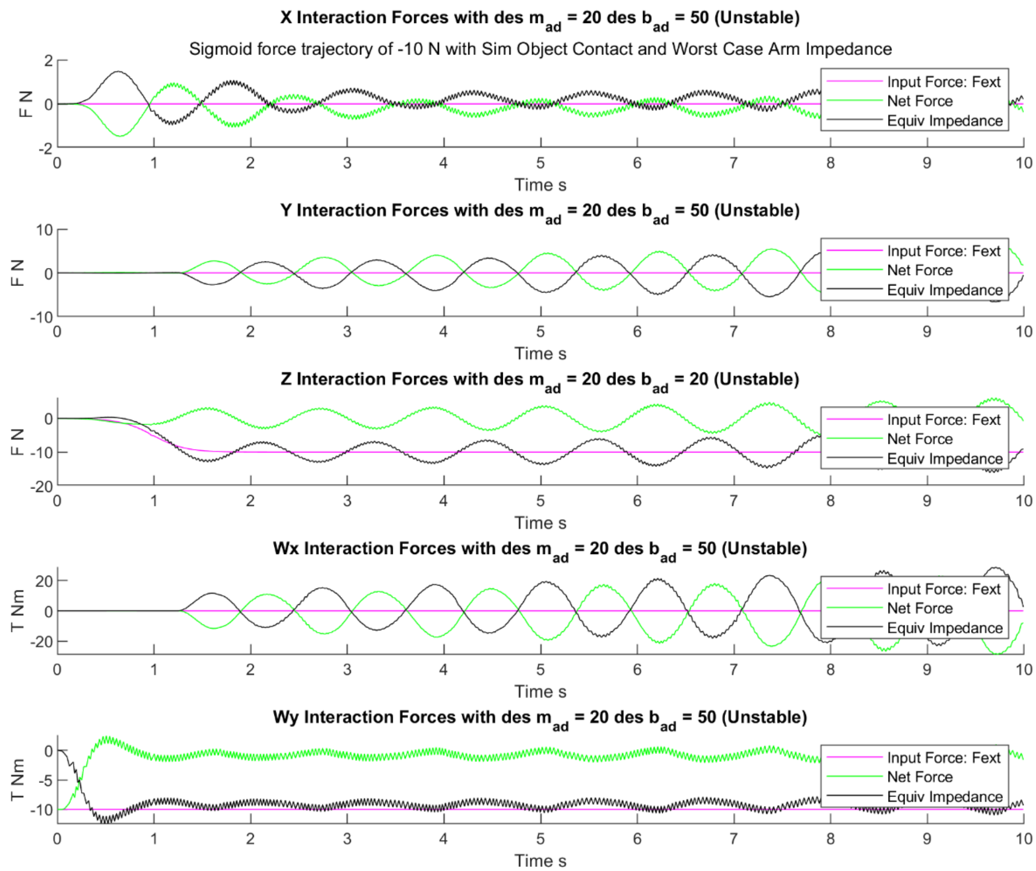


Figure 2 Output results for the unstable impedance values

We hav yet to fully investigate the simulated Admittance Application with Contact in AMBF.