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# Model estimation of a camerastabilizing system

## A cooperation between LINK-SIC and Newton Nordic

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## Introduction

This project is part of a collaboration between the technology company Newton Nordic and the competence center LINK-SIC. The aim of the project is to improve their main product Newton.

## Newton

Newton Nordics main product is a camera stabilizing system called Newton. It uses three motors, one for each dimension of movement together with a sophisticated control system to handle both external disturbances and allowing control of the system by the user.

*Newton and the controller dominion*

## Problem description

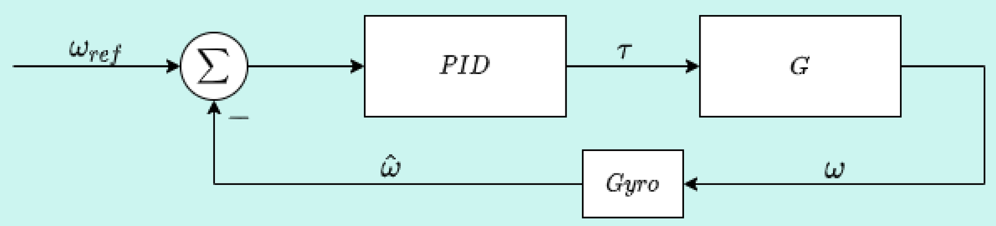
The movement of Newton is controlled by a PID-controller for each axis. These PID-parameters needs to be tuned by hand for each new set up. This can be very challenging for inexperienced users. This project researches the possibilities to estimate a system model which then can be used to tune the PID-parameters automatically.

## Method

The structure of this project has been to first collect relevant data through tests and then try to fit models to the data. Lastly, we have also tried some methods of PID-tuning using system models.

## Modeling

Models are estimated by taking the input data torque and output data rotation speed and then fitting a model to the data. The software used to estimate these models is a Matlab toolbox called System Identification Toolbox.



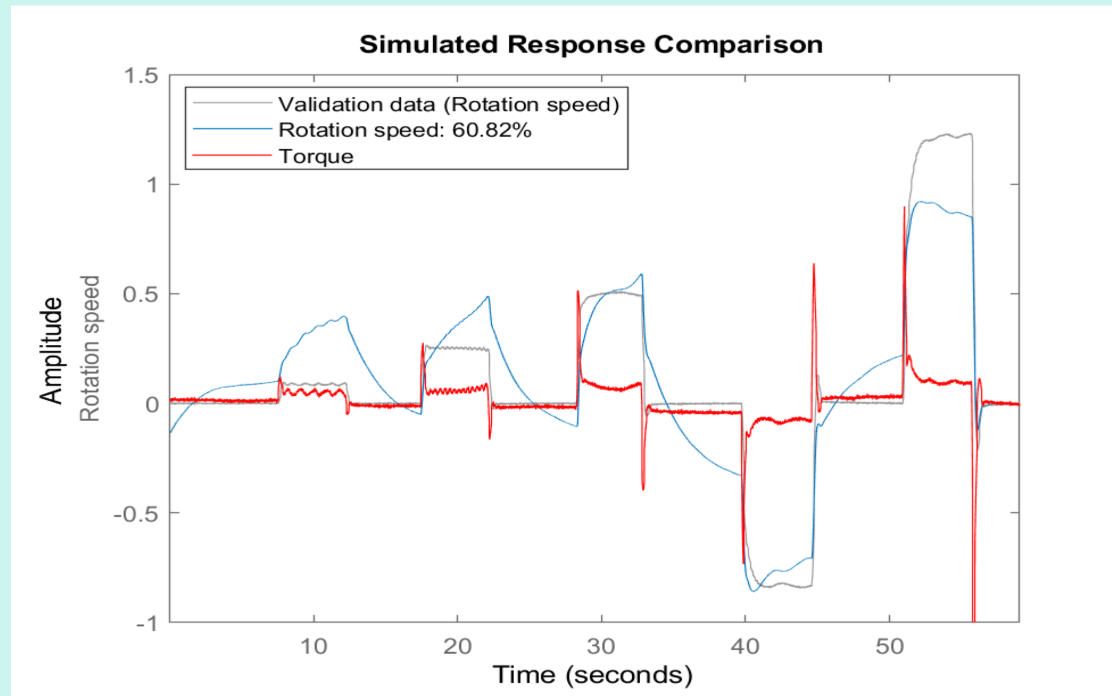

*Newton and the controller dominion*

## Linear models

Different linear models have been tried throughout the project, but the focus has been on linear process models. These are transfer functions with a delay and different number of poles and zeros. One hypothesis was that the system was a first order system, due to viscous friction and moment of inertia. From experiments it showed that the first order model worked as well as higher order system. The experiments also showed that the process model did not manage to keep constant speed.

$$G_{P1D} = \frac{K_p}{1 + T_{p1}s} e^{-T_d s}$$

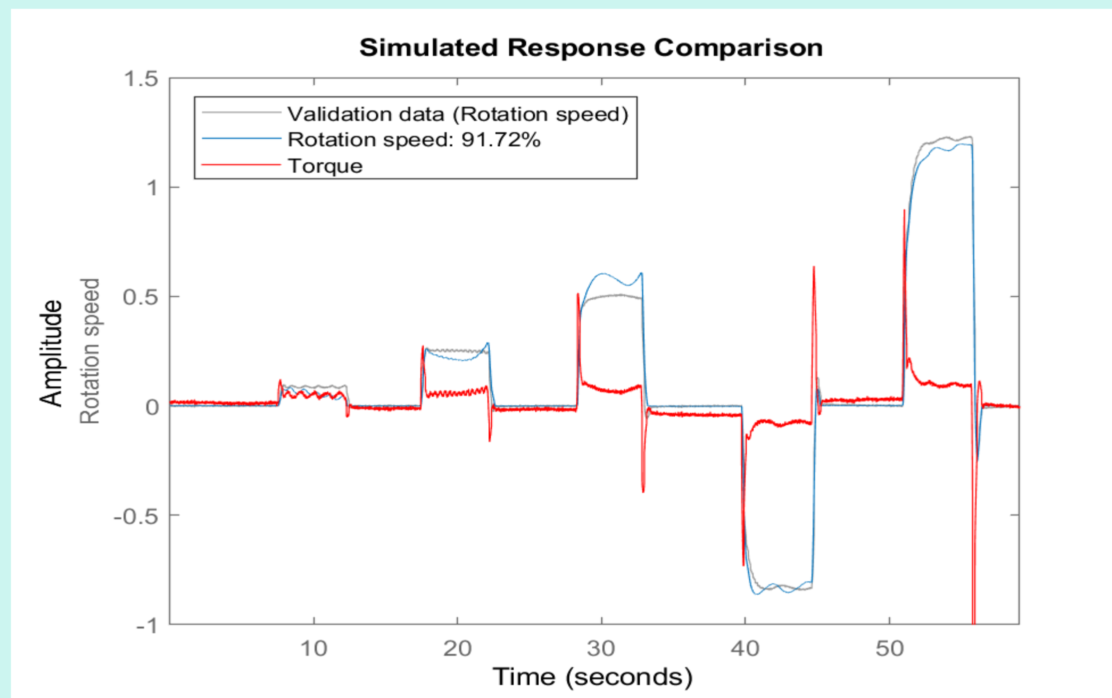
*First order model*




*First order linear model comparison*

## Nonlinear model

Using a nonlinear model including friction gave the best results of any model. With the nonlinear friction model coefficients for friction parameters and the moment of inertia have been estimated. The friction model used included viscous, and coulomb friction using tanh functions. After finding good parameter initial guesses doing tests with different loads the main parameter change was only the moment of inertia.




*Nonlinear dynamic model with friction*

$$F_f = a_1(tanh(b_1\omega) - tanh(b_2\omega)) + a_2 tanh(b_3\omega) + a_3\omega$$

*Nonlinear friction model*

## Control

Experiments showed that the system is nonlinear. A linear approximation for a first order system was made around one working point. This model was used to tune the PID-parameters using IMC-tuning and by pole placement. Experiments showed that pole placement using a linear approximation model worked surprisingly well.

## Results and Conclusions

The system isn't as linear as first thought, there is a relatively large amount of friction in the rotation points compared to the input torque. Therefore simple linear models mostly do not describe the system to a satisfactory level. However nonlinear friction models have described the system very well in the pan axis. More work must be done on the other axes in order to find their model parameters.

## Acknowledgements

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