System identification of a Skeldar helicopter

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Introduction

This project is a part of the collaboration between the competence center LINK-SIC and UMS Skeldar. The aim of the project is to compare two different methods of system identification and evaluate whether using the two-step method is a reasonable way to decrease the work required for preprocessing. The system(s) to be identified are the hovering dynamics in pitch, roll and yaw for Skeldar's helicopter model V-200, and the resulting models are intended for control design.

Figure 1: A Skeldar V-200 helicopter

The direct method

Previous attempts of identifying the cyclic dynamics has been made using a direct method. This method is based on using prefiltered input- and output data and directly fitting a model relating the two.

The two-step method

Since the helicopter has to operate under feedback control during data collection, the input and the disturbances inevitably become correlated. This might lead to bias errors when using estimation techniques such as PEM. The main idea behind the two-step method is to circumvent this issue by utilizing the known excitation signal d and reformulating the closed-loop system as two open-loop systems. The identification procedure is then:

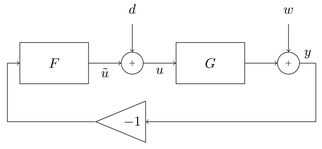

Figure 2: Block diagram of the closed loop system

1. Identify $S : d \rightarrow u$ and form $\hat{u} = \hat{S}$ using a high order blackbox model structure.
2. Identify $G : \hat{u} \rightarrow y$ using a greybox state space model structure.

Since the main input-output relationship without loss can be rewritten as

$$y = G\hat{u} + \underbrace{G(u - \hat{u}) + w}_{=:\tilde{w}}, \tag{1}$$

the two-step method should ideally result in that the virtual noise term $\tilde{w}$ becomes uncorrelated with $\hat{u}$, given that $\hat{S}$ is "good enough", reducing the need for prefiltering.

Results

When comparing the model fits of the best performing two-step models in yaw as well as pitch and roll to the models obtained using the direct approach, the fit achieved using the direct approach is almost always slightly higher than the fit achieved using the two-step approach.

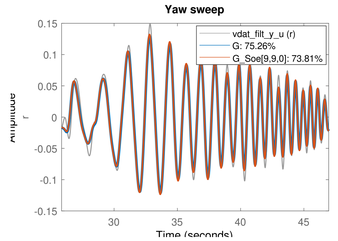

Figure 3: Comparison of simulated outputs from both methods against filtered validation data in yaw.

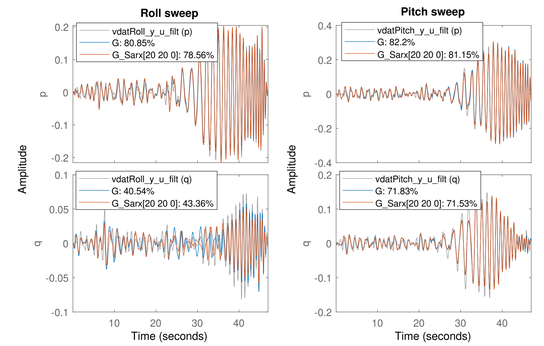

Figure 4: Comparison of simulated outputs from both methods against filtered validation data in pitch and roll.

Conclusions

- The resulting models from the two step method are qualitatively fairly similar to the results from standard identification.
- Two step identification on raw data generally results in a slightly lower but very similar fit-percentage compared to standard identification on filtered data when validated against the same dataset.
- Since the two different methods are based on different assumptions but produce similar results, it is reasonable to assume they are both reliable in this application.

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