Dynamic simulation model of DJI M600 Pro hexacopter

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1 DISCLAIMER

The authors assume no responsibility or liability for any errors or omissions in this model and any errors or damages (including loss of property or life) caused by the use of this model. The model is provided on an ”as is” basis with no guarantees of fitting any specific need or goal. Application of the model in flight control design or in any application of a DJI M600 (Pro) hexacopter is solely the responsibility of the user.

2 Model structure and software requirement

This is a Matlab/Simulink high fidelity 3D simulation model created and tested in Matlab R2019b based-on 3D rigid body modeling of the drone structure (to obtain mass and inertial properties) and flight data-based system identification of its dynamics including aerodynamic effects, engine dynamics and controller loops.

The model is implemented in *DJI_M600_Pro_model.slx* Simulink file including the main blocks:

- Attitude dynamics: it implements the rigid body rotational dynamics considering inertial, aerodynamic and engine torque effects.

- Position dynamics: it implements rigid body translational dynamics considering inertial, aerodynamic and engine thrust effects. It finally gives the NED (North-East-Down) position of the hexacopter.

- PLOT Engine angular rates: this block shows the actual angular rates of the engines in [rad/s].

- References: gives the user defined references and flight mode flag (for details see the description later).

- PLOT tracking results: plots the reference and simulation output signals.

Model_3D_init.m includes the inertial, engine, aerodynamic and control model parameters. *This file should not be modified by the user!*

User_defined_3D_init_run.m is the file which prepares and runs the model. Parameters which can be *and should be* adjusted:

- Mass and inertial setup by selecting flag 1 or 2 according to the description. (line 21)

- DJI OSDK Flight control flag having the same value (flightctrl_flag) as should be commanded by the real onboard controller through OSDK. You can select the options by commenting them out / not. There are some options not included in the model denoted by NOT IMPLEMENTED. Of course you can not run them. (lines 23-45)

- Give simulation runtime (line 55)

- Give X, Y, Z and Yaw reference signal shapes and values. Step (see Fig. 1), doublet (see Fig. 2), half doublet (see Fig. 3) and elongated doublet (see Fig. 4) types can be selected. Step parameters are given by the step. structure, while doublet (all three type) parameters by the doublet. structure. (lines 57-114)

- The initial state values of the 3D Matlab simulation (NED position, NED velocity, Euler angles and angular rates) (lines 121-124)

- NED wind strength with zero vertical (Down) component. *The resulting horizontal wind (from North and East) should not exceed 8m/s*. (lines 128-130)

After setting all the parameters the file runs the DJI M600 Pro Simulink model and plots the results. For any support please contact: *bauer.peter@sztaki.hun-ren.hu* and *nagy.mihaly@sztaki.hun-ren.hu*

3 Simulation test results

Fig.s from 1 to 4 show the four possible type of references and their tracking with the tangential velocity.

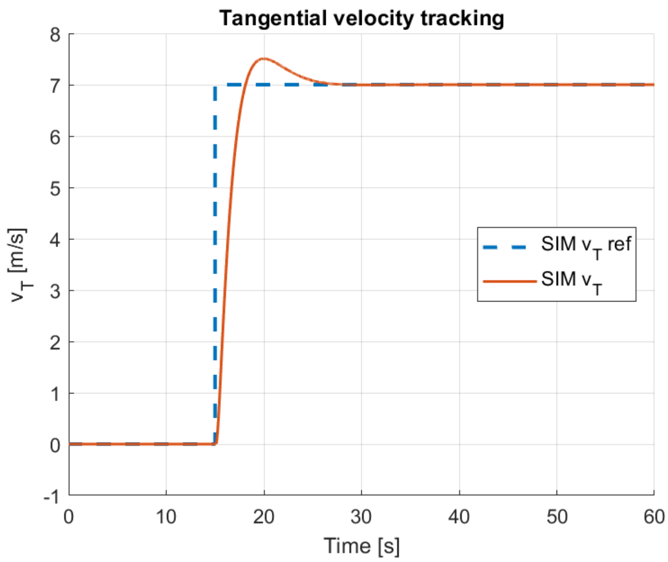

Figure 1: Step velocity response in tangential direction

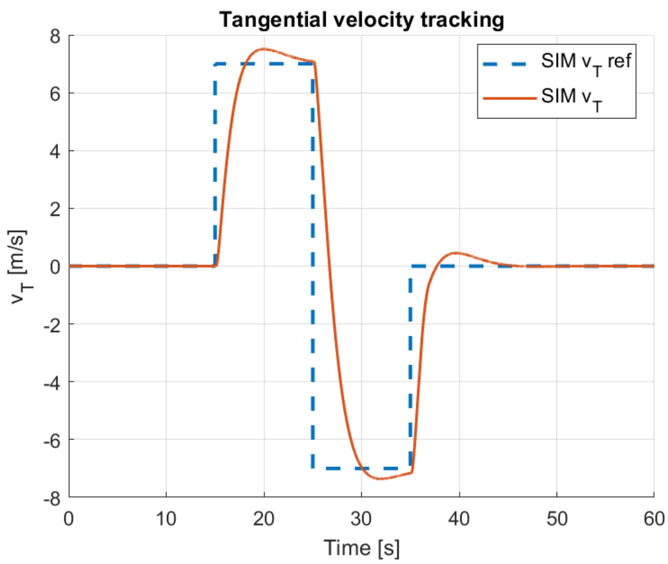

Figure 2: Doublet velocity response in tangential direction

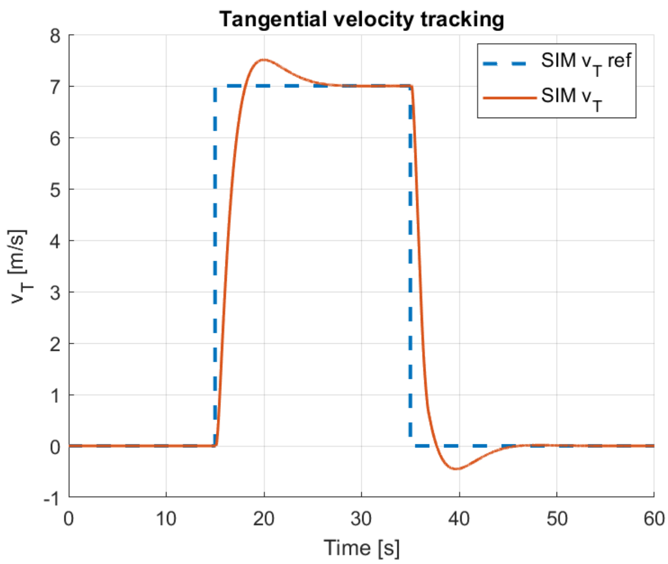

Figure 3: Half doublet velocity response in tangential direction

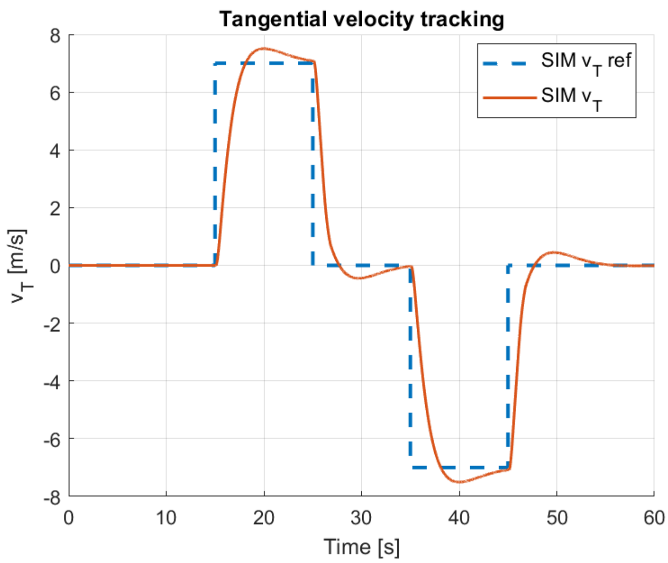

Figure 4: Elongated doublet velocity response in tangential direction

Position and angle tracking works in a special way on DJI M600 which is included in the code. Tracking of a position ’kick’ (very short half doublet) command results in the acceleration following a given velocity reference and then deceleration as shown in Fig.s 5 to 6. Thus a step position reference results in a steady flight speed into the given direction instead of moving away in position with the given reference.

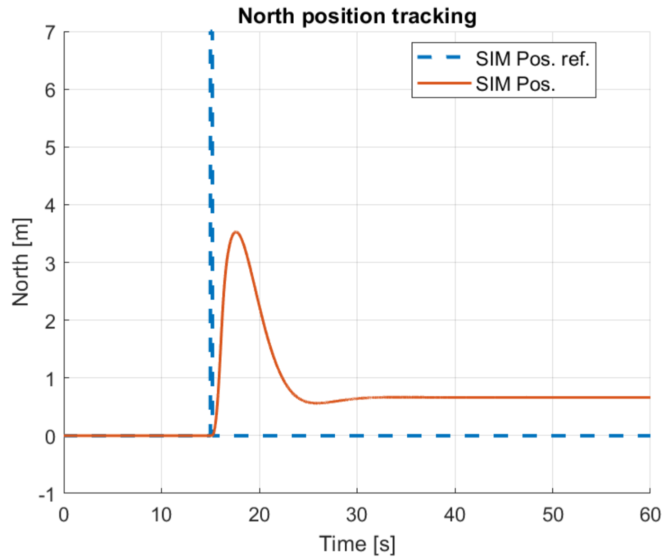

Figure 5: North position change for a short 'position kick' command

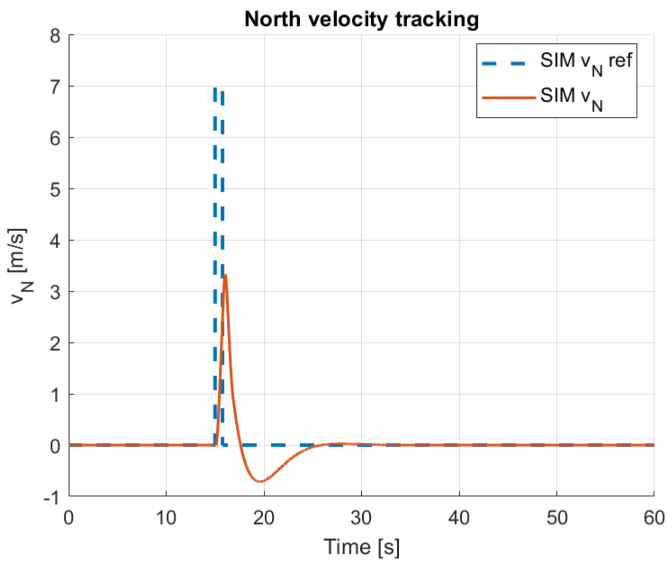

Figure 6: North velocity reference and change for a short 'position kick' command

Angle tracking is shown in Fig.s 7 to 8. The tracking at the first step is as expected following the given reference angle, but backward a braking mode is activated regulating the velocity to zero instead of simply tracking the zero angle reference. Note that originally a zero roll reference was commanded at the end of the half doublet but switching to the braking mode modified this to a large negative value. This is also a speciality of DJI M600 control.

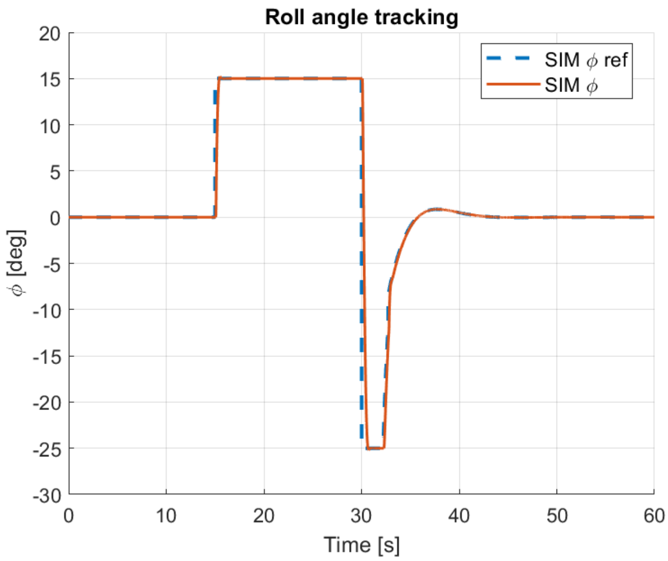

Figure 7: X angle (roll) half doublet tracking

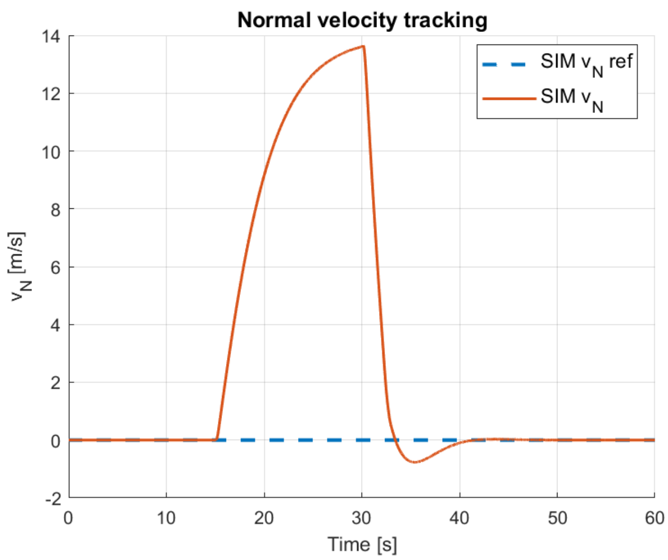

Figure 8: Normal velocity during X angle (roll) half doublet tracking