Fractional Order PI Gimbal Control

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Summary. The paper presents the controller design of a inertial stabilization platform for optical devices in which a one axis gimbal system is used. The main aim is to stabilize the sensor s line of sight (LOS) toward a target, isolating it against the environmental disturbances which heavily affects the system behavior.
The proposed approach is based on a Fractional Order PI (FOPI)controller, whose parameters are designed by using genetic algorithms optimization.
The proposed controller has been compared with a standard Proportional Integrative (PI) controller with particular attention to noise rejection.

Gimbal control via Proportional Integrative and Fractional Order Proportional Integrative

Maintaining the LOS of optical devices installed on moving or flying vehicles, isolating it from the base movements and vibrations is a fundamental task in many applications and a number of controller design techniques have been proposed in literature to approach the problem [3, 12].
The main objective of the controller is to keep the LOS of the device fixed with respect to an inertial reference frame when the vehicle undergoes rotational motion about its axes. Vehicle motion maneuvers (pitch, yaw, roll) couple into gimbal causing a nonlinear torque disturbances for the gimbal mechanisms, see figure 1, and in [13].
Other relevant disturbance sources are the dynamics of the gimballed system and the gimbal mass unbalance. An in deep discussion of the different noise sources can be found in [3].
The gimbal platform considered in this paper, designed for topographic applications, is driven by a brushless dc servo motor and the control system feedback measurement is obtained from a gyroscope that measures the angular rate, as represented in figure 2.

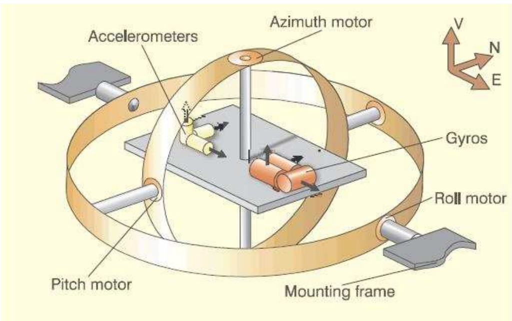

Figure 1: Gimbal structure

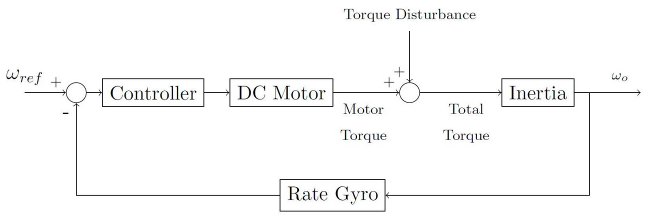

Figure 2: Block scheme of the controlled system

The comparative results related to the application of a PI and a FOPI, [14]controllers, are reported in the following.
Both the controller have been optimized using genetic algorithm, see [15], in Matlab/Simulink environment, adopting the scheme shown in figure 3. The three parameters of the standard PID and the five parameters of the FOPID have been determined applying a genetic algorithm with the following parameters : $population\ size = 200$, $max\ generation = 40$, $number\ of\ bit = 10$ and $generation\ gap = 0.9$.
For the two controllers all the parameters have been taken into account when applying the genetic algorithm, anyway, at the end of the optimization, for both controllers, the proportional gain has been "optimized" to zero.
The following table reports the values of the controller gains and the optimization index, defined as:
The last figure 4 shows the comparison of the two controller.

$$Err = sum(abs(ref - out))/max(size(out)) \tag{1}$$

Table 1: Controller parameters and performance index.

	K_p	K_i	λ	Err
PI	32	204	0	0.36
FOPI	34	237	1.1	0.32

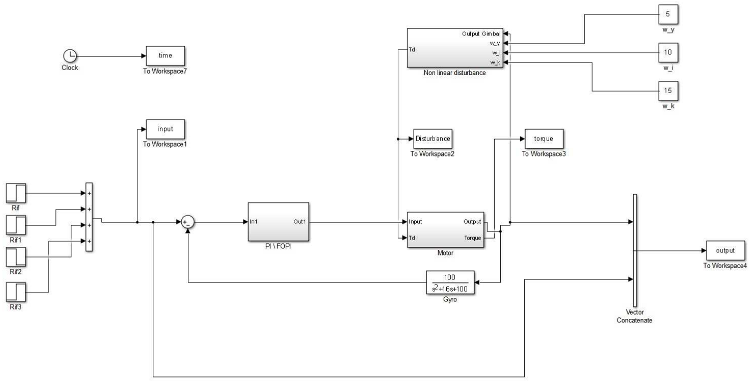

Figure 3: Simulink model of the control system.

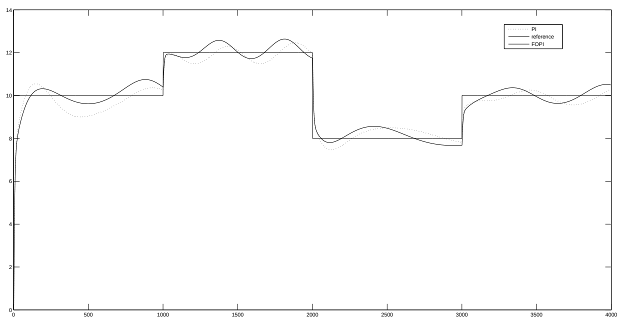

Figure 4: Response of the Gimbal with PI and FOPI controllers.

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