Hybrid Genetic Algorithm and Kalman Filter Approach to Estimate the Clamping Force of Electro-Mechanical Brake

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***Abstract*—In this paper, a hybrid genetic algorithm (GA) and Kalman filter approach to combining motor encoder and current sensor models is presented to accurate estimate the clamping force of an electro-mechanical brake (EMB). Elimination of the clamping force sensor and measurement cables results in lower cost and increased reliability of an EMB system, including its electric motor. A Kalman filter is a special kind of observer that provides optimal filtering of the measurement noise and inside the system if the covariances of these noises are known. The proposed combined estimator is based on Kalman filter optimized by GA in which the motor encoder is used in a dynamic stiffness model and the motor current sensor is used to give measurement updates in a torque balance model. A real-coded GA is used to optimize the noise matrices and improve the performance of the Kalman filter. Experimental results show that, by using the proposed estimator, the virtual clamping force sensor can handle highly dynamic situations, making it suitable for possible use in sensorless fault-tolerant control. It is shown that the proposed combined estimator improves the root mean square error (RMSE) performance. The developed estimator can be used in real vehicle environments because it can adapt to parameter variations.**

***Index Terms*—Electro-mechanical brake, Clamping force, Genetic algorithm, Kalman filter**