Fault Diagnosis and Fault Tolerant Control for Fuzzy Systems: Application to Vehicle Dynamic

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Over the past decades, fault diagnosis (FDI) and fault tolerant control strategies (FTC) have been proposed based on different techniques for linear and nonlinear systems. Indeed a considerable attention is deployed in order to cope with diverse damages resulting in faults occurrence. In the literature, model-based fault diagnosis techniques have shown their interest in the industrial domain and many results on fault detection observer have been reported for linear systems and nonlinear ones. In recent years, Takagi–Sugeno (T–S) fuzzy approach has attracted a growing interest due to its universal approximation of any smooth nonlinear function by a "blending" of some local linear system models. This representation allows greatly facilitates observers/controllers design using numerical tools (LMI formulation). Many results on fault detection observer design for T–S fuzzy systems have been reported in the literature. These works generally considered that the weighting functions depend on measurable premise variables. In the field of diagnosis, this assumption forces to design observers with weighting functions depending on the input $u(t)$ for the detection of the sensors faults, and on the output $y(t)$ for the detection of actuator faults. For this reason, it is interesting to consider general case of unmeasurable variables.

On the other hand, two classes of the existing FTC strategies have been distinguished; passive FTC and active FTC. The last methods require the knowledge of the faults to reconfigure controller laws to maintain system stability. Based on control theory, relaxation schemes have been proposed for fault diagnosis and fault tolerant control. Thus, using LMI formulation and Lyapunov approach, observers and controllers design for T-S systems has been studied using a quadratic Lyapunov functions and non-quadratic approaches to reduce conservatism. Several techniques have been proposed for FDI and FTC design for T-S systems with sensor and actuators failures. For example with the aid of the descriptor approach, in which an augmented fault observer is designed to yield faults and states estimation simultaneously, observer-based output feedback fault tolerant controllers are proposed. The mixed performances are also considered for more sensitivity to faults and robustness against perturbations.

These results are successfully applied for various industrial applications such as vehicle dynamics. Indeed, in the last decades, lots of efforts have been devoted in

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developing vehicles intelligent systems such that active safety systems to improve vehicle-handling characteristics like stability and comfort. Thus, majority of cars are nowadays equipped with various assistance systems such that Traction Control System (TCS), Anti-lock Braking System (ABS) and many variants of Electronic Stability Program (ESP). Various works have been also carried on collision warning, collision avoidance, automated lane-keeping systems. In this context, T-S observers design (Unknown input observer, sliding mode observer,…) is applied for lane departure detection and rollover detection.

Keywords: Takagi-Sugeno fuzzy models, unknown inputs, faults, observers, controller, FDI, FTC, LMI, vehicles dynamics.

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