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**Title:** Active diagnosis and reconfiguration for hybrid systems - Application: Autonomous Satellites.

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**Problematic:**
The growth of embedded system technologies makes controlled dynamic systems (space engines, cars, aircrafts…) more complex. These systems, especially in satellites, combine both continuous (AOCS: Attitude and Orbit Control System, power equipment…) and discrete-event (fault events, control inputs, reconfiguration actions…) behaviors. This leads to hybrid dynamics.
These systems are very expensive and they often perform critical tasks with very limited on-ground ability of intervention. Consequently, autonomy is very crucial. Autonomy calls for an on-line supervision and diagnosis, which guarantee the state tracking in all operating modes in order to perform reconfiguration actions after a fault occurrence.

**Purposes and work framework:**
This work aims to the development of a diagnosis and reconfiguration approach for autonomous satellites. This work is supported by Thalès Alenia Space.

**Context and positioning:**

In this Ph.D. a Model Based Diagnosis (MBD) approach is proposed as well as a hybrid model that aims to combine both continuous and discrete-event dynamics in a unique modeling framework as mentioned in [Henzinger, 1996] and inspired by the language theory from [Ramadge et al, 1989]. This model is then used by the on-line diagnoser, that takes as input the continuous control signals and discrete control inputs and produces a state estimation (faulty or nominal) that is generated on-line.

Our diagnosis approach couples both continuous system [Cocquempot et al, 2004] and discrete-event system [Sampath et al, 1995] techniques.

After a fault occurrence, a reconfiguration action can be performed in order to refine an ambiguous diagnosis (Active diagnosis) and take the system out of the fault mode (Reconfiguration).

In this Ph.D., we propose considering a reconfiguration approach guided by the diagnosability property of the system.

Diagnosability is the property of a system and its monitors to exhibit different observations for all anticipated faults. A hybrid system is diagnosable if every fault occurrence can be detected with a finite number of discrete observable events and with continuous measures provided by system sensors.

The diagnosability property was defined in the literature, in one hand for discrete event systems (DES) [Sampath et al, 1995], and in the other hand for continuous systems (CS) [Travé-Massuyès *et al*, 2004].

In this Ph.D. work new concepts of fault signature are proposed in order to define the diagnosability property for multimode and hybrid systems. Diagnosability criteria are stated and proved.

**Work advancement**

We are working now on the reconfiguration approach, which is guided by the diagnosability properties of the system, in order to add a reconfiguration module to the current diagnosis software. This work is inspired by the works of [Sampath, et al, 1997] on DES active diagnosis and [Tsuda et al, 2001] on hybrid systems reconfiguration.

**Publications :**

State Tracking in the Hybrid Space, Mehdi Bayoudh, Louise Travé-Massuyès and Xavier Olive. In proceeding of the 18th International Workshop on Principles of Diagnosis DX'07, Nashville, USA.

Hybrid systems diagnosability by abstracting faulty continuous dynamics, Mehdi Bayoudh, Louise Travé-Massuyès and Xavier Olive. In proceeding of the 17th International Workshop on Principles of Diagnosis DX'06, Peñaranda De Duero, Spain, June 2006.

**References :**

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[Ramadge et al, 1989] P. J. Ramadge and W. M. Wonham. The control of discrete-Event Systems. *Proc. IEEE*, vol. 77, pp. 81-98, January 1989.

[Sampath et al, 1995] M. Sampath, R. Sengputa, S. Lafortune, K. Sinnamohideen and D. Teneketsis. Diagnosability of Discrete-Event Systems. *IEEE Transactions on Automatic Control*, vol. 40, pp. 1555-1575, 1995.

[Henzinger, 1996] T. Henzinger. The theory of hybrid automata. *In Proceedings of the 11th Annual IEEE Symposium on Logic in Computer Science (LICS'96)*, pages 278–292, New Brunswick, New Jersey, 1996.

[Travé-Massuyès et al, 2004] L. Travé-Massuyès, T. Escobet, S. Spanache, X. Olive. Diagnosability analysis based on component supported analytical redundancy relations. *IEEE Transactions on Systems, Man and Cybernetics, Part A (2004).*

[Tsuda et al, 2001] K. Tduda, D. Mignone, G. Ferrari-Tescate, M. Morari. Reconfiguration Strategies for Hybrid Systems. *Proceedings of the American Control Conference.* Arlington, VA June 25-27, 2001.

[Cocquempot et al, 2004] V. Cocquempot, T. El Mezyani, and M. Staroswiecki. Fault detection and isolation for hybrid systems using structured parity residuals. *IEEE/IFAC-ASCC: Asian Control Conference*, 2004.