NOMDIS

New Operators for Diagnostic intelligent Systems

Project

Context

Monitoring and diagnostic tools are essential for mission control purposes, as well as for assessing and monitoring the health status of spacecraft and satellite components.

The important issue of how to perform rule aggregation and inferencing with synergetic operators (aggregation operators that take into account the dependencies/synergies between overlapping rules/parameters) has never been addressed in the field. Recent developments in the theory of weighted aggregation operators and fuzzy multicriteria decision making have established Choquet integration as an interesting and powerful generalization of both the standard weighted averaging and the ordered weighted averaging. The essential novel feature of Choquet integrals is their capability of modelling and encoding the interaction patterns which correlate the various criteria, making use of techniques borrowed from discrete mathematics, cooperative game theory and weighted aggregation theory.

Goal

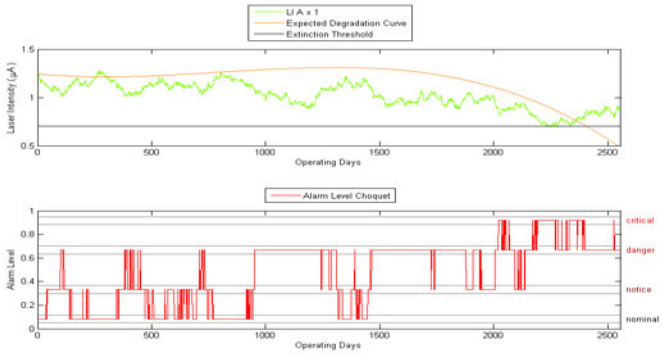
The main goal of NOMDIS is to define a new inference scheme for translating the Choquet integral methodology from interacting fuzzy multicriteria decision systems to interacting rule-based expert systems for monitoring and diagnostic space problems. This novel approach extends the effectiveness and applicability of interactive intelligent systems for monitoring and diagnostic, just as Choquet integration has largely extended the validity and scope of weighted aggregation in fuzzy multicriteria decision making.

Case Studies

Rosetta – development of a fault detection system for monitoring the degradation of the Inertial Measurements Packages (IMP) in terms of gyroscopes laser intensities and deviations from manufacturer degradation curve.

Venus Express – development of a thermal alarm system (incmplete)

Results



The new Sugeno-Choquet inference scheme is adequate to deal with any sort of situation where a FIS has rules that are either redundant (in the sense that they produce similar firing levels), opposed (in the sense that they produce complementary firing levels), or both. As expected, the corrections introduced by this inference scheme will be greater the more intense the relations/synergies between rules are. Further, since the new approach is a generalization of the typical Sugeno FIS it can be used regardless the existence of the mentioned relations.

Key Technologies

Fuzzy Logic

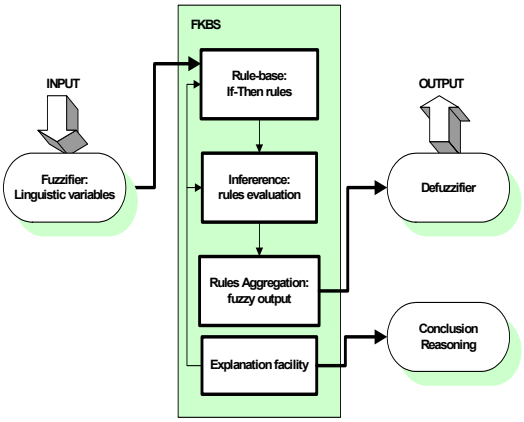
Fuzzy logic is a powerful problem-solving methodology with a myriad of applications in embedded control and information processing. Fuzzy provides a remarkably simple way to draw definite conclusions from vague, ambiguous or imprecise information. In a sense, fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions. Unlike classical logic (**Boolean Logic**) which requires a deep understanding of a system, exact equations, and precise numeric values, **Fuzzy Logic** allows modelling of complex systems using a higher level of abstraction originated from our knowledge and experience.

What are Choquet Integrals?

The Choquet integral is useful in expressing the intended synergies between criteria/rules by means of a fuzzy measure and a non-additive weighted aggregation. The basic idea is to emphasize, either positively or negatively, subsets of criteria/rules that influence each other. The Choquet integral can be applied in inference systems of the Sugeno-type, to explore the possible synergies that exist between rules.

Fuzzy Rule Based System

Fuzzy inference systems or rule-based systems (FRBS) require the development of a rule base, which will contain the set of rules using fuzzy sets. Rules are usually given by the experts or they can be extracted from numerical data. FRBS are primarily used in control but they have a broader interpretation by considering the possible actions: monitoring and diagnostic, suggestion, conclusion, evaluation, classification. Graphically:



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