CLASSIFICATION OF SPATIO-TEMPORAL SIGNATURES OF AUTONOMOUS INTELLIGENT SYSTEMS BY MEANS OF FAST FUZZY RELATIONAL ALGORITHMS

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Signature is a spatio-temporal dynamic trajectory, exhibiting some characteristic static or dynamic features of an intelligent autonomous system, that are to be identified for some a priori predefined purpose.

One of the essential tasks in the studies and design or e.g. multilink mobile systems is to develop a fast pattern recognition method that would classify the spatio-temporal waveforms percieved by some sensors. This classification is a general problem of identifying signatures that has a multitude of uses, amongst others

1) Extraction of essential characteristics of spatio-temporal proprioceptive feedback information for the intelligent control of a multi-level robot (Kohout, 1986).
2) Classification of remotely sensed movement pattersn of a mobile i.e. (underwater) vehicle.
3) Classification of movement trajectories of a human for the purpose of diagnostics of, or dexterity evaluation in, neurological movement disorder.

A family of spatio-temporal signatures represented by a dynamic vector $V_k=(x_1,x_2,x_3,x_4)$, where x_1, x_2, x_3 are spacial variables and x_4 a temporal variable, representing position, velocity, acceleration and time, respectively captures the dynamics of the percieved or sensed abstract point.

The extraction of the essential parameters and their further classification is performed by a four level pattern classifier, where each consecutive level performs extraction of structures of increasing abstraction. The levels can briefly be characterised as follows:

1) Extraction of the essential parameters by means of affinity and fuzzy measures

2) Computation of harsh and mean fuzzy relational products constructing characteristic fuzzy relation.
3) Extracting fuzzy local relational properties by means of fast fuzzy relational algorithms.
4) Further classification of the extracted relational properties by means of fuzzy relational inference or fuzzy power set based approximate quantification.

The selection of the operators on the level 1 depends on the dynamic and other characteristics of the observables. The operators suitable for the use on this level are afinity measures, various norms and conorms (Schweizer, 1985) and some implication operators (Bandler and Kohout, 1986a). Both, the symmetric and nonsymmetric operators have use in this context, some of them in harsh or mean fuzzy relational products (Bandler and Kohout, 1980). On the second level, triangle and square relational products are used (Bandler and Kohout, 1986b). The third abstraction level employs fast fuzzy relational algorithms for the computation of fuzzy interiors and relational closures by which testing of various relational properties is performed (Bandler and Kohout, 1986c; Bandler and Kohout, 1980a). On the fourth level, relational inference rules (Bandler and Kohout, 1984; Bandler and Kohout, 1985) or fuzzy quantification by means of fuzzy power set models (Bandler and Kohout, 1980c).

From the implementational point of view, each pattern recognition level is a fuzzy virtual relational machine which in real time applications has to be embedded into a separate process running on a microprocessor or VLSI hardware substratum. In order to gain extra speed in superfast applications, Relational Products Architectures may be an advantage (Kohout and Bandler, 1985).

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POSTCRIPT

We have gained considerable insight into suitability of various fuzzy implication operators and of various measures while studying classification of dynamics of limb dynamic trajectories of patients with neurological brain disorders. There are about 40 various operators used in various relational products being evaluated at present. See

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