FUZZY ADAPTIVE FILTERING

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The theory of the crisp adaptive systems is well established /1/, at least for linear systems.

In contrast, at this moment, the fuzzy systems are adapted by using heuristic procedures /2/, /3/.

In the following we shall discuss the problem of the adaptive fuzzy systems by extending the principles of the crisp adaptive filtering to fuzzy systems.

Let be a discrete time fuzzy system with two inputs Xk and Wk and an output Yk given by:

$$Yk(y) = \sup_{x,w} [Xk(x) \; t \; Wk(w) \; t \; R(x,w,y)] \qquad (1)$$

where $Xk \in F(X)$, $Wk \in F(W)$, $R \in F(X \times W \times Y)$, $Yk \in F(Y)$; $F(X)$ represents the family of all fuzzy sets defined on X; R is a known fuzzy relation; t represents a t-norm.

Let be the desired output of the system a sequence of fuzzy sets $Dk \in F(Y)$, $k=1,2,\ldots,N$ for a known input sequence of fuzzy sets $Xk \in F(X)$, $k=1,2,\ldots,N$.

Denote by

$$Sk = f(Dk,Yk), \quad f : F(Y \times Y) \to F(Y) \qquad (2)$$

a sequence of fuzzy sets $Sk \in F(Y)$, $k=1,2,\ldots,N$ which measures the "similarity" between the reference sequence Dk and the output Yk of the system.

A "block" adaptation problem, for the fuzzy system given by the rel. (2) can be stated as follows:

determine an optimum W^* such that a corresponding fuzzy functional

$$\Phi(S1,S2,\ldots,SN), \quad \Phi: F(Y \times Y \times \ldots \times Y) \to \mathbb{R} \qquad (3)$$

is maximized.

An "on-line" adaptation problem for the same fuzzy system can be stated as follows:

determine the inputs $Wk \in F(Y)$ such that a fuzzy functional

$$g(Sk), \quad g : F(Y) \to [0,1] \qquad (4)$$

obeys a prescribed law.

A first step for the foundation of an adaptive fuzzy filtering theory can be made by solving the above problems.

These problems were solved in /4/, for those cases where

$$Sk(y) = (Dk=Yk)(y) = \inf\{[Dk(y) \varphi Yk(y)], [Yk(y) \varphi Dk(y)]\}$$

$$\Phi(S1,S2,\ldots,SN) = \sum_{k=1}^{N} \sup_{y} Sk(y) \qquad (5)$$

$$g(Sk) = \sup_{y} Sk(y)$$

The preliminary obtained results prove the possibility of extending the principles the crisp adaptive filtering to the fuzzy adaptive systems.

The solving of the previous adaptation problems alows the development of new algorithms for adaptive fuzzy systems, with direct application to adaptive fuzzy control.

References

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