ON THE ROBUSTNESS ASPECTS OF FUZZY LOGIC CONTROLLERS

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A B S T R A C T

Fuzzy logic control is the latest revolution in modern control theory, although it is rather different from all modern control methods. This is due to the fact that fuzzy logic is much closer in spirit to the human thinking and natural language than the traditional logical systems and control techniques. The controller based on the idea of fuzzy logic is called **fuzzy logic controller (FLC)**.

Fuzzy logic is nowadays most used in many "difficult" control systems. In particular, the methodology of fuzzy logic appears to be very useful in unmodelled or highly nonlinear systems (i.e. chemical processes) in which the quantitative classical or modern control techniques are unable to give a satisfactory solution.

Fuzzy logic is based on the idea of the fuzzy set, which differs from a conventional set in the sense that a crisp value may be contained in it not only with membership grades 0(0%) or 1(100%) but also with a grade of membership between them. In a fuzzy set the transmission from membership to non-membership is gradual and not abrupt, as it is in a conventional set.

An FLC is composed by four components: i) a fuzzification interface, ii) a knowledge base, iii) a decisionmaking logic and,

iv) a defuzzification interface.

The essential part of an FLC is a set of rules of the form "if-then", connecting the antecedent with the consequent. The control strategy is obtained by the following procedure: each rule of the fuzzy algorithm is evaluated using the compositional rule of inference introduced by Zadeh [1], and an appropriate fuzzy implication function. This evaluation results in a fuzzy set which describes the control action given to the system by the particular rule. Using the maximum operation we connect all the rules together and obtain the final control action described by a fuzzy set. This control action is transformed into a crisp value by employing a defuzzification technique [2].

In recent years the connection between an FLC and a PID is considered for several reasons [3]. As is well known PID is the most commonly used control scheme in industry. Its popularity is due to its simplicity both from the design and the parameter tuning point of view. Its advantages are rejection of disturbances, zero steady state error, fast transient response etc. However, the capabilities of PID are limited and much research is being carried out in order to improve its performance and especially to enhance some robustness properties. In this effort, fuzzy control can lead PID to faster responses and smaller overshoots so that a better transient response is obtained. This can be achieved by adding or subtracting control action to/from the PID structure. These changes in control action can be viewed as changes in the three terms of the PID controller. Experiments in that field have shown satisfactory results better than the results obtained by the conventional PID [4], [5].

As it is well known, robustness properties are demanded whenever only an imprecise model of the physical system is available. In practice this is the case of almost all real control systems, due to neglected dynamics and nonlinearities, external disturbances, etc. Model uncertainties can be described in terms of either parameter variations or unstructured disturbances (see e.g. [6] and related references).

In the present communication, the robustness obtained by an FLC is compared with the one obtained by PID and LQ methods, as well as by the existing robust control methods such as guaranteed performance and H_∞ methods. The system under consideration is a dc motor.

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