MULTI–OBJECTIVE EVOLUTIONARY OPTIMIZATION OF ACCURACY AND INTERPRETABILITY FOR NEUROMUSCULAR BLOCKADE CONTROL

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ABSTRACT: We further investigate the relationship between accuracy and interpretability during the design of fuzzy systems. Both aspects are of major importance for the control of neuromuscular blockade. After describing how these goals can be measured, a multi-objective evolutionary optimization scheme is set up. The results show that even for the best optimization runs at the accuracy side of the Pareto front, the most accurate solutions detain an acceptable degree of interpretability.

Keywords: interpretability, accuracy, multiobjective optimization, evolutionary optimization, neuromuscular blockade, semantic integrity, fuzzy control

1 INTRODUCTION

Interpretability and accuracy should have been two of the main concerns in fuzzy system design. We say should have, because the former aspect, interpretability (sometimes also called comprehensibility, or transparency) tends to be neglected in favour of the later.

In recent studies this trend has been largely inverted. Researchers are more and more aware that in many domains it's very important not only to be able to control efficiently a system, or reproduce as close as possible its behaviour, or even accurately perform a classification task, but also to endow these systems with mechanisms that allow its user to understand how tasks are being performed. When fuzzy sets and systems are used, this understanding can be accomplished by everyday expressions from a natural language [**?**]. For a recent survey of the literature on accuracy and interpretability the reader is referred to [**?**, **?**].

In an attempt to further investigate the essence of the relationship between interpretability and accuracy in the framework of Fuzzy Modelling and Control a multiobjective optimization process was set up. This process optimizes both the localization and width of membership functions. Furthermore, it provides a basis to rationalize the comparison between non-dominated solutions (i.e., fuzzy systems).

The multiobjective, combinatorial and non-linear nature of this class of problems makes them well suited to be tackled with evolutionary approaches. Moreover the ability to choose from a working set of many potential alternative solutions is essential both to the system designer and to the user.

In the bio-medical field, the automatic infusion of anesthesia (i.e., automatic neuromuscular blockade control) provide us with a case-study where the accuracy and the interpretation of the controller are both highly desirable. Some of the main reasons are [**?**, **?**]: *(i)* although automatic feedback control of infusion has been shown to outperform manual control [**?**, **?**] it's necessary to overcome the reluctance of the anaesthetist to perform his task in a different manner, *(ii)* (once overstepped the previous one) it's necessary to deliver a control system which provides a clear and quick perception on how its decisions are being made so that the anaesthetist could validate online these decisions and suggest alternative ones, if necessary. *(iii)* It's also clear that the control system should permit the introduction or modifications of control rules in an anaesthetist-friendly way, allow her/him to use his own clinical knowledge and experience.

Of course, the merits of the control system are also to be related to its robustness, reliability and performance in the clinical environment. Due to its features fuzzy control is a particularly interesting approach to this problem.

The paper is organized as follows. In the following section we briefly define the conditions of our study. This comprises the mathematical model of the patients as well as the control scheme used. In section 3 the optimization process is described, including a description of the semantic measures and its translation into objective functions. Section 4 summarizes the obtained results while section 5 draws some conclusions and ends the paper.