Model-Based Control using Interval Type-2 Fuzzy Logic Systems

Rómulo Antão[1], Alexandre Mota[1], Rui Escadas Martins[1]

1 — Department of Electronics, Telecommunications and Informatics & IEETA, University of Aveiro

The development of control algorithms flexible enough to correctly manipulate real world processes close to their best performance without human supervision has been one the most sought goals of control and system modelling theory.

Recently, the formalisms of the new Type 2 Fuzzy Logic introduced methodologies capable of overcoming the inherent uncertainties of approximating real world processes by a computational model. Yet, despite increasingly present in non-linear modelling literature, model-based control theory is currently not taking full advantage of the improvements that Type 2 Fuzzy Logic provides. Therefore, the present work proposes the development of a new control methodology based on the Generalized Predictive Control (GPC) theory supported by Interval Type 2 Takagi Sugeno Fuzzy Logic Systems (Type 2 TS FLS), as presented in Figure 1.

The developed control algorithm is based on locally linear approximations of the Type 2 Takagi Sugeno model and is evaluated using a non-linear process based on the yeast fermentation reaction. The performance of the closed loop systems is evaluated by subjecting the process to quick changes in the operation regime and to unmeasured external disturbances.

As depicted in Fig.2, the achieved results demonstrate that, at the expense of a small increase in the computational effort, the use of a Type 2 Fuzzy Logic System improved the accuracy of the process's prediction model and provided a better support for the employed control strategy comparatively to other GPC state-of-the art implementations. Control systems developed according to this modelling approach evinced an overall improved transient behaviour, presenting significant advantages when the controlled process is subject to unmodeled disturbances. The proposed method stands as an alternative to non-linear Model Predictive Control methods that require more complex online non-linear optimization algorithms to extrapolate the optimal control actions in real-time.

FIGURE 1
Structure of the MPC algorithm based on Type 2 Takagi Sugeno Fuzzy Models (Type 2 TS FM).

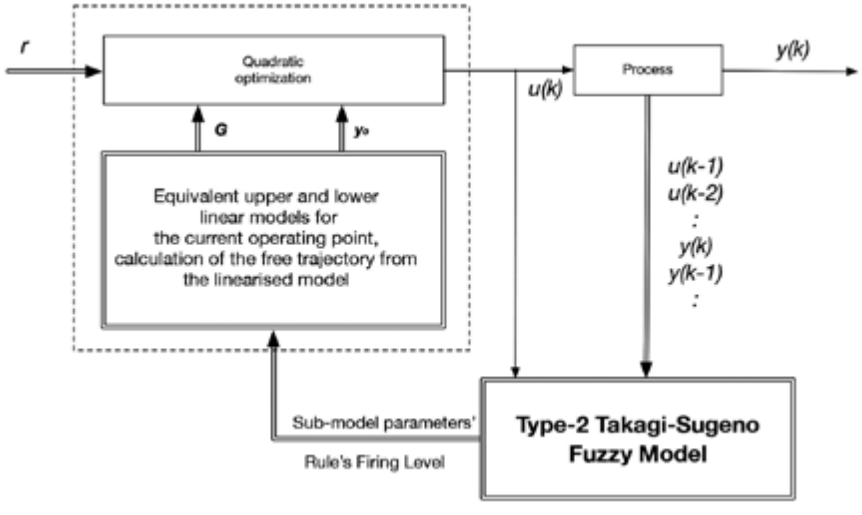

FIGURE 2
Evaluation of the closed loop performance after the Fermentation process is disturbed by a change in the inlet Substrate temperature at instant Time=50 (ARX – Auto-Regressive model with eXogenous inputs; A1 C0: Type 1 TS FLS; A2 C1: Type 2 TS FLS).