Fuzzy logic, where blur makes more sense than clear

86?F, hot or warm? 65?F, cool or cold? 100 mL glass contains 30 mL of water, empty or full?

Same tricky questions in daily life happen in engineering world as well. The Boolean logic of either being 0 or 1 would not be able to cover the concept of partial truth where the values sit in between completely true and completely false.

Fuzzy logic, which may be viewed as an extension of classical logical systems, provides an effective conceptual framework for dealing with the problem in an environment of uncertainty and imprecision. The logic underlying the mode of reasoning is approximate rather than exact, it provides a promising approach where ambiguity in the system parameters are present. Linguistic variables are often used to handle the concept of partial truth such as “warm” in the range between “cold (0)” and “hot (1)”.

The fuzzy logic control system was built in three steps. The first step was to partition the universe of interval spanned by each variable into several fuzzy subsets with appropriate linguistic labels (e.g., high, medium and low for temperature). Next, a membership function was postulated for each fuzzy subset, followed by assigning the fuzzy relationships between input fuzzy subsets and output fuzzy subsets, thus forming rule-base.

In this study, a fuzzy logic control system was built to monitor the enzymatic hydrolysis reaction and control feeding operations for a fed-batch approach. Glucose concentration from hydrolysis was initially analyzed online and digested glucose was assigned as input while feeding time and speed of biomass were responses in a fuzzy logic control rule-base system. The performance of fuzzy logic control was evaluated for fed-batch enzymatic hydrolysis.

The dilemma for enzymatic hydrolysis of lignocellulosic biomass is that, when a certain amount of cellulose was digested during a sample interval, which means the system would have the ability to digest same or similar amount of cellulose in the next sample interval, this amount of cellulose should be fed into system. However, with the extra lignin being fed with the biomass, solids content of current system would not be able to maintain constantly at 10 %, which in turn would decrease the ability of cellulose digestion. While if an equivalent amount of biomass was chosen to be fed into the system to maintain solids content, the addition of cellulose available for digestion would be about 47% less than what the reaction needed.

Fuzzy logic control strategy successfully solved this dilemma through the settings in membership functions and rule-base, as feeding of a proper amount of cellulose in biomass and maintaining solids content in system can be well balanced by providing a flexible range for each factor. Compared to traditional controls, fuzzy logic provides the advantages of less input information and efficient real-time responses. Difficult model prediction for interference of added pretreated feedings was successfully avoided. Fuzzy logic proved to be a robust and effective online feeding

control tool for fed-batch enzymatic hydrolysis.

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