Virtual colleagues

THE VIRTUAL PLANT OPERATOR IS A NOVEL CONTROL CONCEPT FOR COMPLEX PRODUCTION PROCESSES AS FOR EXAMPLE IN THE BAKING INDUSTRY

++ figure 1

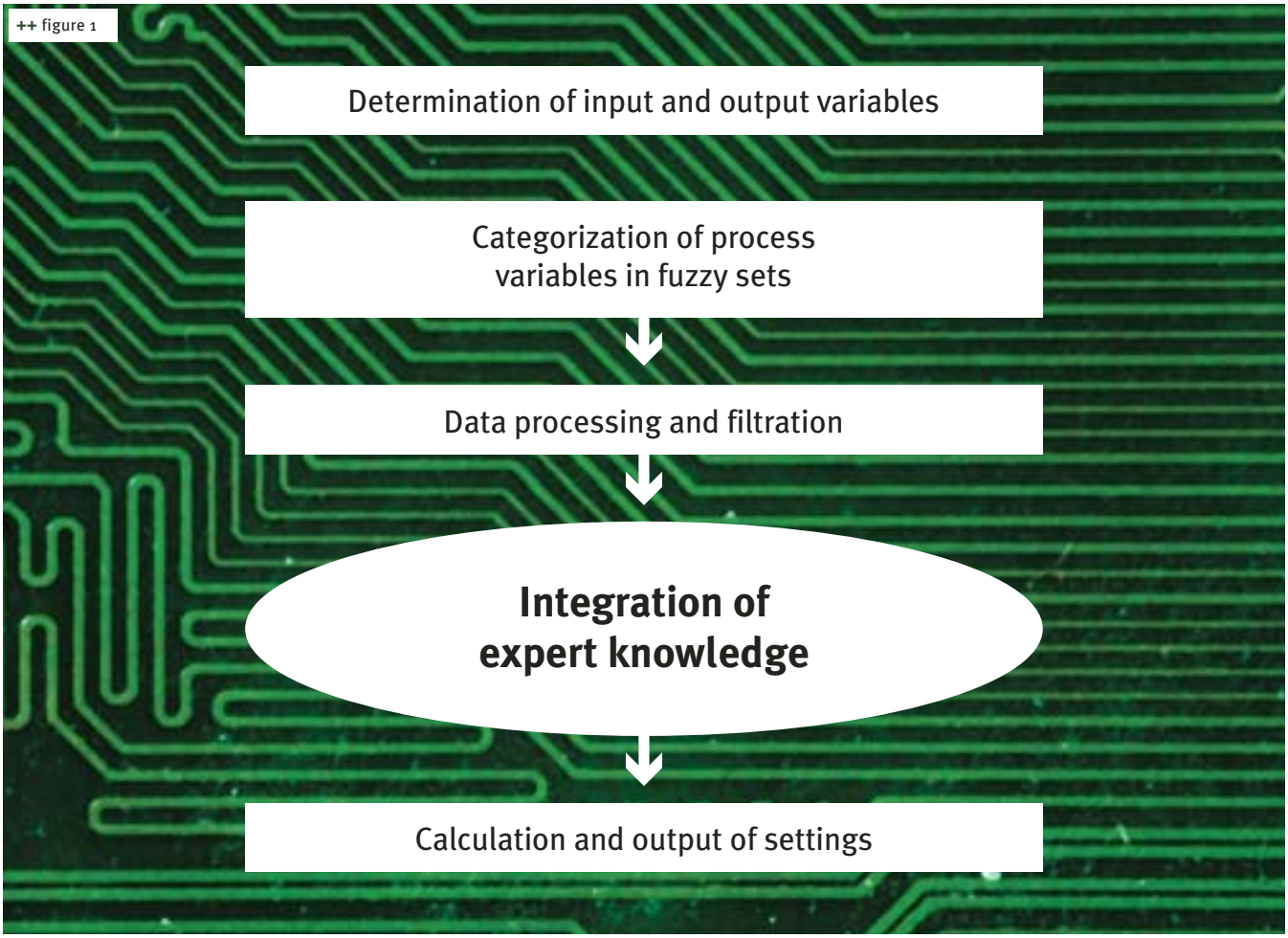

Photo (background): a_karta/sxc.hu

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++ figure 1
Stepwise procedure for establishing a virtual plant operator

Reliable automation of industrial production lines in large producing companies is an important requirement for meeting production costs, plant safety and product quality. High degrees of automation, as for example is common in the automotive industry is increasingly found in the food industry and the bakery trade. Besides the use of robotics, the automation task is often done by programmable logical controls (PLC). Here, a recipe which states the individual processing steps is stored in the control's memory and processes step by step. Plant operators monitor this process and may interfere by changing recipe parameters or pre-set values. It is desirable for each company to limit the amount of manual interference as much as possible. However, experience from different fields of the food industry show that a permanent monitoring is required due to the complexity of the food systems and different raw material qualities. Bad weather, novel breeds and constantly changing raw material markets make it difficult for many manufacturers to maintain efficient production processes and uniformly high quality. An experienced plant operator with his expert knowledge and sure instinct, trained over many years is able to recognize deviations from the ideal process early on and can thus act immediately to balance deviations. To support this approach and develop automation processes based on experience, a virtual plant operator has been developed.

Function of the virtual plant operator

In general, the virtual plant operator is based on the approach to integrate complex expert knowledge into a computer program using fuzzy logic. Other than traditional controls,

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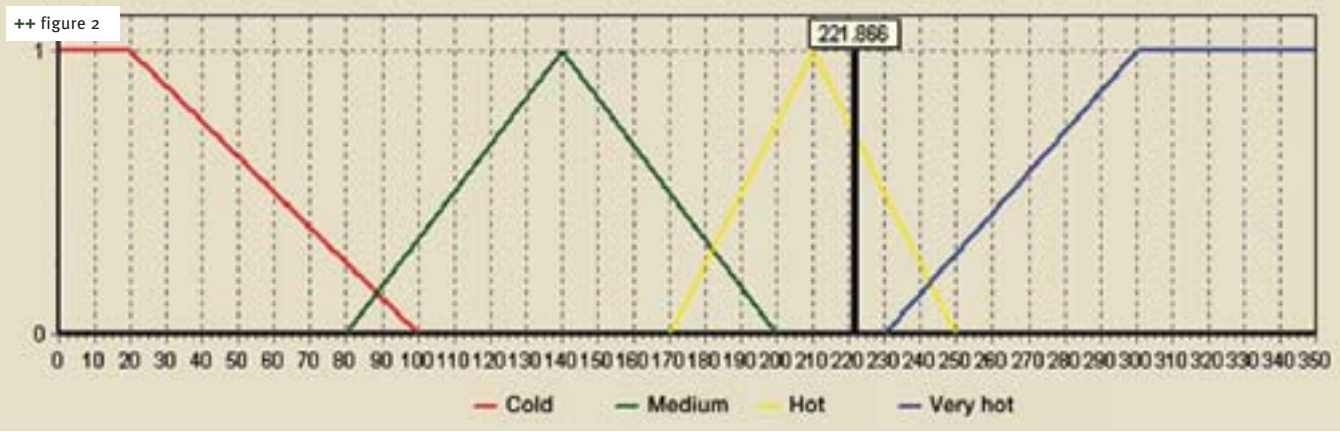
fuzzy control systems are able to not only process values such as YES or NO (or ON and OFF, respectively), but also intermediate values (logical values) such as 0.5 which are between TRUE (=1) and FALSE (=0). This way, fuzzy information such as SLIGHTLY, QUITE or VERY can be treated mathematically. The application of fuzzy logics is useful if there is no pure mathematical link between the input and output parameters and the process or processing steps can be described linguistically. In this case, fuzzy logic can be used to derive a mathematical description from verbally formulated sentences and rules and then integrated into a computer system. The process requires several steps as can be seen from the schematic depiction in figure 1. ▶

++ figure 2



++ figure 2
Definition of a baking temperature as fuzzy sets

First, all relevant input parameters have to be determined and their membership to so-called fuzzy sets determined. This process is depicted in figure 2.

First of all, the range for this value (temperature from 0 °C to 350 °C in figure 2) is subdivided into different sections. As in the habitual language use, "hot" is not a defined temperature (e.g. 221 °C) but a temperature range. The individual sections are called fuzzy sets. For example the temperature range from 80-200 °C is allocated to the value "medium (green) while the range from 170-250 °C has the value "hot" (yellow).

The fuzzy sets overlap on purpose to define a smooth transition between the two sections. In the transition section from 170 to 200 °C, the oven temperature can be called "medium" as well as "hot". Only if the temperature exceeds 200 °C, is it allocated to the range "hot". The overlapping sections in the fuzzy sets smooth the transition and dampen the oscillation behavior of the control.

Input and output parameters for the controls include measuring values and settings available from the process control system such as temperatures, pressures, filling levels, belt speeds or possibly available laboratory values. In addition, derivatives of process variables with respect to time, known from the daily operation in the plant, are used as input parameters. They are needed for the identification of trends and allow early interference.

The most important aspect of a virtual plant operator and the heart of the control is the control basis in which the entire knowledge about the plant's operation is integrated. This is done using linguistic links of the input parameters as if-then sentences. A simple rule for the temperature control of baking processes could be: "IF temperature = hot AND derivative temperature = positive AND humidity = low THEN heating power = reduce". In principle, an infinite number of rules with the links "AND", "OR", "AND NOT" and "OR NOT" can be used. Complex processes require between 10 and 30 rules. The result of the co-operation of the individual rules is the output parameter for the control interference of the plant.

Use in the baking industry

Virtual plant operators have been used for some years now with positive results in different fields of the food industry. Examples of the application of this technology are drying of sheeted gelatin, acetic acid fermentation, anaerobic waster water treatment or filtration of mash and beer. In all these fields, deviating processing conditions cause problems in the production process. In these cases, virtual plant operators offer the possibility to monitor all important processing parameters and they change over time constantly, to link them and to decide on the right steps for the further process. Because the entire knowledge on an optimum plant operation is contained in the control's basis in an understandable way, this archive is fully available at any time and is independent of changes in personnel or shifts. The positive experiences from other food industry branches and the similarity of some raw materials used have supported the introduction of the virtual plant operator in the baking industry as well. A practical implementation of a control which makes use of a virtual plant operator is currently under investigation. Temperature control of baking ovens or the targeted influence of the air flow in continuous baking processes could be possible fields of application. **+++**