

A SYSTEM AND METHOD FOR GENERATING ALARMS IN A PROCESS CONTROL SYSTEM

FIELD OF INVENTION

This invention relates to a system and method for generating alarms in a process control system.

BACKGROUND OF THE INVENTION

In the prior art, alarm systems are based upon classical crisp logic such that an alarm is activated if the monitored device begins to operate in an abnormal pre-set condition. Most alarms only have two states : i.e., on or off, and heavy reliance is placed upon an operator to resolve the abnormal condition. Thus, the experience level of an operator is a determining and unreliable factor in responding to the alarm and resolving the abnormal condition.

In the prior art systems, it is hard to show the strength or the seriousness of the alarm to the operator. For example, although both temperatures of 80°C and 100°C can trigger a temperature high alarm, the latter is more serious. Also, in prior art systems, it is hard for a system to be intelligent and flexible because of inherent characteristics of the classical crisp logic, and there may be situations where some rules conflict with each other. These and other serious problems of the prior art are solved by the present invention.

In the prior art, US patent number 4,812,819 teaches an alarm system having a functional relationship. Each activated alarm is analysed and its relative importance with other currently activated alarms and signals is determined in accordance with the functional relationships that the newly activated alarm has with other concurrently activated alarms. There is a need to define the functional relationships of the alarms, and if new alarms are added, there is a need to update the definitions.

SUMMARY OF THE INVENTION

The invention is a system for generating alarms in a process control system, including a plurality of field devices having process values and a repository of fuzzy membership functions capable of generating a continuous output.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates one preferred embodiment of the invention.

Figure 2 illustrates the process flow of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 illustrates one preferred embodiment of the invention comprising a system for monitoring of field devices. The process values 100 of field devices are input to a first repository 101 of fuzzy membership functions for a plurality of alarm conditions. The process values can be input as raw data directly from the field devices, or can be data which has been converted from the raw data. The fuzzy membership functions calculate the input process value and generate a continuous output.

A warning device 102 is provided to receive the continuous output and produce a warning signal which varies according to the continuous output. A solution module 103 is provided to receive the continuous output and recommend an action for the continuous output. The solution module includes a second repository 104 of predefined rules to be applied to the continuous output, and a third repository 105 of recommended actions when the continuous output is applied to the second repository of predefined rules.

A fuzzy membership function, which is predefined by a user, is applied to a process value to provide a continuous output based on the input data. The function can have more than one process value. In a simple example of a fuzzy membership function, PV1 is the process value and A1 is the output of the fuzzy membership function as provided below:-

$$A1 = e^{-\left(\frac{100-PV1}{50}\right)^2} \quad \text{for PV1 having the values between 0 to 100.}$$

In this example, for PV1 = 0, A1 = exp (-4); and for PV1 = 100, A1 = 1. As the output increases from exp (-4) to 1, the continuous output is transmitted to the warning device. When the warning device receives the output, it produces a warning signal. The warning signal can be implemented alone, or as a combination of, sound, light, or a visual display.

For the case of a warning signal which in the form of a sound, the warning device changes the sound with the increasing continuous output by increasing the intensity of a constant sound, or increasing the frequency of a beeping sound. For the case of a warning signal which is in the form of a light, the warning device changes the light with the increasing continuous output by increasing the intensity of a constant light, or increasing the frequency of a blinking light. If the warning signal in the form of a visual display, for example a display having varying images, the image density increases with the continuous output received by the warning device. Another example of a visual display is one which has multiple blocks, and the blocks are lit up gradually one at a time as the warning device receives an increasing continuous output.

The advantageous of providing a continuous alarm is to alert an operator of an impending alarm, so that preventive actions can be taken to avoid an alarm occurrence. Since an alarm means that a field device has failed, taking preventive actions reduce such failures and this helps to improve the productivity of the field devices.

Based on the continuous output, the solution module can provide an operator with recommendations on how to attend to the alarm. The recommendations are provided when the continuous output is applied to a second repository of predefined rules. The recommendations include actions such as checking on the field device physically, performing maintenance on the field device, or updating the process parameters and/or conditions. The recommended actions for the respective rules are predefined based on a user manual of a field device and/or previous experiences of the maintenance, engineering or operations personnel. The recommended actions can be displayed on a user interface or any non-interactive display screen.

The following examples illustrate how the continuous output from the fuzzy membership function, in combination with the repository of rules, provide better recommendations to an Operator.

In a first example, the fuzzy membership functions and rules are defined as follows:

Alarm A1 is activated if the output PV1 exceeds the value 50; and alarm A2 is activated if the output PV2 does not exceed the value 30. A first rule R1 is stated to recommend activating switch S1 if A1 is activated, and a second rule R2 to deactivate S1 if A2 is activated.

For PV1 having a value of 80 and PV2 having a value of 25 in the prior art, both A1 and A2 will be activated. If both A1 and A2 are activated, it is not clear if S1 should be activated or not, since the rules R1 and R2 conflict with each other.

However, if the PV1 and PV2 are applied to the membership functions below in one embodiment of the system in the invention,

$$A1 = e^{-\left(\frac{100-PV1}{50}\right)^2} \quad (PV1 \in [0,100])$$

$$A2 = e^{-\left(\frac{PV2}{30}\right)^2} \quad (PV2 \in [0,100])$$

For PV1 having a value of 80 and PV2 25, A1 equals to 0.852 and A2 equals to 0.5 respectively. Applying R1 and R2, the system of the invention can recommend the Operator to switch on S1 since the value of A1 is higher than the value of A2.

In another example, the fuzzy membership functions and rules are defined as follows:-

Alarms A1 and A2 are activated, if the respective outputs PV1 and PV2 exceed the value 50. A rule R1 states to recommend opening valve V1 if A1 and A2 are both activated.

Applying PV1 having a value of 80 and PV2 having a value of 45 to a system in the prior art, the system would be unable to provide a recommended action to the Operator until both A1 and A2 are activated.

Applying the same values to an embodiment of the system of the invention,

if the PV1 and PV2 are applied to the membership functions below,

$$A1 = e^{-\left(\frac{100-PV1}{50}\right)^2} \quad (PV1 \in [0,100])$$

$$A2 = e^{-\left(\frac{100-PV2}{50}\right)^2} \quad (PV2 \in [0,100])$$

A1 equals to 0.852 and A2 = 0.3 respectively. A Zadeh operator such as “AND”, “OR”, or “NOT” can be applied to take the preferred value of A1 and A2. In this case, the Zadeh operator “AND” in fuzzy logic is applied to take the minimum value of A1 and A2 for the

output of A1 and A2. The output of this function is 0.3. Based on R1, the system can recommend the Operator to open V1 by 30%.

Figure 2 illustrates the process flow of one embodiment of the system. Step 200 is the step of obtaining the process values from field devices. The process values are calculated in Step 202 by the fuzzy membership functions to generate a continuous output. Step 203 applies Fuzzy Logic on preset rules to the output for generating recommended actions. Step 204 shows the alarms. Step 205 performs one of the recommended actions. Step 206 determines if the problem has been solved by the action, and whether the alarm has been deactivated. If no, Step 205 is repeated. Otherwise, the process flow is re-started from Step 200.

In an alternative embodiment of the system, a data feedback module 106 is provided to apply the continuous output to any device such as a field device or a transmitting device. It can be applied back to the field device with the input process value, or any other field device which requires the continuous output to function. The output can be entered into a transmitting device to be transmitted to remote alarm receivers such as mobile phones and pagers.

We claim

1. A system for generating alarms in a process control system including:
 - (a) a plurality of field devices having process values;
 - (b) a first repository of fuzzy membership functions capable of generating a continuous output when the process value is input therein;
 - (c) a warning device for receiving said continuous output and producing a warning signal which varies according to said continuous output; and
 - (d) a solution module to receive said continuous output and recommend an action for said continuous output.
2. A system as claimed in claim 1 wherein said solution module includes a second repository of predefined rules to be applied to said continuous output.
3. A system as claimed in claim 2 wherein said solution module further includes a third repository of recommended actions for recommending an action when said continuous output is applied to a predefined rule.
4. A system as claimed in claim 1 further including a data entry module to apply said continuous output to a field device.
5. A method for generating alarms in a process control system including the steps of:
 - (a) providing process values of a plurality of field devices to a first repository of fuzzy membership functions;
 - (b) calculating said process values using said fuzzy membership functions;
 - (c) generating a continuous output from the calculation;

- (d) receiving said continuous output;
- (e) producing a warning signal which varies according to said continuous output;
- (f) applying a plurality of predefined rules to said continuous output; and
- (g) providing a plurality of recommended actions when said plurality of predefined rules are applied to said continuous output.

6. A method as claimed in claim 5 further including the step of displaying said generated continuous output on a varying display.

7. A method as claimed in claim 5 further including the step of converting said generated continuous output into a sound signal.

8. A method as claimed in claim 7 wherein the strength of said sound signal varies with a change in the continuous output.

9. A method as claimed in claim 5 further including the step of converting said generated continuous output into light signal.

10. A method as claimed in claim 9 wherein the strength of said light signal varies with a change in the continuous output.