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Methods of Excluding Uncertain Diagnostic Functions with the Addition of Extra Control Signals

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ABSTRACT: For efficient and accurate monitoring and diagnostics of air flow velocity variations in the pneumatic chamber with considering various factors that lead to false air flow velocity variations in the pneumatic chamber is proposed to add an additional control signal, contributing more accurately assess the presence or absence of one or another controlled feature and methods to improve the reliability of the information transmission, based on the method duplication of information transmission composed Boolean function showing diagnoses D_1, D_2, D_3 in the disjunctive normal form.

KEYWORDS: pressure in the pneumatic chamber, control and diagnostics method of air flow speed, diagnosis using Boolean functions.

I. INTRODUCTION

During the collection of raw cotton with vertical spindle cotton pickers type MX-1.8 [1, p.23-24] because of the inability of automatic control gap between the drums, as well as contamination of the green mass of cotton bushes, as well as due to thickness of cotton bushes and other plants occur jamming spindles, strippers and stuck the pneumatic chamber of cotton picker, resulting in increased gather losses, reduced productivity of cotton picker and purity of the harvested raw cotton. That's why, air flow speed variation (relative pressure) in the pneumatic chamber of cotton picker is required to diagnose.

II. STATEMENT OF A PROBLEM

In [4] established that the main disadvantages of fuzzy diagnoses of cotton picking machines' pneumatic chamber state are: the complexity of the diagnosis by the sensor output signals (transducers), which give control signals for one or the other of the estimated parameters (states) in the pneumatic chamber. In this case, the dependence of the output signal (pressure-symptoms) of pneumatic chamber by the many (complex) input signals, i.e.: the intensity (degree) the disclosure of raw cotton; clogging the pneumatic chamber; Fan speed and other parameters.
Analysis of the system [3], assessing the state of symptoms corresponding diagnoses showed that only the above input and output states are impossible to assess the actual condition of the pneumatic chamber, as there are many uncertain conditions. For excluding the uncertainty states of symptoms must enter additional checking symbol (signal). In this regard we offer to carry out additional monitoring of the presence or absence of flow of raw cotton passing on the pneumatic chamber by photovoltaic (PV) sensor.
It is assumed that if a raw cotton flow passes continuously for certain time at the line of intersection of the photoelectric sensor, in the output of the photoelectric sensor is logic signal "1" or vice versa - "0". Let us assume that the output

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signal of logical "1" corresponds to the presence symptom (diagnosis y_4), and the presence of a "0" signal corresponds to the absence symptom y_4.

Thus, the combined use of additional controlled input x_D, with an introduction by the photoelectric converter, and data of the absolute pressure sensor form the truth table showing the possible output state control system, evaluating the state signs the pneumatic chamber.

Note that depending on the intensity of raw cotton disclosure beds cotton cotton spindles assembled on the pneumatic chamber can take place either continuously, which corresponds to the signal "1" or intermittently, corresponding to logic signals "0" or "1". So we draw up a truth table for the two cases (variants) with the numbering unprimed and primed (Table 2).

Possible control according to output signals from the diagnostic device and the state of input signals (attributes) in the pneumatic chamber with the additional control symbol $x_Д$, are shown in Table 1.

The dependence of the output signal from the device state of the input signals (signs) in the pneumatic chamber with the additional control symbol y_4.

Table 1

The states of the input signals			The states of the output signals				
№	x_1	$x_Д$	y_1	y_2	y_3	y_4	Note
First option							
1	0	0	0	0	0	0	Impossible condition
2	1	1	0	0	1	1	condition D_3
3	1	1	0	1	0	1	condition D_2
4	1	1	0	1	1	1	condition D_3
5	1	1	1	0	0	1	condition D_1
6	1	1	1	0	1	1	condition D_3
7	1	1	1	1	0	1	condition D_2
8	1	1	1	1	1	1	Impossible condition
Second option							
1'	0	0	0	0	0	0	Impossible condition
2'	0	1	0	0	1	1	condition D_3
3'	0	0	0	1	0	0	condition D_2
4'	0	1	0	1	1	1	condition D_3
5'	1	0	1	0	0	0	condition D_1
6'	1	1	1	0	1	1	condition D_3
7'	1	0	1	1	0	0	condition D_2
8'	1	1	1	1	1	1	Impossible condition

III. ANALYSIS OF TABLE 1

During the formation of states - appearance of symptoms D_1, D_2, D_3 will be based on the following reasoning, which explain an example: It is necessary to determine availability state of symptom diagnosis D_2. In table 1 there are output states (lines 3,7, 3 ', 7') - binaries: 0101,1101,0100 and 1100. Here combinations of condition of all second bits

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(from left to right) corresponds to the symptom of the diagnosis D_2 and the status of additional control symbol y_4 (last bits of code combinations) confirms or denies the existence of symptoms - diagnoses D_1, D_2 or D_3.
Taking into account the above stated and using information transmission theory, to improve the reliability of the evaluation of diagnoses will use the method duplication of information transfer. According to this method (for the largest number of matching units in the digits of the selected codes) can determine the conditions Boolean functions reflecting the analyzed diagnoses. Applying this method determine the total number of units in the respective code bits (lines 3,7, 3 ', 7'). Counting the number of units in the selected codes showed that the total value of the units of the second category four codewords is 4, which confirms the correctness of evaluation feature state - of diagnosis D_2.
From the set of Boolean functions of diagnosis D_3 shows that the total weight value of the number of repetition units, reflecting the diagnosis D_3 (the third and fourth digits of lines 2,4,6, and 2 ', 4', 6 ') confirms the diagnosis D_3 features relative to other features (the total value for the third category of units equal to 4). Therefore, in such conditions (set operation) diagnostic device may generate the output logic signal "1" corresponding diagnosis D_3. Similarly, it is possible to determine the accordance of diagnosis D_1.
When assigns a particular condition symptoms, some of the diagnoses in Table 1, the following assumptions are made: as symptom condition, for example diagnosis D_1 is close to condition of symptom D_2 and therefore accept a Boolean function D_1 as a function of reflecting the diagnosis D_2, i.e., Boolean function D_1 is glued to the Boolean function D_2 and so on. Arguing in the same way you can write a set of logical functions describing diagnoses D_1, D_2 and D_3, based on the reference symbol y_4.
Thus, according to the above analysis and the assumptions on Table 1 write Boolean functions, expressing the respective diagnoses D_1, D_2, D_3.
System Boolean functions describing the symptoms of the diagnosis D_1 is as follows (lines 5, 5 '):

$$D_1 : \begin{bmatrix} D_1 = \overline{y_1} \vee y_2 \vee y_3 \vee \overline{y_4} \\ D_1^{'} = \overline{y_1} \vee y_2 \vee y_3 \vee k_4 \end{bmatrix} \quad (1)$$

System of Boolean functions describing the symptoms of the diagnosis D_2 is as follows (lines 3,7,3 ', 7'):

$$D_2 : \begin{bmatrix} D_2 = y_1 \vee \overline{y_2} \vee y_3 \vee \overline{y_4} \\ D_2 = \overline{y_1} \vee \overline{y_2} \vee y_3 \vee \overline{y_4} \\ D_2^{'} = y_1 \vee \overline{y_2} \vee y_3 \vee y_4 \\ D_2^{'} = \overline{y_1} \vee \overline{y_2} \vee y_3 \vee y_4 \end{bmatrix} \quad (2)$$

System of Boolean functions describing the symptoms of the diagnosis D_3 is as follows (lines 2,4,6; 2', 4',6'):

$$D_3 : \begin{bmatrix} D_3 = y_1 \vee y_2 \vee \overline{y_3} \vee \overline{y_4} \\ D_3 = y_1 \vee \overline{y_2} \vee \overline{y_3} \vee \overline{y_4} \\ D_3^{'} = y_1 \vee y_2 \vee \overline{y_3} \vee \overline{y_4} \\ D_3^{'} = \overline{y_1} \vee y_2 \vee \overline{y_3} \vee \overline{y_4} \\ D_3^{'} = y_1 \vee \overline{y_2} \vee \overline{y_3} \vee \overline{y_4} \end{bmatrix} \quad (3)$$

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Thus, according to [5, p.148-155] and formula (2), (3) and (4) we can write a single Boolean function, forming diagnosis D_1 following disjunctive and conjunctive normal form.

$$D_1 = \left(\overline{y_1} \vee y_2 \vee y_3 \vee \overline{y_4}\right) \wedge \left(\overline{y_1} \vee y_2 \vee y_3 \vee y_4\right) \qquad (4)$$

For the diagnosis D_2:

$$D_2 = \left(y_1 \vee \overline{y_2} \vee y_3 \vee \overline{y_4}\right) \wedge \left(\overline{y_1} \vee \overline{y_2} \vee y_3 \vee \overline{y_4}\right) \wedge \left(y_1 \vee \overline{y_2} \vee y_3 \vee y_4\right) \wedge \left(\overline{y_1} \vee \overline{y_2} \vee y_3 \vee y_4\right) \qquad (5)$$

For the diagnosis D_3:

$$\begin{gathered} D_3 = \left(y_1 \vee y_2 \vee \overline{y_3} \vee \overline{y_4}\right) \wedge \left(y_1 \vee \overline{y_2} \vee \overline{y_3} \vee \overline{y_4}\right) \wedge \left(y_1 \vee y_2 \vee \overline{y_3} \vee \overline{y_4}\right) \wedge \left(\overline{y_1} \vee y_2 \vee \overline{y_3} \vee \overline{y_4}\right) \wedge \\ \wedge \left(y_1 \vee \overline{y_2} \vee \overline{y_3} \vee \overline{y_4}\right) = \left(\overline{y_1} \vee \overline{y_2} \vee y_3 \vee y_4\right) \wedge \left(\overline{y_1} \vee y_2 \vee y_3 \vee y_4\right) \end{gathered} \qquad (6)$$

In Table 1 there are impossible conditions that must be excluded according to the developed algorithm with corresponding software.

IV. CONCLUSION

At present, almost developed and assembled the air pressure control circuit of the device in the pneumatic chamber of cotton picking machine. The circuit is designed based on a modern AVR microcontroller series. Software is developed in programming language C ++. Control device is powered by the onboard battery 12V by stabilized voltage source.
Application of the developed automated microprocessor based device allows to operatively monitor and predict air pressure variations (presence or absence of faces) in the pneumatic chamber of cotton picking machine, which results to driver eliminate the causes of faces on time. Application of the diagnostic device increases productivity of cotton picking machine and improve the cleanliness collection of raw cotton by 4-5%.

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