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FORMATION OF A MODIFIED FUZZY COLORED PETRI NET

The paper proposes a modified fuzzy colored Petri net (FCPN), where the membership functions of linguistic variables are applied to color markers, and fuzzy conditions of existence are assigned to the arcs, depending on the values of these functions.

The increase in the complexity of real systems and the increase in the number of fuzzy parameters creates the need to develop new modifications of Petri nets (PN) and improve the existing ones. Integration of various types of PN and methods of the theory of fuzzy logic allows to seriously expand the scope of application of existing approaches.

Some kinds of combination of a fuzzy Petri net (FPN) and a colored Petri net (CPN) have been developed which are called FCPN. In [1], the processing time of a part is described by fuzzy variables which are assigned to CPN transitions. Combining CPN with FPN allows to clearly represent interactions and describe causal relationships between genes, where a fuzzy meaning is assigned to positions [2]. The model fully characterizes reliability in several states by means of fuzzy information about the state and dynamic transition between nodes of states in FCPNs, where a fuzzy value is assigned to positions [3]. The duration of activities that appear on the routes of the Workflow process is represented by fuzzy time intervals assigned to transitions [4].

The FCPN is represented as a set of non-empty finite sets and functions: $FCPN = (P, T, F, H, L, Y, \Omega, \Sigma, \lambda, \varphi, \psi, \tilde{R}, \tilde{G}, \tilde{\mu}_0)$, where $P = \{p_1, p_2, p_3 \dots\}$ and $T = \{t_1, t_2, t_3 \dots\}$ – respectively, sets of positions and transitions; $F: P \times T \rightarrow \{0, 1, 2, \dots\}$ and $H: T \times P \rightarrow \{0, 1, 2, \dots\}$ – respectively, the incidence functions of the sets of positions and transitions; $L = \{\beta_1, \beta_2, \beta_3 \dots\}$ – set of linguistic variables; $Y = \{\gamma_1, \gamma_2, \gamma_3 \dots\}$ и $\Omega = \{\omega_1, \omega_2, \omega_3 \dots\}$ – respectively, a sets of colors of positions and colors of markers; $\Sigma = \{\sigma_1, \sigma_2, \sigma_3 \dots\}$ – a set of variables assigned to arcs; $\lambda: P \times Y \rightarrow \{0, 1\}$ – the color distribution function by position; $\varphi: P \times \Omega \rightarrow \{0, 1, \dots\}$ – function of distributing marker colors by positions; $\psi: \Sigma \times \Omega \rightarrow \{0, 1, \dots\}$ – function of allowing the movement of marker colors by arcs; $\tilde{R} = \{\tilde{r}_1, \tilde{r}_2, \tilde{r}_3 \dots\}$ – a set of fuzzy predicates related to arcs defining additional conditions for performing the transitions; $\tilde{G} = \{\tilde{g}_1, \tilde{g}_2, \tilde{g}_3 \dots\}$ – a set of fuzzy functions of the color of markers defining fuzzy values of terms of linguistic variables; $\tilde{\mu}_0: P \times (\Omega \cup \tilde{G}) \rightarrow \{0, 1, 2, \dots\}$ – initial distribution of markers by positions.

The terms of the linguistic variable characterize the states of the system. The states of the system are determined by the corresponding fuzzy positions. In the presented modified FCPN, certain color of the marker corresponds to each term of the linguistic variable, which leads to a decrease in the number of positions.

The presented approach is demonstrated on the example of a pumping unit control model implemented using a modified FCPN. The CPN TOOLS system is used to implement the simulation. The values of the membership functions of terms are calculated in the Fuzzy Toolbox application of MATLAB and imported into the model. The functioning of the model and the decisions made to normalize the situation depend on the fuzzy information included in the system. Computer simulation experiments of the model are carried out. The obtained experimental results provide opportunities for analyzing the model based on the properties of the PN.

The presented approach has a number of obvious advantages - simplicity and clarity, compact data structure and fuzzy information processing, convenience for research in various fields of science and industrial application.

List of references

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