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Modelling Synthetic Environment Control

The paper highlights the problem of control while events come into being in a stochastic way in a synthetic environment with no unexpected disturbances. The events result from a certain activity in the predefined area. The general model takes into account the number of events which trigger an immediate assumed action in order to eliminate the state of danger or at least to reduce it. Management of excessive unwanted events in such a logistic system is carried out by means of the heuristic approach which was proposed on the basis of preceding experiences.

Introduction

Control processes play an important role in contemporary life. They are used to increase production levels [1], make production systems more flexible and reliable [2], [3], are responsible for avoiding conflicts in storing systems [4] etc. Nevertheless, there are and will always be the areas of life in need of implementing control in order to minimize the amount of human activity which leads to cutting costs of supervision and making the area more secure. So, no matter which area – fictional or real we may think about, there is a lot to introduce or improve in terms of control [5].

The paper highlights the problem of control while events come into being in a stochastic way in a synthetic environment with no unexpected disturbances. The events are the effect of an activity in a certain area. The general model takes into account the number of events which result in an immediate action in order to eliminate the state of danger or at least to reduce it. The management of excessive events in such a logistic system is carried out by means of the heuristic approach. Detecting events occurring stochastically in an area followed by analysis may lead to conclusions which will let the person responsible for securing the area take an appropriate action. However, such an operator can be replaced or supported to a certain extent by a control system which will carry out the proper analysis and inform the person in charge about the current state of the logistic system. Should there appear a forbidden event or too many events accumulate and exceed the assumed limit, then the decision(s) will be made to eliminate the distributing state of danger.

The model presented in this paper could be implemented in systems which warn the operators who decide what kind of action should be taken against excessive threats in the ecological system. First of all, it is important to decide what level of pollution may lead to hazardous states. Environmental system safety must be planned and include interactions between correctly functioning components within it. Preventing or, if possible, reducing accidents throughout the life cycle of a system remains the main goal. Hazards are managed through their identification, evaluation, elimination and control. System safety means putting emphasis on safety [6]. The system can be considered as a whole or it can be treated as a collection of components (then it takes a larger view of hazards than just individual unwanted events). If it becomes impossible to eliminate the hazard, its effects may be minimized and controlled if they occur in order to minimize the damage. If more means are implemented to increase the safety of the system, its safety may be secured in a better way. After the environment is described, assumptions are made. Then environment constraints as well as system functional goals are defined [6], [7].

Practice shows that a number of disturbances may affect each of the e-commerce system components, which in turn may have impact on the functionality, efficiency and overall stability. Over the Internet, on the web server, in the ERP system and a company, there is a number of processes in progress which may be affected by disturbances to a greater or lesser extent. In order to minimize the impacts of faults, it is necessary to identify as many disturbances as possible, specify the metrics of their assessment and, using this data, design the methodology and the plan of immediate modifications of the individual e-commerce system components depending on the current needs of the internal and external environment. Basic information can be obtained on the basis of monitoring of the individual e-commerce system components. Disturbance models may be designed for instance using modelling and simulations and, at the start, a generic model of an e-commerce system based on the basic structure of the regulation circuit can be applied [8]. Events happening in the real time require implementing artificial intelligence methods by means of local agents which are operating in the system consisting of multiple items which have a large number of structural variations [9].

General assumptions and modeling approach

Let *k* be a stage in which events are measured $k = 1,...,K$.

Let us assume that events appear in a stochastic way in an area of our interest in the *k*-th stage as shown on Fig. 1.

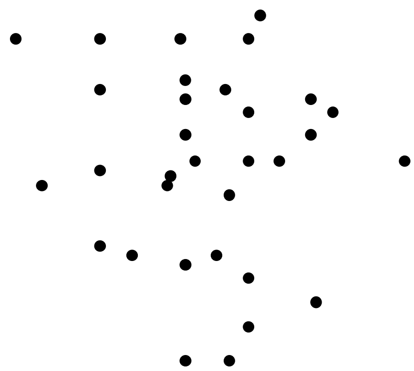

Figure 1 – Detecting sample events

The area is then covered by elementary squares which form the grid square corresponding with the area to be analyzed (Fig. 2). The map takes the form of the square with dimensions consistent with the size of the analyzed area. Let ***the dimensions*** of the discussed ***square be*** $M \cdot N$. Then every elementary square $e_{m,n}$ is referred to as the local square.

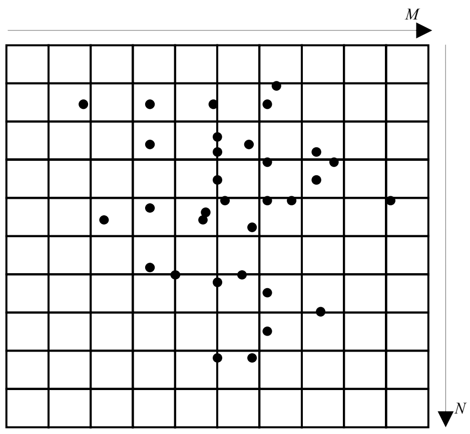

Figure 2 – Putting a grid $M \cdot N$ on the area of events

If an event happens to occur exactly on the common side of two elementary squares, it is automatically moved to a neighboring elementary square as shown on Fig. 3 and subsequently on Fig. 4. If an event occurs exactly in the common point for all four elementary grids, it is also moved to an adequate elementary square. It is assumed that two or more events cannot occur in the same point. However, there can be more than one event in an elementary square. Events found outside the global grid are not analyzed.

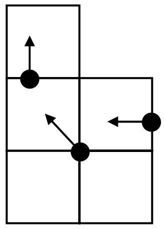

Figure 3 – The direction of moving an event to the neighboring square

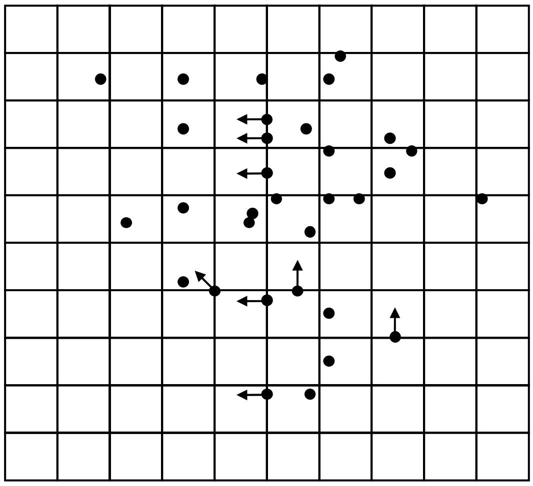

Figure 4 – Moving all events to appropriate squares

Now, we obtain the approximate allocation of events in the given global grid with dimensions $M \cdot N$ (Fig. 5). This graphical form must be transformed into a table form to enable numerical calculations (Fig. 6).

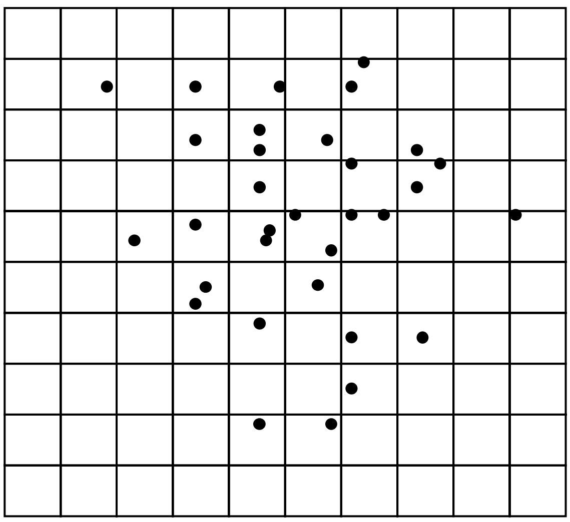

Figure 5 – Illustration of events after the transformation process

0	0	0	0	0	0	0	0	0	0
0	1	0	1	1	0	2	0	0	0
0	0	0	1	2	1	0	1	0	0
0	0	0	0	1	0	1	2	0	0
0	0	1	1	2	2	2	0	0	1
0	0	0	2	0	1	0	0	0	0
0	0	0	0	1	0	1	1	0	0
0	0	0	0	0	0	1	0	0	0
0	0	0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Figure 6 – Illustration of events after the transformation (table form)

Having all events placed in the adequate squares, the process of calculating the number of events in them starts. Now, the matrix of state of the logistic system in the *k*-th stage is introduced: $\Gamma^k = \left[\gamma^k_{m,n}\right]$, $\gamma^k_{m,n} = 0,1,...$ where $\gamma^k_{m,n}$ is the number of events in an elementary square $e_{m,n}$ in the *k*-th stage.

The state of the logistic system changes after the recorded event disappears or a new event is detected in the system:

$$\Gamma^0 \rightarrow \Gamma^1 \rightarrow ... \rightarrow \Gamma^{k-1} \rightarrow \Gamma^k \rightarrow \Gamma^{k+1} \rightarrow ...$$

The number of detected events in an elementary square $e_{m,n}$ is defined as follows:

$$\gamma^{k+1}_{m,n} \begin{cases} = \gamma^k_{m,n} & \text{if there was no change of the number events in the elementary grid } e_{m,n} \text{ in the } k\text{-th stage,} \\ \neq \gamma^k_{m,n} & \text{otherwise.} \end{cases}$$

The table on Fig. 6 is transformed into its matrix form for events in the analyzed sample *k*-th stage which is shown below:

$$\Gamma^k = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 2 & 1 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 2 & 0 & 0 \\ 0 & 0 & 1 & 1 & 2 & 2 & 2 & 0 & 0 & 1 \\ 0 & 0 & 0 & 2 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

It is obvious that if there is no event in an elementary square $e_{m,n}$, no action is required. Only if a certain number of events is exceeded, the appropriate action will be ignited.

We can divide actions in the logistic system into local and global ones.

Let us now introduce the vector of actions to be taken globally:

$$B = [b_z],\ z = 0,1,...,Z,$$

where b_0 is no action to be taken globally, b_z is the *z*-th action to be taken globally, b_Z is the urgent action to be taken globally.

Events are calculated in every k-th state. If no event is detected, the state does not change. If a new event occurs in the global map, it means the state changes. The number of events in the analyzed map with dimensions $M \cdot N$ in the k-th stage equals:

$$\sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k}.$$

We assume that the limit number of events $\omega_{M,N}$ in the logistic system is set for further calculations. The course of action adequate to the current state in the k-th stage is suggested below:

$$0 \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < (M \cdot N)\omega_{M,N} \rightarrow b_0;$$

$$(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < 2(M \cdot N)\omega_{M,N} \rightarrow b_1;$$

$$2(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < 3(M \cdot N)\omega_{M,N} \rightarrow b_2;$$

$$\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$(z-1)(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < z(M \cdot N)\omega_{M,N} \rightarrow b_{z-1};$$

$$z(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < (z+1)(M \cdot N)\omega_{M,N} \rightarrow b_z;$$

$$(z+1)(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < (z+2)(M \cdot N)\omega_{M,N} \rightarrow b_{z+1};$$

$$\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

$$(Z-1)(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} < Z(M \cdot N)\omega_{M,N} \rightarrow b_{Z-1};$$

$$Z(M \cdot N)\omega_{M,N} \le \sum_{m=1}^{M}\sum_{n=1}^{N}\gamma_{m,n}^{k} \rightarrow b_Z.$$

Let us introduce the vector of an appropriate action to be taken locally in the analyzed square $e_{m,n}$ in any stage: A=$\lfloor a_u \rfloor$, $u = 0,1,...,U$, where a_0 is no action to be taken locally, a_u is the u-th action to be taken locally, a_U is the urgent action to be taken locally.

We also assume that the limit number of events ω in any elementary square $e_{m,n}$ of the logistic system is set for further calculations. If the number of events in the given square with coordinates m,n exceeds the number ω, then an appropriate action must be taken and similarly other actions are defined in the following equations:

$$0 \le \gamma_{m,n}^{k} < \omega \rightarrow a_0;$$

$$\omega \le \gamma_{m,n}^{k} < 2\omega \rightarrow a_1;$$

$$2\omega \le \gamma_{m,n}^{k} < 3\omega \rightarrow a_2;$$

$$\dots\dots\dots\dots\dots\dots$$

$$(u-1)\omega \le \gamma_{m,n}^{k} < u\omega \rightarrow a_{u-1};$$

$$u\omega \le \gamma^{k}_{m,n} < (u+1)\omega \ \rightarrow \ a_u \, ;$$

$$(u+1)\omega \le \gamma^{k}_{m,n} < (u+2)\omega \ \rightarrow \ a_{u+1} \, ;$$

....

$$(U-1)\omega \le \gamma^{k}_{m,n} < U\omega \ \rightarrow \ a_{U-1} \, ;$$

$$U\omega \le \gamma^{k}_{m,n} < \ \rightarrow \ a_U \, .$$

We can now propose a matrix of actions to be taken locally depending on the given square $e_{m,n}$: $X = \lfloor x(a_u)_{m,n} \rfloor$, $m = 1,...,M$, $n = 1,...,N$, $u = 0,1,...,U$, where $x(a_u)_{m,n}$ is the u-th action to be taken in the m-th column of the n-th row.

Let us introduce the matrix of remaining capacity of the elementary square $e_{m,n}$ of the logistic system (the capacity to be used before the need to take the urgent action locally occurs):

$$P^k = \left[p^{k}_{m,n} \right], \ m = 1,...,M \, , \ n = 1,...,N \, ,$$

where $p^{k}_{m,n}$ is the number of events which still can happen in the elementary square $e_{m,n}$ before the alarm state is reached.

It is assumed that the maximal number of events that can happen in any square $e_{m,n}$ before the alarm is risen for this square cannot exceed $U\omega$. Taking this into account and knowing the matrix of state of the logistic system $\Gamma^k = \left[\gamma^{k}_{m,n} \right]$, where $\gamma^{k}_{m,n}$ is the number of events in the k-th step in the elementary square $e_{m,n}$, we can calculate its remaining capacity of the elementary square $e_{m,n}$:

$$p^{k}_{m,n} = U_{\omega} - \gamma^{k}_{m,n} \, .$$

The remaining capacity of the whole analyzed system can be calculated as shown below:

$$C^k = \sum_{m=1}^{M} \sum_{n=1}^{N} p^{k}_{m,n}$$

The above lets the operator of the system make the appropriate decision (e.g. concerning the use of extra means of transport in case the remaining capacity goes down). However, if in any case the equation $U\omega \le \gamma^{k}_{m,n}$ comes true, then the decision a_U for the elementary square $e_{m,n}$ is to be taken immediately.

Conclusions

The logistic system described in the paper hereby analyzes the general case which can be met in the synthetic environment only. It could be implemented in storing, transport, production and other systems where decisions must be taken immediately. However, such an idea does not guarantee that after its implementation into the given logistic system it will immediately improve the decision making process. Detailed alternations will have to be made in order to adjust it to the semi-detached environment. In the real system, there are usually specific situations which have not been described in the article. There are also disturbances caused by factors which make the whole model even more complicated. However, every system which must be simplified at the stage of modelling is deprived of many details which can be added in the upgraded version of the model. The system modelled hereby requires further analysis. The main goals of it are the ways of calculating the remaining capacity of the whole logistic system and creating a simulator which will enable us to verify the assumptions stated in the paper.

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Р. Буцкі

Моделювання процесів управління в синтетичному середовищі

У статті розглядаються питання управління в синтетичному середовищі із стохастичними подіями за відсутності збурень. Події є результатом певної діяльності в наперед визначеному околі. Загальна модель управління враховує події, які спричиняють дії спрямовані на ліквідацію небезпечних станів або, принаймні, на зменшення їх наслідків. Управління надлишковою кількістю подій у логістичній системі такого типу здійснюється за допомогою евристичного підходу з використанням наявного досвіду.

Р. Буцки

Моделирование процессов управления в синтетической среде

В статье рассматриваются вопросы управления в синтетической среде со стохастическими событиями при отсутствии возмущений. События являются результатом определенной деятельности в заранее определенной окрестности. Общая модель управления учитывает события, вызывающие действия, направленные на ликвидацию опасных состояний или, по крайней мере, на уменьшение их последствий. Управление избыточным количеством событий в логистической системе такого типа осуществляется с помощью эвристического подхода с использованием имеющегося опыта.

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