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DEVELOPMENT OF MODEL, BASED ON PETRI NETS, FOR THE PLANNING STAGE OF ROBOTIC SYSTEMS DESIGN SYSTEM

РОЗРОБЛЕННЯ МОДЕЛІ НА ОСНОВІ МЕРЕЖ ПЕТРІ ДЛЯ СТАДІЇ ПЛАНУВАННЯ СИСТЕМИ ПРОЕКТУВАННЯ РОБОТОТЕХНІЧНИХ СИСТЕМ

This article is devoted to development of model, based on Petri nets, which corresponds planning stage of RTS automatic design. The model was developed according to the algorithm of the planning stage, which is the basic one in five-level representation of the robotization project estimation process, and enables to explore the dynamics of the process and the reliability of the corresponding component of the RTS design system, also providing the possibility of additional RTS correction in a broader functional and constructive spectrum. (This article is an extended version of the paper presented at the conference CADMD'2014 — Andrii Pukach, Bohdan Dupak, Pavlo Denysyuk: Development of model, based on Petri nets, for the planning stage of robotic systems design system. Proceedings of the XXII Ukrainian-Polish Conference CAD in Machinery Design – Implementation and Educational Issues, CADMD'2014, 10–11 October, 2014, L'viv, Ukraine. – Pp. 25–33)

Key words: design, robotic systems, planning, model, Petri nets.

Стаття присвячена розробленню моделі на основі мереж Петрі, що відповідає стадії планування автоматизованого проектування РТС. Модель розроблена відповідно до алгоритму стадії планування, що є базовим у п'ятирівневому представленні процесу оцінки проекту роботизації, і дає змогу дослідити динаміку процесу та надійність відповідної складової системи проектування РТС, забезпечуючи, тим самим, також і можливість додаткової корекції РТС у більш широкому функціональному та конструктивному спектрі. (Стаття є розширеною версією матеріалів доповіді, представленої на конференції CADMD'2014 – Andrii Pukach, Bohdan Dupak, Pavlo Denysyuk: Development of model, based on Petri nets, for the planning stage of robotic systems design system. Proceedings of the XXII Ukrainian-Polish Conference CAD in Machinery Design – Implementation and Educational Issues, CADMD'2014, 10–11 October, 2014, L'viv, Ukraine. – Pp. 25–33)

Ключові слова: проектування, робототехнічні системи, планування, модель, мережі Петрі.

Introduction

During the last decades general trends of world science and technology are largely focused on miniaturization of components of microelectronical devices and systems, automation of their functioning (as well as full automation through the development of artificial intellect), globalization of communication, as well as complete or partial replacement of many human activities to expand ranges of human possibilities, increasing computing power and further detailed research and deepening of knowledge about everything surrounding us.

One of the most important areas of modern technical and scientific progress are robotic systems (RTS) and complexes (RTC) [1-5]. Although the fundamental principles of scientific and applied field of robotic systems were laid in late 60-s of this century, their massive implementation was limited (even impossible) because of technical capabilities of implementation. With the development of appropriate technical means of implementation of such systems and complexes components, which became possible primarily through the development of micro and nanotechnology [6-10], RTS become actively penetrate not only into manufacturing, space and military technologies, but also in everyday use, medicine, agriculture and other areas of human activity.

Since RTS are extremely complicated systems, an important role in their development and implementation plays a detailed analysis of their structure and operation process at the design stage, carried out using the corresponding design systems. Development of mobile robotic design system requires a corresponding instrumental-functional components presented in the context of different types of system support, such as: mathematical support, informational, software, technical support, and others. Particular attention in the design of complex systems, including the development of RTS and RTC, is assigned to system-level design, which is one of the fundamental levels of design process and ensures the correctness of the system work and functioning as a whole. At the same time detection of possible errors and defects in the system design stage allows significant savings in time, material, human and financial resources in the development of an appropriate system. That is why the importance of system design stage in the development of complex systems cannot be overemphasized.

Another important step in the development of RTS, especially for categories of industrial robots, is estimation of the robotization project, main task of which is ensuring the most successful usage of developed RTS at solving of specific or typical problems and tasks.

To analyze the dynamics and reliability of RTS design system at the planning stage the corresponding model, developed on Petri nets [6-8], is presented in this paper.

Main Part

Development of RTS and receiving of prototypical sample is extremely important, but not decisive stage. Another no less important step is the evaluation of the robotization project [5], which includes: planning, outfitting, modeling, installation (implementation) and production (functioning) (see. Fig. 1). Each of the stages is required, and all of them together provide the most effective results during the implementation of the developed RTS.

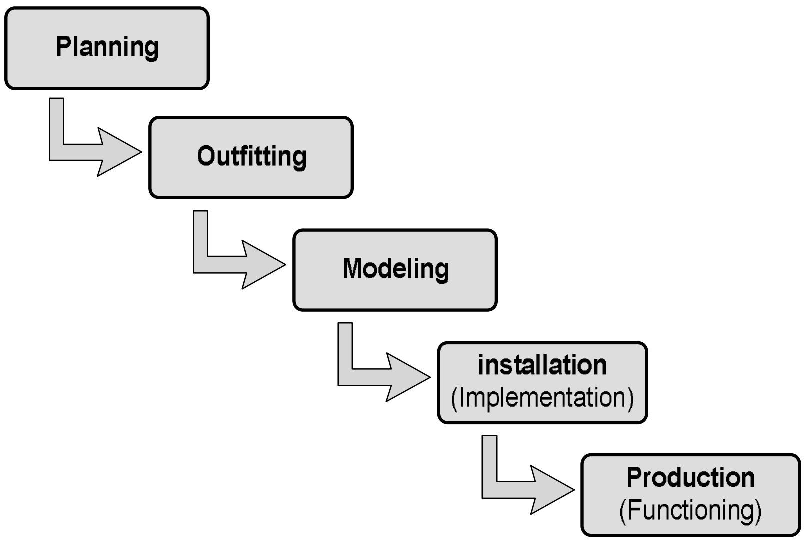

Fig. 1. Main stages of the evaluation process of the robotization project

Planning, in turn, is divided into several consecutive stages [5] (see. Fig. 2) and starts from the selection of the potential automatization object. The following steps of the planning stage are applied to selected automatization object with possibility of failure the selected object according to the corresponding output results of a particular stage.

Main purpose of automatization goals definition stage consists in the feasibility of the robotization of specific objects or processes, determining an economic efficiency indicators of robotization performance in manufacturing, or improvement the specific parameters of technological process, as well as the quality of works, which were performed by using the proposed RTS. In addition, the goals definition is directed at analysis of opportunities and needs for further larger scale implementation of robotization in investigated scientific-research or applied field. In addition, an analysis of possible complications during the implementation of RTS is extremely important step in robotics planning, such as: analysis of RTS behavior in critical situations, ensuring the possibility of RTS return to the normal operation after leaving the critical situation, the point of repair and maintenance of RTS, and the ability to use RTS for other specific purposes.

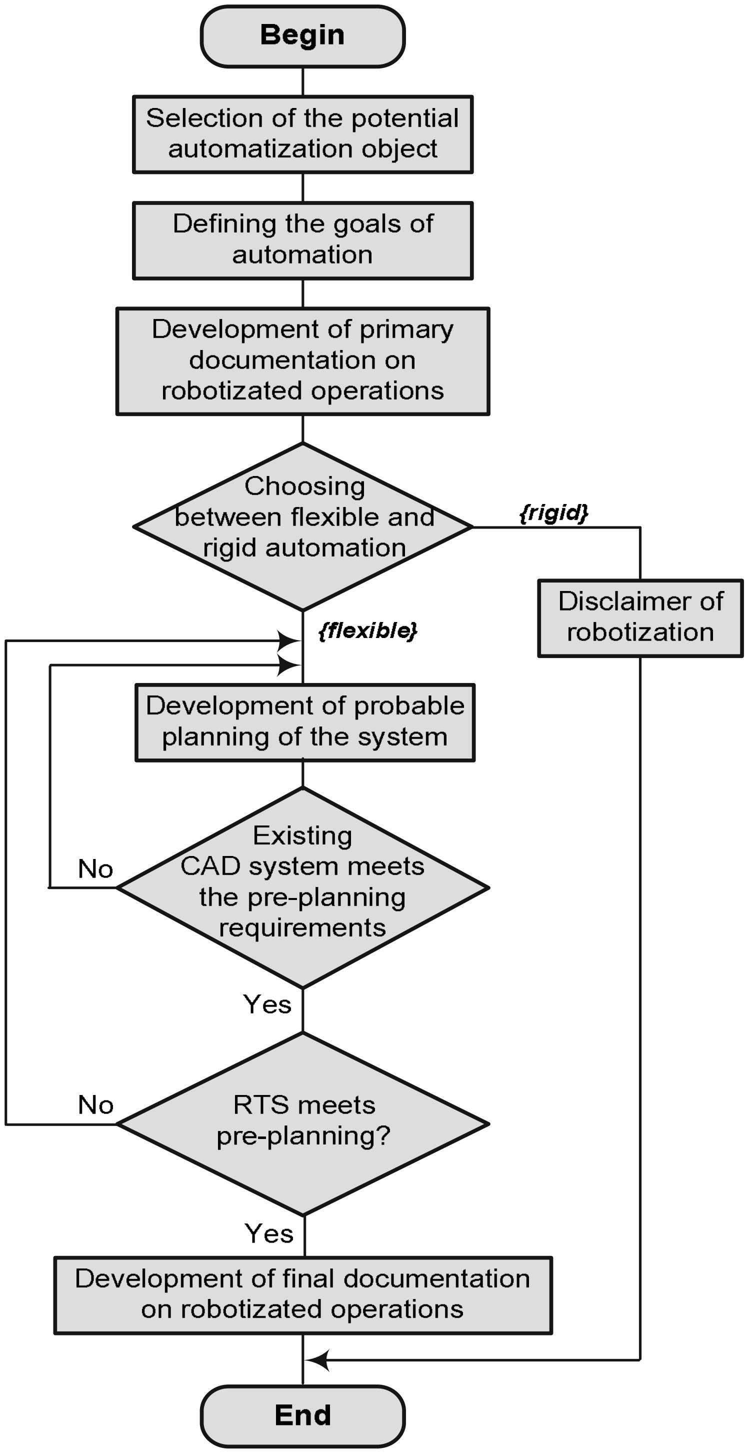

Fig. 2. Block diagram of the general algorithm of the planning stage

The choice between flexible and rigid automatization consists in the analysis of possible RTS alternatives by providing a rigid automatization of the investigated processes or objects, as the most simple technical solution on automating processes are based on the principles of hard (or special) automation, while multipurpose universal reprogrammed RTS provide greater flexibility for solving the problem of automation, but they are not always feasible from an economic point of view. If robotics is carried out for short periods, involves frequent changes of location, or a small seriality production (in the case of industrial robots), usage of rigid automation mechanism in such cases is inappropriate. Execution speed and the possibility of combining the operations are also important influence factors when choosing between rigid and flexible automatization.

Stage of a possible planning of system (see. Fig. 2) includes the development of sketches and drawings of probable automated system, which includes studied RTS object (or process) and all mechanisms of their interaction. Development of RTS planning is a cyclical process.

At the final stage of planning (stage of development the documentation on robotyzed operations) such parameters should be included, as: duration of RTS work cycle, duration of operations, data about performance of necessary prevent and repair RTS tools, as well as data describing the productivity and quality of work, carried out using RTS. Also, information about the object or process, which are subject to robotization by commissioning the proposed RTS, must be added to the data.

In order to analyze the dynamics of the planning process, and reliability of the corresponding planning subsystem of the RTS design system, an appropriate model, based on Petri nets, has been developed in this article, and is presented in Figure 3.

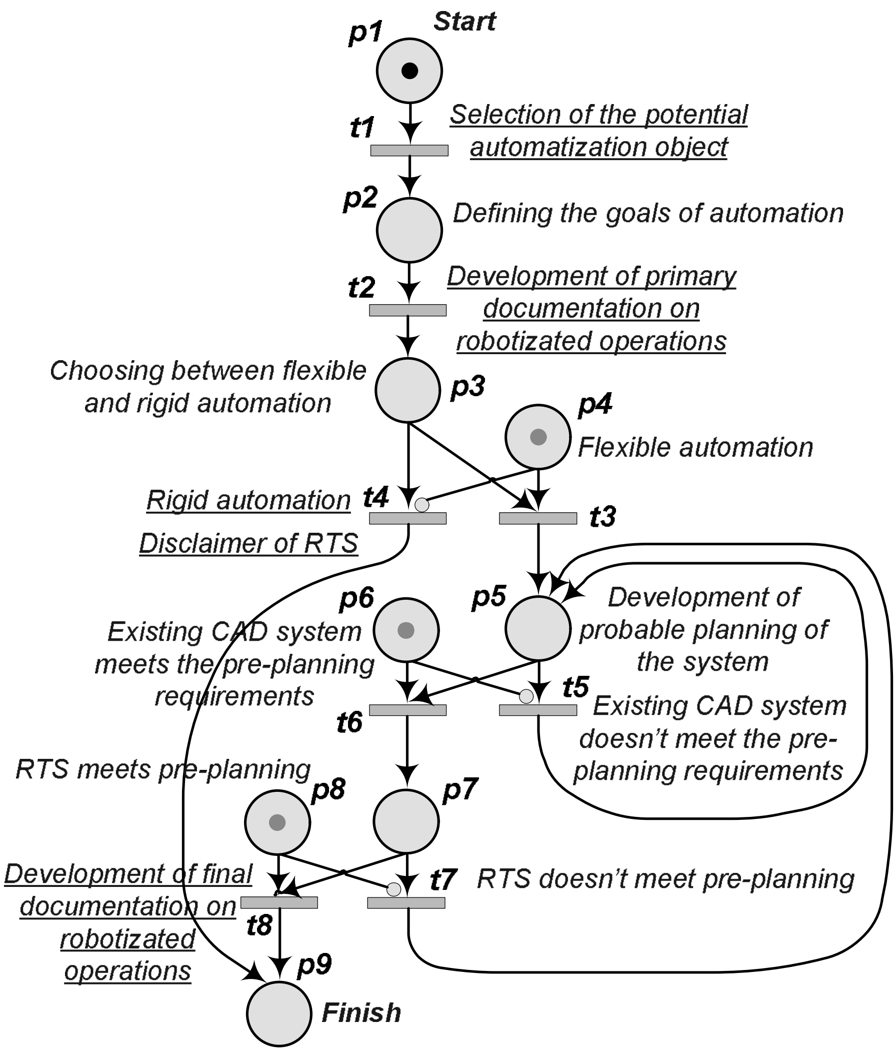

Fig. 3. RTS planning stage representation model, based on Petri nets

Developed model works according to the proposed algorithm (see fig.2) as follows. Model launching is carried out by placing the marker in the initial position p1. After that transition t1 is activated and marker moves to the position p2, which corresponds the stage of setting automation goals. From the position p2 by activating the transition t2 marker gets in position p3, from where at presence (or absence) of marker at position p4 by activation of the corresponding transitions (t3 or t4) marker gets into position p5 or p9 respectively. In particular, at presence of the marker in position p4 (which indicates about the possibility of flexible automation) activation of the transition t3 occurs, and marker moves into the position p5. At absence of marker in the same position p4 (which indicates about the impossibility of flexible automation) activation of the transition t4 occurs, in other words rejection of RTS in favor of rigid automation is carried out, and marker enters the final position — the position of model work completing, p9. Once the marker got at position p5, which is responsible for the achievement of the probable system planning development phase, two following scenarios are possible: 1) at presence of marker at the position p6 (which indicates that current CAD meets the pre-planning requirements) activation of the transition t6 occurs, and marker moves into the position p7; 2) at absence of marker at the position p6 (which indicates that current CAD does not meet the pre-planning requirements) activation of the transition t5 occurs, and marker returns the position p5 (or in other words a return to the probable system planning development phase occurs). After the marker has reached position p7, depending on presence (or absence) of marker at position p8 activation of one of the corresponding transitions t7 or t8 occurs. For example, at presence of marker in position p8 (which indicates that RTS meets pre-planning requirements) activation of the transition t8 occurs, and marker enters the final position — the position of model work completing, p9. At absence of marker in position p8 activation of the transition t7 occurs, and marker returns the position p5 (or in other words a return to the probable system planning development phase occurs).

Detailed description and dedication of positions and transitions are presented in Table 1 and Table2, respectively.

Table 1

Positions of the developed model and their detailed description

Position	Description
p1	Model functioning start position
p2	Position of automation goals definition stage
p3	Position, representing the achievement of the stage of selection between flexible and rigid automation
p4	Flexible automation posistion. Presence of marker in this position is responsible for the selection of flexible automation, or the usage of RTS in other words
p5	Position of system pre-planning development stage
p6	Existing CAD (Computer Aided Design) system meets the pre-planning requirements. Presence of marker in this position represents matching between existing CAD and requirements for automated planning according presented probable planning of the system
p7	Position, responsible for acievement a stage of matching between RTS and pre-planning requirements
p8	Presence of marker in this position indicates about conformity of RTS and pre-planning requirements
p9	Model functioning finish position

Table 2

Transitions of the developed model and their detailed description

Transition	Description
t1	Selection of the potential automatization object
t2	Development of primary documentation on robotizated operations
t3	Development of flexible automation
t4	The choice in favor of rigid (hard) automation. Disclaimer of RTS
t5	Deciding that existing CAD system doesn’t meet pre-planning requirements
t6	Existing CAD system meets the pre-planning requirements. Moving to the stage of conformity between RTS and pre-planning requirements
t7	Deciding that proposed RTS doesn’t meet pre-planning requirements
t8	Development of final documentation on robotizated operations

A reach state graph was build as well. It is presented below, in fig. 4.

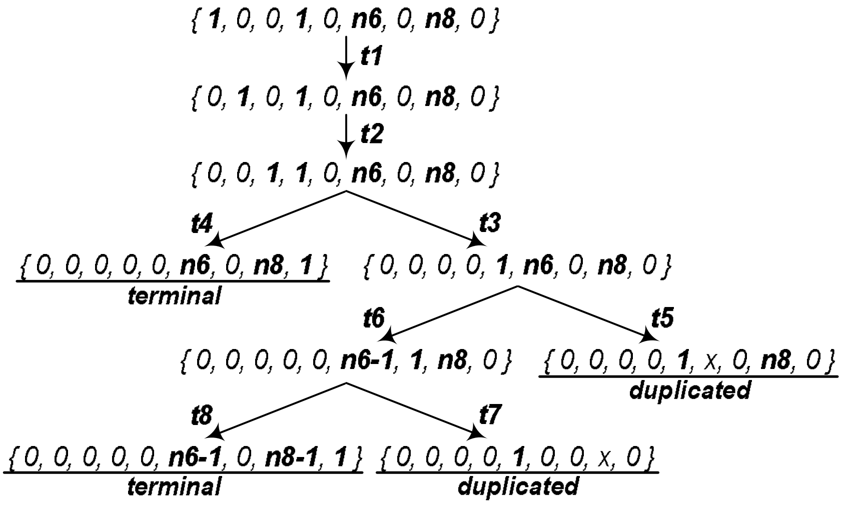

Fig. 4. State reachability graph of the developed model

Depicted state reachability graph (see fig.4) demonstrates finite and feasibility of each of the states of the developed model. It should also be noted that the markers from the positions p6 and p8 of the model (see. Fig. 3) are in the queue, it means that presence (absence) of markers in these positions depends on particular cyclic iteration of model branching, which is also displayed on presented state reachability graph by markers “x”, which were placed in these positions (see. fig. 4).

Conclusions

A model, based on Petri nets, which corresponds RTS automated design planning stage, was developed and presented in this article. The model was developed according to the algorithm of the planning stage, which is basic in 5-th-level representation of the robotization project estimation process, and gives an opportunity to investigate the dynamics of the process and reliability of corresponding component (subsystem) of RTS design system. A detailed description and dedication of positions and transitions of the developed model are given in this article, and corresponding state reachability graph, which demonstrates finite and feasibility of each of the states of the developed model, was built and presented. The peculiarity of the developed model is that it allows to take into account some parameters and factors of robotization of the investigation objects or processes at all during RTS system level design, thus providing the possibility of correcting the RTS at a wide range of quality indicators.

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EDUCATIONAL PROGRAMS FOR CALCULATING THE PARAMETERS OF MEMS USING CLOUD COMPUTING

НАВЧАЛЬНІ ПРОГРАМИ РОЗРАХУНКУ ПАРАМЕТРІВ МЕМС З ВИКОРИСТАННЯМ ХМАРНИХ ОБЧИСЛЕНЬ

The paper proposes a structure for implementing of the system for calculating the parameters of microelectromechanical systems using cloud technologies. Considered the advantages of this system over existing models.

Key words: microelectromechanical systems, educational systems, cloud computing.

Запропоновано структуру для реалізації системи для обчислення параметрів мікроелектромеханічних систем із використанням хмарних технологій. Розглянуто переваги даної системи над існуючими зразками.

Ключові слова: мікроелектромеханічні системи, навчальні системи, хмарні обчислення.

Introduction

In recent decades, thanks to the rapid development of electronics and the growth of the population, is attracting an increasing number of MEMS (sensors, actuators, etc.) to be used everywhere, from cars and ending with toys, so it is important to accurately calculate parameters such sensors for further use. One of these parameters, for example, is the capacity of MEMS capacitive sensor with a circular membrane. The sensor may be imposed electrostatic pressure, and in these cases membrane will shift. During this shift capacity between the membrane and the back wall of our sensor will change, and it is important to know how much change capacity at imposing pressure on it. It is therefore very important to first determine as accurately as possible displacement of the membrane compared to the initial state, and then the capacitance between it and the back wall of the sensor. Similar problems arise in the calculation of other MEMS elements. So, in fact, the calculation of the parameters of MEMS is very important and topical area of research today [1]. Is also an urgent need to create corresponding educational programs for calculating of the MEMS parameters using the latest design technologies (cloud computing, etc.) for educational use in the preparation of specialists (masters and PhD students) in the design and research of MEMS.

Cloud computing

Modern design methods often use a number of intensive computations, which is associated with frequent use of numerical methods, which entails time-consuming. Although the time spent in the performance of these calculations can be reduced by scaling of computer technology, involving power increasing of computing components using vertical scaling, or increase of the number of computing nodes in the horizontal scaling. However, the process of scaling is quite costly in material terms is not always fast during the examination without the involvement of experts in the field, so to solve this problem is to use cloud services, which are based on the model of cloud computing. This model provides centralized