ГІПОТЕЗИ. НЕСТАНДАРТНІ МЕТОДИ РІШЕННЯ НАУКОВИХ ТА ІНЖЕНЕРНИХ ПРОБЛЕМ ПРИЛАДОБУДУВАННЯ

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PHANTOM CHAINS TONTOR OF BIONIC OBJECT'S MOVEMENTS OF AUTOMATED SYSTEMS. Part 1

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This presented work results provides an understanding of how phantom life cycle diagrams of abstract objects can be formed based on the conditions of their existence. Thus, an essential feature of the action of these objects is their possibility of application in automated systems, which is an important aspect of the development of technical bionic means and systems.

The problem of using a phantom for modeling actions, movements of objects in space, features of the obtained results is quite widely used in various fields of scientific research. However, there remain tasks related to understanding how the main actions of robotic working bodies of automated systems take place. Thus, it becomes possible to create formalized models of the processes of performing actions of experimental objects in medicine, industry, astronomy, based on phantom constituents of chain and step geometric elements.

Thus, it is possible to present similar bionic objects in medical automated systems, which refers to the design of bionic prostheses, exoskeleton systems, as well as systems for scientific research of biomechanical properties of objects. At the same time, we analyze the peculiarities of motor movements, for which we create and analyze phantom models of TONTOR steps and their combination into phantom chains.

Prospects for further research, which will be presented in the next part of this work, are the creation of analytical models of phantom features of the existence of various bionic technical means in view of their connection between the volume of the abstract object and the phantom. Similar analytical approaches make it possible to determine the phantom matrix model of the life cycle of a bionic abstract object in automated systems.

Keywords*: phantom chains; TONTOR step; automated systems; object; movement trajectory; single TONTOR cycles; multi-cycle process of steps.*

Introduction

The development of modern industrial automated production requires new approaches to the production of technical means that are used in various fields, such as, for example, precision instrument construction, medicine, and instruments for scientific research. Therefore, the problems of increasing the accuracy of manufacturing and operation of these tools require an understanding of how to ensure full correspondence between the characteristics of the model (phantom) and the real object.

At present, even a simplified consideration proves that the implementation of a technological phantom, that is, combining it with a real function into one whole, is a rather complex process. Therefore, the final mathematical equations give a description of the simplest phantom step. The main problem here lies in the presence of a scrap phantom that acts on the entire cycle of the TONTOR step [1, 2, 3], trying to destroy the volume creation process and even after its creation. As a result, the beginning and end of the step have uncertain coordinates, which is relevant for any process of creating an abstract object. But the peculiarity of the step is that, having a certain reference to the starting point, the end of the trajectory of the object's movement ends in the coordinates specified by the TONTOR touching process. In a broad sense, the step itself has no limitations in its physical basis. Currently, it can be any physical, chemical, biological, etc., phenomenon [4, 5, 6]. So, for example, the usual dialogue between an operator and an automated system during the execution of technological processes can be imagined as a series of steps, each of which has its own physical and mathematical description. This is possible due to the fact that the mathematical apparatus of description is abstract and can use phenomena from any field of science or technology. Thus, if we discard all secondary features, we get the very fact of a certain action, and the mathematical description of this action becomes a secondary phenomenon.

Here we can note that the movement actions of technological process objects [2, 7, 8], manipulators of the automated system make up conditional chains that combine elementary movements into a single work trajectory. Such trajectories have a phantom basis, i.e. preliminary modeling of working motor movements in space. In these cases, the task of combining phantom actions with real motion actions of objects and the working manipulator of the system arises again, which is the achievement of the goal of increasing the accuracy of the execution of the movement trajectory.

The problem of using a phantom for modeling actions, movements of objects in space, features of the obtained results is quite widely used in various fields of scientific research and is considered [6, 7, 8, 9, 10, 11, 12].

However, there remain tasks related to understanding how the main actions of robotic working bodies of automated systems take place. Thus, it becomes possible to create formalized models of the processes of performing actions of experimental objects in medicine, industry, astronomy, based on phantom constituents of chain and step geometric elements [13, 14, 15].

Formulation of problem

So, as a result of these theses, we have the opportunity to build functions of technological processes on the basis of the fact itself. Quite simple examples, where the concept of a step is clearly defined, can be considered the movement of objects with the help of robotic manipulators in the workspace of automated equipment used in technological processes.

At the same time, it is possible to operate on their number and direction to the final purpose, such as such technological processes that have the similarity of the fact of movement in space. This may refer to certain automated technological processes of assembly, which are diverse in their features, for example, with the use of conveyor technology.

In these cases, the movement of the object in the workspace has a character that can be described in a certain way by the chain trajectories of manipulator movements. At the same time, the problem arises again, consisting in the combination of phantom chain movements with real motor actions of the manipulators, that is, the implementation of TONTOR steps. The peculiarity of such trajectories is the realization of phantom lazy actions of the working manipulator of the automated system.

So, in the previous works [1, 2, 3, 11], we partly considered the mathematical and physical basis of the formation of the technological phantom and its main components.

Therefore, the main purpose of this work is to model chain phantom movement of objects in the

At the same time, the same TONTOR cycle is performed, which consists in selecting objects. In the same way, objects are moved by successive movements of the working automated manipulator.

workspace of the system of technological automated equipment, taking into account the nature of the formation of these movements. At the same time, both elementary components of TONTOR steps and their chain combinations are taken into this account.

Abstract invariance of phantom TONTOR steps of an abstract object

Thus, a common technological process operation may consist in moving an object from one place to another. An example can be the stepping of a manipulator robot when it moves on a flat surface, while there may be cases when a certain obstacle falls under it. Similar cases can occur when using walking hexapods, bionic prostheses, exoskeletons, etc.

In this way, we have a number of technological processes and, as a consequence, the schedules inherent in them (Fig. 1).

The first case (Fig. 1) requires accurate calibrated movements, because if you place technological objects in any way during the technological process of assembly, you will lose quality, that is, you need accuracy of movement and accuracy of spatial coordinates.

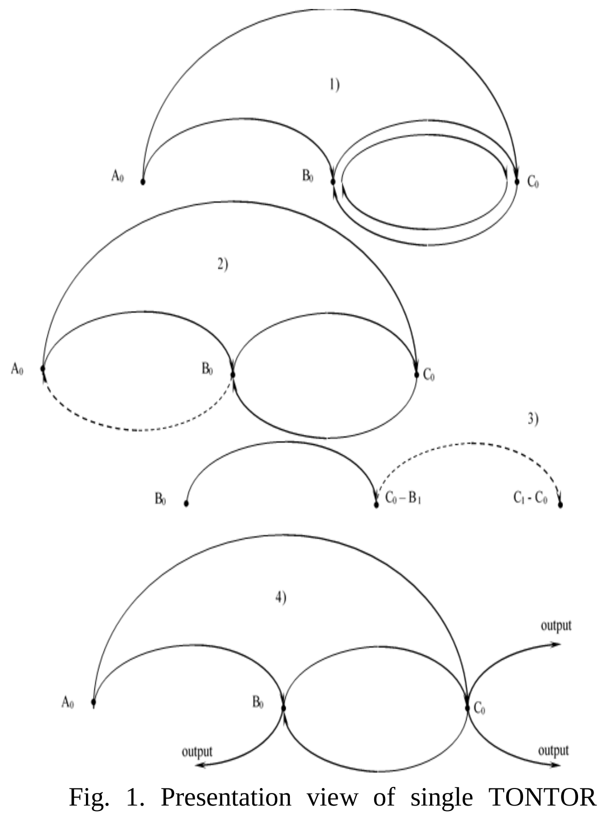


Fig. 1. Presentation view of single TONTOR cycles

As a result, it is necessary to develop a number of technological phantom solutions for the bionic automated system:

• it is necessary to make a decision, where to move the manipulator of the automated technological system or the manipulator of another;

• and this can be done only in the presence of a suitable area of the workplace, or in the case of use in bionic prostheses and exoskeletons, in the presence of appropriate areas for movement;

• then it is necessary to calculate the movements taking into account the obstacle that may arise on the way.

This figure (2) Fig. 1 shows single phantom cycles. Here, the A_0 means the starting point from which the loop entry begins. Dots B_0 and C_0 indicate the location of an object or some substance. But under the condition that: if it is located in a dot (position), then it must be moved to a dot (position), and in the opposite direction.

At the same time, exit from the position A_0 in the cycle is carried out. But our object can be either in position B_0 or C_0.

The entry into this cycle is represented by the lines $A_0 \longrightarrow B_0$ and $A_0 \longrightarrow C_0$. The following actions take place in positions B_0 and C_0. When approaching the position, the final phase of TONTOR begins, i.e. working out "accuracy" of execution. A disconnection cycle occurs behind this position. These positions are the poles of a possible change in the essence of the cycle. If there is movement of the object in these actions, then it moves along the inner circle of the cycle (Fig. 1.2), i.e. $B_0 \longrightarrow C_0 \longrightarrow B_0 \longrightarrow C_0 \longrightarrow$ and so on. There is no polarity change in the cycle, it is monopolar, but the pole of entry into the cycle is important for it. Entry into the cycle occurs at the position (B_0 or C_0), where the searched object is located.

The connection with the given examples is as follows:

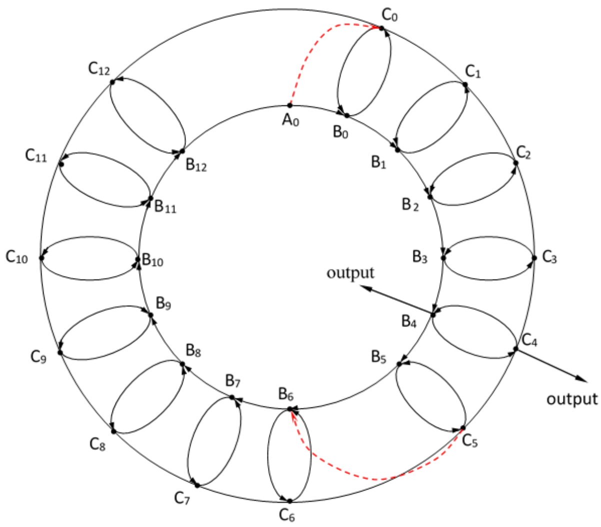
• if there is a process of assembling or assembling objects to the cart, then this is the cyclogram in Fig. 8.1.3, and if they are immediately disposed of, then this is the cyclogram "in" (Fig. 1.4);

• cyclogram (Fig. 1.4), i.e. in the position to open, and in the position to secure;

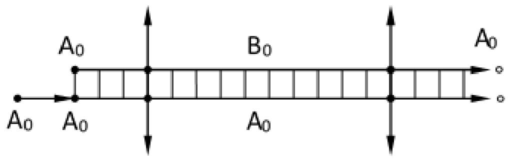
• objects move according to cycles (Fig. 1.3) and (Fig. 1.4);

• the stepping of the bionic object on the surface occurs according to the cyclogram (Fig. 1.4), and also with the reverse cycle with $B_0 \longrightarrow A_0$; and so on.

Single phantom cycles are combined according to the same principle and form cyclograms of the second order (Fig. 2). Such a cyclogram can be represented as a ring formed by single cycles. In such a cycle, single-digit positions (that is, dots B_0 or C_0) are located either on the outer or on the inner circle.



а)



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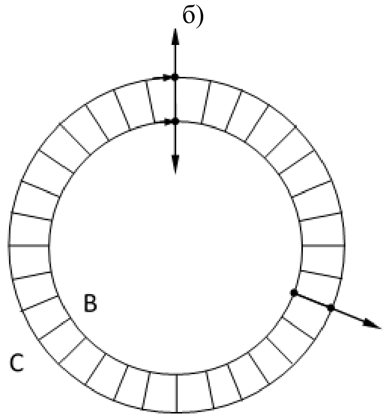

в)

Fig. 2. Image of a multi-cycle process of steps (second order of complexity)

Moreover, for convenience, it is very important to use the direction of movement (Fig. 3). If the assembly process takes place, then the radius vector is directed to the middle of the circle formed by the positions "B_o, B_1, B_2, B_3,..., B_n", and if the objects go outside, then all the radius vectors have a centrifugal direction. Now our objects are scattered outside the circle formed by the positions "C_o, C_1, C_2, C_3,..., C_n".

Arrows indicate how to exit these cycles. That is, as was indicated, exclusively through the poles. Using this simplification, it is possible to display the Great or phantom life cycle of the object (Fig. 4).

Such a drawing makes it possible to imagine, at least a little, how the life cycles of objects take place.

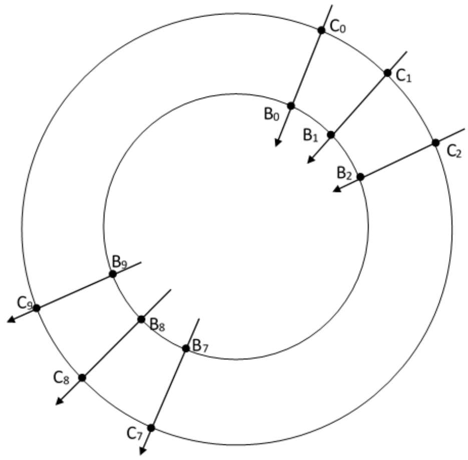

Fig. 3. The movement of objects in the multi-cycle process of stepping

Behind such cycles there is an initial position A_0 - from where the entire life cycle begins, and it does not matter what, since it does not make a big difference in principle.

The point is the number of these cycles and their quality. The finale takes place in the position D_0, where the object recedes into oblivion. It should be noted that this can be not only what the entity has done during its life, but also the plan of its future life. All other cycles located on this line are cycles that the object reproduces during its lifetime. It is clear that for simple objects like a brick this life cycle will be very simple, but for a living being this picture is even very simplified. In such cycles there are entire chains of cycles and transitions. Their order is determined by the distance from the main one, that is, the first order ($A_0 \rightarrow D_0$). They are marked with numbers in the picture.

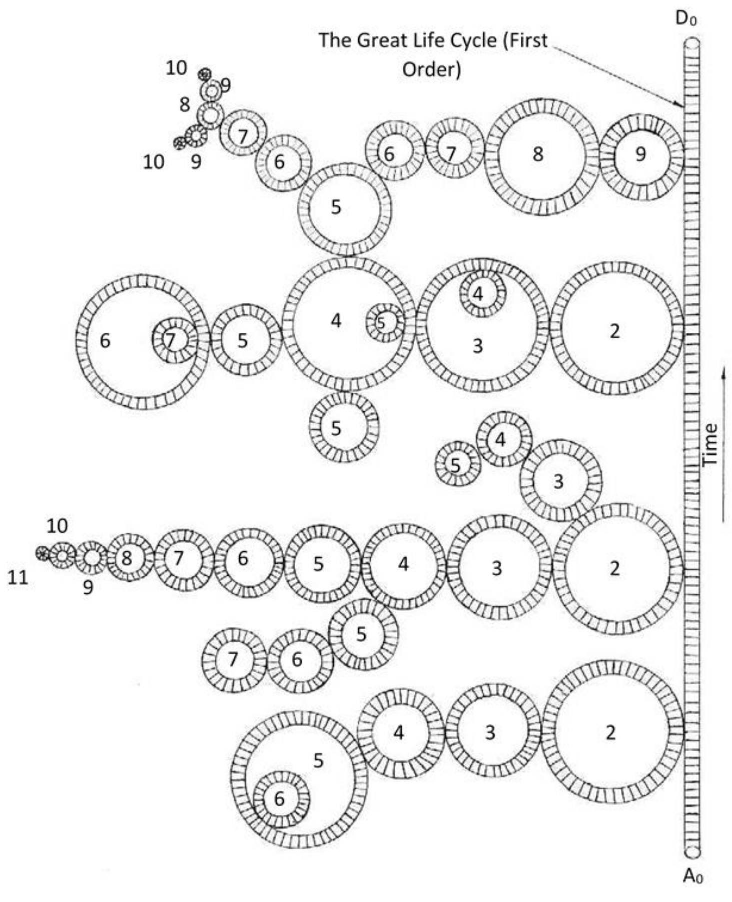

Fig. 4. The great or life cycle of an object's stepping phantom (cycle orders are indicated by numbers)

The smallest cycle that can be reproduced here is a semi-single cycle, because there is nothing smaller than it. The unfolding in time occurs in such a way that, if there is a chain of chains, then the number of the lower order receives the chain of cycles that occurs earlier in time. The later in time gets a higher number, but this has nothing to do with the size of the closed loop. In addition, it should be noted that the position D_0 is average for this type of objects and is therefore not stable. This position has the property of generally moving throughout the life cycle.

Thus, everything proved above indicates that the principles of invariance can be used for the phantom TONTOR steps. In this case, each step, regardless of the physical parameters, is denoted by a vector of a certain length, which indicates the beginning and end of the action.

Phantom chains of steps TONTOR

So, from everything previously said, we have the opportunity to formulate a thesis regarding the appearance of the chains of TONTOR steps.

In this case, we can imagine one step as a material risk. Chains are made of such lines as in Fig. 2.a. Currently, a separate fragment of the circuit is displayed in Fig. 5.

At the same time, we will assume that the points A_{i+1}, A_{i+2}, A_i, A_{i-1}, A_{i-2}, are the starting points of the phantom step and the points B_{i-2}, B_{i-1}, B_i, B_{i+1}, B_{i+2} are its end. You can exit phantom stepping only with a phantom connection between points A and B. The link of the step is unbreakable, that is, it is the law of stepping.

So, Fig. 4 shows only a part of the great life cycle.

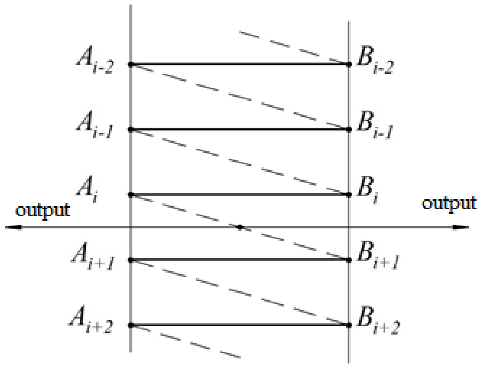

Fig. 5. A fragment of TONTOR chain

This part of the steps has only a phantom character, which we have the opportunity to observe. In order to consider further transformations of stepping chains, we will assume that a separate stepping link contains all properties of the step, which had the description [ ]. These may include the following:

- the very fact of the step as such;
- the distance to which it is made;
- step execution time;
- step execution speed;
- mass of the object to be moved;
- the energy inherent in a specific step;
- other parameters are not specified above.

So, if we accept the conditions defined above, then we have the opportunity to consider the minimum step as a discrete step, and a large cycle as its function. Thus, one great step can be written in the following form

$$L(K) = \sum_{i=1}^{n} \mathbf{K}_i. \quad (1)$$

If we consider that the sum of the steps in (1) is equal to the length of the phantom circle, then the step function is proportional to $2\pi R$. Since the number of steps can only be an integer value, the dependency must be fulfilled

$$2\pi R = n \cdot \mathbf{K}. \quad (2)$$

At the same time, from (2) we have the value of the abstract radius:

$$R = \frac{n \cdot \mathbf{K}}{2\pi}, \quad (3)$$

that is, the value of the radius of a unit step is an abstract dimensionless number. In this case, we have the opportunity to use the affine transformation, that is, the geometric parameters of the circle.

As a result, any steps in space, regardless of their shape and length, can be displayed as a geometrically regular circle. At the same time, the imaginary trajectory of the movement will have the following equation

$$\int_{(L)} \mathbf{K}(x, y) dl = 2\pi R, \quad (4)$$

that is, any trajectory in the stepping record has the form of a flat curve in the form of a circle.

Since, according to mathematical laws, any flat function can be considered as the sum of two functions $P(x, y), Q(x, y)$, and then the integral (8.4) can be considered as their sum, i.e.

$$\int_{(L)} P(x, y)dx + \int_{(L)} Q(x, y)dy = 2\pi R,$$

$$K(x, y) = P(x, y) + Q(x, y).$$

If the center of the circle $x^2 + y^2 = R^2$ is shifted relative to the origin of the coordinates by the same amount x_0, y_0, then the equation takes the usual form

$$(x - x_0)^2 + (y - y_0)^2 = R^2.$$

In our case, the radius vector from (3) is fundamental at a defined critical value K and n. Dependence (3) for a unit radius vector has a value according to the antier function

$$E\left(\frac{2\pi}{\mathbf{K}}\right) = n. \quad (5)$$

From (5), we determine that the critical value of the step is equal to 2π. Then the minimum number of steps is $n = 1$. In the parametric form, the circle has the following form

$$\left.\begin{aligned} x &= x_0 + R\cos t \\ y &= y_0 + R\sin t \end{aligned}\right\},$$

where the angle t is formed by a moving radius with the positive direction of the axis O_x, $0 \le t \le 2\pi$. On the other hand, using the dependence (3), we obtain

$$\left.\begin{aligned} x &= x_0 + \frac{n\mathbf{K}}{2\pi}\cos t \\ y &= y_0 + \frac{n\mathbf{K}}{2\pi}\sin t \end{aligned}\right\}.$$

The magnitude of the angle *t* is defined as $\frac{2\pi}{n}\cdot i$. In most cases, you can very successfully use polar coordinates, that is, the equation of a circle in this case takes the form

$$R^2 - 2RR_0\cos(\varphi - \varphi_0) + R_0^2 = \left(\frac{n\mathbf{K}}{2\pi}\right)^2.$$

In this equation, R_0 and φ_0 are the polar coordinates of the center of the circle of steps.

For further research, let's move from the rectangular coordinate system (Fig. 5) to the polar coordinate system (Fig. 6). For now, we choose a four-quadrant coordinate system, when each quadrant corresponds to its own phantom. In this case, four types of phantoms correspond to the principles of stepping.

According to the diagram movement (Fig. 6) from point A_0 to point D_0, the abstract object passes the state of interaction with all four phantoms. The points A_0 and D_0 do not coincide both from a theoretical and a practical point of view, which is proved in [2]. The transition points from one phantom to another are indicated by the intersection of the circle (1) of the large life cycle with the coordinate axes, namely: the transition point $A_0(x, y)$ from $\mathbf{\Phi}^I$ to $\mathbf{\Phi}^{II}$, the transition point $D_0(x, y)$ from $\mathbf{\Phi}^{II}$ to $\mathbf{\Phi}^{III}$, the transition point $-A_0(x, y)$ from $\mathbf{\Phi}^{III}$ to $\mathbf{\Phi}^{IV}$.

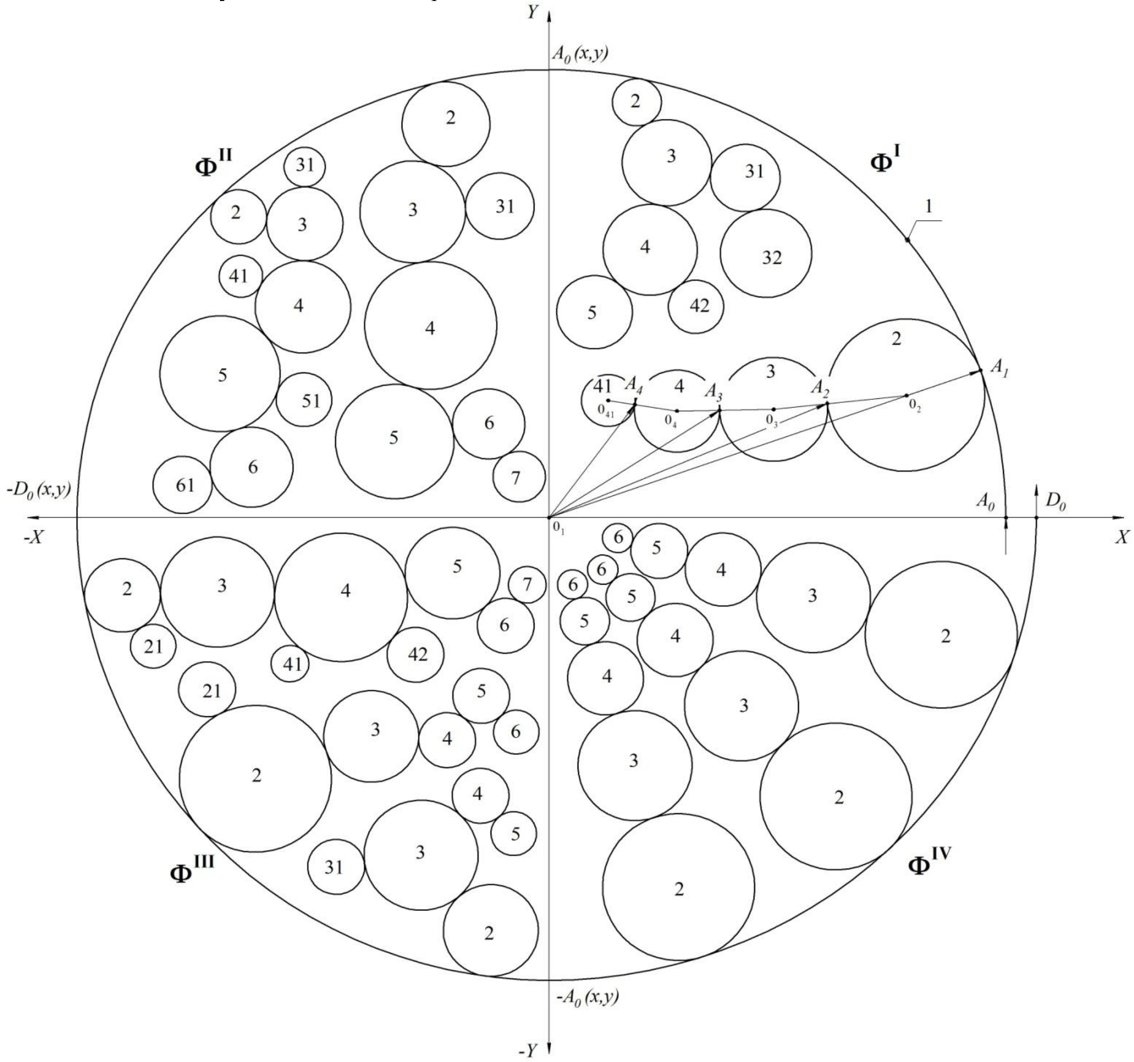

Fig. 6. Polar model of the great life cycle

The main task of studying these processes is to determine the coordinate and moment of transition between different orders. Consider this situation on one transition when the first order has a transition to the second, and the second to the third, and so on. Thus, the center of the circle of the first order is the center of the circle O_1. Transition from the first order to the second point A_1. The center of the second order point O_2. Transition from the second order to the third point O_3. The center of the third order is the point O_3. That is, according to this principle, we have the possibility of describing the entire chain of steps in all quadrants.

Let's take the following distance markers as a series of vectors, that is, let

$O_1A_0 = O_1A_1 = a$; $O_1A_2 = b$; $O_1A_3 = c$; $O_1A_4 = d$.

Thus, if we have a vector $\mathbf{a}$, and its components a_1 and a_2, then we have the opportunity to represent this vector in the form of a matrix

$$\begin{bmatrix} a_1 \\ a_2 \end{bmatrix}.$$

The transformation of vector **a** into vector **b** is performed using a matrix by multiplying the corresponding matrices, i.e

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}.$$

In turn, the transformation of vector **b** into vector **c** is performed using the matrix β, i.e

$$\begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}.$$

When converting vector c to vector d, the matrix is used, i.e

$$\begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}.$$

Thus, vector transformations have the following dependence

$$\begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} d_1 \\ d_2 \end{bmatrix}.$$

In a broad sense, all vectors are arranged in a "fan". In addition, the inter-vector angles have fluctuations in size $\pi/2$ of no more than on one side and up to a complete absence on the other. The sizes of the cycles can be quite different, but their arrangement in one line when all the centers of the cycles are on the same line of the vector indicates that this arrangement is optimal. In this case, the vector line has a description through the usual equation straight through the center of the diagram, i.e. $y = kx$. If the centers of the cycles are not on this vector, then each of them has its own vector with a similar mathematical description. But in addition to the centers of cycles, there are closing points between cycles. In the given example, these are chords A_1A_2, A_2A_3, A_3A_4 (Fig. 6). In the last circle, the chord is equal to the diameter of the cycle circle. It is quite clear that each chord is equal to the diameter only in the ideal case.

In general, these chords are vectors that connect the entry and exit points of a defined system. Each cycle is an affine description of a closed trajectory. Moreover, this trajectory takes place in the potential field.

And the work performed in such a circuit is zero. The number of steps in the cycle (n) (5) is usually an even number, so its division into two parts gives either two even or two odd identical numbers. But the numbers are usually not the same because the "start" and "finish" places in the cycle are sometimes quite arbitrary. This situation arises because each step is linked to specific coordinates with a fairly high accuracy. The only situation when the moment of start and finish is clearly defined is during cyclic technological operations. During such operations as, for example, processing of the same type of parts on automatic machines with CNC. For biological objects, such cyclograms and transitions to each other and vice versa are a typical phenomenon.

As a result, we have the opportunity to determine various types of movement of bionic objects, which is related to automated systems in industry, medicine, logistics, scientific research.

Conclusions

This part of the presented work results provides an understanding of how phantom life cycle diagrams of abstract objects can be formed based on the conditions of their existence. Thus, an essential feature of the action of these objects is their possibility of application in automated systems, which is an important aspect of the development of technical bionic means and systems.

Thus, it is possible to present similar bionic objects in medical automated systems, which refers to the design of bionic prostheses, exoskeleton systems, as well as systems for scientific research of biomechanical properties of objects. At the same time, we analyze the peculiarities of motor movements, for which we create and analyze phantom models of TONTOR steps and their combination into phantom chains.

Prospects for further research, which will be presented in the next part of this work, are the creation of analytical models of phantom features of the existence of various bionic technical means in view of their connection between the volume of the abstract object and the phantom. Similar analytical approaches make it possible to determine the phantom matrix model of the life cycle of a bionic abstract object in automated systems.

Thus, it is necessary to develop a base of analytical models that determine the characteristics of spatial and temporal characteristics of bionic technical means when applying models of phantom chains and real space-time coordinates of the movement of objects and the entire system.

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ФАНТОМНІ ТОНТОР ЛАНЦЮГИ РУХУ БІОНІЧНИХ ОБ'ЄКТІВ АВТОМАТИЗОВАНИХ СИСТЕМ. Частина 1

Представлені результати роботи дають змогу зрозуміти, як можна формувати фантомні діаграми життєвого циклу абстрактних об’єктів на основі умов їх існування. Таким чином, істотною особливістю дії цих об’єктів є можливість їх застосування в автоматизованих системах, що є важливим аспектом розвитку технічних біонічних засобів і систем.

Проблема використання фантома для моделювання дій, переміщень об’єктів у просторі, особливості отриманих результатів досить широко використовується в різних галузях наукових досліджень і розглядається

Проте залишаються завдання, пов'язані з розумінням того, як відбуваються основні дії роботизованих робочих органів автоматизованих систем. Таким чином, стає можливим створення формалізованих моделей процесів виконання дій експериментальних об’єктів у медицині, промисловості, астрономії на основі фантомних складових ланцюгових і ступінчастих геометричних елементів.

Таким чином, подібні біонічні об’єкти можна представити в медичних автоматизованих системах, що відноситься до проектування біонічних протезів, екзоскелетних систем, а також систем наукового дослідження біомеханічних властивостей об’єктів. Паралельно аналізуємо особливості рухових рухів, для чого створюємо та аналізуємо фантомні моделі кроків TONTOR та їх поєднання у фантомні ланцюжки.

Перспективами подальших досліджень, які будуть представлені в наступній частині роботи, є створення аналітичних моделей фантомних особливостей існування різноманітних біонічних технічних засобів з огляду на їх зв’язок між об’ємом абстрактного об’єкта та фантомом. Подібні аналітичні підходи дають змогу визначити фантомно-матричну модель життєвого циклу біонічного абстрактного об’єкта в автоматизованих системах.

Ключові слова: фантомні ланцюги; крок ТОНТОР; автоматизовані системи; об'єкт; траєкторія руху; одиничні цикли ТОНТОР; багатоцикловий процес крокування.

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