ГІПОТЕЗИ. НЕСТАНДАРТНІ МЕТОДИ РІШЕННЯ НАУКОВИХ ТА ІНЖЕНЕРНИХ ПРОБЛЕМ ПРИЛАДОБУДУВАННЯ

UDC 621.9.08

BASIC PRINCIPLES OF SPATIAL POSITION OF IMAGINARY AND REAL TONTOR STEP

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The article defines the relevance of modeling the parameters of spatial location of an abstract object when performing various functions. Thus, modeling makes it possible to determine object movement trajectories both during industrial application in technological processes and when used to create bionic objects, for example, the action of artificial limbs, correction of the movement trajectory of an object with spatial orientation defects.

The main goal of research was to substantiate the analytical models of object movement, taking into account spatial coordinate systems, according to which coordinate transformations are carried out during the functioning of an abstract object of various applications.

The creation of a sensory complex to compensate for violations of limb functions based on the justification of analytical models of vector field of main systems of the object, characteristic of its vital activity, can solve the possibility of real actions of an abstract biotechnical object in interaction with other objects of the external environment. It is necessary to compare the idealized parameters of vector fields with the real current characteristics of the object under study and to determine the difference as a differential function that corresponds to diagnostic parameters of state of object's limbs trajectory. Or when applied in industrial conditions, errors in the reproduction of the movement trajectory are taken into account.

As a result, the study of nature of this functional dependence of the state violation and its restoration in the automated mode of operation of the integrated tool will allow the creation of a computer-integrated hardware solution for the identification of objects that interact by approaching and touching their surfaces.

Thus, determining the positioning of TONTOR step in the space of movement of objects and during their interaction provides the possibility of the functioning of each abstract object when performing various types of work.

At the same time, it is necessary to significantly develop the base of physical and mathematical models that determine the vector fields of objects in dynamics over a certain time, taking into account the TONTOR step of the phantom and real spaces of the existence and operation of the object. Thus, hardware implementation of this hypothesis increases the accuracy of identification of objects interactions with a human limb, regardless of its condition, and the accuracy of determining their relative location in space.

***Key words**: TONTOR step; positioning; object; spatial coordinates; movement trajectory; surface lines.*

Introduction

Currently, overcoming the consequences of various kinds of violations of the functional state of human limbs as a result of diseases of the bone system, nervous system, and amputations is an urgent problem. For this, transplantation of a healthy limb (or its part), prosthetics, and the use of artificial means of support are most often used. But these means are only able to partially restore her sensorimotor functions of the body's limbs.

Thus, technical means are currently known [1 - 7], which aim to create bionic systems of prosthetic devices that adapt to the patient's body. At the same time, the use of adaptive physiological functionality is a feature of a bionic prosthesis. At the same time, known systems of bionic limbs capable of repeating a set of movements of the patient's fingers or hand use a set of sensors, performing multi-channel measurements of biological signals and complicating the device itself and its cost.

At the same time, the task of determining the formation, type of materials, and identification of the type of contact surface of various objects that approach and come into contact with the limbs in a disturbed state remains unexplored, and therefore, there is an emergency situation in the contact interaction when the dynamic load on the limbs is exceeded.

Thus, the creation of a bionic sensor complex, which provides support for a violation of the functional state of the body's limbs based on the analysis of integrated signals of the field structures of objects, is an urgent scientific and applied task of automated device construction in the field of prosthetics and orthopedics.

An integral task in the creation of such complexes is the determination of the distances of the surface of the working body from the surface of the touching object, the space-time coordinates of the working body's stepping.

On the basis of research, authors are created the basic principles of physical and mathematical modeling, which allow to reflect the fluid processes that arise in objects of various nature as a result of interaction with internal and external factors [8 - 10]. These studies provide an opportunity to determine changes in the object's characteristics, identify trends and the dynamics of their development, which are the basis for diagnosing the state of abstract biotechnical object and technological object at processing [12]. As a result of this theory, it was indicated in which direction research should be conducted in order to fully solve the problem of diagnosing the nature of the movement trajectory violation. Guided by these principles, it is possible to determine the direction of compensation for such a violation to restore the patient's condition.

Currently, the implementation of similar tasks is based on the creation of a number of models of abstract biotechnical object's interaction and its reaction to a standard external stimulus.

Thus, based on the principles of TONTOR theory [11], analytical models for the diagnosis of signs of diseases of the nervous system, associated with a violation of trajectory of the limbs movement and their specific symptoms of the condition, have been created.

Therefore, it is proposed to continue the results of these theoretical and experimental author's studies in the direction of creating an integrated sensory complex to support the normal functional state of the limbs in presence of signs of disease, as well as when using artificial prosthetic limbs. A similar problem can be solved by a certain TONTOR step in space of the mutual location of objects.

Formulation of problem

The proposed work is a continuation of a number of theoretical studies and experimental research works. Initially, the methods and system of diagnostics and forecasting of the state of the biotechnical object were created, which were based on the principles of TONTOR theory, which is based on the analysis of the field structures of electromagnetic fields of objects.

Therefore, main goal of this work was to create analytical models that determine the basic principles of location in the space of an abstract object's TONTOR step, which implements the functions of mutual action of objects when they are touched.

Modeling a TONTOR step in the movement space of an abstract object

Projecting a straight line in space onto the coordinate axes, we get equations in vector form. Focusing on the methods of determining a straight line in three-coordinate space, we can determine the basic planes that allow us to determine the spatial location of the straight line. Currently, we have three planes that determine the location of the motion vectors in the imaginary coordinate system $\left[\bar{\mathbf{K}}\right]$ and in the real system $\left[\tilde{\mathbf{K}}\right]$. To solve this problem, we define the main three surfaces by which we obtain the basic principles of the location $\left[\bar{\mathbf{K}}\right]$ of the motion vectors and the accompanying $\left[\tilde{\mathbf{K}}\right]$.

In addition, in the plane $\mathrm{P}(x, \mathrm{y}, \mathrm{z}) = 0$ are the realization vectors $\mathbf{I}_0(\mathrm{R})$ and $\mathbf{I}_\varphi(\mathrm{R})$. By their essence, these vectors are borderline cases of a surface that coincides with a real surface $\mathrm{I}(x, y, z) = 0$ within the defined movement (Fig.1).

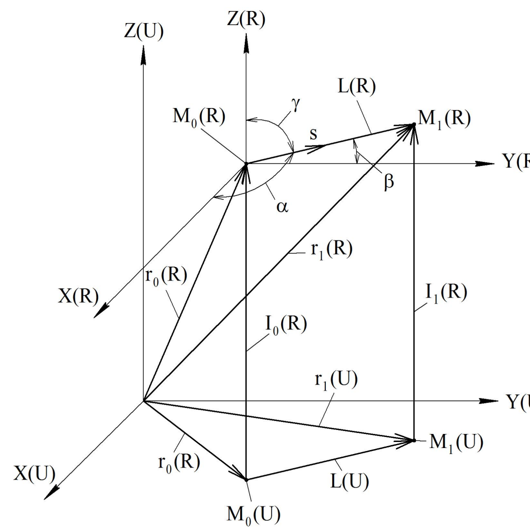

Fig. 1. TONTOR step in space of moving the object

So, as a result, we have four surfaces in two projection coordinate systems, namely:

$$\begin{aligned} &\mathrm{U}_x + \mathrm{U}_y + \mathrm{U}_z + \mathrm{U}_0 = 0 \\ &\mathrm{W}_x + \mathrm{W}_y + \mathrm{W}_z + \mathrm{W}_0 = 0 \\ &\mathrm{P}_x + \mathrm{P}_y + \mathrm{P}_z + \mathrm{P}_0 = 0 \\ &\mathrm{R}_x + \mathrm{R}_y + \mathrm{R}_z + \mathrm{R}_0 = 0 \end{aligned} \qquad (1)$$

The system of equations (1) is the basis for solving the accuracy of the technological process and its possibility.

In order to solve the problem of location and accuracy of execution of an abstract vector $\left[\bar{\mathbf{K}}\right]$ in real space, that is $\left[\tilde{\mathbf{K}}\right]$, we need to solve a number of equations that determine the parameters we need.

At the same time, we are forced to assume that the imaginary coordinate system is compatible with the measurement coordinate system (1) and equation of the length of a real straight line

$$\left[\tilde{\mathbf{K}}\right] = L(R) = \int_{\phi_1}^{\phi_2} \sqrt[2]{(\rho')^2 + (\rho)^2}\, d\phi = \\ = \frac{p}{1 + e\cos\phi} \int_{\phi_1}^{\phi_2} \sqrt{1 - \sin^2\phi}\, d\phi \qquad (2)$$

The values of angles φ_1 and φ_2 are determined from the polar equation of the straight line.

So, for the imaginary plane, we have the following dependencies, that is, in the vector form from (1) and (2) as

$$\mathbf{r}_U \mathbf{N}_U + U_0 = 0, \mathbf{N}_U = (U_x, U_y, U_z), \\ \mathbf{r}_U = (X_U, Y_U, Z_U) \qquad (3)$$

If the normal vector $\mathbf{N}_U$ is defined as $\left|\mathbf{N}_U\right| = \sqrt{U_x^2 + U_y^2 + U_z^2} = 1$, then the equation of the plane $U(x, y, z) = 0$ can be written in form of the normal equation of plane

$$x_U \cos\alpha_U + x_y \cos\beta_U + x_z \cos\gamma_U - \rho_U = 0, \rho > 0$$

$$\cos\alpha_U = \frac{U_x}{\left|\mathbf{N}_U\right|}, \cos\beta_U = \frac{U_y}{\left|\mathbf{N}_U\right|}, \cos\gamma_U = \frac{U_z}{\left|\mathbf{N}_U\right|}.$$

and measurement coordinate systems

$$\mathbf{r}_w \mathbf{N}_w + W_0 = 0, \mathbf{N}_w = (W_x, W_y, W_z), \mathbf{r}_w = (x_w, y_w, z_w).$$

If the normal vector $\mathbf{N}_w$ is defined as $\left|\mathbf{N}_w\right| = \sqrt{W_x^2 + W_y^2 + W_z^2} = 1$, then equation of the plane $W(x, y, z) = 0$ can be written in form of the normal equation of plane

$$x_W \cos\alpha_W + y_W \cos\beta_W + z_W \cos\gamma_W - \rho = 0, \rho \geq 0$$

$$\cos\alpha_W = \frac{W_x}{\left|\mathbf{N}_w\right|}, \cos\beta_W = \frac{W_y}{\left|\mathbf{N}_w\right|}, \cos\gamma_W = \frac{W_z}{\left|\mathbf{N}_w\right|}.$$

At the same time, the real coordinate system receives the following description

$$\mathbf{r}_R \mathbf{N}_R + R_0 = 0, \mathbf{N}_R = (R_x, R_y, R_z), \mathbf{r}_R = (x_R, y_R, z_R)$$

If the normal vector $\mathbf{N}_R$ is defined as $\left|\mathbf{N}_R\right| = \sqrt{R_x^2 + R_y^2 + R_z^2} = 1$, then the equation of the plane can be written in form of the normal equation of plane

$$x_R \cos\alpha_R + y_R \cos\beta_R + z_R \cos\gamma_R - \rho_R = 0, \rho \geq 0,$$

$$\cos\alpha_R = \frac{R_x}{\left|\mathbf{N}_R\right|}, \cos\beta_R = \frac{R_y}{\left|\mathbf{N}_R\right|}, \cos\gamma_R = \frac{R_z}{\left|\mathbf{N}_R\right|}$$

For a real surface, we get

$$\mathbf{r}_P \mathbf{N}_P + P_0 = 0, \mathbf{N}_P = (P_x, P_y, P_z), \mathbf{r}_P = (x_P, y_P, z_P)$$

If the normal vector $\mathbf{N}_P$ is defined as $\left|\mathbf{N}_P\right| = \sqrt{P_x^2 + P_y^2 + P_z^2} = 1$, then the equation of plane $P(x, y, z) = 0$ can be written in form of the normal equation of plane

$$x_P \cos\alpha_P + y_P \cos\beta_P + z_P \cos\gamma_P - \rho_P = 0, \rho \geq 0,$$

$$\cos\alpha_P = \frac{P_x}{\left|\mathbf{N}_P\right|}, \cos\beta_P = \frac{P_y}{\left|\mathbf{N}_P\right|}, \cos\gamma_P = \frac{P_z}{\left|\mathbf{N}_P\right|}.$$

Thus, as a result of all the above, we have the opportunity to formulate a mathematical model of the transfer (or transition) from the imaginary coordinate system to the real vector of the distance between the points $M_0(U)$, $M_1(U)$ of the imaginary coordinate system into the real one $M_0(R)$, $M_1(R)$. At the same time, the basic vector $\left[\bar{\mathbf{K}}\right]$ will be determined in the following two ways by the equations of the plane

$$U_x + U_y + U_z + U_0 = 0 \\ P_x + P_y + P_z + P_0 = 0,$$

or vector equations

$$\mathbf{r}_U \mathbf{N}_U + U_0 = 0 \\ \mathbf{r}_P \mathbf{N}_P + P_0 = 0.$$

Regarding the measurement plane, we will have

$$W_x + W_y + W_z + W_0 = 0 \\ P_x + P_y + P_z + P_0 = 0,$$

or vector equations

$$\mathbf{r}_W \mathbf{N}_W + W_0 = 0 \\ \mathbf{r}_P \mathbf{N}_P + P_0 = 0.$$

The real vector , which is in the real coordinate system, will be defined as the intersection of the plane of the real coordinate system and the plane of the trajectory, i.e.

$$R_x + R_y + R_z + R_0 = 0 \\ P_x + P_y + P_z + P_0 = 0,$$

or vector equations

$$\mathbf{r}_R \mathbf{N}_R + R_0 = 0 \\ \mathbf{r}_P \mathbf{N}_P + P_0 = 0.$$

If we consider the technological transition from an imaginary to a real coordinate system of a vector of imaginary length, then we have the opportunity to obtain the following series of vector equations

$$\mathbf{r_0}(U)+\mathbf{r}_1(U)=\left[\bar{\mathbf{K}}\right]$$
$$\mathbf{r_0}(R)+\mathbf{r}_1(R)+[\mathbf{S}]=\left[\tilde{\mathbf{K}}\right]$$

At the same time, the transition from the imaginary coordinate system to the real one is performed using the realization vectors $\mathbf{I}_0(\mathrm{R})$ and $\mathbf{I}_1(\mathrm{R})$, which are defined as

$$\mathbf{I}_0(\mathrm{R})=\mathbf{Z}_0(\mathrm{U})+\mathbf{Z}_0(\mathrm{R})+[\mathbf{S}]+\mathbf{D}$$
$$\mathbf{I}_1(\mathrm{R})=\mathbf{Z}_1(\mathrm{U})+\mathbf{Z}_1(\mathrm{R})+[\mathbf{S}]+\mathbf{D}$$

Realization vectors during the transition from the imaginary to the real coordinate system represent a finite discrete, i.e., the plane $\mathrm{R}(x,y,z)=0$ is located relative to $\mathrm{U}(x,y,z)=0$ or $\mathrm{W}(x,y,z)=0$ at a distance $P_0=const=n[\mathbf{S}]$, $n=1,2,3...\infty$.

Let's consider more precisely what distortions a straight line that enters the real technological space receives. To do this, consider projections of vector and accompanying coordinates on surface error (Fig. 2).

We introduce a new coordinate system, where the axis $Y_0(\mathrm{R})$ passes through the points $\mathrm{M}_0(\mathrm{R})$, $\mathrm{M}_1(\mathrm{R})$. At the same time, this coordinate system is deviated by an angle relative to the axis $\mathrm{Z(R)}$ (Fig. 2).

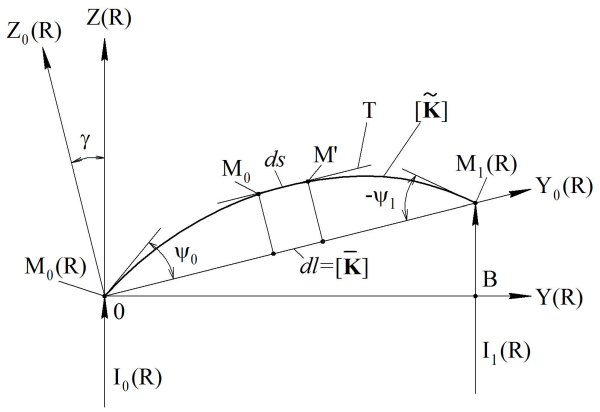

Fig. 2. Parameters of a straight line in real space

Turning the tangent along the vector $\left[\tilde{\mathbf{K}}\right]$ from point $\mathrm{M}_0(\mathrm{R})$ to point $\mathrm{M}_1(\mathrm{R})$ changes the angle of inclination from ψ_0 to ψ_1. The chord $\mathrm{M}_0(\mathrm{R})\mathrm{M}_1(\mathrm{R})$ that contracts the arc of the vector $\left[\tilde{\mathbf{K}}\right]$ is assumed to be equal *L*.

Therefore, the rotation of the tangent from point $\mathrm{M}_0(\mathrm{R})$ to point $\mathrm{M}_1(\mathrm{R})$ is equal to ψ_0-ψ_1.

This means that the full curvature of the arc of the vector is $\frac{\psi_0\text{-}\psi_1}{\mathrm{k(R)}}$, and the curvature $k_0=\frac{2\psi_0}{\left\|\left[\tilde{\mathbf{K}}\right]\right\|}$, s is the angle between the curve and the chord

$$\psi_0=\frac{1}{2}\left\|\left[\tilde{\mathbf{K}}\right]\right\|k_0=\frac{1}{2}Lk_0.$$

L is the length of chord.

Therefore, directly from the definition of the curvature of a plane curve, we have

$$\psi_0=\frac{1}{2}\mathrm{Lk}_0+\mathbf{D}$$

Consider the case when there is a difference in curvature between the beginning and the end of vector, in addition, the initial curvature is twice as large as the final one, so we get:

$$\psi_0=\frac{\mathrm{L}}{2}\cdot\frac{2\mathrm{k}_0+\mathrm{k}_1}{3}+[\mathbf{S}]=\frac{\mathrm{L}}{2}(\mathrm{k}_0+\frac{\mathrm{k}_1\text{-}\mathrm{k}_0}{3})+[\mathbf{S}]$$

Let's rewrite the vector equation in the real coordinate system using Taylor's formula

$$\mathrm{Z}_0(\mathrm{R})=\mathrm{a}\,y+\mathrm{b}\,y^2+cy^3+[\mathbf{S}]$$

$$\mathrm{a}=\left(\frac{dz_0}{dy}\right)_{\mathrm{M}_0}$$
$$\mathrm{b}=\frac{1}{2}\left(\frac{d^2z_0}{dy^2}\right)_{\mathrm{M}_0}$$
$$\mathrm{c}=\frac{1}{6}\left(\frac{d^3z_0}{dy^3}\right)_{\mathrm{M}_0}.$$

At point B we get

$$\mathrm{Y}_{M_1}=\mathrm{L};\mathrm{z}_0(\mathrm{R})=\mathrm{aL+bL^2}+\mathrm{cL}^3+[\mathbf{S}]=0,$$

where from

$$\mathrm{a{=}{-}bL{-}cL^2}+\mathbf{D}.$$

So, with the accepted location of the axes

$$\mathrm{Z}_0(\mathrm{R})=-(\mathrm{b}+\mathrm{cL})\mathrm{L}+\mathrm{by}^2+cy^3+[\mathbf{S}],$$
$$\frac{dz}{dy}=tg\psi=\psi+[\mathbf{S}]=$$
$$=-(\mathrm{b}+\mathrm{cL})\mathrm{L}+2\,\mathrm{b}\,y^{s2}+3cy^3+[\mathbf{S}], \tag{4}$$

and the curvature in the floating point M

$$\mathrm{k}{=}{-}\frac{d\psi}{d\mathrm{L}}=-\frac{d\psi}{dy}\cdot\frac{dy}{dS}=-\frac{d\psi}{dy}\cos\psi=$$
$$=-\frac{d\psi}{dy}\left(1+\frac{\psi^2}{2}+...\right)=-\frac{d\psi}{dy}+\mathbf{D}=-2\mathrm{b{-}bc}y{+}\mathbf{D}.$$

According to the equation (4) in points $\mathrm{M}_0(\mathrm{R})$, $\mathrm{M}_1(\mathrm{R})$

$$\psi_0 = -2\text{b}+\mathbf{D}$$
$$\psi_1 = -2\text{b-6cL}+[\mathbf{S}]=\psi_0 - 6\text{cL}+\mathbf{D}.$$

From the last two equations, we get the value b and c due to the curvatures ψ_0 and ψ_1

$$\psi_0 = \frac{\text{L}}{2}\cdot\frac{2\psi_0+\psi_1}{3}+[\mathbf{S}] = \frac{\text{L}}{2}(\psi_0+\frac{\psi_1-\psi_0}{3})+[\mathbf{S}]$$
$$-\psi_1 = \frac{\text{L}}{2}\cdot\frac{2\psi_1+\psi_0}{3}+[\mathbf{S}] = \frac{\text{L}}{2}(\psi_1+\frac{\psi_0-\psi_1}{3})+[\mathbf{S}] \quad (5)$$

Thus, we have to conclude from equation (5) that the curvature is different both for the beginning of the vector $\left[\tilde{\mathbf{K}}\right]$ and for its end.

Consider the difference between the length of the vector and its chord (Fig. 2). To do this, we select a separate element between the arc of the vector and its chord.

From this figure, we can obtain the following dependence

$$\frac{dS}{dy} = \sec\psi = 1+\frac{\psi^2}{2}+[\mathbf{S}], \quad (6)$$

or by equation

$$\psi = -\text{bL+2b}y\text{-cd}^2+3cy^2+[\mathbf{S}]. \quad (7)$$

Substitute (7) into equation (6) and get:

$$\frac{dS}{dy} = 1+\frac{1}{2}\text{b}^2\text{L}^2 - 2\text{b}^2\text{L}y\text{+}2\text{b}^2y^2+\text{bcL}^3 - 2\text{bcL}^2y - 3\text{bcL}y^2+6\text{bc}y^3+[\mathbf{S}].$$

Whence the relative change in length is determined as:

$$\frac{\left[\tilde{\mathbf{K}}\right]-L}{L} = \frac{1}{L}\int_0^L\frac{dS}{dy}dy - 1 = \frac{1}{2}b^2L^2 - b^2L^2+\frac{2}{3}b^2L^2 + bcL^3+bcL^3-\frac{3}{2}bcL^3+[\mathbf{S}] = \frac{1}{2}bL^2\left(\frac{b}{3}+cL\right)+[\mathbf{S}]$$

The disadvantage of the considered situation is that the form of the projection of an imaginary straight line onto real space does not have a clear mathematical dependence, that is, there is no connection with the environment.

In addition, the curvature of the real vector is determined by the angles ψ_0 and ψ_1, which are only indirectly connected by the torsion coefficient of space. Therefore, let's present the next stage of the problem in a slightly different way. We will assume that distortions in space represent elliptical deformation.

In the principles of this thesis, it is possible to imagine that the deformation of one half of the space in contact with the surfaces of an abstract object, which is touched by the working body of the manipulator, can be described according to the parabolic law. This may be the next task of exploring TONTOR steps.

Conclusions

The creation of a sensory complex to compensate for violations of limb functions based on the justification of analytical models of the vector field of the main systems of the object, characteristic of its vital activity, can solve the possibility of real actions of the object when interacting with other objects. At the same time, it is necessary to compare the idealized parameters of the vector fields with the real current characteristics of the object under study and to determine the difference as a differential function that corresponds to the diagnostic parameters of the state of the trajectory of the object's extremities.

As a result, the study of the nature of this functional dependence of the state violation and its restoration in the automated mode of operation of the integrated tool will allow the creation of a computer-integrated hardware solution for the identification of objects that interact by approaching and touching their surfaces.

Thus, determining the positioning of TONTOR step in the space of movement of objects and during their interaction provides the possibility of the functioning of each abstract object when performing different types of work.

At the same time, in the perspective of research, it is necessary to significantly develop the base of physical and mathematical models that determine the vector fields of objects in dynamics over a certain time, taking into account the tontor step of the phantom and real spaces of the existence and operation of the object. Thus, hardware implementation of this hypothesis increases the accuracy of identification of objects of interaction with a human limb, regardless of its condition, and the accuracy of determining their relative location in space.

In further research, it is advisable to consider the ellipsoidal model of the tontor step as a distortion of the shape of the object or its trajectory of movement in space. This will make it possible to simulate the real shape of the surfaces of objects that interact with each other in various processes, in particular in technological processes, in the processes of recognition of the external environment by a bionic object.

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УДК 621.9.08

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ОСНОВНІ ПРИНЦИПИ ПРОСТОРОВОГО РОЗТАШУВАННЯ УЯВНОГО ТА РЕАЛЬНОГО КРОКУ ТОНТОР

У статті визначено актуальність моделювання параметрів просторового розташування абстрактного об’єкта при здійсненні різних функцій. Таким чином, моделювання надає можливості визначати траєкторії руху об’єкта і при промисловому застосуванні в технологічних процесах, і при застосуванні для створення біонічних об’єктів, наприклад, дії штучних кінцівок, коректування траєкторії руху об’єкта з вадами орієнтації в просторі.

Основною метою дослідження було обгрунтування аналітичних моделей руху об’єкта з врахуванням просторових координатних систем, за якими здійснюють перетворення координат при функціонуванні абстрактного об’єкта різного застосування.

Створення сенсорного комплексу компенсації порушень стану функцій кінцівок на підставі обгрунтування аналітичних моделей векторного поля основних систем об’єкта, характерних для його життєдіяльності, може вирішити можливість реальних дій абстрактного біотехнічного об’єкта при взаємодії з іншими об’єктами

зовнішнього середовища. Необхідним є порівняння ідеалізованих параметрів векторних полів із реальними плинними характеристиками досліджуваного об’єкта та визначення розходження як диференційної функції, яка відповідає діагностичним параметрам стану траєкторії руху кінцівок об’єкта. Або при застосуванні в промислових умовах враховують похибки відтворення траєкторії руху.

Як наслідок, дослідження характеру цієї функціональної залежності порушення стану та його відновлення в автоматизованому режимі роботи інтегрованого засобу, дозволить створення комп’ютерно-інтегрованого апаратурного рішення ідентифікації об’єктів, які взаємодіють у наближенні та торканні їх поверхонь.

Таким чином, визначення позиціонування ТОНТОР кроку в просторі руху об’єктів та при їх взаємодії надає можливості функціонування кожного абстрактного об’єкта при виконанні різних типів роботи.

Водночас, необхідно значно розвинути базу фізичних і математичних моделей, які визначають векторні поля об’єктів у динаміці упродовж певного часу, з урахуванням ТОНТОР кроку фантомного та реального просторів існування та роботи об’єкта. Таким чином, апаратурна реалізація цієї гіпотези підвищує точність ідентифікації об’єктів взаємодії з кінцівкою людини незалежно від її стану та точність визначення їх взаємного розташування у просторі.

Ключові слова: крок ТОНТОР; позиціювання; об’єкт; просторові координати; траєкторія руху; лінії поверхні.

Надійшла до редакції
15 лютого 2022 року

Рецензовано
26 квітня 2022 року