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MANAGEMENT OF STUDENTS' EDUCATIONAL ACTIVITY BY SEMANTIC NETWORKS IN ENGINEERING TRAINING

(УПРАВЛІННЯ НАВЧАЛЬНОЮ ДІЯЛЬНІСТЮ СТУДЕНТІВ ЗА ДОПОМОГОЮ СЕМАНТИЧНИХ МЕРЕЖ В ІНЖЕНЕРНОМУ НАВЧАННІ)

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Ключові слова: семантичні мережі, фрейм, граф, представлення знань, навчання, механіка.

У статті представлені семантичні мережі, які презентують відношення між фізичними величинами в механіці. Ці семантичні мережі сконструйовано на основі фреймового підходу. У статті подані методи застосування цих семантичних мереж для визначення різних величин (швидкості обертових частин механічних пристроїв, кутового прискорення). Обговорюються можливості застосування цих семантичних мереж для навчання інженерів, які розраховують та конструюють машини і механізми

Стаття присвячується пам'яті професора Марвіна Мінського – видатного вченого XX століття, який працював в галузі штучного інтелекту, штучних нейронних систем і когнітивних наук

1. Introduction

The modern society has several significance features: the information became the industrial strength; the information technologies have played a crucial role in the creation of new production technologies; the0p increasing role of sign in representation of knowledge.

These features are the reason why the modern society was called "information society". Information society imposes its own requirements on the forms and methods of a presentation of scientific, engineering and educational information. The consequence of these requirements was the appearance in 80 years of the twentieth century "frame approach" to knowledge representation (M. Minsky, 1979) [3]. The "frame approach" allows to build the semantic networks as graphs for knowledge representation and to use it for the engineering, science investigations and teaching.

The aim of this article is to build the semantic works as graphs of knowledge representation in mechanics and to use it for the training of engineering students which calculate the machines and the mechanisms.

2. Methodology

The graphs have been used in the mechanics at first for the representation of an energy circulation in physical systems (H. Paynter, 1969 and D. Findeisen) [4; 1]. These graphs have been called "bond graphs", its basic idea has been expressed as "effort – flow". The bond graphs are the exact tool for the representation of the general structure of the energy in the system and for an investigation of relationships between its characteristics (J. Wojnarowski, 1981–2012) [13–17]. Bond graphs played a significant role in the development of the mechanics, but they have one shortcoming: they were built for each individual task, but not for a class of problems.

This problem can be solved with use frame approach to construct of the graph. "Frame" is the cognitive scheme that can be filled out by variety information. The frame can be expressed in a graphic or a verbal form. The frame in a graphic form consists of *vertices* and *arcs*. The vertices have the values and the arcs express the relationship between vertices (Harary F., 1973 and Schmidt G., Str hlein Th., 1989) [2; 5]. The frame that is unfilled by the information (vertices and arcs) is called "*proto-frame*", the filled frame is called "*exo-frame*". Expert systems use the relationships of "is", "has", "there". The graphs built with use such relationships have been called "semantic networks". Such semantic networks have the shortcoming that is common with bond graphs: they could be built for each task only therefore they are not an instrument for solving of the class of problems. Let us to use the other relationships between the values for the building of knowledge representation in the mechanics, namely: "differentiation" and "integration". Let us build the proto-frame with use of these relationships: if B1 and B2 are the values, D1 is the operator of the differentiation and D2 is the operator of the integration (fig. 1).

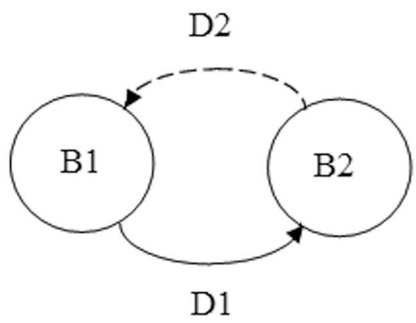

Fig. 1. The proto-frame with relatioships called "differentiation" and "integration"

Let's fill out the vertices and the arcs of the proto-frame by the information from the kinematics: the linear and circular motion. We receive the exo-frames (fig. 2).

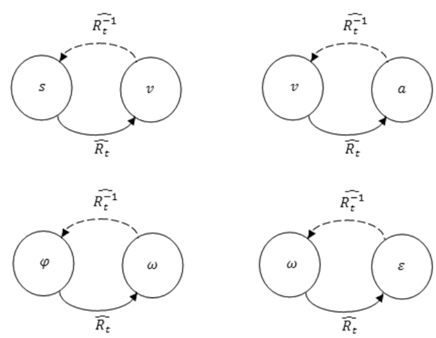

Fig. 2. The exo-frames in the kinematics showing the relation between the distances (s, φ), velocities (v, ω) and accelerations (a, ε) defined for the linear and circular motion

The exo-frames use the operator of the differentiation $(D1 = \hat{R}_t)$ and the operator of the integration $(D2 = \hat{R}_t^{-1})$. The action of the operators $\hat{R}_t$ and $\hat{R}_t^{-1}$ can be demonstrated, for example, for the distance s and the velocity v with use of equations (1, 2):

$$\hat{R}_t s(t) = \frac{ds(t)}{dt}, \qquad (1)$$

$$\widehat{R}_t^{-1} v(t) = \int_{t_1}^{t_2} v(t) dt . \qquad (2)$$

Let’s connect the vertices which have the equal values (for example, v or ω on fig. 2). Let’s connect the vertices with values which are different by a coefficient (for example, a and ε : $a = R\varepsilon$) by ribs. We receive the semantic network as graph GK for knowledge representation in kinematics (fig. 3).

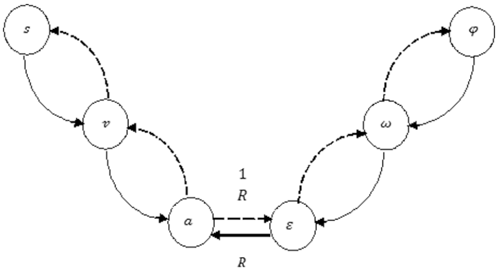

Fig. 3. The semantic network as graph GK which represent the knowledge in kinematics. The continuous arcs mark the differential operator $\widehat{R}_t$; the dotted arcs mark the integrated operator $\widehat{R}_t^{-1}$. The ribs represent the multiplication on the numeric coefficient.

Let’s build the semantic network for knowledge representation in mechanics. Let’s create the four exo-frames in dynamics (fig. 4).

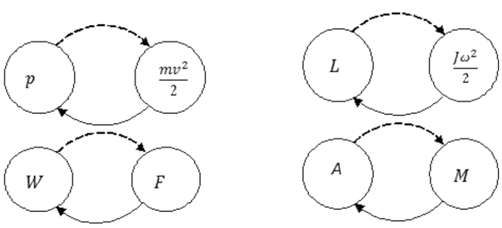

Fig. 4. The exo-frames in dynamics showing the relations between the values: impuls (p) and kinetic energy ($\frac{mv^2}{2}$); angular momentum (L) and angular kinetic energy $\left(\frac{J\omega^2}{2}\right)$; force () and work (); torgue () and work of the force moment (A).

Let's build the semantic network as graph GM, applying the same principles that were applied in the construction of the graph GK (fig. 5).

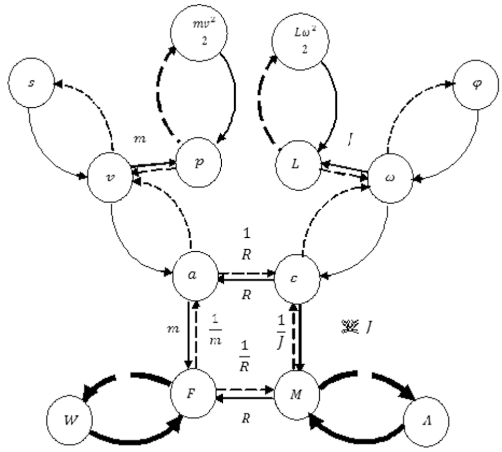

Fig. 5. The graph GM for knowledge representation in the mechanics

The fine continuous arcs on fig. 5 designate the differential operator $\widehat{R}_t$; the fine dotted arcs indicate the integrated operator $\widehat{R}_t^{-1}$; the medium thickness continuous arcs designate the differential operators $\widehat{R}_v$ for translational motion and $\widehat{R}_\omega$ for rotational motion respectively; the medium thickness dotted arcs designate the differential operator $\widehat{R}_v^{-1}$ for translational motion and $\widehat{R}_\omega^{-1}$ for rotational motion respectively; the thick continuous arcs designate the differential operator $\widehat{R}_x$ for translational motion and $\widehat{R}_\phi$ for rotational motion respectively; the thick dotted arcs designate the differential operator $\widehat{R}_x^{-1}$ for translational motion and $\widehat{R}_\phi^{-1}$ for rotational motion respectively.

The semantic networks GK and GM can be used to calculate the parameters of rotational and translational motion of the various parts of machines and mechanisms.

3. Results

The semantic networks GK and GM are connected graphs then we can find the routes to solve the tasks for calculation of machines. Some examples are presented early (V. Shvets, 2007–2014) [6–12].

Let us consider several tasks for calculation of machines and mechanisms.

Example 1. To define the angular speed of a flywheel this rotates according to the law $\phi(t) = A + Bt + Ct^2$ through $2s$ from a start of a motion where: $B = 16\frac{rad}{s}$, $C = 2\frac{rad}{s^2}$.

Let's use the semantic network GK for solving of this task. The route for solving is: $\left(5, \widehat{R}_t, 3\right)$, where the numbers of vertices and arc designed in brackets. Let's run the actions in accordance of this route:

$$\omega(t) = \widehat{R}_t \phi(t) = B + 2Ct \qquad (3)$$

Substituting into equation (3) the values of B, C, t we receive the solving of task: $\omega(2) = 8\left(\frac{rad}{s}\right)$.

Example 2. To find the angular speed of the flywheel made as a disk with the moment of inertia $J = 40kgm^2$, under the influence of the force moment $M = 20Nm$ throught $3s$ from the start of the motion.

Let's use the semantic network GK for solving of this task. The route for solving is: $\left(1, \widehat{R}_t^{-1}, 3\right)$, where the numbers of vertexes and arc designed in brackets. Let's run the actions in accordance of this route:

$$\omega(t) = \widehat{R}_t^{-1} \varepsilon(t) = \int_0^t \varepsilon(t)dt = \int_0^t \frac{M}{J}dt = \frac{M}{J}t. \qquad (4)$$

Substituting into equation (4) the values of M, J, t we receive the solving of task: $\omega(3) = 1.5\left(\frac{rad}{s}\right)$.

Example 3. The work done flywheel depends from ϕ on the law: $A(\phi) = k\phi$, where $k = 2Nm$. To define the angular acceleration of the flywheel from time, if parameters of the flywheel are: $m = 5kg, r = 50cm$

Let's use the semantic network GM for solving of this task. The route for solving is: $\left(9, \widehat{R}_\phi, 1\right)$, where the numbers of vertices and arc designed in brackets. Let's run the actions in accordance of this route:

$$J\varepsilon = \widehat{R}_\phi A(\phi) = \frac{dA(\phi)}{d\phi} = k. \qquad (5)$$

Substituting to equation (5) the value of $J = \frac{mr^2}{2}$ and k, we receive the value of angular acceleration: $\varepsilon = 320\frac{rad}{s^2}$.

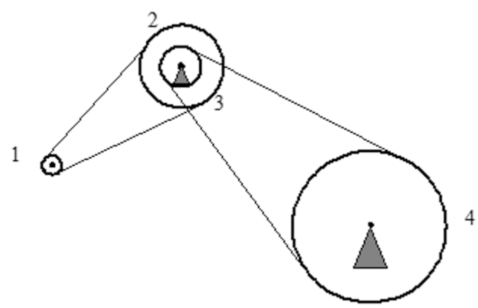

Fig. 6. The belts drive of movement transferred from the disk 1 to the disk 4

Example 4. The movement from the disk 1 to the disk 4 is transferred by means of two belt drives. Disks 2 and 3 are rigidly fixed on the axis (fig. 6). Radiuses of disks are equal: $r_1 = 8cm$, $r_3 = 10cm$, $r_4 = 50cm$. The equation rotation of the disk 1 looks like to

$\phi_1(t) = A + Bt + Ct^2$, where $B = 16\frac{rad}{s}$, $C = -2\frac{rad}{s^2}$. Find the equation rotation of the disk 4.

Let's find the solution by several steps.

Step 1. Let's execute the differential transition from vertex 5 to vertex 3 of the semantic network GK by route $(5, \widehat{R}_t, 3)$ and find the angular speed of the disk 1:

$$\omega_1(t) = \widehat{R}_t\phi_1(t) = B + 2Ct \qquad (6)$$

Step 2. Let's find the angular speed of the disk 2, given that at the belt of the movement linear speed both disk during each moment of the time is identical:

$$\omega_1(t)r_1 = \omega_2(t)r_2, \qquad (7)$$

from where:

$$\omega_2(t) = \omega_1(t)\frac{r_1}{r_2}. \qquad (8)$$

Step 3. Let's find the angular speed of the disk 3, given that the disk 2 and the disk 3 are rigidly fixed on the general axis, therefore its angular speeds are equal:

$$\omega_3(t) = \omega_1(t)\frac{r_1}{r_2} \qquad (9)$$

Step 4. Let's find the angular speed of the disk 4, given that linear speed of both disk (3 and 4) is identical at the belt drive of movement from the disk 3 to the disk 4:

$$\omega_3(t)r_3 = \omega_4(t)r_4, \qquad (10)$$

from where:

$$\omega_4(t) = \omega_1(t)\frac{r_1 r_2}{r_2 r_4} \qquad (11)$$

Substituting to equation (11) the data of task condition we receive:

$$\omega_4(t) = D + Ft \qquad (12)$$

where $D = 0.8\frac{rad}{s}$, $F = -0.2\frac{rad}{s^2}$.

Step 5. Let's execute the integral transition from vertex 3 to vertex 5 of the graph GK by route $(3, \widehat{R}_t^{-1}, 5)$ and find the equation rotation of the disk 4.

$$\phi_4(t) = \int_0^t \omega_4(t)dt = \int_0^t (D + Ft)dt = Dt + F\frac{t^2}{2}, \qquad (13)$$

where $D = 0.8\frac{rad}{s}$, $F = -0.2\frac{rad}{s^2}$.

Conclusion

Thus, the semantic networks as relational graphs of knowledge representations in mechanics have been created on a basic of the frame approach. These semantic networks are connected graphs and it allows finding the routes for the definition of different values in mechanics: the speed, the acceleration, the energy of the movement ets. The features of these semantic networks are that the new types of relations have been used: differential and integrational relations between physical quantities.

Such semantic networks are the convenient tools for engineering training and for calculations, for the design and for the creating of different parts of machines and mechanisms and can easily be programmed.

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