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MOTION CHARACTERISTIC CODE AT THE SCREW MOTION FOR SOME BASIC KINEMATICS BLOCKS USING DUAL-VECTOR ALGEBRA

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ABSTRACT
In this paper the motion characteristic code that complies to functional synthesis during the mechanisms design is elaborated.
Motion characteristic code includes motion, continuity, linearity and direction of kinematics blocks.
Screw motion using dual-vector algebra in its general presentation includes dual number, direction and position vector of motion that fulfils topological synthesis during the mechanisms design process.
Motion characteristic code at the screw motion for a number of basic kinematics blocks are also given in the paper.

Key words: Motion characteristic code, screw motion, dual-vector, dual-number, basic kinematics blocks, input motion, output motion, spatial orientation.

1. INTRODUCTION

The concept of mechanisms design includes four phases: (1) motion characteristics, (2) functional design, (3) design topology and (4) dimensional synthesis.
In this paper the functional synthesis is elaborated including solution of building blocks using Motion Characteristic Code (MCC) and topological synthesis which includes assembling of the building blocks using dual-vector algebra [1,2,5].
The mechanism building blocks with single kinematics degree of freedom – one input and one output desired motion are discussed in this paper.
In this paper Motion Characteristic Code (MCC) includes motion, continuity, linearity and direction of kinematics blocks [1].
The dual-vector algebra contains information for the type of motion, its direction and its position [1,5,7,8].
During the synthesis of the mechanisms for several basic kinematics blocks has been given: (1) Input Motion Characteristic Code and Input Screw Motion (2) Output Motion Characteristic Code and Output Screw Motion and (3) Basic Kinematics Block (Figure 1, 2, 3) [1].

2. METODOLOGY OF DUAL - VECTOR ALGEBRA

It is known that motion of any solid body in three-dimensional space can be represented through screw kinematic couples [4].
Screw can be represented by displacement and line. Line contains the information about position and direction of the motion. Displacement represents the transformation between rotational and

translational motion. The motion transformation can be divided into a dual-number and dual-vector [1, 4, 5].
The final expression for screw motion for basic kinematics block is given as:

$$\hat{S} = (\alpha + \varepsilon a)\left[\begin{Bmatrix} l_x \\ l_y \\ l_z \end{Bmatrix} + \varepsilon \begin{Bmatrix} r_y l_z - r_z l_y \\ r_z l_x - r_x l_z \\ r_x l_y - r_y l_x \end{Bmatrix}\right] \quad (1)$$

3. METODOLOGY OF MOTION CHARACTERISTIC CODE (MCC)

Some authors, the motion in input and output of the kinematics block have used Motion Transformation Matrices of First Level (MTL^1) and Operational Constraint Vector (OCV) [2, 3, 5, 6]. Similarly, in this paper Motion Characteristic Code (MCC) including data is used to determine the type of motion, continuity, linearity and direction of building blocks.

Table1. Motion Characteristic Code (MCC)

MOTION CHARACTERISTIC CODE (MCC)			
Motion type	Continuity	Linearity	Direction
Rotation (Value: 0)	Continuous (Value: 0)	Linear (Value: 0)	Unidirectional (Value:0)
Translation (Value: 1)	Intermittent (Value: 1)	Non-Linear (Value: 1)	Bidirectional (Value:1)
Screw (Value: 2)			

Table 2.Representation of motion characteristics

<table>
<tr><th>CATEGORY</th><th colspan="18">VALUE</th></tr>
<tr><td><u>Motion Type</u>
Rotation: 0
Translation: 1
Screw: 2</td><td colspan="6">0</td><td colspan="6">1</td><td colspan="6">2</td></tr>
<tr><td><u>Continuity</u>
Continuous: 0
Intermittent: 1</td><td colspan="4">0</td><td colspan="2">1</td><td colspan="4">0</td><td colspan="2">1</td><td colspan="4">0</td><td colspan="2">1</td></tr>
<tr><td><u>Linearity</u>
Linear: 0
Non-Linear: 1</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">0</td><td colspan="2">1</td><td colspan="2">1</td></tr>
<tr><td><u>Periodic</u>
Yes: 0
No: 1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr>
</table>

Motion Characteristic Code from the *Table 1* can be described by:

$$MCC = (MotionType, Continuity, Linearity, Direction) \quad (2)$$

Therefore it is notable that Motion Characteristic Code contains four elements. For example, a simple rotational motion of an electric motor is coded as 0000 meaning rotation, continuity, linearity and unidirectional motion.
In the *Table 2* has been given all possibilities to identify kinematics function of building blocks during synthesis process.
Kinematics function for each building block is presented correctly through two Motion Characteristic Codes: the first one represents characteristics of input motion and the second one characteristics at output.

4. MOTION CHARACTERISTIC CODE (MCC) AND SCREW MOTION FOR SOME BASIC KINEMATIC BLOCKS

Analyzing screw motion for simple order kinematics couples and their synthesis, the high order kinematics couples can be realized.

Therefore, for a number of basic kinematics blocks are given: motion characteristic code (MCC), screw motion input and output, type of the basic kinematics block and spatial orientation [1].

4.1. Basic kinematics block – Pulley-Belt (Figure 1)

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	**OUTPUT**
0-Rotation 0-Continuous 0-Linear 0-Unidirectional	0-Rotation 0-Continuous 0-Linear 0-Unidirectional

Input: $l_x = 0; r_x = 0$ Output: $l_x = 0; r_x = D$

$l_y = 0; r_y = 0$ $l_y = 0; r_y = 0$

$l_z = 1$ $l_z = -1; r_z = 0$

Input MCC (0000): $$\hat{S}_I = (\theta_I + \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\0\end{Bmatrix}\right]. \quad (3)$$

Output MCC (0000): $$\hat{S}_O = (G(\theta_I) + \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\-1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\D\\0\end{Bmatrix}\right]. \quad (4)$$

4.2. Basic kinematics block – Six-bar dwell linkage (Figure 2)

Input MCC (0000): $$\hat{S}_I = (\theta_I + \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\0\end{Bmatrix}\right]. \quad (5)$$

Output MCC (0010): $$\hat{S}_O = (F(\theta_I) + \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\-(D_1 + D_2)\\0\end{Bmatrix}\right]. \quad (6)$$

4.3. Basic kinematics block – Sprocket –Chain (Figure 3)

Input MCC (0000): $$\hat{S}_I = (\theta_I + \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\0\\1\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\0\end{Bmatrix}\right]. \quad (7)$$

Output MCC (0000): $$\hat{S}_O = (G(\theta_I) + \varepsilon \cdot 0)\left[\begin{Bmatrix}0\\1\\0\end{Bmatrix} + \varepsilon\begin{Bmatrix}0\\0\\D\end{Bmatrix}\right]. \quad (8)$$

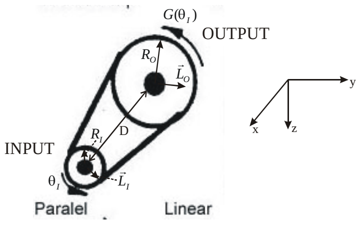

Figure 1 Pulley-Belt

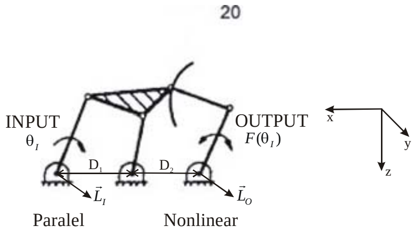

Figure 2 Six-bar dwell linkage

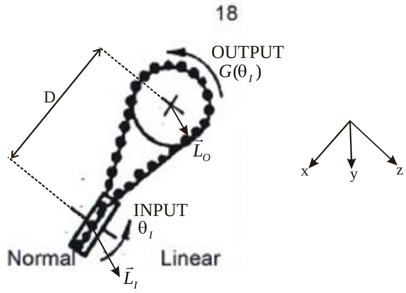

Figure 3 Sprocket-Chain

4. CONCLUSIONS

Based on analysis of the synthesis methodology of the mechanisms using motion characteristic code and dual-vector algebra, representation of input-output of the screw motion and motion characteristic code for three basic kinematics blocks, can be concluded that:

- Through Motion Characteristic Code (MCC) the functional synthesis at mechanisms design can be done;
- Motion Characteristic Code (MCC) comparing to Operational Constrained Vector (OCV) is simpler for operation during the mechanisms design;
- Through dual-vector algebra the topological synthesis for mechanisms design can be used;
- The determination of the screw motion at input and output using dual-vector for basic kinematics blocks presents a good base for synthesis of the high order mechanisms;
- The methodology of Motion Characteristic Code (MCC) and dual-vector algebra enables realization of a high number of alternate solutions on mechanisms design.

5. REFERENCES

[1] Buza K.: Kontribut sintezës së mekanizmave duke shfrytëzuar algjebrën e vektorit-dual, Disertacioni i doktoraturës (Doctorate thesis), Prishtina, 2006

[2] Buza K.: Disajnimi automatik i mekanizmave me ndihmen e programeve aplikative, Punim magjistrature, (Master science work), Prishtina, 2003

[3] Buza K., Pirraj B., Gojani I., Pajaziti A., Anxhaku A.: General Matrix Model at the Second Level of Automatic Synthesis Procedre of the Mechanisms, Proceedings of the 10th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2006, Barcelona –Lloret de Mar, Spain, 11-15 September, 2006, pp. 785-788.

[4] Buza K., Gojani I., Pajaziti A., Anxhaku A.: Screw Motion of Some Basic Kinematic Blocks Through Dual-Vector Algebra, Proceedings of the 11th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology", TMT 2007, Hammamet, Tunisia, 05-09 September, 2007, pp. 891-894.

[5] Moon Y.-M., Kota S.: Automated synthesis of mechanisms using dual-vector algebra, Mechanism and Machine Theory 37, pp.143-166, Ann Arbor, 2002

[6] Waldron K. J., Kinzel G. L.: Kinematics, Dynamics and Design of Machinery, Second Edition, John Wiley and Sons, USA, 2004.

[7] R.Featherstone, Plücker Basis Vectors, Department of Information Engineering, The Australian National University.

[8] Y.-M.Moon, Reconfigurable Machine Tool Design: Theory and Application, Ph.D. Dissertation, The University of Michigan, Ann Arbor, Michigan, 2000.