Serial, Anthropomorphic, Spatial, Mechatronic Systems can be Studied More Simply in a Plan

Abstract: The mobile, mechatronic, robotic, serial, spatial, anthropomorphic type systems, which are currently the most used in the machine building industry, can be studied much more simply in a plan instead of the usual spatial study. This not only simplifies the understanding of these systems (including from a didactic point of view) but also facilitates computational methods, moving from matrix analytical methods to more simple classical methods. Usage is done by conversion, so nothing is lost from the essence of physical-mathematical phenomena. The idea of moving from spatial to planar study has been centered over time on all major mechanisms when it was possible, precisely for ease of calculation and working methods, but also for a better understanding of physical phenomena. The vast majority of classical mechanisms can be treated as they move in most cases into a master plan. This is the case with known mechanical transmissions, classic motors of all types, working mechanisms, engine or lucrative cars, etc. In anthropomorphic robots, the method is no longer used because they work clearly in a well-defined space. We used the idea to divide this space into a main work plan that can rotate around a main axis so that the study of all movements is done in the workplan and then the rotations of these parameters corresponding to the rotation of the work plane around the main axis of rotation. The physical-mathematical methods are greatly simplified in this way, from matrix difficult calculations to simple, classical analytical calculation methods.

Keywords: Anthropomorphic Robots, Kinematics, 3D calculation, 2D calculation

Introduction

The mobile, mechatronic, robotic, serial, spatial, anthropomorphic type systems, which are currently the most used in the machine building industry, can be studied much more simply in a plan instead of the usual spatial study. This not only simplifies the understanding of these systems (including from a didactic point of view), but also facilitates computational methods, moving from matrix analytical methods to more simple classical methods. Usage is done by conversion, so nothing is lost from the essence of physical-mathematical phenomena. The idea of moving from spatial to planar study has been centered over time on all major mechanisms when it was possible, precisely for ease of calculation and working methods, but also for a better understanding of physical phenomena. The vast majority of classical mechanisms can be treated as they move in most cases into a master plan. This is the case with known mechanical transmissions, classic motors of all types, working mechanisms, engine or lucrative cars, etc. In anthropomorphic robots, the method is no longer used because they work clearly in a well-defined space. We used the idea to divide this space into a main work plan that can rotate around a main axis so that the study of all movements is done in the workplan and then the rotations of these parameters corresponding to the rotation of the work plane around the main axis of rotation. The physical-mathematical methods are greatly simplified in this way, from matrix difficult calculations to simple, classical analytical calculation methods.
rotations of these parameters corresponding to the rotation of the work plane around the main axis of rotation. The physical-mathematical methods are greatly simplified in this way, from matrix difficult calculations to simple, classical analytical calculation methods.

Today the moving mechanical systems are utilized in almost all vital sectors of humanity (Reddy et al., 2012). The robots are able to process integrated circuits (Aldana et al., 2013) sizes micro and nano, on which the man they can be seen only with electron microscopy (Lee, 2013). Dyeing parts in toxic environments, working in chemical and radioactive environments (Padula and Perdereau, 2013; Perumaal and Jawahar, 2013), or at depths and pressures at the deep bottom of huge oceans, or conquest of cosmic space and visiting some new exoplanets, are with robots systems possible (Dong et al., 2013) and were turned into from the dream in reality (Garcia et al., 2007), because of use of mechanical platforms sequential gearbox (Cao et al., 2013; Petrescu et al., 2009). The man will be able to carry out its mission supreme (Tang et al., 2013; Tong et al., 2013), conqueror of new galaxies (de Melo et al., 2012), because of mechanical systems sequential gear-box (robotics systems) (Garcia-Murillo et al., 2013).

Robots were developed and diversified (Lin et al., 2013), different aspects (He et al., 2013), but today, they start to be directed on two major categories: Systems serial (Liu et al., 2013; Petrescu and Petrescu, 2011b) and parallel systems (Petrescu and Petrescu, 2012c). Parallel systems are more solid (Tabaković et al., 2013; Wang et al., 2013) but more difficult to designed and handled and for this reason, the serial systems were those which have developed the most. In medical operations or radioactive environments are preferred mobile systems parallel, because of their high accuracy positioning.

As examples of such combined mechanisms, several kinematic schemes of gears and gears can be observed, presented by Kojevnikov (1969; AUTORENKOLLEKTIV, 1968; Şaskin, 1963; 1971; Maros, 1958; Rehwald et al., 2000; 2001; Antonescu, 1993; 2003; Antonescu and Mitračhe, 1989).

The main problems with plane and spatial gears and gears refer to kinematic analysis and geometric-kinematic synthesis under certain conditions imposed by technological processes, Bruja (2001; Buda and Mateucă, 1989; Luck and Modler, 1995; Niemeyer, 2000; Tutunaru, 1969; Popescu, 1977; Braune, 2000; Dudita, 1989; Lichtenheldt, 1995; Lederer, 1993; Lin, 1999; Modler et al., 1998; Modler and Wadewitz, 2001; Modler, 1979; Neumann, 1979; 2001; Stoica, 1977; Petrescu and Petrescu, 2011c-d; Petrescu, 2012d-e; Petrescu, 2016; Petrescu et al., 2017a-q; Aversa et al., 2017a-c; 2016a-o; Mirsayar et al., 2017; Petrescu and Petrescu, 2016a-c; 2013a-d; 2012a-d; 2011a-b; Petrescu, 2012a-c; 2009; Petrescu and Calautit, 2016a-b; Petrescu et al., 2016a-b; Maros, 1958; Modler and Wadewitz, 2001; Manolescu, 1968; Margine, 1999).

Materials and Methods

Figure 1 shows the geometric-kinematic scheme of a base structure 3R.

From this platform you can study by adding any other modern n-R scheme.

![Fig. 1: The geometric-kinematic scheme of a base structure 3R](image-url)
The platform (system) of Fig. 1 has three degrees of mobility, made by three actuators (electric motors) or actuators. The first electric motor trains the entire system in a rotation motion around a vertical axis O0z0. The motor (actuator) number 1 is mounted on the fixed member (bay, 0) and drives the mobile element 1 in a rotation motion around a vertical axis. On the mobile element 1, then all the other components (components) of the system are built.

There follows a planar (vertical) cinematic chain consisting of two movable elements and two kinematic motor couplings. It is the movable kinematic elements 2 and 3, the assembly 2,3 being moved by the second actuator mounted in the coupling A fixed on the element 1. Thus the second electric motor fixed by the element 1 will drive the element 2 in a relative rotation relative to element 1, but automatically it will move the entire kinematic chain 2-3.

The last actuator (electric motor) fixed by element 2 in B will rotate element 3 (relative to 2).

The rotation \( \varphi_{10} \) made by the first actuator is also relative (between elements 1 and 0) and absolute (between elements 1 and 0).

The rotation \( \varphi_{20} \) of the second actuator is also relative (between elements 2 and 1) and absolute (between elements 2 and 0) due to the positioning of the system.

The rotation \( \varphi = \varphi_{32} \) of the third actuator is only relative (between elements 3 and 2), the corresponding absolute (between elements 3 and 0) being a function of \( \varphi = \varphi_{32} \) and \( \varphi_{20} \).

The kinematic chain 2-3 (made up of moving kinematic elements 2 and 3) is a planar cinematic chain that falls into one plane or one or more parallel planes. It is a special cinematic system that will be studied separately. The kinematic coupler A (O2) and B (O3) become the first fixed coupler and the second movable coupler, both of which are C5 cinematic couplers, of rotation.

In order to determine the degree of mobility of the planar kinematic chain 2-3, the structural formula given by relation (1), where \( m \) represents the number of movable elements of the planar kinematic chain, in our case \( m = 2 \) (with respect to the two moving kinematic elements 2 and 3) and C5 represents the number of fifth order kinematic couplings, in the present case C5 = 2 (with the A and B or O2 and O3 couplings):

\[
M_s = 3 \cdot m - 2 \cdot C_5 = 3 \cdot 2 - 2 \cdot 2 = 6 - 4 = 2
\]

The kinematic chain 2-3 having the degree of mobility 2 must be driven by two motors.

It is preferred that the two actuators are two electric, DC, or alternating motors. The action can also be done with other engines. Hydraulic, pneumatic, sonic, etc.

The schematic diagram of the planar kinematic chain 2-3 (Fig. 2) resembles its kinematic scheme.

The three electric motors (actuators) in Fig. 1 drive the mobile platform (system) 1.

Fig. 2: The schematic diagram of the planar kinematic chain 2-3 bound to the element 1 considered to be fixed.

The guide element 2 is connected to the fixed element 1 by the motor coupler O2 and the drive element 3 is connected to the mobile element 2 by the motor coupler O3.

This results in a two-degree open cinematic chain made by the two actuators, ie the two electric motors mounted in the kinematic couplers A and B or O2 or O3.

**Results; Direct Kinematics of the Plan 2-3**

Figure 3 shows the cinematic diagram of the open 2-3 chain (Petrescu, 2014).

The kinematic parameters \( \varphi_{20} \) and \( \varphi_{30} \) are known in kinematics and must be determined by analyzing the parameters \( x_M \) and \( y_M \), which represent the scaled coordinates of the point M (endeffector M).

The \( d_2 + d_3 \) vectors are projected onto the Cartesian axis system considered fixed, xOy, identical to xO2y2. The system of scalar equations is obtained (2):

\[
\begin{align*}
-x_{2M} &= x_u + x_{\alpha} + x_{3M} = d_z \cdot \cos \varphi_{20} + d_1 \cdot \cos \varphi_{30} = d \cdot \cos \phi \\
y_{2M} &= y_u + y_{\alpha} + y_{3M} = d_z \cdot \sin \varphi_{20} + d_1 \cdot \sin \varphi_{30} = d \cdot \sin \phi
\end{align*}
\]

After determining the cartesian coordinates of the M point using the relations given by the system (2), the parameters of the angle can be obtained immediately using the relations established within the system (3):

\[
\begin{align*}
\cos \phi &= \frac{x_u}{d} = \frac{x_u}{\sqrt{x_u^2 + y_u^2}} \\
\sin \phi &= \frac{y_u}{d} = \frac{y_u}{\sqrt{x_u^2 + y_u^2}} \\
\phi &= \text{sign} \cdot \arccos \left( \frac{x_u}{d} \right)
\end{align*}
\]

\[
M_s = 3 \cdot m - 2 \cdot C_5 = 3 \cdot 2 - 2 \cdot 2 = 6 - 4 = 2
\]
The system (2) is written more concise in the time-dependent form (4), resulting in the speed system (5), which derives from time, in turn generates the acceleration system (6):

\[
\begin{align*}
x_v &= d_2 \cdot \cos \theta_0 + d_2 \cdot \cos \phi_0 \\
y_v &= d_2 \cdot \sin \theta_0 + d_2 \cdot \sin \phi_0 \\
\phi_v &= \frac{d_2 \cdot \sin \theta_0 + d_2 \cdot \sin \phi_0}{d_2} \\
\end{align*}
\]

\[
\begin{align*}
\dot{x}_v &= \dot{d}_2 \cdot \cos \theta_0 + \dot{d}_2 \cdot \cos \phi_0 - d_1 \cdot \sin \theta_0 \cdot \omega_{30} \\
\dot{y}_v &= \dot{d}_2 \cdot \sin \theta_0 + \dot{d}_2 \cdot \sin \phi_0 - d_1 \cdot \cos \theta_0 \cdot \omega_{30} \\
\dot{\phi}_v &= \frac{\dot{d}_2 \cdot \sin \theta_0 + \dot{d}_2 \cdot \sin \phi_0}{d_2} - d_1 \cdot \cos \theta_0 \cdot \omega_{30} \\
\end{align*}
\]

\[
\begin{align*}
x_a &= \ddot{x}_v - \dot{d}_2 \cdot \cos \theta_0 \cdot \omega_{30}^2 - d_1 \cdot \cos \theta_0 \cdot \omega_{30}^2 \\
y_a &= \ddot{y}_v - \dot{d}_2 \cdot \sin \theta_0 \cdot \omega_{30}^2 - d_1 \cdot \sin \theta_0 \cdot \omega_{30}^2 \\
\phi_a &= \frac{\ddot{d}_2 \cdot \sin \theta_0 + \ddot{d}_2 \cdot \sin \phi_0}{d_2} - d_1 \cdot \cos \theta_0 \cdot \omega_{30}^2 \\
\end{align*}
\]

Note: The angular speeds of the actuators were considered constant (relations 7):

\[
\dot{\phi}_0 = \alpha_0 = ct; \theta = a0 \Rightarrow \sin \theta_0 = ct
\]

Is considered \( e_{30} = \dot{\theta} = e_{30} = 0 \)

Relationships (3) are also derived and the velocity (8) and acceleration (9) systems are obtained:

\[
\begin{align*}
d^2 &= x_{\hat{M}} + y_{\hat{M}} \\
2 \cdot d \cdot \dot{d} &= 2 \cdot x_{\hat{M}} \cdot \dot{x}_{\hat{M}} + 2 \cdot y_{\hat{M}} \cdot \dot{y}_{\hat{M}} \\
d \cdot \dot{d} &= x_{\hat{M}} \cdot \dot{x}_{\hat{M}} + y_{\hat{M}} \cdot \dot{y}_{\hat{M}} \\
d \cdot \cos \phi &= x_{\hat{M}} \\
d \cdot \sin \phi &= y_{\hat{M}} \\
\dot{d} \cdot \cos \phi - d \cdot \sin \phi \cdot \dot{\phi} &= \dot{x}_{\hat{M}} \cdot (- \sin \phi) \\
\dot{d} \cdot \sin \phi + d \cdot \cos \phi \cdot \dot{\phi} &= \dot{y}_{\hat{M}} \cdot (\cos \phi) \\
\dot{\phi} &= \frac{\dot{x}_{\hat{M}} \cdot (- \sin \phi) + \dot{y}_{\hat{M}} \cdot (\cos \phi)}{d} \\
\ddot{\phi} &= \frac{x_{\hat{M}} \cdot \dot{x}_{\hat{M}} + y_{\hat{M}} \cdot \dot{y}_{\hat{M}}}{d}
\end{align*}
\]
\[
\frac{d^2}{dt^2} = x_{d, \theta}^2 + \frac{y_{O3}^2}{d^2}
\]
\[
2 \cdot \ddot{d} = 2 \cdot \dot{x}_{M} \cdot \dot{x}_{M} + 2 \cdot \dot{y}_{M} \cdot \dot{y}_{M}
\]
\[
\ddot{d} = \dot{x}_{M} \cdot \dot{x}_{M} + \dot{y}_{M} \cdot \dot{y}_{M}
\]
\[
d^2 + d \cdot \ddot{d} = x_{M}^2 + y_{M}^2 + y_{O3}^2 + \dot{y}_{O3} \cdot \dot{y}_{O3}
\]
\[
\ddot{d} = x_{O3}^2 + x_{O3} \cdot \dot{x}_{O3} + y_{O3} \cdot \dot{y}_{O3} + y_{O3} \cdot \dot{y}_{O3} - \dot{d}^2
\]

\[
\dot{d} \cdot \cos \phi = x_{O3}
\]
\[
\dot{d} \cdot \sin \phi = y_{O3}
\]
\[
d \cdot \cos \phi - d \cdot \sin \phi \cdot \dot{\phi} = \dot{x}_{O3} \cdot (-\sin \phi)
\]
\[
d \cdot \sin \phi + d \cdot \cos \phi \cdot \dot{\phi} = \dot{y}_{O3} \cdot (\cos \phi)
\]

\[
\dot{d} = \frac{x_{O3} + x_{O3} \cdot \dot{x}_{O3} + y_{O3} + y_{O3} \cdot \dot{y}_{O3} - \dot{d}^2}{d}
\]

Next, positions, speeds and accelerations will be determined, depending on the scaled positions of point O3. Start from the scaled coordinates of point O3 (10):

\[
\begin{align*}
\dot{x}_{O3} &= d \cdot \cos \phi_{O3} \\
\dot{y}_{O3} &= d \cdot \sin \phi_{O3}
\end{align*}
\]

The absolute speed of the O3 point (speed module) is given by the relationship (13):

\[
v_{O3} = \sqrt{x_{O3}^2 + y_{O3}^2}
\]

\[
= \sqrt{d^2 \cdot \alpha_{O3}^2 \cdot \sin^2 \phi_{O3} + d^2 \cdot \alpha_{O3}^2 \cdot \cos^2 \phi_{O3}}
\]

\[
= \sqrt{d^2 \cdot \alpha_{O3}^2}
\]

\[
= d \cdot \alpha_{O3}
\]

The absolute acceleration of the O3 point for constant angular velocity is given by the relationship (14):

\[
a_{O3} = \frac{x_{O3} \cdot \dot{x}_{O3} + y_{O3} \cdot \dot{y}_{O3}}{d}
\]

\[
= \frac{d^2 \cdot \alpha_{O3}^2 \cdot \cos \phi_{O3} + d^2 \cdot \alpha_{O3}^2 \cdot \sin \phi_{O3}}{d^2 \cdot \alpha_{O3}^2}
\]

\[
= \frac{d^2 \cdot \alpha_{O3}^2}{d^2 \cdot \alpha_{O3}^2}
\]

\[
= \alpha_{O3}
\]

The scalar kinematic parameters of the M point, endefactor, will also be determined, depending on the position parameters of the O3 and M points (relational systems 15-17):

\[
\begin{align*}
\dot{x}_{M} &= x_{O3} + d \cdot \cos \phi_{O3} \\
\dot{y}_{M} &= y_{O3} + d \cdot \sin \phi_{O3}
\end{align*}
\]

\[
\begin{align*}
\dot{x}_{M} &= \dot{x}_{O3} - d \cdot \sin \phi_{O3} \cdot \alpha_{O3} = -y_{O3} \cdot \alpha_{O3} \\
\dot{y}_{M} &= \dot{y}_{O3} + d \cdot \cos \phi_{O3} \cdot \alpha_{O3} = x_{O3} \cdot \alpha_{O3}
\end{align*}
\]

The scalar speeds and accelerations of the O3 point were made according to the initial positions (scaling) and the absolute angular velocity of the element 2. The angular velocity was considered constant.

**Discussion**

The technique of determining velocities and accelerations according to positions is extremely useful in the study of system dynamics, vibrations and noise caused by the system. This technique is common in studying system vibrations. The vibrations of the scalar positions of point O3 are known and the vibrations of the speeds and accelerations of that point as well as other points of the system are readily determined as a function of the known scaling positions of the O3 point. It is also possible to calculate the local noise levels at different points of the system as well as the overall noise level generated by the system with a sufficiently large approximation compared to the noise obtained by experimental measurements with the appropriate equipment. The study of system dynamics can also be developed by this technique.
The physical-mathematical methods are greatly simplified in this way, from matrix difficult calculations to simple, classical analytical calculation methods.

Acknowledgement

This text was acknowledged and appreciated by Dr. Veturia CHIROIU Honorific member of Technical Sciences Academy of Romania (ASTR) PhD supervisor in Mechanical Engineering.

Funding Information

Research Contract

1. Research contract: Contract number 36-5-4D/1986 from 24IV1985, beneficiary CNST RO (Romanian National Center for Science and Technology) Improving dynamic mechanisms

2. Contract research integration. 19-91-3 from 29.03.1991; Beneficiary: MIS; TOPIC: Research on designing mechanisms with bars, cams and gears, with application in industrial robots

3. Contract research. GR 69/10.05.2007: NURC in 2762; theme 8: Dynamic analysis of mechanisms and manipulators with bars and gears

4. Labor contract, no. 35/22.01.2013, the UPB, ”Stand for reading performance parameters of kinematics and dynamic mechanisms, using inductive and incremental encoders, to a Mitsubishi Mechatronic System” “PN-II-IN-CI-2012-1-0389”

All these matters are copyrighted! Copyrights: 394-qodGnhhtej, from 17-02-2010 13:42:18; 463-vpstuCGsiy, from 20-03-2010 12:45:30; 631-sqfsgqvutm, from 24-05-2010 16:15:22; 933-CrDztEfjqow, from 07-01-2011 13:37:52.

Author’s Contributions

This section should state the contributions made by each author in the preparation, development and publication of this manuscript.

Ethics

Authors should address any ethical issues that may arise after the publication of this manuscript.

References

Aldana, N.D., C.L. Trujillo and J.G. Guarnizo, 2013. Active and reactive power flow regulation for a grid connected vsc based on fuzzy controllers. Revista Facultad de Ingeniería, 66: 118-130.

Antonescu, P. and M. Mitrache, 1989. Contributions to the synthesis of the mechanisms used as windscreen wipers. SYROM'89, Bucharest, 4: 23-32.
Aversa, R., D. Parcesepe, R.V. Petrescu, G. Chen and F.I.T. Petrescu et al., 2016b. Glassy amorphous metal injection molded induced morphological defects. Am. J. Applied Sci., 13: 1476-1482.

Aversa, R., D. Parcesepe, R.V.V. Petrescu, F. Berto and G. Chen et al., 2017d. Process ability of bulk metallic glasses. Am. J. Applied Sci., 14: 294-301.

Aversa, R., E.M. Buzea, R.V. Petrescu, A. Apicella and M. Neacsu et al., 2016a. Present a mechatronic system having able to determine the concentration of carotenoids. Am. J. Eng. Applied Sci., 9: 1106-1111.

Aversa, R., F. Tamburrino, R.V. Petrescu, F.I.T. Petrescu and M. Artur et al., 2016d. Biomechanically inspired shape memory effect machines driven by muscle like acting NiTi alloys. Am. J. Applied Sci., 13: 1264-1271.

Aversa, R., F.I.T. Petrescu, R.V. Petrescu and A. Apicella, 2016a. Biomimetic FEA bone modeling for customized hybrid biological prostheses development. Am. J. Applied Sci., 13: 1060-1067. DOI: 10.3844/ajassp.2016.1060.1067

Aversa, R., F.I.T. Petrescu, R.V. Petrescu and A. Apicella, 2016o. Flexible stem trabecular prostheses. Am. J. Eng. Applied Sci., 9: 1213-1221.

Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016i. Mitochondria are naturally micro robots-a review. Am. J. Eng. Applied Sci., 9: 991-1002.

Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016j. We are addicted to vitamins C and E-A review. Am. J. Eng. Applied Sci., 9: 1003-1018.

Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016k. Physiologic human fluids and swelling behavior of hydrophilic biocompatible hybrid ceramo-polymeric materials. Am. J. Eng. Applied Sci., 9: 962-972.

Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016l. One can slow down the aging through antioxidants. Am. J. Eng. Applied Sci., 9: 1112-1126.

Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016m. About homeopathy or «Similia similibus curentur». Am. J. Eng. Applied Sci., 9: 1164-1172.

Aversa, R., R.V. Petrescu, A. Apicella and F.I.T. Petrescu, 2016n. The basic elements of life's. Am. J. Eng. Applied Sci., 9: 1189-1197.

Aversa, R., R.V. Petrescu, A. Apicella, I.T.F. Petrescu and J.K. Calautit et al., 2017e. Something about the V engines design. Am. J. Applied Sci., 14: 34-52.

Aversa, R., R.V. Petrescu, B. Akash, R.B. Bucinell and J.M. Corchado et al., 2017b. Kinematics and forces to a new model forging manipulator. Am. J. Applied Sci., 14: 60-80.
Petrescu, F.I. and R.V. Petrescu, 2012d. Kinematics of the planar quadrilateral mechanism. Engevista, 14: 345-348.

Petrescu, R.V. and F.I. Petrescu, 2013a. Lockheed Martin. 1st Edn., CreateSpace, pp: 114.

Petrescu, R.V. and F.I. Petrescu, 2013b. Northrop. 1st Edn., CreateSpace, pp: 96.

Petrescu, R.V. and F.I. Petrescu, 2013c. The Aviation History or New Aircraft 1 Color. 1st Edn., CreateSpace, pp: 292.

Petrescu, F.I. and R.V. Petrescu, 2013d. Cinematics of the 3R Dyad. Engevista, 15: 118-124.

Petrescu, F.I.T., 2014. Sisteme Mecatronice Seriale, Paralele si Mixte. 1st Edn., Create Space Publisher, ISBN-10: 1495923819, pp: 224.

Petrescu, F.I. and R.V. Petrescu, 2016a. Parallel moving mechanical systems kinematics. Engevista, 18: 455-491.

Petrescu, F.I. and R.V. Petrescu, 2016b. Direct and inverse kinematics to the anthropomorphic robots. Engevista, 18: 109-124.

Petrescu, F.I. and R.V. Petrescu, 2016c. Dynamic cinematic to a structure 2R. Revista Geintec-Gestao Inovacao E Tecnol., 6: 3143-3154.

Petrescu, F.I.T. and J.K. Calautit, 2016a. About Nano fusion and dynamic fusion. Am. J. Applied Sci., 13: 261-266.

Petrescu, F.I. and J.K. Calautit, 2016b. About the light dimensions. Am. J. Applied Sci., 13: 321-325. DOI: 10.3844/ajaspp.2016.321.325

Petrescu, R.V.V., R. Aversa, A. Apicella, F. Berto and S. Li et al., 2016a. Ecosphere protection through green energy. Am. J. Applied Sci., 13: 1027-1032.

Petrescu, F.I.T., A. Apicella, R.V.V. Petrescu, S.P. Kozaitis and R.B. Bucinell et al., 2016b. Environmental protection through nuclear energy. Am. J. Applied Sci., 13: 941-964.

Petrescu, R.V., R. Aversa, B. Akash, R. Bucinell and J. Corchado et al., 2017a. Modern propulsions for aerospace-a review. J. Aircraft Spacecraft Technol., 1: 1-8.

Petrescu, R.V., R. Aversa, B. Akash, R. Bucinell and J. Corchado et al., 2017b. Modern propulsions for aerospace-part II. J. Aircraft Spacecraft Technol., 1: 9-17.

Petrescu, R.V., R. Aversa, B. Akash, R. Bucinell and J. Corchado et al., 2017c. History of aviation-a short review. J. Aircraft Spacecraft Technol., 1: 30-49.

Petrescu, R.V., R. Aversa, B. Akash, R. Bucinell and J. Corchado et al., 2017d. Lockheed martin-a short review. J. Aircraft Spacecraft Technol., 1: 50-68.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017e. Our universe. J. Aircraft Spacecraft Technol., 1: 69-79.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017f. What is a UFO? J. Aircraft Spacecraft Technol., 1: 80-90.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017g. About bell helicopter FCX-001 concept aircraft-a short review. J. Aircraft Spacecraft Technol., 1: 91-96.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017h. Home at Airbus. J. Aircraft Spacecraft Technol., 1: 97-118.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017i. Airlander. J. Aircraft Spacecraft Technol., 1: 119-148.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017j. When boeing is dreaming – a review. J. Aircraft Spacecraft Technol., 1: 149-161.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017k. About northrop gruman. J. Aircraft Spacecraft Technol., 1: 162-185.

Petrescu, R.V., R. Aversa, B. Akash, J. Corchado and F. Berto et al., 2017m. About helicopters. J. Aircraft Spacecraft Technol., 1: 204-223.

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017n. The modern flight. J. Aircraft Spacecraft Technol.

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017o. Sustainable energy for aerospace vessels. J. Aircraft Spacecraft Technol.

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017p. Unmanned helicopters. J. Aircraft Spacecraft Technol.

Petrescu, R.V., R. Aversa, B. Akash, F. Berto and A. Apicella et al., 2017q. Project HARP. J. Aircraft Spacecraft Technol.

Petrescu, F.I. and R.V. Petrescu, 2017r. Design of Planar Mechanisms. 1st Edn., Scrisul Românesc Publishing House of Craiova.

Reddy, P., K.V. Shihabudeen and J. Jacob, 2012. Precise non linear modeling of flexible link flexible joint manipulator. IReMoS, 5: 1368-1374.

Rehwald, W. and K. Luck, 2000. Kosim – Koppelgetriebesimulation. Fortschritt Berichte VDI, Reihe 1, Nr. 332. Dusseldorf: VDI Verlag.

Rehwald, W. and K. Luck, 2001. Betrachtungen zur Zahl der Koppelgetriebetypen. Wissenschaftliche Zeitschrift der TU Dresda, 50: 107-115.

Şaskin, A.G., 1963. Sintezu zubciato - riciajnih mehanizmov s vástoem. Teoria mašin I mehanizmov s vâstoem. Teoria mašin I mehanizmov, Moskva, 94-95:. 88-110.

Şaskin, A.G., 1971. Zubciato Rîciajnîh mehanizmî. 1st Edn., Izd. Maşinostroenie, Moskva.

Stoica, I.A., 1977. Gear wheel Interference. 1st Edn., DACIA Publishing House, Cluj-Napoca.
Tabaković, S., M. Zeljković, R. Gatalo and A. Zivković, 2013. Program suite for conceptual designing of parallel mechanism-based robots and machine tools. Int. J. Adv. Robotic Syst., 10: 1-13. DOI: 10.5772/56633

Tang, X., D. Sun and Z. Shao, 2013. The structure and dimensional design of a reconfigurable PKM. Int. J. Adv. Robotic Syst., 10: 1-10. DOI: 10.5772/54696

Tong, G., J. Gu and W. Xie, 2013. Virtual entity-based rapid prototype for design and simulation of humanoid robots. Int. J. Adv. Robotic Syst., 10: 1-9. DOI: 10.5772/55936

Wang, K., M. Luo, T. Mei, J. Zhao and Y. Cao, 2013. Dynamics analysis of a three-DOF planar serial-parallel mechanism for active dynamic balancing with respect to a given trajectory. Int. J. Adv. Robotic Syst., 10: 1-10. DOI: 10.5772/54201

Tutunaru, D., 1969. Rectangular and Inverse Planar Mechanisms. 1st Edn., Technical Publishing House, Bucharest.

Source of Figures

Petrescu, 2014.