A NEW APPROACH OF THE MECHANICAL STRUCTURES TOPOLOGICAL GEOMETRY – CURBES TYPES IDENTIFICATION

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ABSTRACT

The current trend regarding the mechanical structures identification is focused on the topological approach. These approach follow the market current trend in the machine tool's domain, appeared as result of the technological development in the IT domain. The mechanical structure is regarded as a whole, using specifically identifications method, as: the parameter circulation method, neural network and genetic algorithms.

In order to apply this approach is needed that the elements of the mechanical structure (surfaces and curves) to may be recognized and classified.

In this paper is proposed a method for recognition of technical frequent used curves (involutes arc, straight lined segment and ellipse arc). The method is based on a neural network trained to recognize these form types.

KEYWORDS: surface identification, forms recognition, neural network

1. INTRODUCTION

Nowadays the current trend in the mechanical structures identification domain is oriented to the topological approach. In this approach, the mechanical structure is regarded as a whole and is identified by specifically methods as: the parameters circulation method, the genetic algorithm method, the neural network method.

In order to apply these methods is necessary to recognize the elements which compound the mechanical structure and to automatically classify these elements.

The form recognition method presented in this paper is based on the using of the neural network.

The neural network was trained to recognize forms frequent meet in technical appliances as arc of ellipse, involutes arc and straight lined segments.

The circle's arc curve type was assimilated with arc of ellipse given that is particularly case of ellipse.

2. POINTS GENERATION FOR NETWORK TRAINING

In order to train the neural network was generated a training matrix formed by these three type of presented curves.

In the first stage we try to choose on the each curve type points characterized by a regular distribution of the X coordinate, but the expression of

the parametrical equations of these curves don't lead at the expected results.

Due of this reason we preferred to express the point's position by polar coordinates and to pick points characterized by a regular distribution of the q coordinate. After the points choose, was make the transition on the Cartesian coordinates and the network was initialized based on the Y coordinate of these points.
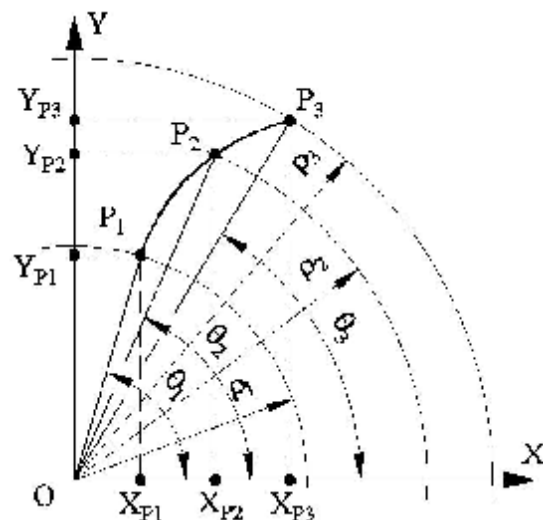

Fig. 1. Cartesian coordinates (X; Y) and polar coordinates (r; θ)

2.1. Generation of points on an ellipse's arc

In order to generate points on an ellipse arc we start from the ellipse parametrical equations:

$$E \begin{vmatrix} X = a \cdot \cos a; \\ Y = b \cdot \sin a. \end{vmatrix} \qquad (1)$$

Using the notation $R = b$ and $e = \dfrac{a}{b}$, is possible the expressing of an ellipse family characterized by equations:

$$E_e \begin{vmatrix} X = R \cdot e \cdot \cos(a); \\ Y = R \cdot \sin(a). \end{vmatrix} \qquad (2)$$

Was generated six ellipse of this family, on each ellipse calculating 7 points, see figure 2.

The coordinates of these points are presented in table 1.

Table 1.

| q	a	e											
		0.5		0.6		0.7		0.8		0.9		1	
		X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0	1.570796	0	10	0	10	0	10	0	10	0	10	0	10
0.087266	1.48353	0.43578	9.9619	0.52293	9.9619	0.61009	9.9619	0.69725	9.9619	0.7844	9.9619	0.87156	9.9619
0.17453	1.396266	0.86824	9.8481	1.0419	9.8481	1.2155	9.8481	1.3892	9.8481	1.5628	9.8481	1.7365	9.8481
0.2618	1.308996	1.2941	9.6593	1.5529	9.6593	1.8117	9.6593	2.0706	9.6593	2.3294	9.6593	2.5882	9.6593
0.34907	1.221726	1.7101	9.3969	2.0521	9.3969	2.3941	9.3969	2.7362	9.3969	3.0782	9.3969	3.4202	9.3969
0.43633	1.134466	2.1131	9.0631	2.5357	9.0631	2.9583	9.0631	3.3809	9.0631	3.8036	9.0631	4.2262	9.0631
0.5236	1.047196	2.5	8.6603	3	8.6603	3.5	8.6603	4	8.6603	4.5	8.6603	5	8.6603
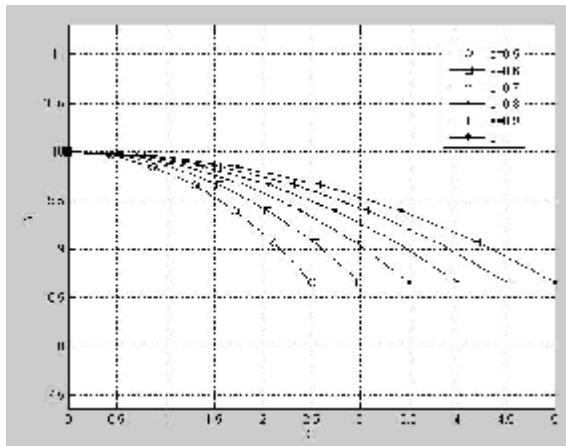
Fig. 2. Ellipse family

2.2. Generation of points on a straight lined segment

Was considered the equations of a straight lined segment in form:

$$Y = R + X \cdot tg\, b . \qquad (3)$$

The determination of points characterized by an even distribution of the q polar coordinate was made intersecting this straight line with the line with equation

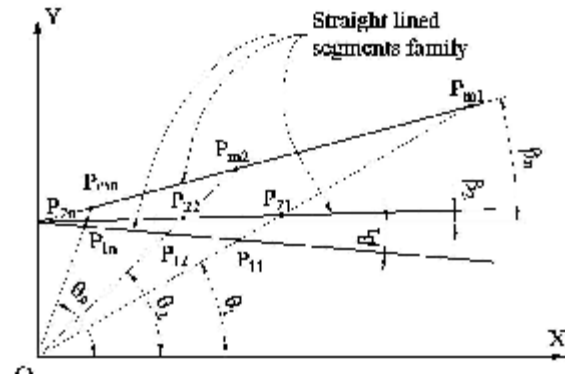$$Y = X \cdot tg\, q , \qquad (4)$$

see figure 3.

Fig. 3. Straight lined segment family (*m* segments; *n* points on each segment)

In this way were determined the Cartesian coordinates of these points, in form:

$$X = \frac{R}{tg\, q - tg\, b}; $$
$$Y = \frac{R \cdot tg\, q}{tg\, q - tg\, b}. \qquad (5)$$

The transition from Cartesian coordinates to polar coordinates was made with relations

$$r = \sqrt{X^2 + Y^2}; $$
$$q = \arctan\left(\frac{Y}{X}\right). \qquad (6)$$

In this way was obtained a straight lined segments family, corresponding to the values presented in table 2.

Table 2

q	a	b								
		-0.17453		-0.15708		L	0.15708		0.17453	
		X	Y	X	Y	L	X	Y	X	Y
0	1.570796	0	10	0	10	L	0	10	0	10
0.087266	1.48353	0.8616	9.8481	0.86293	9.8633	L	0.88718	10.141	0.88859	10.157
0.17453	1.396266	1.7101	9.6985	1.7154	9.7283	L	1.8139	10.287	1.8199	10.321
0.2618	1.308996	2.5586	9.5488	2.5704	9.5929	L	2.7982	10.443	2.8124	10.496
0.34907	1.221726	3.4202	9.3969	3.4413	9.4549	L	3.8624	10.612	3.8893	10.686
0.43633	1.134466	4.3088	9.2402	4.3424	9.3122	L	5.0349	10.797	5.0808	10.896
0.5236	1.047196	5.2401	9.076	5.2898	9.1622	L	6.3546	11.006	6.4279	11.133

2.3. Generation of points on an involutes arc

Were considered the involutes equations in form:

$$X_1 = R_b \cdot \sin q - R_b \cdot q \cdot \cos q;$$
$$Y_1 = R_b \cdot \cos q + R_b \cdot q \cdot \sin q. \qquad (7)$$

In order to generate an involutes family was considered a series of base radius in the domain [5; 10] mm. For analyze these points was made the coordinates transformation:

$$X = X_1 + A;$$
$$A = \begin{Vmatrix} 0 \\ R - R_b \end{Vmatrix}, \qquad (8)$$

or, after development,

$$X = R_b \sin q - R_b q \cos q;$$
$$Y = R_b \cos q + R_b q \sin q + (R - R_b). \qquad (9)$$

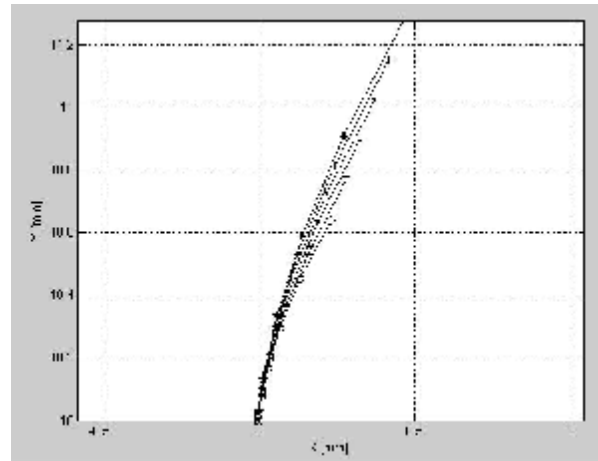With these equations was obtained the involutes family presented in figure 4.

Fig. 4. Involutes family

The points Cartesian coordinates corresponding for each base radius are presented in table 3.

Tabelul 3

q	R											
	5		6		7		8		9		10	
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
0.000	0.000	10.000	0.000	10.000	0.000	10.000	0.000	10.000	0.000	10.000	0.000	10.000
0.087	0.001	10.019	0.001	10.023	0.002	10.027	0.002	10.030	0.002	10.034	0.002	10.038
0.175	0.009	10.076	0.011	10.091	0.012	10.106	0.014	10.121	0.016	10.136	0.018	10.151
0.262	0.030	10.168	0.036	10.202	0.042	10.236	0.048	10.269	0.053	10.303	0.059	10.337
0.349	0.070	10.295	0.084	10.354	0.098	10.414	0.112	10.473	0.126	10.532	0.140	10.591
0.436	0.136	10.454	0.163	10.544	0.190	10.635	0.217	10.726	0.245	10.816	0.272	10.907
0.524	0.233	10.639	0.279	10.767	0.326	10.895	0.372	11.023	0.419	11.150	0.466	11.278

3. NEURAL NETWORK GENERATION

With the goal to recognize the above mentioned forms, was created a neural network on type real basis. The neural network model is presented in figure 5.

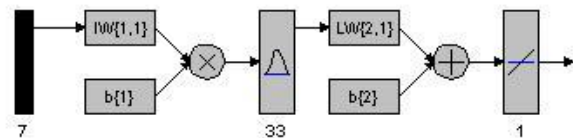The network was created using Matlab software, version 7.

Fig. 5. Neural network model

After the network training, this was simulated with the points matrix presented in table 4.

In the same table are given the results obtained after the simulation.

Is obviously that the results are good enough in order to recognize the type of each curve.

Table 4

Point	Y	Y	Y	Y	Y	Y	Y	Y
1	10	10	10	10	10	10	10	10
2	9.9544	10	10.046	9.9619	9.9619	9.9619	10.032	10.038
3	9.9084	10	10.093	9.8481	9.8481	9.8481	10.128	10.151
4	9.8615	10	10.142	9.6593	9.6593	9.6593	10.286	10.337
5	9.8128	10	10.194	9.3969	9.3969	9.3969	10.502	10.591
6	9.7614	10	10.251	9.0631	9.0631	9.0631	10.771	10.907
7	9.7063	10	10.312	8.6603	8.6603	8.6603	11.087	11.278
Expected value	*10*	*10*	*10*	*1*	*1*	*1*	*100*	*100*
Obtained value	*10.005*	*10.000*	*9.995*	*0.975*	*0.975*	*0.975*	*100.050*	*100.040*

4. CONCLUSIONS

The form recognition method presented in this paper is based on the using of the neural network.

The neural network was trained to recognize forms frequent meet in technical appliances.

Were generated six curves of each type; on each curve were calculated 7 points.

The neural network is fast enough to be used in technical appliances and the recognition accuracy is very good.

In order to use measured data, the points coordinates have to be scaled so be in the training domain [0; 10] mm.

ACKNOWLEDGEMENTS

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