Rating Of Kinematic Chains Using Genetic Algorithm

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Abstract— Structural synthesis of kinematic chains is more interesting area for researchers since many years. In the analysis of kinematic chains for various industrial applications especially Robotics and Automation, it is necessary to rank the various kinematic chains on the basis of its capability in transmitting the input energy towards optimizing the energy resources. Enumeration of kinematic chains and detection of isomorphism plays a very important role in the synthesis. Earlier, many researchers' evolved methods to rate the kinematic chains based on computational algorithms. All these methods more or less involved in large amount of computations in the algorithms. In the present paper, genetic algorithm is applied for the detection of isomorphism and rating of kinematic chains by taking 8-link 1-dof kinematic chains (16) as a specific case.

Keywords— **kinematic chain, fitness, generation, isomorphism, rating**

I. INTRODUCTION

In structural synthesis of kinematic chains, detection of isomorphism, finding distinct mechanisms, rating play a major role. Earlier many researchers [1-8] developed several methods applied to Kinematic chains and planetary gear trains in these parameters. Much research was not carried out by the researchers in the field of Genetic algorithms. In this paper, 8-link 1-dof planar kinematic chains are studied for the rating using Genetic algorithm developed earlier.

II. FUNDAMENTAL CONCEPTS

Rao A.C.[2] developed a Genetic algorithm for topological characteristics of kinematic chains. In that concept, fundamentals of 'genetics' are followed in a broad sense applied in kinematic chains' structural synthesis. Each links of K-chain is said to have a 'fitness' which is equal to its connectivity. For each links, all other links are said to be 'Environment'. Formation of a closed loop K-chain is possible by 'mating' or joining of links. Direct joining of links is considered to be 'first generation'. Joining the links with '1' link in between is said to be 'second generation' and the concept extends to all other generations.

DEVELOPMENT OF ADJACENCY MATRIX FOR FIRST GENERATION

Adjacency matrix is the matrix representation of all the linkages in a kinematic chain. If a link A is connected to link B, it is represented by '1' else '0'. Also the connectivity of any link with itself is also considered to be '0'. Each kinematic chain of 8-link 1-dof (16 no.) is tested and adjacency matrices are prepared. Each row of the adjacency matrix consists of '0's and '1's, which can considered as 'fitness' values of that link in K-chain.

MATING OF LINKS

All the fitness values or strings of links of a kinematic chain are compared with all other linkages in that K-chain. The relative value of the mating is expressed as a 'numerical measure' in such a way that the 'off-spring' results are used to compare the characteristics of K-chains effectively. The result between two digits of two links are said to be 'off-spring'. The off-spring is generated by following the rules as:

Rule: If the bit values of both string are equal it results '0' value else it results'1'.

For example, in a kinematic chain, the two strings of two links A and B are as follows:

Link A: 0 0 1 1 0
Link B: 1 0 1 0 1
The mating of Link A and Link B results 1 + 0 + 0+ 1 + 1 = 3 according to the rule described above.

In the same way, all the links of a K-chain are compared and resulted off-spring values are expressed as a matrix format. Summation of all the fitness values is said to be 'Fitness' of that K-chain. It is again expressed in detail in a string format, by which differentiation of 'fitness' values of two K-chains can be known very easily.

In same way, next higher generations' adjacency matrices are corresponding fitness matrices can also be known according to the procedure described above.

EXAMPLE 1:

An 8-link 1-dof kinematic chain (Chain No. 1 in Appendix I) is considered.

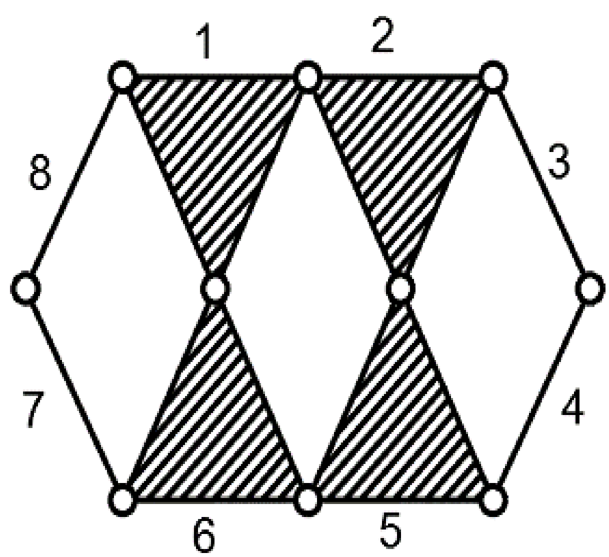

Fig. 1 Chain No. 1

The Adjacency values are shown in matrix form as:

Link	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	0	1	0	0	0	1	0	1
2	1	0	1	0	1	0	0	0
3	0	1	0	1	0	0	0	0
4	0	0	1	0	1	0	0	0
5	0	1	0	1	0	1	0	0
6	1	0	0	0	1	0	1	0
7	0	0	0	0	0	1	0	1
8	1	0	0	0	0	0	1	0

The first generation fitness values are shown as:

Link	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
1	0	6	3	5	2	6	1	5	28
2	6	0	5	1	6	2	5	3	28
3	3	5	0	4	1	5	4	4	26
4	5	1	4	0	5	3	4	4	26
5	2	6	1	5	0	6	3	5	28
6	6	2	5	3	6	0	5	1	28
7	1	5	4	4	3	5	0	4	26
8	5	3	4	4	5	1	4	0	26
								Total	216

String : 216-4(28)-4(26)

Rating of Kinematic chains based on 'Fitness'

By the procedure mentioned in the earlier section, all the 'Fitness' values along with the 'String' are generated. Higher rating will be given for the 'Higher fitness'.

III. RESULTS & CONCLUSIONS

Rating of all the 16 no. 8-link 1-DOF kinematic chains based on the 'fitness' values is shown in the Table I.

TABLE I

RATING OF KINEMATIC CHAINS BASED ON FITNESS STRING

Chain No.	Fitness	String	Rating
1	216	4(28)-4(26)	2
2	216	2(30)-2(28)-2(26)-2(24)	3
3	212	2(30)-29-28-3(24)-23	9
4	216	3(30)-3(26)-2(24)	4
5	216	2(30)-2(28)-2(26)-2(24)	5
6	218	32-31-30-28-25-3(24)	1
7	216	4(30)-4(24)	6
8	200	2(28)-2(26)-2(24)-2(22)	15
9	216	2(30)-2(28)-2(26)-2(24)	7
10	212	32-2(28)-2(26)-3(24)	10
11	214	35-30-27-2(26)-2(24)-22	8
12	204	2(30)-2(26)-2(24)-2(22)	14
13	212	36-3(32)-24-4(22)	11
14	212	36-2(30)-26-24-3(22)	12
15	208	2(36)-4(24)-2(20)	13
16	200	29-28-5(24)-23	16

According to the procedure described, all the distinct kinematic chains of 8-link 1-dof are rated. This method can be extended to higher linkages and DOF.

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APPENDIX I: 8-LINK 1-DOF KINEMATIC CHAINS

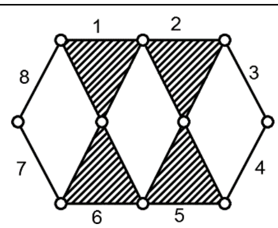

Fig. 1: Chain No.1

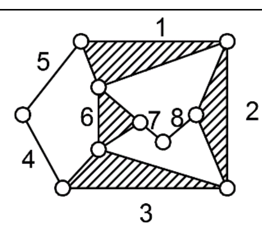

Fig. 2:Chain No.2

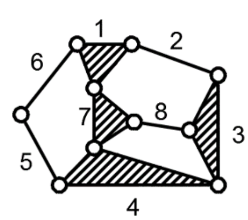

Fig. 3:Chain No.3

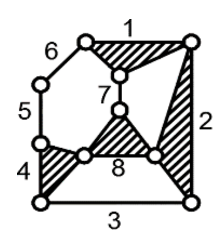

Fig. 4:Chain No.4

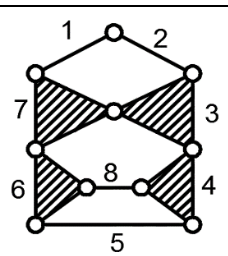

Fig. 5:Chain No.5

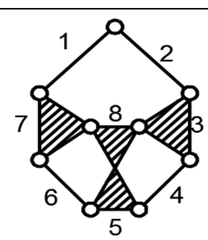

Fig. 6:Chain No.6

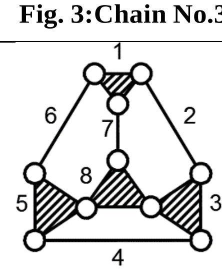

Fig. 7:Chain No.7

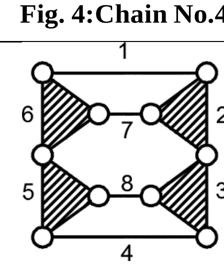

Fig. 8:Chain No.8

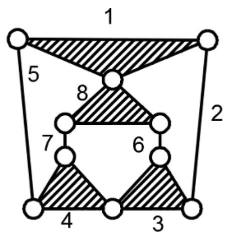

Fig. 9:Chain No.9

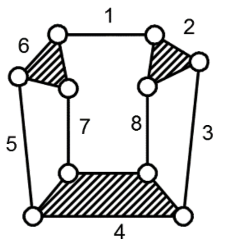

Fig. 10:Chain No.10

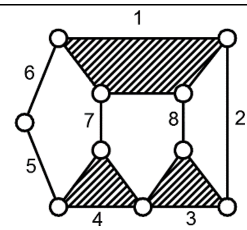

Fig. 11:Chain No.11

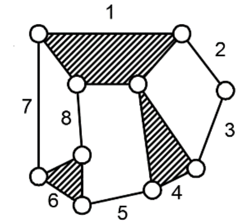

Fig. 12:Chain No.12

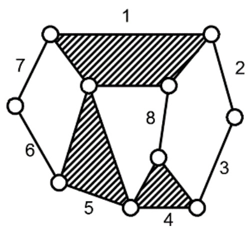

Fig.13:Chain No.13

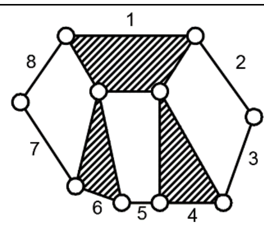

Fig. 14:Chain No.14

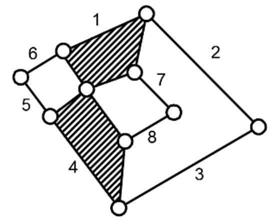

Fig. 15:Chain No.15

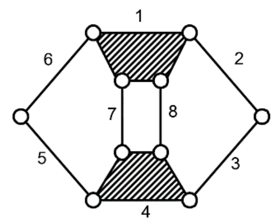

Fig. 16:Chain No.16