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ELITE COMPUTERIZED RATING SCHEME TO EVALUATE SIMPLE JOINTED PLANNER KINEMATIC CHAINS: IMPLEMENTED ON KINEMATIC CONFIGURATION OF VARIOUS INDEPENDENT SUSPENSION SYSTEM

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ABSTRACT

The meticulous knowledge of the kinematic chain is essential for the designer in mechanical engineering and importunate effort has made to know about kinematic chain as much as possible. The existing literature shows that methods have been reported by C.N. Rao and A.C.Rao to predict the performance and rate the kinematic chains and mechanism among several configurations. In the present work a methodology is used which is based on the influence of type of links, type of joints and type of loop present in a kinematic chain to predict the performance of kinematic chains without carrying out the dimensional synthesis. The work already reported has been used to explore the performance rating of catalogue of 8 – Link, 1 –degree of freedom simple jointed planar kinematic chain. For the whispered analysis required programme is developed in C language. Developed system is implemented to detect rating of independent suspension system mechanism and results shows that current methodology is superior.

KEYWORDS: Kinematic Chain, Degree of Freedom

INTRODUCTION

Analysis and synthesis of kinematic chains is very important from the view point of mechanical engineering design and it is only natural that many researchers have directed their efforts to study various aspects of mechanisms Machine designer have been synthesizing kinematic chains unconsciously since time immemorial. Reuleaux was made fist systematic attempt, but, limited to type synthesis. Hartenberg and Denavit classic book change the scenario and make synthesis as an independent area of study. Then after, number synthesis was introduced wherein one chooses the number of binaries, ternaries etc. so as to build a chain with the desired degree of freedom. Structure analysis and synthesis of chains and mechanisms have been the subject of many studies the last several years [1]. One very important problem involved in structure analysis of chains is the determination of distinct mechanism of a chain and to detect isomorphism among kinematic chains. Attempts have been made in the past to solve this problem, and a number of algorithm proposed by Crossley [3], mainly based on the Graph Theory [9], are available in the literature. Many methods have been reported to detect isomorphism by many investigators. Most of these methods are based on link adjacency matrices [1] or Distance matrices [2] which was first introduced by Freudenstein and Dobrajanskyj [15].

It is, of course, know that a chain with greater number of links will generate specified motion more accurately because more design parameters like link ratios are available to the designer, but out of distinct chains consisting of same number of links it is not known how the type of link and their layout affect the dimensional behavior of the chain in the sense of structural error.

As the number of linkages, increases at the same time the possible configuration increases i.e. more number of distinct kinematic chain are possible hence predicting the performance of a given category of kinematic chain is difficult. A methodology has been developedbyDr.A.C.Rao[20] where performance of kinematic chain is carried out without doing dimensional synthesis.

A rating scheme uses link assortment, joint value, primary Hamming number, secondary Hamming number & loop value of chain for predicting the performance. And same has been implemented on suspension system to validate the methodology.

METHODOLOGY

The said method is based on the link assortment, Joint Values and Family used to form primary and secondary Hamming matrix. The 8 link 1 degree of freedom simple jointed kinematic chain having 16 numbers of possible configuration but in this paper only one configuration selected to show methodology. And other results got from the computer programmed output.

Given below Figure.1 (Kinematic chain) is used for the sample calculation.

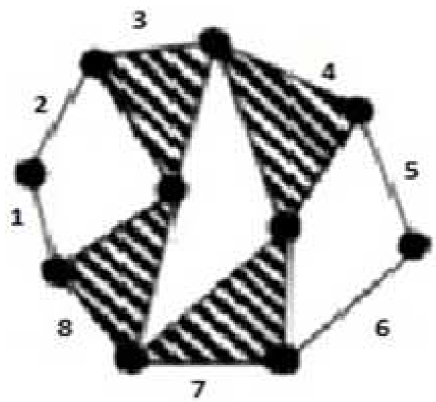


Figure 1: Sample Configuration of 8- Link, 1 Degree of Freedom

The connectivity of figure 2 is given below.

1 - 2, 8

2 - 1, 3

3- 2, 4, 8

4- 3, 5, 7

5- 4, 6

6- 5, 7

7- 4, 6, 8

8- 1, 3, 7

Step 1: Generating a Connectivity Matrix

The connectivity matrix is a square matrix, whose diagonal elements are zero. The size of matrix is equal to number of links in a given kinematic chain hence size of connectivity matrix for Figure 1 is [8 x 8].The link which are directly connected are denoted as 1 and links which are separated denoted as 0.The connectivity matrix of Figure 1 is as shown below.

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

Figure 2

Step 2: To Get Link Assortment and Joint Value from the Connecting Matrix

To get Link Assortment:Sum of the elements of each row of matrix 1 which gives the type of link.e.g. 1st link of matrix is binary (2) and 3rd link of the matrix is ternary (3) Now, as per the definition of link assortment the type of link in a given kinematic chain gives the link assortment hence link assortment of the Figure 1 is 4(2), 4(3).

To get Joint Values: At the simple joints only two links are joined and the summation of the type of link of the two is joint value.

e. g. In the matrix the first link is binary and which is connected with second link which is also binary and first link is connected with eighth link which is ternary,hence, joint value of that joints are (2+3) and (2+2). Count the joint value of all the joints in the given kinematic chain.

So, the joint value for the given Figure 1 is 2(2+2),4(3+3) ,4(2+3).

Step 3:Generating Primary Hamming Matrix and to Get Primary Hamming Number

The Primary Hamming matrix is generated form the connectivity matrix. The element of the ith row has considered as the binary code representing ith link. For example in our matrix .

Link 1: 0	1	0	0	0	0	0	0	1
Link 2: 1	0	1	0	0	0	0	0	0

Primary Hamming number between any two links is the number of digit at which the corresponding codes differ. For example $h_{1,2}$ the hamming number between links 1 and 2 of matrix is 4. Link wise hamming number for all the links has computed and another matrix is generated the elements of which are h_{ij}can be formulated.

Primary Hamming Matrix

SUM

0	4	1	5	4	4	3	5	26
4	0	5	3	4	4	5	1	26
1	5	0	6	3	5	2	6	28
5	3	6	0	5	1	6	3	28
4	4	3	5	0	4	1	5	26
4	4	5	1	4	0	5	3	26
3	5	2	6	1	5	0	6	28
5	1	6	2	5	3	6	0	28

216

Primary hamming number of chain is summation of all the elements of primary hamming matrix hence primary number for the given configuration is 216.

Step 4: Secondary Hamming Matrix and To get Secondary Hamming Number

The Secondary hamming matrix is generated form the primary hamming matrix. The elements in the i^{th} row of primary hamming matrix may be considered as its hamming code for example the element of link 1 and 2 of matrix 2 are,

Link 1:	0	4	1	5	4	4	3	5
Link 2:	4	0	5	3	4	4	5	1

“The secondary hamming number between two links is defined as the sum of the primary hamming numbers off the entire digit at which they differ”

i.e. secondary hamming number S_{ij} between links i and k for an n link chain is given by the relation. $S_{ik} = (h_{ij}+h_{kj})$

It may be noted that $(h_{kj} + h_{kj}) = 0$, if $h_{ij} = h_{kj}$. So, the value between link 1 and link 2 is 36.Same way generation of the whole matrix for the given configuration can be done and Secondary Hamming matrix is given below.

00	36	54	54	16	36	54	54	304
36	00	54	54	36	16	54	54	304
54	54	00	56	54	54	12	56	340
54	54	56	00	54	54	56	12	340
16	36	54	54	00	36	54	54	304
36	16	54	54	36	00	54	54	304
54	54	12	56	54	54	00	56	340
54	54	56	12	54	54	56	00	340
								2576

The Secondary hamming number ofchain has defined as summation of all the elements of secondary hamming matrix. The value of Secondary hamming matrix in our case is 2576.

RATING SCHEME

Rating of Simple Jointed Planner Kinematic chain is done as per steps given below.

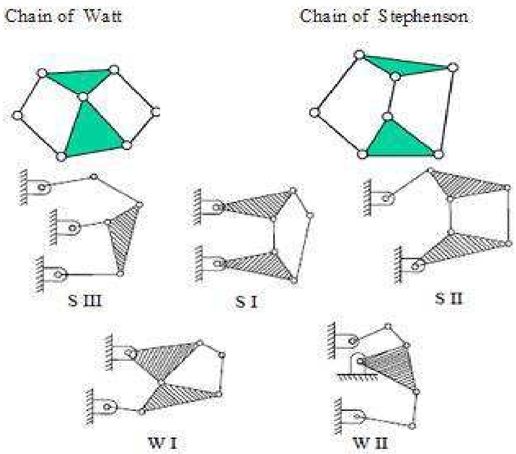
Step 1: All the chains of a particular category of simple jointed planner kinematic chains are arranged in ascending order of their link assortment.

Step 2: All the chains of a particular category of simple jointed planner kinematic chain are arranged in ascending order of their joint value.

Step 3 : In a given family the chains which are having same link assortment and same joint value then, the chains are arranged in ascending order of followed by primary Hamming number followed by secondary Hamming number.

VALIDATION WITH CASE STUDY 6 BAR INDEPENDENT SUSPENSION SYSTEM

Below of possible different types of suspension structures and their rating based on above mention rating scheme.



Chain No.	Link Assortment	Joint Value	Primary Hamming Number	Secondary Hamming Number	Rated Chain
S-III	4(2),2(3)	1(2+2),6(2+3)	100	800	5
S-I	4(2),2(3)	1(2+2),6(2+3)	100	808	4
S-II	4(2),2(3)	1(2+2),6(2+3)	100	808	3
W-I	4(2),2(3)	2(2+2),4(2+3) 1(3+3)	100	888	1
W-II	4(2),2(3)	4(2+2),3(2+3)	100	878	2

As per our scheme the structure which having higher vaule is selected for the application.So,here W-I gives better perfomance among others,which can be validate by dimensional synthesis also. So, we can conclude that Watt Chain is better than Stephenson Chain.Detail dimenstional synthesis carried out by the Hrishikesh V. Deo , Nam P. Suh [18] and prove that the Watt I configuration meets the functional and design parameter,so, our results is match with dimensional synthesis.

CONCLUSIONS

Used technique for the rating of simple jointed planner kinematic chain is a standard test where dimensional synthesis need not be carried out. The methodology is generic and can be implemented on n-link, f- degree of freedom chain with slight modification. The method is compatible for the digital computer. Our analysis using the said methodology results that six-bar Watt-I linkage suspension, is better than other configuration of watt chain & Stephenson chain.

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