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Detection of Isomorphism in Planar Kinematic Chains

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Abstract:

This work manages the location of isomorphism among planar kinematic chains among 6 link 1 d.o.f. (degree of freedom), 8 link 1 d.o.f., 9 link 2 d.o.f. and 10 link 3 d.o.f. kinematic chains. This investigation will help the designer to avoid duplication of the kinematic chains at the conceptual phase of design. A distance matrix (DM) is shaped utilizing the qualities based on the parameter in this approach. Isomorphism is detected based on kinematic chain string (KCS) of distance matrix (PM).

Keywords **— Isomorphism, Planar Kinematic Chain, Distance Matrix, Degree of freedom, Kinematic Chain string.**

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I. INTRODUCTION

Kinematic synthesis deals with a kinematic chain/mechanism structural synthesis. The structural synthesis of cinematic chains consists of identifying all imaginable cinematic chains with a certain number of links, freedom degrees and joints. The study of the film structure of mechanisms is available for an understanding of their capabilities. Understanding the structure promptly improves the list, differentiate evidence, order, and identify isomorphism between cinematic chains and mechanisms. It also leads to the selection of the most appropriate chain for the given set of structural features. Davies and Crossley [1] proposed the basic union strategy dependent on Franke's documentation [2], It consisted of a clump of 40 9-link 2-DOF kinematic chains and 230 10-link 3-DOF kinematic chains. Hass and Crossley [3] utilized to synthesise a class of four dof kinematic chains, use Franke's notation.. Soni [4] In addition, two general constraint kinematic chains were synthesised using Franke's notation. A. C. Rao [5] established the standard and estimations for inspecting kinematic chains and inversion for stiffness, mechanical advantage, compactness and suitability for use as platform type robots. Peter Mitrouchev [7] manages the bound morphological decision for kinematic instruments in mechanical technology. It depends on sub-chain balances of structures considering the situation of the edge and gripper of the robot. Sets of gatherings of commonly balanced instruments are recognized. Along these lines, killing the balanced ones limits the number of likely designs. According to Peter Mitrouchev [8], Mechanisms and Machines Theory (MMT) has made a substantial contribution to the synthesis of planar and spatial mechanisms with atypical dof. The kinematic diagrams of MMT have a substantial structure in a section of modern industrial robots with planar chains. Mitrouchev is interested in a formula that may be used to calculate the number of actuator attachment options for planar pin-jointed primary motivational mechanisms in robotics. It is determined by the structural balances of the sub-chains in relation to the area of the robot's actuator. It is understood that there are groups of assemblages of usually even components. Rao, A.C. [9] Parallelism is a key feature of closed kinematic chains, especially those with degrees of independence greater than one, because such kinematic chains can be used as robot controllers. There are many chains for an indicated number of connections and d.o.f., and the designer should have proof to choose the best likely chain for the established goal. Rao, A.C and A Srinath [10] according to research, the structural parallelism between kinematic chain links affects their relative displacements. A more significant mechanical advantage and a more exact function creation can be realised by carefully selecting the input and output links. This concept helps to select the best chain from a huge number of chains with the same amount of links and freedom. Bedi and Sanyal [11] method for isomorphism detection in planar cinematics presented utilising a joint-based technique The topological characteristics and reverses of planar cinematic chains are identified. Joint connection identification at all levels, isomorphic connectivity-based identification at all levels and unique inversions are all part of the joint technique outlined. Bedi and Sanyal [12] A modified joint connectivity methodology was developed for the differentiating verification of the topological properties of planar kinematic chains.

II. ISOMORPHISM IN PLANAR KINEMATIC CHAINS

Distance Matrix: By combining the separation between the individual links, a distance matrix D may be created for each kinematic chain. With every corner to corner component Dii = 0, the matrix components will be Dik = least number of joints between links i and k.

Node Number: - A node number is a numerical value assigned to each link's individual node. The node number is relegated as the fraction of various nodes, and the node number is the number parameter at a given link.

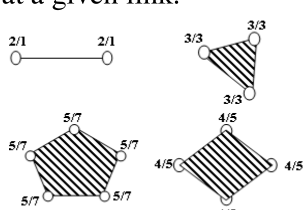


Fig. 1 Node Number for links

Joint Code: - A joint code is defined as a multiple node connecting at a particular joint.

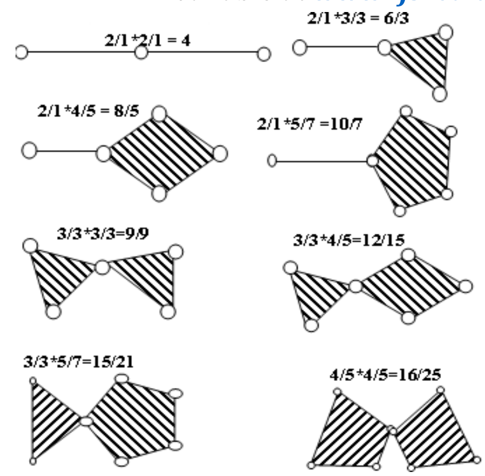


Fig. 2 Joint codes of all possible combination of links

Kinematic Link Value (KLV): Each row of distance matrix components will yield a certain value when added together. This value is referred to as the kinematic link value for that specific link.

Kinematic Link String (KLS): - It refers to the components in an ascending order of a certain line (or column) of the Distance Matrix.

Kinematic Chain String (KCS): - The KCS for a certain chain is calculated by expanding all of the Kinematic Link Values of that chain along with all of the matrix components.

Total Chain Value String (TCVS):-The addition of the components of each row value of a specific link will give the Total Chain Value string for that specific link.

A. 6 Link 1 DOF Planar Chain

The strategy includes a parametric methodology for identification of isomorphism. The strategy is clarified utilizing Watt and Stephenson's chain. A separation framework (DM) is shaped utilizing the qualities based on the parameter. Watt chain has appeared in fig. 3. Connection An and D are ternary connection, and connection B, C, D and E are twofold connection. Every hub of double connection is allotted a hub code "2" and for ternary connection, joint code"3/3" is allocated. Likewise, the quaternary link and pent nary link had the node code 4/5 and 5/7, respectively.

For easy figuring a non-fragmentary value, each joint is provided with an incentive based on taking the L.C.M. of common characteristics, through which we can use the same denominator for all common code for various connections available.

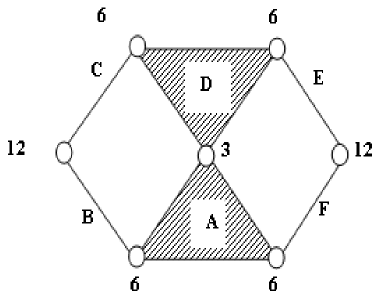


Fig. 3 Watt Chain

A node that combines a binary connection, a binary link, and a ternary connection to a ternary link and a ternary one is thus assigned a node 12/3,6/3,3/3 as shown in Fig 3.

A distance matrix (DM) for Fig 3 is given below:-

	A	B	C	D	E	F	
A	0	6	9	3	9	6	**33**
B	6	0	12	9	15	12	**54**
C	9	12	0	6	12	15	**54**
D	3	9	6	0	6	9	**33**
E	9	15	12	6	0	12	**54**
F	6	12	15	9	12	0	**54**
							282

As in the matrix, ternary link A is linked to binary link B for the Watt chain and a node number is allocated '6.' The shortest separation, i.e. 6+3=9, is considered for interconnectivity connection A and link C. Therefore the joint code will be "3" etc for the connectivity between link A and connection D. For a 6 link watt chain a 6*6 matrix will be established.

Kinematic Link String (KLS) for link A, B, C, D, E & F are:- [0,2(6),3,2(9)], [0,2(12),6,9,15], [0,6,9,15,2(12)], [0,2(6),3,2(9)], [0,2(12),6,9,15], [0,2(12),6,9,15] respectively.

Watt chain as show in fig 3 the Kinematic Link Value (KLV) for link A, B, C, D, E & F are: - 33, 54, 54, 33, 54, and 54 respectively & Kinematic Chain String (KCS) for Watt chain are 324, 2 [1(3), 4(6), 4(9), 4(12), 2(15)].

Fig. 4 Stephenson Chain

A distance matrix (DM) for Fig 4 is given below:-

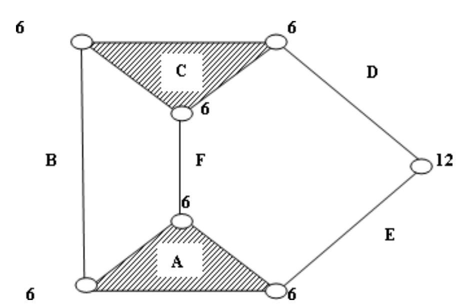
	A	B	C	D	E	F	
A	0	6	12	18	6	6	**48**
B	6	0	6	12	12	12	**48**
C	12	6	0	6	18	6	**48**
D	18	12	6	0	12	12	**60**
E	6	12	18	12	0	12	**60**
F	6	12	6	12	12	0	**48**
							312

As in the matrix, ternary link A is coupled with binary link B for the Stephenson chain and the node value is allowed '6.' The shortest distance between link A and link C a, i.e. 6+6=12, and the connectivity between the connect and interface D is deemed to be the shortest separation, i.e. 6+12=18. In addition, the network connecting interface A and interface E will have a combined value of "6, etc. A 6*6 grid will be shaped for a 6 connection Stephenson chain.

Kinematic Link String (KLS) for interface A, B, C, D, E and F are:- [0,3(6),12,18], [0,2(6),3(12)], [0,3(6),12,18], [0,6,3(12),18], [0,6,3(12),18], [0,2(6),3(12)] separately.

As shown in fig 4, Stephenson chains the Kinematic Link Value (KLV) for connecting A, B, C, D, E and F are 48, 48, 48, 60, 60 and 48 individually. The total of all the Kinematic Link Value (KLV) of a Stephenson chain will give the Kinematic Chain String (KCS) is 312, 2[6(6), (12), 2(18)].Watt chain & Stephenson chain have distinctive Kinematic Chain String (KCS) thus, they are non-isomorphic.

III. 10 LINK 1 DOF KINEMATIC CHAIN COUNTER EXAMPLE



Consider Counter Example appeared in Reference [5] fig 5 and fig 6 kinematic chains have different KCS hence they are non-isomorphic.

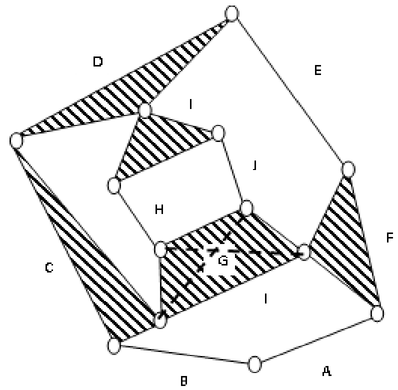


Fig. 5 10 link 1 dof kinematic chain

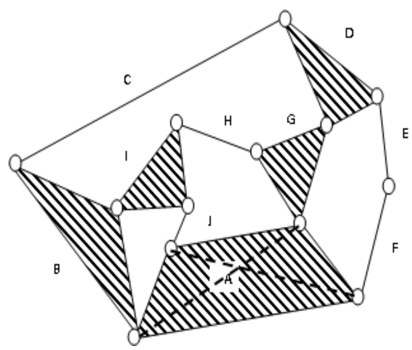


Fig. 6 - 10 link 1 dof kinematic chain

For kinematic chain (fig 5)
Kinematic Chain String (KCS) of the chain = [2(20), 2(25), 4(40), 45,5 (50), 4(60), 3(70), 4(75)80, 4(90), 3(100), 8(110), 115, 125, 2(160)].
For kinematic chain (fig 6)
Kinematic Chain String (KCS) of the chain = 2 [2(20), 2(25), 3(40), 2(45), 5(50), 4(60), 2(65),5(150), 2(70), 5(75), 3(85), 95, 3(100), 2(110), 115, 125, 135, 175].

10 link 1 dof kinematic chain fig 5 & fig 6 have different Kinematic Chain String (KCS) hence they are non-isomorphic

IV. RESULT

The approach described applies to eight link 1 dof, nine link 2 dof and ten link 3 dof cinematic chains. Table 1 for 8 link 1 dof kinematic chain (appendix–I) isomorphism test result shown and from this table after comparing each kinematic chain string for 16 kinematic chains for 8 link 1 dof found non-isomorphic.

TABLE I
ISOMORPHISM IN 8 LINK 1 DOF KINEMATIC CHAIN

Chain No.	KLV	Kinematic Link String	Kinematic Chain String
1	1200 2025	2(75),2(150),2(225),300 150,2(225),2(300),375,450	2[5(75), 6(150), 8(225), 5(300), 2(375), 2(450)]
2	1200 2150	2(75),2(150),2(225),300 150,2(225),2(300),2(475)	2[4(75), 6(150), 8(225), 6(300), 4(475)]
3	1800 1350 1125 1950	2(150),2(225),300,2(375) 75,3(150),225,2(300) 2(75),2(150),3(225) 150,2(225),2(300),2(375)	2[3(75), 8(150), 8(225), 5(300), 4(375)]
4	1725 1350 1200 2100 2025 1425 1125 1800	2(150),2(225),2(300),375 75,3(150),2(225),375 2(75),2(150),2(225),300 150,2(225),300,2(375),450 150,225,3(300),2(375) 75,3(150),2(225),450 2(75),2(150),3(225) 2(150),2(225),300,2(375)	2[3(75), 8(150), 8(225), 4(300), 4(375),450]
5	1350 2025 1800 1200	75,3(150),2(225),375 150,3(300),225,2(375) 2(150),2(225),300,2(375) 2(75),2(150),2(225),300	2[3(75), 8(150), 7(225), 5(300), 5(375)]
6	1875 1425 2025 1275 975	2(150),225,3(300),450 75,4(150),2(300) 150,225,4(300),450 75,4(150),2(300) 3(75),4(225)	2[3(75), 9(150), 4(225), 10(300), 2(450)]
7	1500 1800	75,2(150),2(225),300,375 2(150),2(225),300,2(375)	2[2(75), 8(150), 8(225), 4(300), 6(375)]
8	1725 1425	2(150),2(300),2(225),375 75,2(150),2(225),2(300)	2[2(75), 8(150), 8(225), 8(300), 2(375)]
9	450 575 600 650 425 575	25,3(50),75,2(100) 2(50),75,4(100) 3(50),3(100),150 2(50),75,2(100),125,150 2(25),50,3(75),100 2(50),2(75),2(100),125	2[2(25), 8(50), 5(75), 10(100), 125,2(150)]
10	330 560 660 370 590	2(20),2(40),3(70) 40,2(60),80,100,2(110) 50,70,90,2(100),110,140 20,40,2(50),2(60),90 2(50),70,2(100),2(110)	2[2(20), 3(40), 4(50),4(60), 3(70),80,90, 4(110),140]

11	440 600 800 580 400 690 630 520	20,3(40),70,90,140 40,60,2(80),100,110,130 50,3(100),150,160 3(50),90,100,110,130 20,2(20),3(60),100 50,70,2(100),2(110),150 40,60,2(80),100,110160 40,50,60,2(80),100,110	2[20,3(40), 4(50), 3(60),70 ,3(80),90, 5(100), 3(110),130, 140,150, 160]
12	1110 1560 1860 1710 1200 2070 1800	60,3(120),2(210),270 120,150,180,2(240),300,33 0 3(150),270,300,390,450 2(150),210,270,2(300),330 60,2(150),3(180),300 150,210,2(300),2(330),450 120,180,2(240),300,330,39 0	2[60,3(120), 5(150), 3(180), 2(210), 3(240), 2(270), 4(300), 3(330),450]
13	1440 1920 2145 1485 1475 1590 1515	4(120),2(270),420 120,3(240),300,390 150,225,2(300),2(375),420 75,2(150),2(225)270,390 75,2(150),2(225),270,390 120,150,225,3(240),375 120,150,225,3(240),300	2[75,4(120), 4(150), 4(225), 6(240), 3(270),300, 375, 2(390)420]
14	1440 1680 1800 1920	4(120),2(270),420 120,150,3(240),300,390 3(150),270,300,2(390) 2(150),4(300),420	2[4(120), 6(150), 6(240),(270) ,5(300), 4(390),420]
15	1032 1632	48,3(120),2(168),288 120,168,2(240),2(268)	2[48,6(120), 5(168), 6(240), 10(288)]
16	1440 1980	4(120),240,2(360) 120,3(240),300,360,480 2(120),5(240)	2[8(120), 12(240), 2(300), 4(360), 2(480)]

V. CONCLUSIONS

This work report proposes a fundamental, effective and reliable mechanism for distinguishing isomorphism. The present report manages cinematic synthesis and mechanism research. Kinematic synthesis mainly manages the structural chain/mechanism synthesis. The isomorphism of cinematic chains can be easily identified using this method. This work demonstrates a universal mechanism for identifying the optimum potential reversal of a simple joint flat cinematic structure. It can be easily modified at any moment with regard to the number of links and the level of opportunity, as well as the n number of the linkages and the dof can be very effectively adapted. Such an approach can also be automated and coding may be done to save time and outcomes more rapidly. The results are contrasted and the prior findings are well understood.

REFERENCES

[1] Davies, T. H., & Crossley, F. R. E. (1966). Structural analysis of plane linkages by Franke's condensed notation, Journal of Mechanism.

[2] Franke, R. (1951). Vom Aufbau der Getriebe: Die Baulehre der Getriebe. Dt. Ingenieur-Verlag.

[3] Haas, S. L., & Crossley, F. R. E. (1969). Structural synthesis of a four-bit binary adding mechanism.

[4] Soni, A. H. (1971). Structural analysis of two general constraint kinematic chains and their practical application..

[5] Rao, A. C. (1995). Topological characteristics of linkage mechanisms with particular reference to platform-type robots. Mechanism and Machine theory, 30(1), 33-42.

[6] Mruthyunjaya, T. S., & Balasubramanian, H. R. (1987). In quest of a reliable and efficient computational test for detection of isomorphism in kinematic chains. Mechanism and Machine Theory, 22(2), 131-139.

[7] Peter Mitrouchev, Formulation for actuators' number enumeration for main planar structures in robotics, European Journal of Mechanics A/Solids 27 (2008) 622–646.

[8] Peter Mitrouchev, Sub-chain symmetry approach for morphological choice of planar mechanisms in robotics, European Journal of Mechanics A/Solids 25 (2006) 166–188.

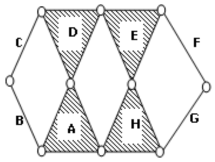
[9] Rao, A. C. (2004). Parallelism in planar kinematic chains (manipulators). Mechanism and machine theory, 39(10), 1111-1122.

[10] Rao, A. C., & Srinath, A. (2007). Planar linkages: Structural influence on mechanical advantage and function generation. Mechanism and machine theory, 42(4), 472-481.

[11] Bedi, G. S., & Sanyal, S. (2010). Joint connectivity: a new approach to detection of isomorphism and inversions of planar kinematic chains. Institution of Engineers (India), 90, 23-26.

[12] Bedi, G. S., & Sanyal, S. (2011). Modified Joint Connectivity approach for identification of topological characteristics of Planar Kinematic Chains. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 225(11), 2700-2717.

Appendix – I 8 Link 1 DOF Kinematic Chain



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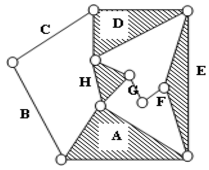

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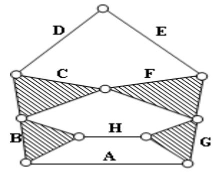

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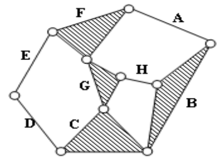

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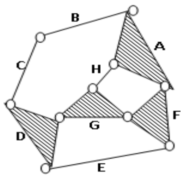

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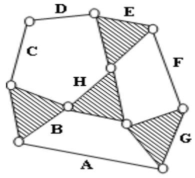

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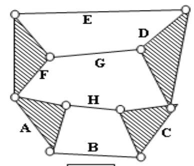

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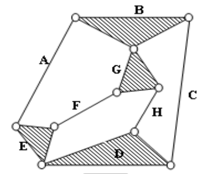

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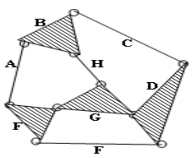

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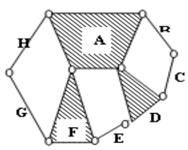

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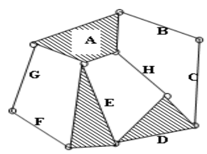

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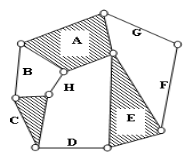

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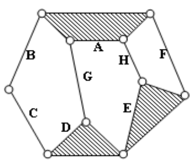

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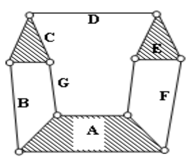

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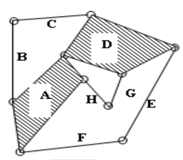

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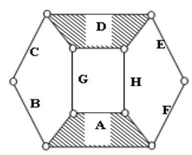

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