Generalized Representation of the Planer Kinematic Chains having Different Types of Kinematic Pairs

Sayeed Ahamad[1], Aas Mohammad[2]

[1]Research Scholar, [2]Professor,
Department of Mechanical Engineering, Jamila Millia Islamia University, New Delhi, India

Abstract

Development of the method for generalizing the planer kinematic chains having same number of links but different kinematic pairs. By using link-link form of the incidence matrix or [JJM] Matrix. and elements of the matrix was chosen as one and zero depending on the absence or presence of a direct kinematic connection in between the joints, we found that kinematic chains having same number of link and different kinematic pair are isomorphic but in real practice it should be different. To overcome this problem we are trying to develop a different set of matrix called kinematic pair matrix**.**

Keyword: *Isomorphism, Kinematic Chain, Structural Invariants, Kinematic Pair Matrix*

I. Introduction

Recently people have done several attempts to develop different method to find out isomorphism among two kinematic chains. Mohammad, A. and Agrawal, V. P [1], performed of identify the different mechanisms and they detect the isomorphism among the chain having different kinematic pairs. Ashok Kumar Sharma and Arvind Kumar Shukla [2], use kinematic chains which is represent by matrices and elements of matrices that is used for detection of isomorphism among the kinematic chains, they used chains of one degree of freedom ,six links and eight links. Uicker, J. J. and Raicu, A [3], described a method for the identification and recognition of equivalence of kinematic chains and used to testing the equivalence of kinematic chains using different kinematic pairs. Mruthyunjaya, T. S. and Raghavan, M. R.[4], presented the Computer aided analysis of the structural synthesis of kinematic chains, and they used the link link incidence matrix to represented the simple jointed kinematic chains ,procedures have produced to determine its structural characteristics such as degree of freedom, chains, different mechanisms. Nageswara Rao, C. and Rao, A. C. [5], preformed the Selection of best frame, input and output links for function generators modelled as probabilistic system, they identify to replace the 0 or 1 in the given known matrix by the distances motion have to flow in the chains from the one vertex to other. Rao, A. C. [6], performed the Kinematic chains, isomorphism, inversion and types of degree of freedom, using the concept of Hamming distances. Ambekar, A. G. and Agrawal, V. P. [7], suggest the method to identify the mechanisms, path generators and the function generators through the set of identification numbers. Ambekar, A. G. and Agrawal, V. P. [8], performed the Identification and classifications of kinematic chains and their mechanisms used the identification codes. Shende, S. and Rao, A.C. [9], identify the problems in the detection of isomorphism which encountered in the structural synthesis of kinematic chains. Manoj Kumar Lohumi, Aas Mohammad and Irshad Ahmad Khan [10], performed the hierarchical clustering algorithm which developed for the identification of distinct mechanisms. J. N. YADAV and C. R. Pratap, V. P. Agrawal, [11], given the method for detecting the isomorphism among the kinematic chains with the help of simple joints used new invariants known as arranged sequence of the modified total distance ranks of all links, ASMTDRL. Ashok Dargar, Ali Hasan, Rasheed Ahmed Khan,[12], identify the distinct mechanisms derived from the given kinematic chain. these presented in the form of a flow matrix. Zichos, H. [13], proposed the tribology a system approach to science and technology of friction, lubrication and wear. Czichos, H. [14], identify the System approach to the analysis of wear problems. Gandhi, O. P. and Agrawal, V. P. [15], developed a diagraph approach to system wear evaluation and analysis. Hsiung, C. Y. and Mao, G. Y [16], used linear algebra concept for detecting the isomorphism. Mohammad, R. A. Khan and V. P. Agrawal, [17], performed the Identification of kinematic chains and distinct mechanisms using extended adjacency matrix. To identify the isomorphism among the kinematic chains and having different kinematic pairs and using graph theory [18] to [24]. In this paper we developed a new matrix called Kinematic pair Matrix to identify the isomorphism of kinematic chains and mechanism having different type of kinematic pairs.

During development of kinematic chain and mechanisms there is chances of duplication. To identify this duplication researchers have proposed various methods.

ISSN (Online): 2230-7893
www.IJCEM.org

These methods were based on adjacency matrix and the distance matrix.

II. Proposed Methodology

Structural Invariant of the Mechanism

KP matrix is the unique representation of the mechanism having different types of kinematic pairs. All information related to the types of links and types of kinematic pairs existing in the mechanism is incorporated in kinematic pair matrix. Therefore its determinant of kinematic pair matrix may be taken as **structural invariant** of the kinematic pair matrix and in turns may be treated as structural invariants of the particular kinematic chain or mechanism. This invariant may be used to detect isomorphism among the planer kinematic chain and mechanism. Therefore structural invariant is written as determinant KP (Det. KP).
[KP] Matrix is the representation of kinematic chains and mechanisms, hence identification number is obtained from this matrix is also the representation or characteristics number of this chain.

Identification Number

The identification number is the number which is desired sum of the [KP] Matrix.
Determinant [KP] = Invariants of KC or mechanisms
The proposed method is used to detect the isomorphism using kinematic pair matrix and its invariants.

The Kinematic Pair [KP] Matrix

The KP matrix representation may be given as,

$[KP] = \{P_{ij}\}$;

Where P_{ij} = Square of the type of KP elements between the i^{th} and j^{th} link those are directly connected.
Otherwise $P_{ij} = 0$; those are not connected directly

Designation of the kinematic pairs:
Lower pair : 1.0
Higher pair : 2.0

Further classification of kinematic pairs:

For Lower Pair:

Turning pair : 1.1;
Sliding pair : 1.2;
Screw pair : 1.3;

For Lower Pair:

Point Contact : 2.1;
Line Contact : 2.2;

Presentation of the [KP] Matrix

$$KP = \begin{bmatrix} P_{11} & P_{12} & P_{13} & . & . & . & P_{1n} \\ P_{21} & P_{22} & P_{23} & . & . & . & P_{2n} \\ . & . & . & . & . & . & . \\ . & . & . & . & . & . & . \\ P_{n1} & P_{n2} & P_{n3} & . & . & . & P_{nn} \end{bmatrix}$$

Example: 1. Shear Press

The large base that is bolted to the table is designated as the frame. The motion of all other links is determined relative to the base. The base is numbered as link 1. Pin joints are used to connect link 1 to 2, link 2 to 3, and link 3 to 4. These joints are lettered *A* through *C*. In addition, the cutter slides up and down, along the base. This sliding joint connects link 4 to 1, and is lettered *D*. Finally, the motion of the end of the handle is desired. This is designated as *point of interest X*.

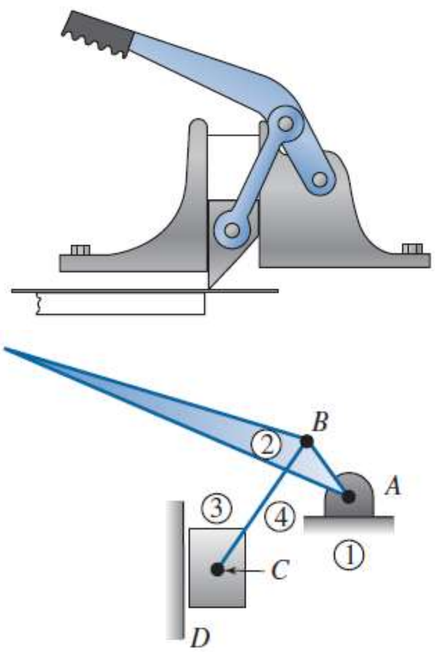

Fig. (1a): Shear Press Fig. (1b): Kinematic Diagram for shear Press

Kinematic Pair Matrix for Shear Press:

Substitutes the values of different kinematic pairs in the kinematic pair matrix, we obtain KP for shear press.

$$KP = \begin{bmatrix} 4.00 & 1.21 & 1.44 & 0.00 \\ 1.21 & 4.00 & 0.00 & 1.21 \\ 1.44 & 0.00 & 4.00 & 1.21 \\ 0.00 & 1.21 & 1.21 & 4.00 \end{bmatrix}$$

Determinant of KP = I KP I = 152.623

Example. 2. Vese Grips

In this problem, no parts are attached to the ground. Therefore, the selection of the frame is rather arbitrary. The top handle is designated as the frame. The motion of all other links is determined relative to the top handle. The top handle is numbered as link 1. Four pin joints are used to connect these different links (link 1 to 2, 2 to 3, 3 to 4, and 4 to 1). These joints are lettered *A* through *D*. The motion of the end of the bottom jaw is desired. This is designated as point of interest *X*. Finally, the motion of the end of the lower handle is also desired. This is designated as point of interest *Y*.

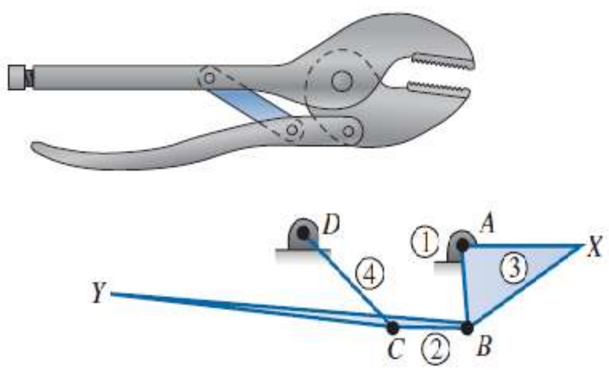

Fig. (2a): Vise Grips Fig. (2b): Kinematic Diagram for Vise Grips

Kinematic Pair Matrix For Vise Grips

Substitutes the values kinematic pairs in the kinematic pair matrix, we obtain the kinematic pair KP matrix for Vise Grips.

$$\text{KP} = \begin{bmatrix} 4.00 & 0.00 & 1.21 & 1.21 \\ 0.00 & 4.00 & 1.21 & 1.21 \\ 1.21 & 1.21 & 4.00 & 0.00 \\ 1.21 & 1.21 & 0.00 & 4.00 \end{bmatrix}$$

Determinant of KP = I KP I = 162.297

Since the values of these two determinants are different for both examples hence, these are invariants.

In this scheme, each node with message searches for possible path nodes to copy its message. Hence, possible path nodes of a node are considered. Using NSS, each node having message selects its path nodes to provide a sufficient level of end-to-end latency while examining its transmission effort. Here, it derives the CSS measure to permit CR-Networks nodes to decide which licensed channels should be used. The aim of CSS is to maximize spectrum utilization with minimum interference to primary system. Assume that there are M licensed channels with different bandwidth values and y denotes the bandwidth of channel c. Each CR-Networks node is also assumed to periodically sense a set of M licensed channels. Mi denotes the set including Ids of licensed channels that are periodically sensed by node i. suppose that channel c is periodically sensed by node i in each slot and channel c is idle during the time interval x called channel idle duration. Here, it use the product of channel bandwidth y and the channel idle duration x, tc = xy, as a metric to examine the channel idleness. Furthermore, failures in the sensing of primary users are assumed to cause the collisions among the transmissions of primary users and CR-Networks nodes.

III. Result and Discussion

The determinant value for the shear press is det of KP = I KP I = 152.623

The determinant value for the Vise Grips is det of KP = I KP I = 162.297

Since both the determinants values are different, therefore, both these kinematic chains (Shear Press and Vise Grips) are non-isomorphic.

Therefore the determinant of kinematic pair matrix may be taken as **structural invariant** of the kinematic pair matrix and in turns may be treated as structural invariants of the particular kinematic chain or mechanism.

The proposed invariants are able to detect the isomorphism in the kinematic chains.

Conclusion

We observed that the determinants of two kinematic chains or mechanisms as shown in fig 1(b) and (2b), are different, it reveals that the determinants are different for both the mechanisms. Hence these mechanisms are treated as non-isomorphic or distinct mechanisms.

This method is able to clearly identify the isomorphism among the kinematic chains or mechanisms having different kinematic pairs.

The proposed method is extended further for more for more kinematic chains having the different kinematic pairs.

In the present work, the useful adjacency matrix is modified and is called modified adjacency matrix $[A_m]$ in which the elements a_{ij} are the joint value of the i^{th} and j^{th} links that are directly connected, otherwise $a_{ij}= 0$. This $[A_m]$ matrix is able to distinguish the type of the joint between the two links.

References

[1] Mohammad, A. and Agrawal, V. P. Identification and isomorphism of kinematic chains and mechanisms. 11th ISME Conference, IIT Delhi, India, 1999, pp. 197–202.

[2] Ashok Kumar Sharma and Arvind Kumar Shukla, A New Method for Detection of Structural Properties of Planar Kinematic Chain, Proceedings of the 1st International and 16th National Conference on Machines and Mechanisms (iNaCoMM2013), IIT Roorkee, India, Dec 18-20 2013

[3] Uicker, J. J. and Raicu, A. A method for the identification and recognition of equivalence of kinematic chains. Mach. Theory, 1975, 10, 375–383.
[4] Mruthyunjaya, T. S. and Raghavan, M. R. Computer aided analysis of the structural synthesis of kinematic chains. Mech. Mach. Theory, 1984, 19, 357–368.
[5] Nageswara Rao, C. and Rao, A. C. Selection of best frame, input and output links for function generators modelled as probabilistic system. Mech. Mach. Theory, 1996, 31, 973–983.
[6] Rao, A. C. Kinematic chains, isomorphism, inversions and type of freedom, using the concept of Hamming distances. Indian J. Tech., 1988, 26, 105–109.
[7] Ambekar, A. G. and Agrawal, V. P. Identification of kinematic generator using min. codes. Mech. Mach. Theory, 1987, 22(5), 463–471.
[8] Ambekar, A. G. and Agrawal, V. P. Identification and classification of kinematic chains and mechanisms using identification codes. The Fourth International Symposium on Linkage and computer aided design methods. Bucharest, Romania, Vol.1(3), pp. 545–552.
[9] Shende, S. and Rao, A.C. Isomorphism in kinematic chains. Mech. Mach. Theory, 1994, 29(77), 1065-1070.
[10] Manoj Kumar Lohumi, Aas Mohammad and Irshad Ahmad Khan, Hierarchical clustering approach for determination of isomorphism among planar kinematic chains and their derived mechanisms.
[11] J. N. YADAV and C. R. Pratap, V. P. Agrawal, Computer aided detection of isomorphism among kinematic chains and mechanisms using the concept of modified distance, *Received 6 September 1994; in revised form 17 August 1995; received for publication 10 October 1995*
[12] Ashok Dargar, Ali Hasan, Rasheed Ahmed Khan, A method of identification of kinematic chains and distinct mechanisms. Received in the final form November 19, 2009
[13] Zichos, H. Tribology – a system approach to science and technology of friction, lubrication and wear, tribology series–1, 1978 (Elsevier, Amesterdam).
[14] Czichos, H. System approach to the analysis of wear problems. Conference of Lubrication, Friction and Wear in Engineering, Melbourne, 1 Australia, 1980, pp. 247–252.
[15] Gandhi, O. P. and Agrawal, V. P. A diagraph approach to system wear evaluation and analysis. STLE/ASME Tribology Conference, New Oreleans, 1994, Vol. 116, pp. 268–274.
[16] Hsiung, C. Y. and Mao, G. Y. Linear algebra, 1998 (World Scientific Publishing, Singapore).
[17] Mohammad, R. A. Khan and V. P. Agrawal, Identification of kinematic chains and distinct mechanisms using extended adjacency matrix, IMeche, 221 (2006) 81-88.
[18] Jensen, P.W., 1987, *Cam Design and Manufacture,* Marcel Dekker, Inc., New York, NY.
[19] Erdman, A.G. and Sandor, G.N., 1991, *Mechanism Design: Analysis and Synthesis,* Prentice Hall, Upper Saddle River, NJ.
[20] Martin, G.H., 1982, *Kinematics and Dynamics of Machines,* McGraw-Hill, New York, NY.
[21] Davies, T.H., 1968, An Extension of Manolescu's Classification of Planar Kinematic Chains and Mechanisms of Mobility $m \geq 1$, Using Graph Theory, J*ournal of Mechanisms,* 3, 87–100.
[22] Hartenberg, R.S. and Denavit, J., 1965, *Kinematic Synthesis of Linkages, M*c Graw-Hill, New York, NY.
[23] Tang, C.S. and Liu, T., 1988, The Degree Code-A New Mechanism Identifier, in *Proceedings of the ASME Mechanisms Conference: Trends and Developments* in Mechanisms, Machines, and Robotics, 147–151.
[24] Tsai, L.W. and Roth, B., 1972, Design of Dyads with Helical, Cylindric, Spherical, Revolute and Prismatic Joints, *Mechanism and Machine Theory,* 7, 85–102.

Author Bibliography

	**Sayeed Ahamad** Sayeed Ahamad, M.Tech student, received B.Tech in Mechanical and Industrial Engineering from UPTU Lucknow, UP, and presently pursuing M.Tech in Machine Design from Jamia Millia Islamia University,New Delhi (India). Email: sayeedmi08@gmail.com
	**Professor Aas Mohammad** Department of Mechanical Engineering, Jamia Millia Islamia. He is actively involved in research and Teaching and research field includes Theory of Machine, and Graph Theory. He has number of papers published in conference proceedings and journals. Email: **am200647@gmail.com**