Title of Ph.D Thesis:

TO DEVELOP NEW METHODS TO DETECT ISOMORPHISM AND DISTINCT MECHANISMS IN KINEMATIC CHAIN

Submitted by: Syed Shane Haider Rizvi

Supervisor: Dr.Ali Hasan Cosupervisor: Prof. R.A.Khan

ABSTRACT

Isomorphism identification and determination of the distinct mechanisms are two of the most difficult problems in the structural study of kinematic chains. Isomorphism detection at the preliminary stage of design significantly reduces the design cycle time by preventing the duplication of already developed chains. Further more the determination of distinct mechanisms forecasts the applicability of the chain to develop different machines. The aim of this study is to provide an efficient solution of both the problems viz. 1. Isomorphism identification, 2. Determination of the distinct mechanisms as well as a new way for the categorization of the kinematic chains. The present work developed three new approaches for the problems under consideration.

First approach leads to develop Chain Identification (CI) matrix. This new matrix classifies the chains by assigning a unique Group Identification Number (GIDN). The chains are grouped according to their link assortment. Further the Eigen values of CI matrix are used to get the structural invariants i.e. LSI (Link Structural Invariant) and CSI (Chain Structural Invariant). These invariants identify the isomorphs and the distinct mechanisms. The use of CI matrix successfully combats the problems under consideration and also works well on counter examples of other approaches available in the literature.

The second approach deals with the problem by forming the Link Identity (LI) matrices. The absolute sum of the coefficients of the characteristic polynomial of the LI matrix gives the structural invariant LS (Link Signature). The distinct LS values of

a chain confers the number of distinct mechanisms. The sum of all LS values gives another structural invariant CS (Chain Signature). Isomorphism detection is the byproduct of this approach because isomorphic chains have the same value of CS. It will help the designer to select the best kinematic chain and a mechanism to perform the desired task, at the conceptual stage of design. This approach can be applied to any kinematic chain having simple or multiple joints.

The third approach suggests an extension of the Adjacency Matrix (AM), which forms the basis of new a matrix i.e. Inversion Adjacency Matrix (IAM). IAM is a link level matrix. IAM can be obtained by replacing the diagonal element of the AM for the selected fixed link from '0' to '1'. If the Eigen values of the two IAM's are same then the corresponding links are said to be identical links. The absolute sum of the Eigen values of the IAM is known as Link Identification Value (LIV). Number of distinct LIV's shows the number of distinct inversions. Two isomorphic chains have one to one correspondence between the LIV's of the chains. The sum of the LIV's of a chain is its Chain Identification Value (CIV). The two isomorphic chains have the same value of CIV. The approach is tested on several examples and found successful.

All the three matrices introduced in this work are capable of being used for kinematic chains having simple or multiple joints, for the sake of convenience, the second approach is extended to the chains with multiple joints by considering the type of joints instead of the degree of the links. On the similar grounds the other two approaches are also extended for the chains and their results are shown in this study.

The methods has been found to be successful in distinguishing all known 16 kinematic chain of 8-links, 230 kinematic chain of 10-links having 1-F and 98 chains with 10 links having 3-F. The advantage of these methods is that they are very easy to compute using MATLAB software.