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INTRODUCTION

In the early stage of mechanism design, it is helpful to have all possible kinematic chain with required number of links and degree of freedom. Over the past several years much work has been reported in the literature on structural synthesis and analysis.

In the structural synthesis of linkages there is following fundamental problem: "To determine all the modes of joining of n members to form chains with a certain degree of mobility. The four-bar, six-bar and eight-bar chains are simple enough to be assembled by visual inspection. Higher link chains demand greater skill, patience and draftsmanship. Method reported by Davies uses Franke's notation and has a tendency to remain incomplete with too small a number. Manolescu had earlier used Assur groups but that method has the opposite drawback; isomorphic forms infiltrate into the results and so the problem of weeding them out still remains. Manolescu later tried a different approach by transforming Barnov Trusses using "graphisation". Mruthyunjaya [8] started with a multiple jointed binary chain and transformed them gradually in stages until all the joints became simple joints. The closest any method has come so far in terms of directness of approach is the contracted link adjacency matrix method proposed by Hwang and Hwang [10] in which uses construction of modified adjacency matrix. But, by far most popular synthesis has been via graph theory, where the synthesis procedure involves 1) forming contracted graph i.e. graphs representing pattern of polygonal links and 2) determining ways of adding vertices representing binary links to the contracted graph.

The reason why the designers have been plodding through so many new routes instead of sticking to what ought to have been a straight as an arrow path is easy to visualize. The total sets of all possible chains for a given number of links and family descriptions can be extremely long, but yet can be prepared by some effort The crux of problem all these years has been the absence of a reliable and computationally efficient technique to pick the non-isomorphic chain i.e., to put it bluntly, isomorphism tests are cumbersome, slow or unreliable.

The present methodology is entirely different from all other methods, envisages generation of n-link, f-degree-of-freedom chains from a basic chain i.e. distinct (n-2) link, f-degree-of-freedom chain in two ways, the first of these being joining a string of two binary links (dyad) to the distinct link pair of (n-2)-link, f-d.o.f chain. All the chains generated in this manner will consist of at least one string of two binary links. In the second approach a (n-2) link f-d.o.f. chain is first converted to (n-1) link f-d.o.f. chain by incorporating a link, at the distinct joint and then reconverting it to n-link, f-d.o.f. chain by joining another binary link across two of its eligible links which must therefore be non adjacent links.

Each (n-2) link, f-d.o.f. basic chain will lead to a number of n-link chains and as a result number of chains generated by all basic chains will be quite large. To save time and effort, i.e. to make the algorithm computationally efficient, care is taken right at the beginning to avoid formation of degenerate, immobile chains (structures) and isomorphic chains. The Hamming number technique, which was originally developed to test isomorphism, is explored further to reveal identity among links and joints of a chain. This information is utilized in generating distinct link pairs, distinct joints, and avoiding adjacent link pair through which only distinct chains are generated from each of the basic chains. When these chains are stored in the stack of eligible chains they undergo isomorphism check which is further strengthened by using Secondary Hamming string and Tertiary Hamming strings as an isomorphic indices. When applied to 230 distinct 10-link kinematic chain, primary Hamming number has failed in two chains to overcome this shortcoming. Secondary Hamming number is used in this methodology.

The genesis of kinematic chains so formed is clearly defined. Therefore, sketching of simple jointed kinematic chains is facilitated easily which is otherwise cumbersome, tedious and time consuming The other advantage of the methodology is that data generated for synthesis leads to the analysis too. Primary Hamming number technique which is formulated to detect isomorphism among kinematic chains with slight modifications can give inversions, best inversions, type of freedom in multi degree of freedom chains, and best actuator location.

The unified computerized methodology presented will be made more meaningful, if, structural error performance in terms of output error can be predicted on a comparative basis without carrying out the dimensional synthesis. The concept of symmetry is introduced to rate the performance of kinematic chain in terms of output error Schemes are developed based on link assortments, joint values, loop values and symmetry to rate the simple jointed kinematic chains. The data generated during synthesis and analysis is used to rate the chains. Further, to establish the order of rating obtained mathematically, the optimal dimensions of six-bar chain (Watt and Stephenson-III) for same function and range is obtained. The synthesis of a mechanism to perform desired function is reduced to the problem of solving the n-simultaneous equations. Equations are obtained by describing the derived configuration at one of the precision points. Position Equations are one containing link dimensions and angular position of input out links, as well as angular position of three intermediate links. As the equations are of highly non-linear character, a complete solution has not been possible. The solution is obtained by Gauss-elimination procedure. The correction vector δ is calculated and the procedure is repeated till $|(\delta_i / r_i)| < 10^{-4}$.

Using the position equation, output angle for a given input, angle constant and synthesized link dimension as parameters, error is calculated and structural error performance is obtained. Numerical example taken shows that structural error for a function generation is significantly less for a Stephenson chain compared to Watt chain. Hence, Stephenson chain is superior to Watt chain in generating a function since its links are more uniformly deployed (symmetrical).