Mechanism and Machine Theory 46 (2011) 492–514

Contents lists available at ScienceDirect

Mechanism and Machine Theory

journal homepage: www.elsevier.com/locate/mechmt

Generating functions for mechanism specialization

Yii-Wen Hwang [a], Shu-Hong Lin [a,*], Chiu-Chin Wu [b]

[a] Department of Mechanical Engineering, National Chung Cheng University, Chia Yi, Taiwan, ROC
[b] Department of Mechanical Engineering, Chienkuo Technology University, Chang Hua, Taiwan, ROC

ARTICLE INFO

Article history:
Received 26 May 2010
Received in revised form 17 November 2010
Accepted 27 November 2010
Available online 8 January 2011

Keywords:
Type synthesis
Generating function

ABSTRACT

This paper proposes an innovative mathematical method for generating specialized mechanisms without having to check for isomorphic mechanisms. Specifically, using the basic permutation group types, the analysis derives four generating functions and four mathematical operators, which it then uses to generate complex generating functions for six- and eight-link specialized mechanisms that can be classified based on a link or a joint permutation group. Because each function is a polynomial in which every term is a specialized mechanism, there is no need to inspect for isomorphism. The accuracy and efficiency of the method is verified using numerical examples and Polya's theory.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

In general, mechanisms are type synthesized using the following three-step procedure: identifying the appropriate mechanism type (e.g., the numbers or link and joint types and necessary design constraints), enumerating the basic kinematic chains and their required numbers of links and joints, and the specialization of mechanisms [1]. In this latter, each kinematic chain is specialized through the assignation of link and joint types to obtain all possible mechanism configurations.

Type synthesis and mechanism specialization have been the subject of many studies [1–42], which have variously based the structural synthesis of the kinematic chains on the graph theory [2–9], a characteristic polynomial [10–16], or approaches based on codes [17–25], matrices [26–28], or other elements [29–39]. In some such investigations, a generation of the multiple kinematic chains or mechanisms during the synthesis and specialization processes requires complex procedures for the detection (or computer-aided assignation) and deletion of isomorphic mechanisms [40–42]. For example, as early as 1975, Uicker and Raicu [10] differentiated isomorphism using the characteristic polynomial of the link adjacency matrix. Over a decade later, in 1986, Ambekar and Agrawal [18,19] defined first the maximum and then the minimum code for the isomorphism examination. In 1987, Mruthyunjaya and Balasubramanian [12] reported the fail instance in a ten-link kinematic chain, after which Tang and Liu [21] used a similar arrangement to derive the corresponding link adjacency matrix and create an isomorphism inspection degree code.

Somewhat earlier, in 1984, Yan and Hwang [22] had employed the constituted relationship of links and joints to define a linkage path code, which they also applied to the isomorphism inspection. In 1996, Yadav, Pratap and Agrawal [25] used this constituted relationship to define what they called a link–path code for identifying the inversion mechanism in a kinematic chain. Subsequently, Chang et al. [26] and Cubillo and Wan [27] investigated the kinematic chain isomorphism using the eigenvalue and eigenvector of the link adjacency matrix, which Srinath and Rao [28] then used to identify the correlation matrix and derive a chain string for use in the isomorphism inspection. In 1991, taking the combinational theory as their basis, Yan and Hwang [34] applied Polya's theory and the concept of the permutation group to count specialized mechanisms, an application that Yan and Hung [35–38] later extended by using Burnside's theorem to count the specialized mechanisms with specific constraints. In 1995, Pucheta and Cardona [39] applied the concept of the degree code to the mechanism isomorphism and obtained a planar mechanism with rotation and prismatic pairs.

* Corresponding author.
E-mail address: iverson_lin@hotmail.com (S.-H. Lin).

0094-114X/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.mechmachtheory.2010.11.018