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Geometric design of interference-free planar linkages

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Abstract

The paper presents a systematic methodology for synthesis of link geometry for interference free planar mechanisms with a given set of kinematic dimensions. All links are assumed to be flat, of same thickness; all the joints are assumed to be of revolute type. For this class of physical systems, the procedure guarantees that the complete range of kinematic motion will be available when the mechanism is fabricated. The order of assembly of the links at the time of fabrication, called *layer assignment* is studied in detail. It is established that the geometry of a link is not only affected by other links in its layer but also by the joints connecting links in other layers. Three types of infeasibilities have been identified and characterized. They are structural, kinematic and geometric infeasibilities. A mechanism without these infeasibilities can actually be fabricated. The concepts of geometric inversion and implicit sweep have been employed for efficient determination of infeasibilities and generation of the geometric description of the links. The theory has been implemented in computer and worked out examples for four-bar and Stephenson six-bar chain design have been included in the paper.

Zusammenfassung

Das Papier stellt eine systematische Methodenlehre für Synthese von Verbindung Geometrie für Störung freien planaren Einheiten mit einem gegebenen Satz kinematischen Maßen dar. Alle Verbindungen werden angenommen, um, von der gleichen Stärke flach zu sein; alle Verbindungen werden angenommen, um von der revolute Art zu sein. Für diese Kategorie der körperlichen Systeme, garantiert das Verfahren, daß die komplette Strecke der kinematischen Bewegung vorhanden ist, wenn die Einheit fabriziert wird. Der Auftrag des Zusammenbaus der Verbindungen zu der Zeit der Herstellung, benannt Schichtanweisung wird im Detail studiert. Es wird hergestellt, daß die Geometrie einer Verbindung nicht nur durch andere Verbindungen in seiner Schicht aber auch durch die Verbindungen anschließenden Verbindungen in anderen Schichten beeinflußt wird. Drei Arten infeasibilities sind gekennzeichnet worden und gekennzeichnet worden. Sie sind strukturelle, kinematische und geometrische infeasibilities. Eine Einheit ohne diese

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infeasibilities kann wirklich fabriziert werden. Die Konzepte der geometrischen Umstellung und der impliziten Schleife sind für leistungsfähige Ermittlung von infeasibilities und von Erzeugung der geometrischen Beschreibung der Verbindungen eingesetzt worden. Die Theorie ist im Computer eingeführt worden und ausgearbeitete Beispiele für Vierstab und Stephenson Sechsstab Kette Design sind im Papier umfaßt worden.

Keywords: Mechanism synthesis; Geometric design; Swept area

1. Introduction

The paper presents a methodology for synthesis of link geometry for interference-free planar mechanisms. Kinematic synthesis of linkages guarantees that if a mechanism is built with the given kinematic dimensions and assembled according to the given kinematic structure, the mechanism will perform the intended task satisfactorily. Given a physical artifact, obtaining the kinematic structure and dimension of its links is quite straightforward. However, conversion of the result of kinematic synthesis to a physical artifact is a non-trivial task. As illustrated in Fig. 1, the kinematic diagram (Fig. 1(a)) of the earth moving equipment in Fig. 1(b) is easily obtained. But, in the actual design process, information similar to that in Fig. 1(a) is generated first, using methods of *kinematic synthesis*, from the functional specifications in terms of workspace extent, required horizontal or vertical reach, stability during dumping, maximum allowable fluid pressure in actuator cylinders etc. The actual machine should not only satisfy these requirements but also ensure that the links do not interfere with each other or with the ground except at the designated portions of the bucket during its operation. Mass distribution on the links should be such that it is strong enough, but at the same time, light for minimizing power requirement and maximizing stability. Thus obtaining the actual engineering description of the links of a mechanism from its kinematic structure is a non-trivial task and is generally done by iterative trial and error procedures relying mostly on the designer's experience and expertise. Hence it is time consuming,

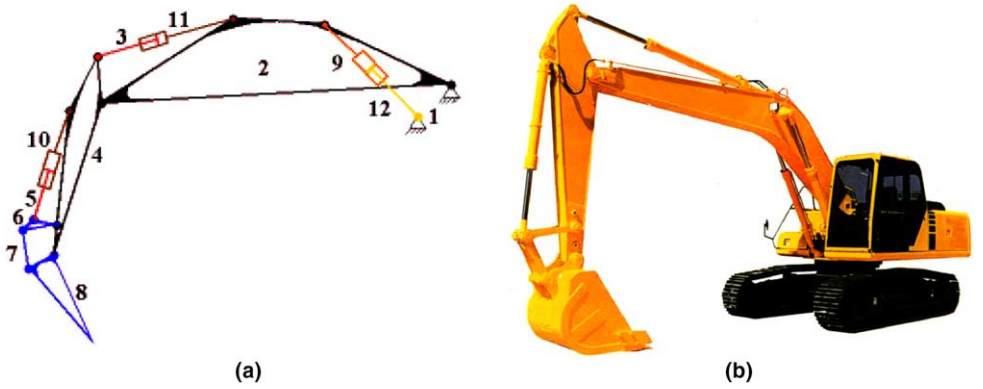

Fig. 1. Relationship between a kinematic diagram and the physical device: (a) kinematic diagram of an earth moving and (b) 3D view the earth moving equipment.