

A family of mixed double-Goldberg $6R$ linkages

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A complete family of double-Goldberg $6R$ linkages is reported in this article by combining a subtractive Goldberg $5R$ linkage and a Goldberg $5R$ linkage through the common link-pair or common Bennett-linkage method. A number of distinct types of overconstrained linkages are built, namely the mixed double-Goldberg $6R$ linkages. They all have one degree of freedom and their closure equations are derived in detail. One of them degenerates into a Goldberg $5R$ linkage. From the construction process and geometry conditions, the corresponding relationship between the newly found $6R$ linkages and the double-Goldberg $6R$ linkages, constructed from two Goldberg $5R$ linkages or two subtractive Goldberg $5R$ linkages, has been established.

Keywords: Goldberg $5R$ linkage; double-Goldberg $6R$ linkage; overconstrained linkage; common link-pair method; common Bennett-linkage method

1. Introduction

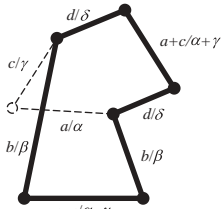
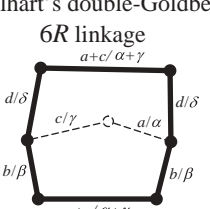
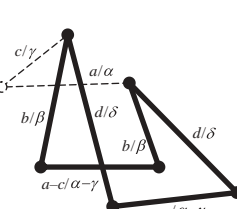
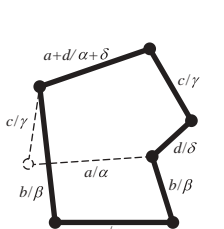
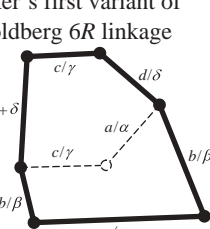
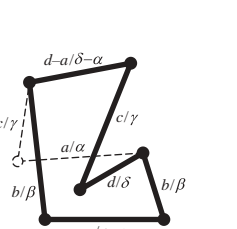
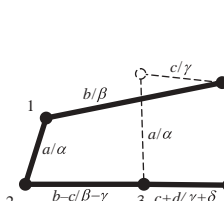
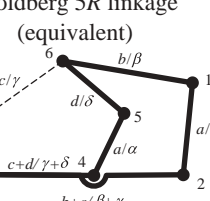
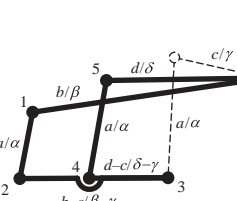
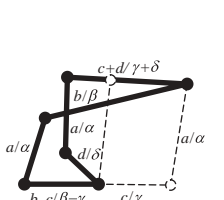
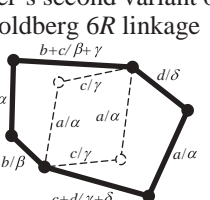
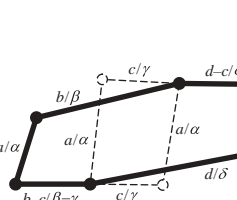
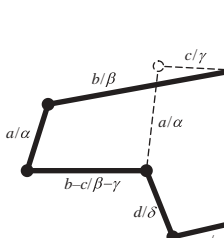
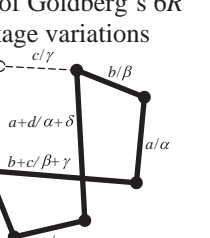
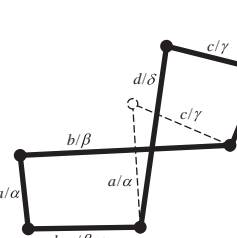
Various research has been devoted to the invention of single degree-of-freedom overconstrained linkages by combining two or more existing overconstrained linkages. Among them, the Bennett linkage has been a popular construction element since it was proposed in 1903 (Bennett 1903, 1914). Myard (1931) was the first to form $5R$ and $6R$ overconstrained linkages with two Bennett linkages. Later, Goldberg (1943) built a family of $5R$ and $6R$ linkages with two or three Bennett linkages.

For the $5R$ linkages, Baker (1979) re-examined both Myard linkages and the Goldberg $5R$ linkage. He pointed out that the former can be considered as a special case of the latter. A generalized Goldberg $5R$ linkage, initially introduced by Goldberg, was derived by Wohlhart (1991*a*) in detail. Recently, Lee (2002) gave an investigation into the kinematics of the generalized Goldberg $5R$ linkage. Song & Chen (2011) proposed a subtractive Goldberg $5R$ linkage and investigated its kinematic properties.

For the $6R$ linkages, several linkages were found by different researchers using a combination construction method. Waldron (1968) merged two Bennett linkages on a common joint and constrained the relative positioning of the links from these two Bennett linkages to build one of his hybrid $6R$ linkages. Yu & Baker (1981)

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Table 3. The complete families of double-Goldberg 6R linkages.

the mixed double-Goldberg linkage from linkages S and G	the double-Goldberg linkage from two G linkages	the subtractive double-Goldberg linkage from two S linkages
<p>I</p> 	<p>Wohhart's double-Goldberg 6R linkage</p> 	
<p>II</p> 	<p>Baker's first variant of Goldberg 6R linkage</p> 	
<p>III</p> 	<p>Goldberg 5R linkage (equivalent)</p> 	
<p>IV</p> 	<p>Baker's second variant of Goldberg 6R linkage</p> 	
<p>V</p> 	<p>one of Goldberg's 6R linkage variations</p> 	

(Continued.)