Dynamically Isotropic Hexapods for High-Performance 6-DOF Manipulation

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Abstract
Recent advances in synchrotron facilities have led to a growing need for 6-DOF precise manipulation. Hexapods are the most widely used parallel robots which provide 6 DOFs. To obtain high precision and high dynamic performance in hexapods, it is necessary to design them in such a way that low eigenfrequencies are avoided (while the eigenfrequencies are also functions of the complex 3D geometry of hexapods). Theoretically, maximizing the lowest eigenfrequency leads to a condition where multiple eigenfrequencies become equal, which is known as (complete or partial) dynamic isotropy. Thus, one may consider a dynamically isotropic hexapod as the optimal design solution, where precision and dynamic performance is a goal. In this work, we analytically address this problem and establish a practical guideline in order to design generalized hexapods with complete dynamic isotropy. The findings are based on the recently defended PhD dissertation by Behrouz Afzali-Far.

Fig. 1 Standard hexapod

Fig. 2 A general 3D platform constrained at three arbitrary nodes

Fig. 3 Arrangements of kinematic couplings: the 3-2-1 arrangement (left); the 2-2-2 arrangement (right).

Fig. 4 The proposed generalized hexapod (GGSP)

Generalized studies
To remove the classical isotropic constraint, we have generalized our studies, as shown in Fig. 2. Our generalized studies formulate the conditions of dynamic isotropy in hexapods as well as the isotropic conditions for the two kinematic arrangements which are shown in Fig. 3.

Novel isotropic architecture of hexapods
Based on the generalized studies, a novel architecture of hexapods (GGSPs, see Fig. 4) is proposed, in which the classical isotropic constraint is removed

and replaced by

Main advantages:
- Dynamic isotropy for a wide range of inertia conditions
- Static and dynamic isotropy at the same time
- The struts (actuators) can still be identical, which is easy to design and fabricate

Background of the project