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Analytical index of dynamic isotropy and its application to hexapods

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Abstract

Dynamic isotropy is a condition where eigenfrequencies of a robot are equal, which could be equivalent to the maximization of the lowest eigenfrequency. Accordingly, dynamic isotropy can be considered as an effective criterion to optimize dynamic performance of a robot. In this paper, we firstly present the mathematical conditions in order to obtain dynamic isotropy in hexapods. These conditions are presented for two cases (with and without considering the strut inertia). Then, it is proven that complete dynamic isotropy is physically impossible to achieve in hexapods where the platform is a single (rigid) body, but a semi-complete dynamic isotropy is feasible. It is also analytically proven that the dynamic isotropy leads to the maximization of the lowest eigenfrequency, even for the semi-complete dynamic isotropy. In a generalized approach, to obtain isotropy or near-isotropy solutions, we have established an analytical tool named "analytical index of dynamic isotropy" in order to directly obtain solutions as close as possible to isotropy. The developed method can be applied to all forms of isotropy and is not limited to dynamic isotropy in hexapods. This work is a continuation of the PhD thesis by the first author.

Keywords: Dynamic isotropy, Parallel robots, Gough-Stewart platforms, Vibrations, Minimization/Maximization, Optimization, Energy Harvesting

Nomenclature

Table 1: Subscripts/superscripts

C	Cartesian space
H	Initial distance from the base to the platform-plane
R	Radius
b	Base
c_p	Platform's center of mass
$de.$	Decoupled
h	Distance from the platform-plane to the platform center of mass
i, j, k	Integers
max	Maximum
min	Minimum
p	Platform
st	Strut
x, y, z, α, β, γ	Refers to each coordinate of the "Cartesian space"
$\underline{\boldsymbol{e}}_b$, $\underline{\boldsymbol{e}}_p$	Base-basis and platform-basis, respectively

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