A Novel Approach to Design Planar Four-Bar Linkages for Approximation Motion Synthesis

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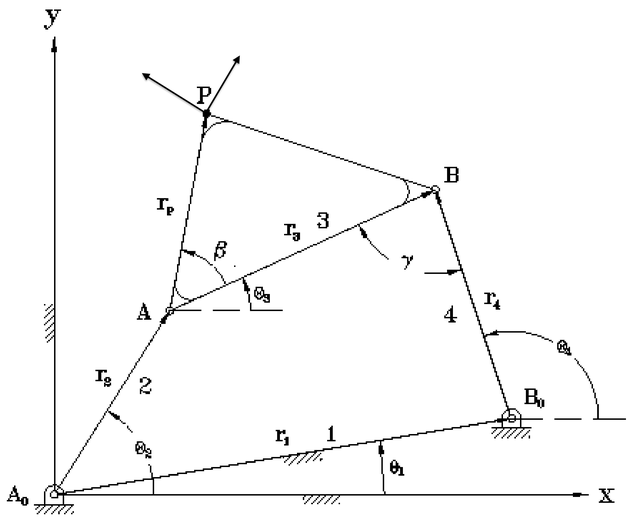
Objective: To determine a method for performing approximate motion synthesis of four-bar linkages without position metrics

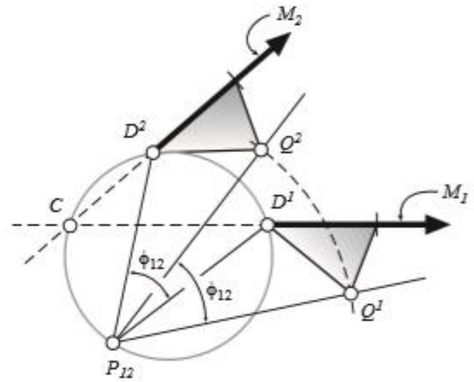
Introduction

According to mechanism synthesis theory, a planar four-bar linkage can be synthesized to achieve at most five positions exactly. Typical design problems will involve many more positions than five where approximately achieving all positions is sufficient. Earlier methodologies use position metrics to measure how well the mechanism performs. Position metrics are problematic in that they involve arbitrary length scales. Our approach eliminates the position metric and uses only the displacement poles.



A planar four-bar linkage

What is a Pole?



The pole for a desired position:

$$\vec{\mathrm{P}}_{ij} = A_i\left(A_i - A_j\right)^{-1}\left(\vec{d}_j - \vec{d}_i\right) + \vec{d}_i$$

The pole for an approximated position:

$$\vec{\mathrm{Q}}_{ij} = B_i\left(B_i - B_j\right)^{-1}\left(\vec{e}_j - \vec{e}_i\right) + \vec{e}_i$$

Mathematical Statement of the Design Problem

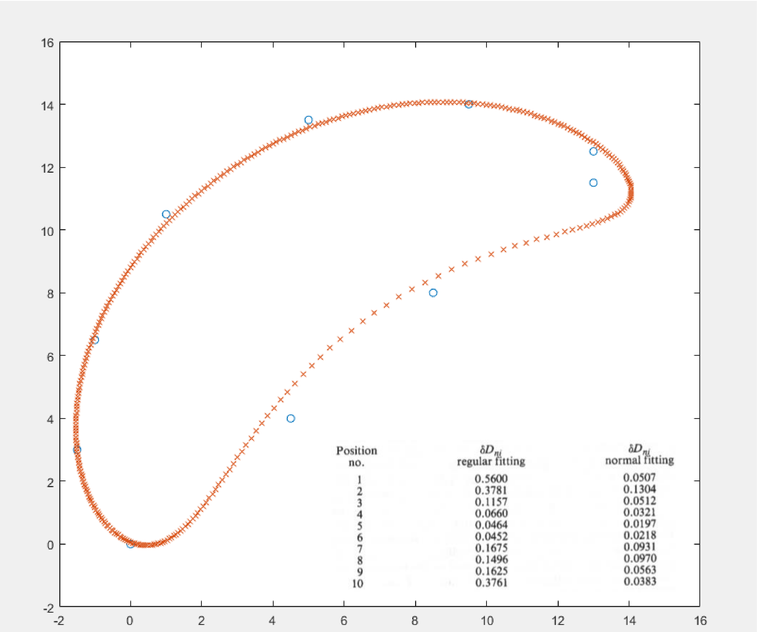
$$\text{Minimize J} = \sum (\vec{\mathrm{P}}_{ij} - \vec{\mathrm{Q}}_{ij})^T (\vec{\mathrm{P}}_{ij} - \vec{\mathrm{Q}}_{ij})$$

References

Ravani, B., and B. Roth. "Motion Synthesis Using Kinematic Mappings". *Journal Of Mechanisms, Transmissions, And Automation In Design*, vol 105, no. 3, 1983, pp. 460-467. *ASME International*, doi:10.1115/1.3267382.

Kinzel, Edward C. et al. "Function Generation With Finitely Separated Precision Points Using Geometric Constraint Programming". *Journal Of Mechanical Design*, vol 129, no. 11, 2006, pp. 1185-1190. *ASME International*, doi:10.1115/1.2771575. Accessed 10 Apr 2020.

What does a Solution Look Like?



What does a Solution Look Like for Five or Fewer Positions?