METHODOLOGICAL ANALYSIS OF FINTIE HELICAL AXIS BEHAVIOR IN JOINT KINEMATICS

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SUMMARY

The Finite Helical Axis (FHA) is still confronted with representational difficulties. The present study investigates the effect of noise in the estimation of the Finite Helical Axis parameters. Furthermore, a method is presented to describe the Helical axis dispersion as a way to demonstrate the stability and quality of the joint movement. Optimal noise reduction and angle intervals are presented as well as the minimum Convex Hull method.

INTRODUCTION

Although a far more stable approach and very common in spacecraft dynamics and graphic imaging, the FHA struggles with interpretational and representational difficulties compared to a six degrees of freedom analysis especially in clinical context and among medical professionals. The dispersion of the 3D-motion axis has been used to express the stability of the motion in kn kinematics and cervical spine analyses (Osterbauer et al. 1992; Panjabi 1979; Woltring et al. 1985). However, these type of graphical representations does not allow for mathematical and statistical comparison of data in lar dataset. It may as well cause difficulties to establish reproducibility measures and to set normative data for comparison in clinical cases. The present study represents a methodological analysis focusing on the effect of noise and angle intervals on the estimation of FHA parameters an the quantification of the FHA behavior.

METHODS

The algorithm used in this methods is based on the method first presented by Mozzi in 1763 and elaborated by Ceccarelli (2000). The helical axis characteristics are extracted from R and v by defining a matrix U that fulfils U = RT - R (Söderkvist et al. 1993). The parameters n, T, c and t can be derived from U.

$$= \frac{1}{\overline{\quad + \quad + \quad}} \cdot$$

$$= \begin{cases} \arccos \dfrac{\quad + \quad + \quad - 1}{2} \\ \arcsin \overline{\quad + \quad + \quad} \end{cases} ?$$

$$= \frac{1 + \cos}{2 \sin} \cdot \quad -$$

=

RESULTS

The study of the effect of input noise on the accuracy of the FHA-parameters estimation shows a linear relation between the simulated noise and the error in the corresponding parameter with the following relationships in the parameters: a) 1 degree noise ? 4 degrees error; b) 1 degree noise 2 mm error; c) 1 mm noise ? 1 mm error; d) 1 degree noise ? 2 mm error; e) 1 mm noise ? 1 mm error (Figure 1).

Further analysis showed an inversely proportional relationship between angle steps and FHA angle and position error. The translation along the helical axis was not dependent from the angle steps. The error in the three parameters increased proportionally with the noise level.

FHA axis stability can be determined by calculating the intersection points of the IHA (Instantaneous Helical Axis) for each of the planes perpendicular to the FHA using Convex Hull (CH) technique. The minimum CH is defined as convex polygon with minimum area, which includes all points in a plane (figure 2). The angle between the FHA and each of the IHA was also computed and its distribution was analyzed (figure 2).

CONCLUSION

Input noise has a linear relationship and an inversely proportional relationship with the angle steps have be demonstrated with FHA-estimation accuracy.

The FHA dispersion can be represented by the minimum convex hull and the distribution of angles of the IHA relative to the FHA.

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Figure ***1:*** *The effect of input-noise on FHA-estimation.*

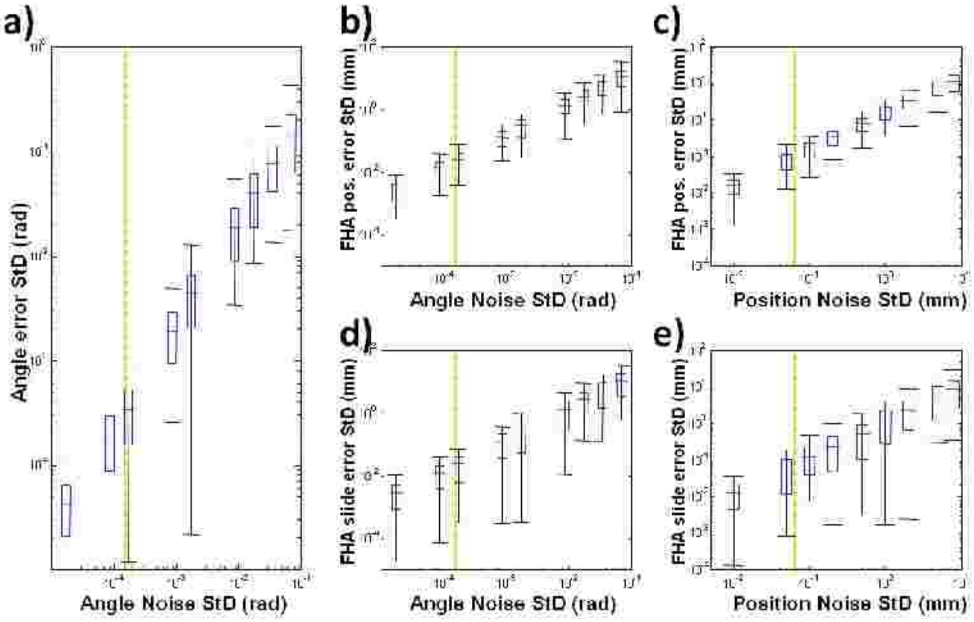

Figure 2*:FHA-representation by Minimum Convex Hull and angle dispersion.*