METHODOLOGICAL ANALYSIS OF FINTIE HELICAL AXIS BEHAVIOR IN JOINT KINEMATICS

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BACKGROUND AND STUDY AIM

Although a far more stable approach and very common in spacecraft dynamics and graphic imaging, the Finite Helical Axis (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 knee kinematics and cervical spine analyses. However, those graphical representations do not allow mathematical and statistical comparison of data in larger dataset. The aim of the present study is to investigate the effect of noise and angle intervals on the estimation of FHA parameters and to introduce a novel approach for the quantification of the FHA behavior.

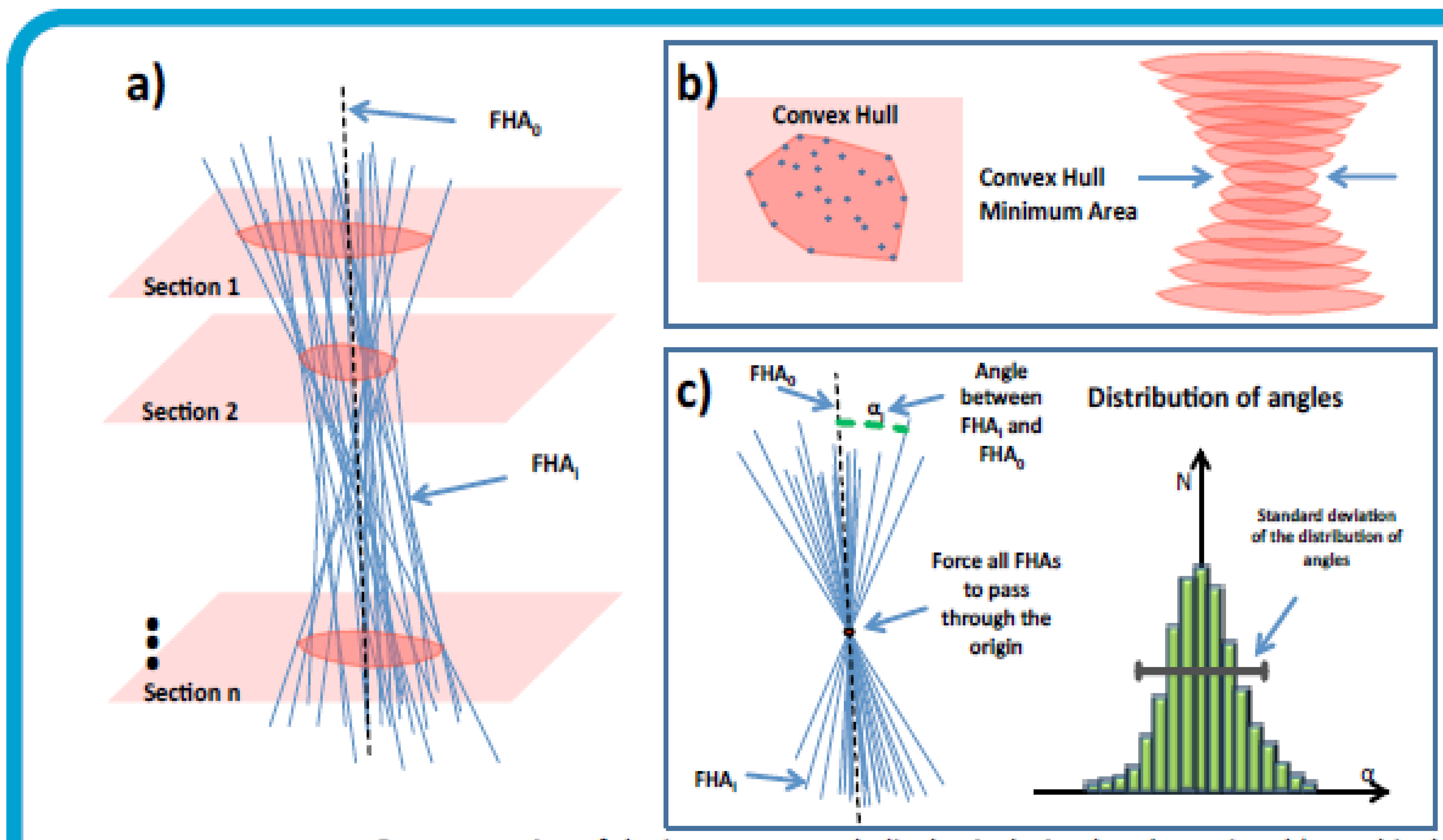

Figure 2 Representation of the instantaneous helical axis during head rotation. b) graphical representation of Convex Hull for a plane and identification of the Convex Hull with minimum area. c) Distribution of angles between each FHA_i and FHA_0.

METHODS

The algorithm used in this study is based on the method first presented by Mozzi in 1763. The helical axis parameters n, Θ, c and t can be derived with simple mathematical calculations. A simulation of body movement and FHA extraction has been performed introducing random noise on position and orientation of a virtual sensor (100 repetitions).

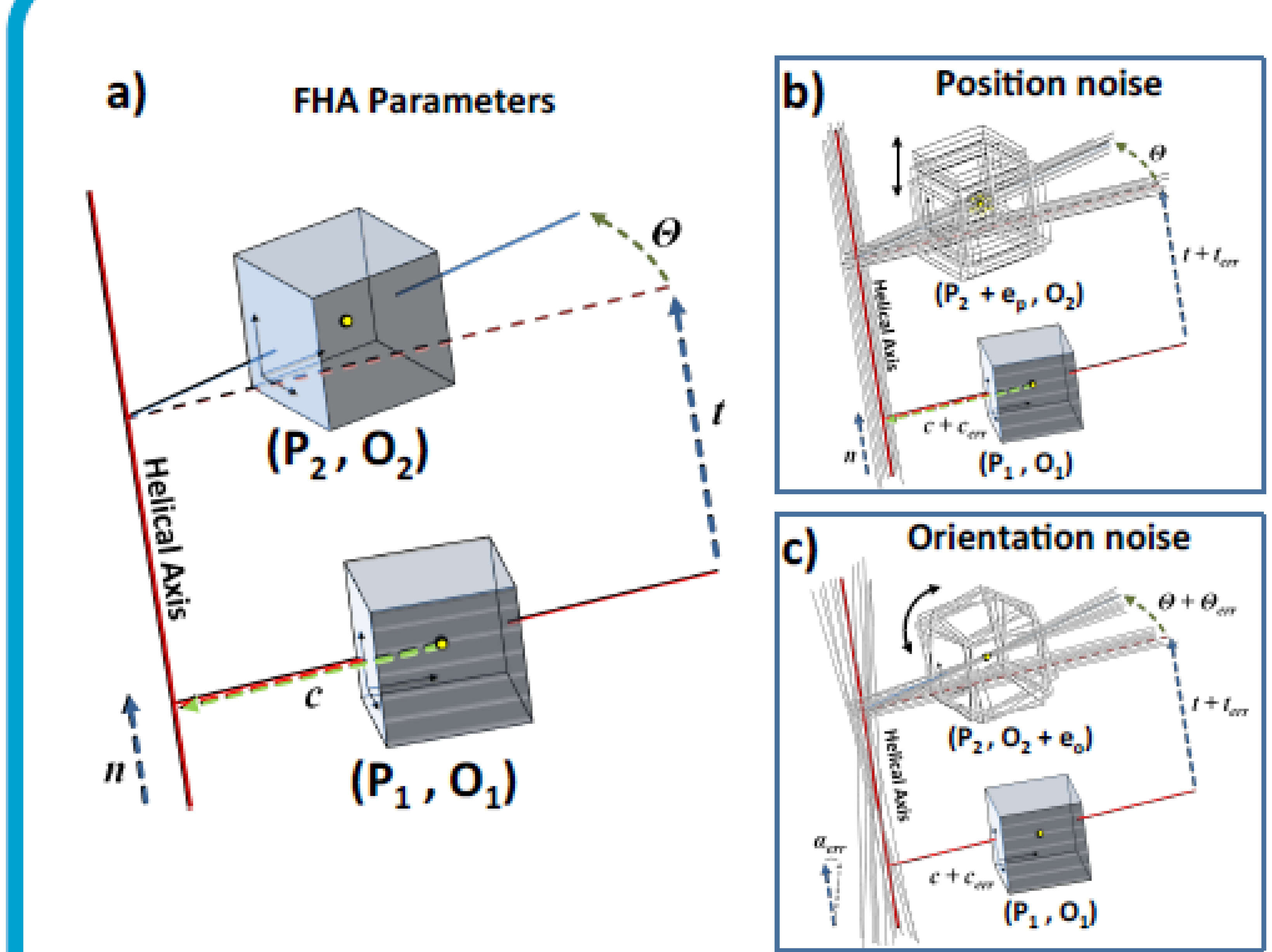

Figure 1 Representation of the helical axis of an object changing position and orientation in space from P_1,O_1 to P_2,O_2. The axis is parallel to the unit vector **n** and has a distance **c** from the object. The angle of rotation is **ϑ** and the translation along the axis is **t**. Graphical representation of the effect of position noise (b) and orientation (c) noise on the FHA parameters.

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 (Figure 1).

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 the 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).

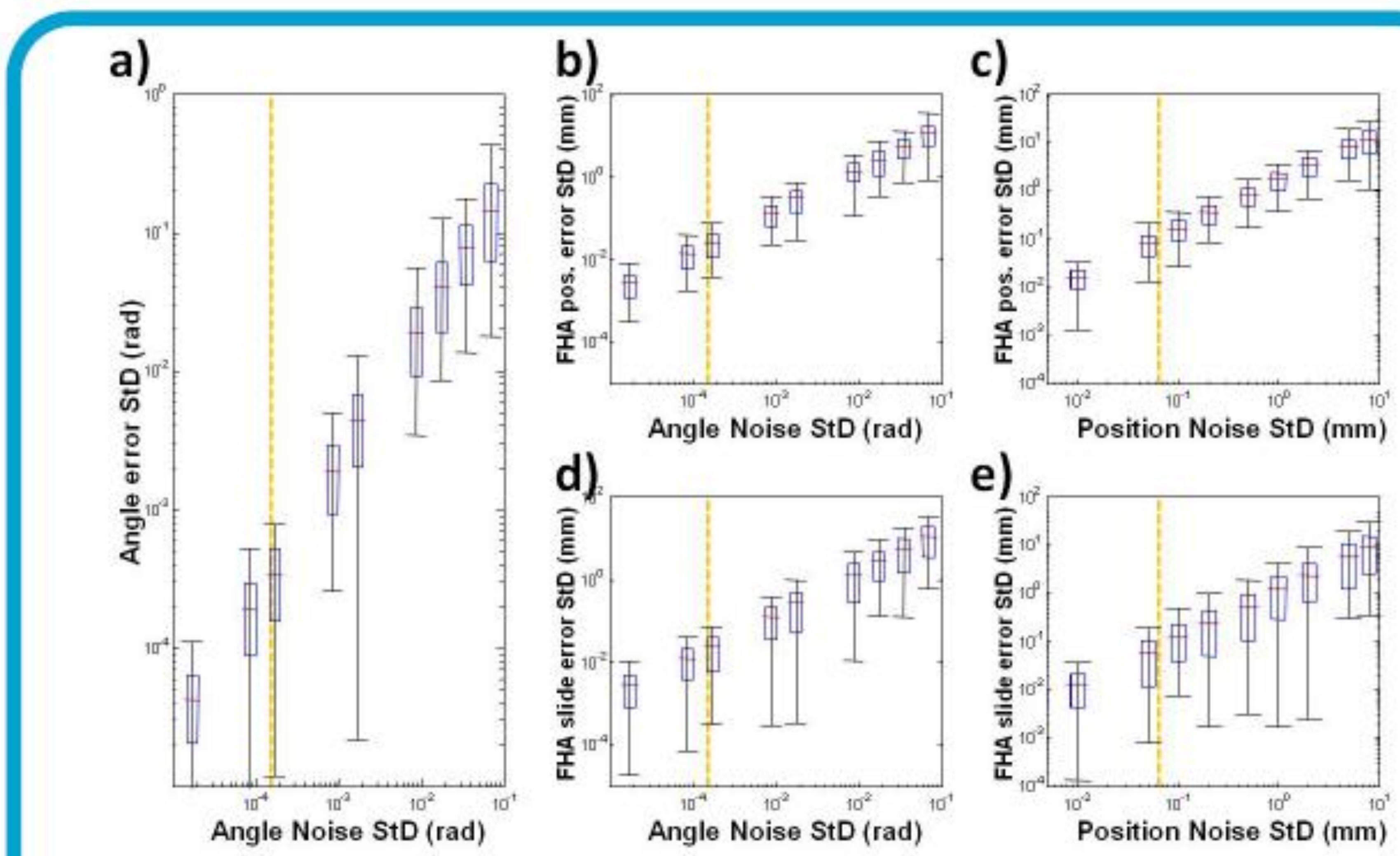

Figure 3 Effect of additive noise in the orientation (a,b,d) and position (c,e) of the sensors on the helical axis parameters. The vertical dashed line represent the nominal noise described in the data-sheet of the Polhemus-G4 sensors. parameters were evaluated: angle error between theoretical helical axis and estimated helical axis with added noise (a), the error between theoretical and estimated position of the helical axis (b, d) and the error in translation along the axis (c,e).

CONCLUSION

Input noise has a linear relationship and an inversely proportional relationship with the angle steps have been 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.

REFERENCES

•Osterbauer, P.J. et al., Journal of manipulative and physiological therapeutics, **15(8)**, pp.501–11, 1992.
•Panjabi, M.M., *Journal of Biomechanics*, **12(12)**, pp.911–920, 1979..
•Woltring, H.J. et al., *Journal of biomechanics*, **18(5)**, pp.379–89, 1985.
•Ceccarelli, M., *Mechanism and machine theory*, **35**, pp.761–770, 2000..