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A method to compensate kinematic cross-talk

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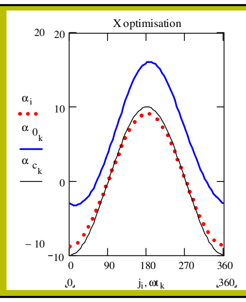
ABSTRACT:
In this presentation the authors want to show that it is possible to compensate the misalignment of a joint with respect to a fixed reference frame and the misalignment of a moving frame with respect to the joint when the joint angles vary periodically. In case both types of misalignment occur together, the cross-talk can be minimized by a least-squares optimization.

Keywords:
Component / kinematic cross-talk / axes misalignment

Purpose:

In this paper we present a method for reorientation based on the use of classic rotation matrices. The determination of the FHA thus can be avoided and the rotation matrices obtained with several measurement devices can be used without differentiation.



Problem:

Compensate both the misalignment between the reference frame and the joint frame and between the joint frame and a rotating link.
Let the misalignment be described by the matrices $R(\sigma)$ and $R(\tau)$
Let the joint rotation be described by the coupled components $R(\alpha_c)$ around the X - axis and $R(\beta_c)$ around the Y-axis, with a joint rotation $R(\delta)$

The misalignment matrices which have to be calculated are given by the Rodrigues expression:

$$R(\sigma) = I + \sin(\sigma)\bar{u}^* + (1-\cos(\sigma))\bar{u}^*\bar{u}^*$$

$$R(\tau) = I + \sin(\tau)\bar{v}^* + (1-\cos(\tau))\bar{v}^*\bar{v}^*$$

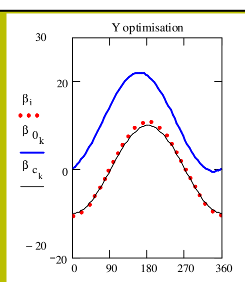
Problem formulation:

Given the matrix R^0 with the decomposition

$$R^0 = R(\xi)R_x(\alpha_c)R_y(\beta_c)R(\delta)R(\varepsilon)$$

Find the unknown parameters $\sigma, \bar{u}, \tau, \bar{v}$ subjected to the constraints

$$\left|u_x^2 + u_y^2\right| = \left|v_x^2 + v_y^2\right| = 1$$



Solution:

To find the matrices one has to determine 6 unknowns. This problem can be solved by using a least-squares optimization. If the hypothesis that the cross-talk effect always leads to an increase of the components along the X and Y axis is assumed true, then one can minimize these components to reduce the cross-talk.

$$Min\left\{\int_T \left(\alpha^2 + \beta^2\right)dt\right\}$$

To correct the misalignments, the original matrix R^0 is multiplied with a correction matrix at the left and at the right

$$R^c = R^{-1}(\sigma)R^0R^{-1}(\tau)$$

With the X and Y components given by $\alpha = -\operatorname{atan}\left(\frac{R^c_{1,2}}{R^c_{2,2}}\right)$ and $\beta = \operatorname{asin}\left(R^c_{0,2}\right)$

The solution shown by the red dots is compared with the given coupled components in black and with the original components in blue.