COMMENT ON "ATTITUDE PARAMETER INSPIRED RELATIVE MOTION DESCRIPTIONS FOR RELATIVE ORBITAL MOTION CONTROL"

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Abstract - This paper is to comment on a published paper (Ref. 1)"Attitude parameterinspired relative motion descriptions for relative orbital motion control".

Index Terms - Attitude parameter, Quaternions, Relative orbital motion, Control

I. INTRODUCTION

Ref. 1 described the Clohessy-Wiltshire (CW) equations using the relative position (L) between deputy and chief satellites and three unit vectors e_1, e_2, e_3 such that

$$e_1^2 + e_2^2 + e_3^2 = 1 \text{ or } e_3 = \pm(1 - e_1^2 - e_2^2)^{1/2}.$$

The authors in Ref. 1 chose three (say, L, e_1 and e_2) of the four parameters and designed a control law, in the hope that the four parameters converge to their desired values, L_r, e_{1r}, e_{2r} and e_{3r}. Then, the authors stated that the convergence of only the chosen parameters to the desired values is guaranteed, and the fourth parameter e_3 may converge to either e_{3r} or $-e_{3r}$ if the unity constraint (1) is satisfied at all times. The authors also conjectured that if the deputy starts closer to e_{3r} than $-e_{3r}$, it will converge to the proper orientation $e3_r$.

In this comment, the author would to like to claim that e_3 must converge to e_{3r} if there is an explicit algebraic relationship f, other than (1), between e_{1r}, e_{2r} and e_{3r} such that for any time t

$$e_{3r} = f(e_{1r}, e_{2r}, t).$$

II. MAIN RESULT

The convergence to e_{3R} is mainly determined by how the desired state is selected, rather than how the initial state is chosen. This claim is easily proved by noting that $e_1 \to e_{1r}$ and $e_2 \to e_{2r}$ must guarantee $e_3 \to f(e_{1r}, e_{2r}, t) = e_{3r}$ as $t \to \infty$.

For example, e_3 must converge to e_{3r} if the desired state is given as Eqs. (47a) – (47c) in Ref. 1. In fact,

$$\begin{aligned} x_r &= 0.05\,\mathrm{COS}(nt), \quad y_r = 0.05\,\mathrm{SIN}(nt), \\ z_r &= 0.02\,\mathrm{SIN}(2nt + \pi/2) + 0.03 \\ &= 0.02\,\mathrm{COS}(2nt) + 0.03 \\ &= 0.02(\mathrm{COS}^2(nt) - \mathrm{SIN}^2(nt)) + 0.03 \\ &= 0.02(x_r^2/0.05^2 - y_r^2/0.05^2) + 0.03 \\ &= 8(x_r^2 - y_r^2) + 0.03 \end{aligned}$$

or

$$\begin{aligned} e_{1r} &= x_r/L_r, e_{2r} = y_r/L_r, \\ e_{3r} &= z_r/L_r = 8L_r(e1_r^2 - e2_r^2) + 0.03/Lr \\ &\equiv f(e_{1r}, e_{2r}, t), \end{aligned}$$

Where $L_r = x_r^2 + y_r^2 + z_r^2$ is a function of time t. This function f is well-defined for any t as L_r is always positive.

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