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

YOONSOO KIM

Department of Aerospace and Software Engineering, and Research Center for Aircraft Parts Technology, Gyeongsang National University, Jinju 52828, Republic of Korea
E-mail: yoonsoo@gnu.ac.kr

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

$$e_1^2 + e_2^2 + e_3^2 = 1$$

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.

ACKNOWLEDGEMENT

This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Ministry of Science and ICT (NRF-2017R1A5A1015311).

REFERENCES

[1] E. A. Hogan and H. Schaub, "Attitude Parameter Inspired Relative Motion Descriptions for Relative Orbital Motion Control," Journal of Guidance, Control, and Dynamics, vol. 37, no. 3, pp. 741–749, 2014.

★★★