Technical Comments

Extension of Angle-Only State-Determination to Curvilinear Coordinates

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REFERENCE 1 presents a closed-form solution for finding the relative state between two space vehicles in close orbits, based on sextant measurements made from one vehicle of the angle between the other and identified stars, using a local-vertical Cartesian coordinate system, x, y, z, (downrange, crossrange, up). A simple modification extends capability to the case in which the relative state is described by curvilinear coordinates, u, v, w. These coordinates, which obey the same linearized equations of motion, provide greater accuracy, especially when the downrange separation is large.[2] One appends a nonlinear geometry block (equations in Ref. 3) to transform line-of-sight angles in Cartesian coordinates ($\delta \equiv \tan^{-1} z/x$ and $\sigma \equiv \tan^{-1} y/(x^2 + z^2)^{1/2}$) to their "curvi-angle" counterparts in the curvilinear system ($\alpha \equiv \tan^{-1} w/u$ and $\nu \equiv \tan^{-1} v/(u^2 + w^2)^{1/2}$). The transformation requires knowledge of in-plane range $\rho \equiv (x^2 + z^2)^{1/2}$. Although neither known initially nor measured by the sextant, ρ can be obtained from the state-determination process. Historically, it was this fact, plus the relative insensitivity of the transformation equations to ρ, which suggested that a bootstrap technique might be successful. In principle, one first estimates a value for ρ, computes state based on this estimate, solves for an improved value of ρ from the state so determined, and then repeats the process. In practice, iterative computation of the non-linear geometry block (setting $\rho = 0$ in the first iteration), followed by the equations of Ref. 1 (with x, y, z, δ, α, replaced by u, v, w, α, ν) converges to the curvilinear solution. Convergence was successfully demonstrated in 245 simulations with different sets of initial conditions covering initial ranges from 50–400 nm, using a convergence criterion of .001 nm.

References

[1] Schneider, A. M., "A Linear Algorithm for Determining Relative Orbital State Using Angle Data," *Journal of Spacecraft and Rockets*, Nov. 1970, Vol. 7, No. 11, pp. 1358–1360.

[2] Templeman, W., "New Investigations in the Field of Error Propagation," *AIAA Progress in Astronautics and Aeronautics: Guidance and Control–II*, Vol. 13, edited by R. C. Langford and C. J. Mundo, Academic Press, New York, 1964, pp. 727–754.

[3] Schneider, A. M., "Combining Angular Measurements, Linear Dynamics, and Curvilinear Coordinates to Determine Relative Orbital State," May 4, 1971, Dept. of Aerospace and Mechanical Engineering Sciences, Univ. of California at San Diego, La Jolla, Calif.

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Comment on "Development of a Biowaste Resistojet"

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A RECENT paper by Halbach and Yoshida[1] incorporates some of this writer's chemical kinetics calculations (cf. Refs. 2–5). Such calculations are necessarily imperfect, relying as much upon practical engineering knowledge as contributing to it. One must divine what reaction paths prevail, and one must keep within computer limits of program size and running time, which is particularly why the imposed limitations for one computational regime may be severely inappropriate for another. The representation in the subject paper unfortunately implies that the calculations are straightforward.

In particular, the following sentence appearing in the theoretical discussion requires reservation: "Thermal decomposition of methane can become significant at temperatures above 3000°R." (Significant carbon formation is implied.) In general, agreement with this would be expected from one's knowledge of various other experimental findings, but it is not an experimental conclusion of the subject project. Neither is it an inference from the theoretical calculations.

The cursory reference given to the formation of condensed carbon as part of the general analytical solution is explained as follows: The computer program was fixed to carry condensed-phase mole fractions through the reaction and mass balance equations, but to delete them when evaluating the gaseous moles per unit total mass. The reaction rate constants for reactions involving condensed-phase species were first estimated via collision theory as if the species were gaseous, of unit size. For example, for $C_2H + M = H + C_2{}^* + M$ (where $C_2{}^*$ is used to designate the condensed phase), the size factor initially utilized was as for $C_2H + M = H + C_2 + M$. Then adjustment was made to account for the fact that reaction would proceed only in that portion of the total volume lying in the surface layer of molecules around a nucleus. It was reasoned that if C_2H (e.g.) and M met within a molecular diameter of the nucleus, then $C_2{}^*$ could be deposited onto the nucleus; the nucleus (rather than M) would absorb most of the substantial energy release. Otherwise, the unlikely endothermic reaction yielding gaseous C_2 would be the only possibility.

For the creation of the adjustment factor, a substantial quantity of condensed carbon was assumed already prevalent in the gas phase, and a representative size for this material as particulate matter was chosen. The relative volumes of "surface" gas and total gas so defined reduced to a ratio of one-millionth, so that the reaction rate constants first estimated for such reactions were devaluated by a factor of one million. Another viewpoint, numerically identical, holds that M must itself be a nucleus, rather than simply any molecule,

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