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Safe Penetration of Jacobian-Based Singularities

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High torque (or equivalently angular momentum) and singularity-free operations are key to rapid robotic manoeuvres, while the angular momentum space often contain mathematical singularities at angular positions where it is impossible to generate the requested change in angular momentum, while the singularities are derivable as singular inversion of a Jacobian matrix of angular gradients.Motion trajectories encountering these singularities diverge, reducing the usable momentum space. Utilizing a 3/4 skewed-pyramid of control moment gyroscopes, a procedure is illustrated to safely penetrate and traverse singularities anywhere in the momentum space, when these singularities stem from singular inverse of Jacobian matrices. The optimal singularity-free configuration is revealed first. Next, a decoupled control strategy is shown to reduce the remaining singular conditions. Analysis and simulation is provided to justify the argument with experimental verification performed on a free-floating satellite simulator. Furthermore, a singularity penetration algorithm is developed, simulated, and experimentally proven to fly through singularities even without singularity reduction.

Biography:

Timothy Sands served as a Chief Academic Officer, Associate Provost, Dean, and Research Center Director, Dr. Sands is currently the Associate Dean of the Naval Postgraduate School and International Scholar Laureate of the Golden Key International Honor Society, a Fellow of the Defense Advanced Research Projects Agency (DARPA) and panelist of both the National Science Foundation (NSF) Graduate Research Fellowship program and the National Defense Science and Engineering Graduate (NDSEG) Fellowship. He holds one patent in spacecraft attitude control and publishes non-government funded research under his continued affiliation with Stanford University or Columbia University.

Notes: