

A GENETIC ALGORITHM APPROACH TO OPTIMAL SENSOR PLACEMENT IN LIQUID HYDROGEN FUEL TANKS

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Abstract

Genetic Algorithms (GAs) offer a robust framework for optimization when vast configuration spaces render analytical methods such as gradient descend algorithms computationally prohibitive. This research employs GAs to determine optimal fill-level sensor layouts for liquid hydrogen (LH2) aircraft tanks, filling a gap in current aerospace instrumentation design. A pivotal element of this approach is the design of the fitness function, which quantifies the certification-related sensor sensitivity across the full range of fill levels and the operational flight envelopes of the aircraft (pitch and roll angles). To evaluate candidate configurations, the GA backend utilizes the open-source 3D geometry library, CadQuery, to calculate the fluid volume content of the tilted tank and the intersection where the sensors meet the liquid surface. The results demonstrate that GAs can evolve novel, high-performance sensor layouts. However, the findings also underscore that integrating domain-specific constraints into the crossover, mutation, and fitness operators is essential for ensuring computationally efficient convergence toward physically viable solutions.