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Commentary

Inertial Navigation Systems (INSs) and Geomagnetic Matching Navigation Techniques

David T Long*

Department of Geological Sciences, Michigan State University, Michigan, USA

DESCRIPTION

The geomagnetic matching navigation approach is significantly constrained by the precision of an a priori geomagnetic reference map. Using conventional geomagnetic navigation techniques is impossible, especially when the aircraft enters an uncharted environment. Therefore, a geomagnetic/INS integrated matching navigation algorithm for long-scale navigation is proposed in this study, which can accomplish navigation tasks regardless of whether there is an a priori geomagnetic map. This technique combines a geomagnetic bionic navigation technique that does not require a geomagnetic map with a magnetogram-based matching navigation technique.

Unmanned Aerial Vehicle (UAV) navigation currently makes extensive use of Inertial Navigation Systems (INSs), which can continuously and autonomously offer complete navigation information about aircraft. However, because INS's error builds up over time, it is challenging to adapt it to the needs of long-range navigation. Therefore, to obtain complementing capabilities and high positioning precision, INS is typically integrated with other navigation systems to ensure the accuracy of navigation.

The benefits of passive autonomy and excellent concealment are two advantages of geomagnetic navigation as a natural coordinate system in the navigation area. Geomagnetic navigation has grown to be a significant aided navigation technology because it is not constrained by time or terrain and can overcome the limitations of INS that accumulate errors over time and distance.

The most widely used geomagnetic navigation research is to correlate the measured geomagnetic information on the navigation path with the onboard preceding geomagnetic map to derive the aircraft's actual position, which is known as the "geomagnetic matching" navigation method. As a result, the accuracy of the previous geomagnetic map plays a role in the precision of geomagnetic navigation. However, it is challenging to guarantee the precision and thoroughness of a priori geomagnetic maps for a number of reasons. As a result, the geomagnetic matching navigation approach, which significantly depends on the accuracy of the magnetic map, is severely constrained.

The majority of geomagnetic matching navigation techniques, including the well-known Magnetic Contour Matching (MAGCOM) and Iterative Closest Contour Point (ICCP) algorithms, the Genetic Algorithm (GA), and the Particle Swarm Optimization (PSO) algorithm, are founded on highly accurate geomagnetic maps. Different interpolation techniques (such as Kriging and Neural Networks (NNs)) are typically employed to refine the magnetic map when the precision of the magnetic map is not high. The geomagnetic reference map could be distorted if the interpolation approach is instead used directly to low-resolution geomagnetic data. Short-scale navigation matching outcomes will be obviously impacted, and due to the intrinsic error buildup, long-scale navigation matching accuracy may also be impacted. The triangle algorithm in star-map matching and a geomagnetic matching navigation algorithm built on the triangle constraint lower the matching distance and complete navigation under the circumstance of low magnetic map resolution by using the least amount of information possible.

Furthermore, in the absence of an a priori geomagnetic map, conventional geomagnetic navigation algorithms are useless. Although many animals lack an a priori geomagnetic map in their brains, recent research has demonstrated that numerous species, including birds, turtles, salmon, and many other organisms, are able to use geomagnetic field information to alter their trajectories. This biological characteristic served as the inspiration for a geomagnetic bio-navigation approach that does not utilize a geomagnetic map, but because it is based on a random walk model, its navigation path is highly convoluted and unsuitable for aircraft. Given that it is well known that the Earth's magnetic field exhibits a magnetic tendency over a significant portion of its surface, a gradient-based geomagnetic bio-navigation algorithm that uses the geomagnetic gradient information of the current position is more appropriate for long-range aircraft navigation.

Correspondence to: David T Long, Department of Geological Sciences, Michigan State University, Michigan, USA, E-mail: long.david@msu.edu

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