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RADIO FREQUENCY INTERFERENCE: ITS PREDICTION AND AVOIDANCE WITH THE SPACE-TIME AI USING VORONOI DIAGRAM

Abstract

As more satellites are being deployed, spectrum space is becoming more congested by radio frequency (RF) for communications between satellites and ground stations, between satellites, or between satellites and vehicles such as airplanes in midair. One of the critical consequences of the congested spectrum space and busy geo-space is radio frequency interference (RFI) which may cause communication disruption. This phenomenon will be outstanding as more constellations will be in geospace. Therefore, the prediction of RFI, and hopefully followed by its mitigation, is crucial for smooth communication. However, the prediction and mitigation are computational challenges for the satellites orbiting at extreme speeds, particularly in the forthcoming constellations of from hundreds to thousands, if not tens of thousands, of satellites. This is because an RFI occurs under specific geometric conditions involving three or sometimes four objects at least, depending on conditions. So, the size of the combinatorial space is of (N, 3) or (N, 4) for each moment in timeline. The cases of higher combinatorial space may not be ignorable. Here we introduce the space-time artificial intelligence (ST-AI) method of SPACEMAP which can efficiently and accurately predict the RFI of own satellites against all known radio-frequency emitting objects in space catalogue. The proposed ST-AI method is based on the Voronoi diagram of space objects. We take advantage of the already-available WatcherCatcher of SPACEMAP function where the anchor point can be a location not only in a 2D plane but also in a 4D spatiotemporal space, i.e., flying airplane and satellites. The efficiency of SPACEMAP is possible by taking advantage of the powerful spatial reasoning features of Voronoi diagrams. Assuming a preprocessing operation to construct the Voronoi diagram over the timeline, the ST-AI method can solve many challenging spatiotemporal problems very fast, i.e., near real-time. This study makes the following additional contributions. First, the method used for the RFI prediction can be similarly used to find a way for RFI deconfliction. Second, the RFI prediction provides a mitigation scheme to avoid corrupted communication due to noise. SPACEMAP runs on AWS and exploits elastic compute and auto scaling features. SPACEMAP currently uses the TLE data from Space-Track and its services are available at https://platform.spacemap42.com.