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INNOVATIVE SENSOR-BASED NETWORK FOR AUTONOMOUS ON-ORBIT STRUCTURAL HEALTH MONITORING

Abstract

The structural integrity of satellites has been a major concern since the very beginning of the Space era. With the renewed interest in space exploration, the growing density of space debris in the Low Earth Orbit and the need to face long-term manned missions, classical passive protections may quickly become obsolete. An interesting alternative would be the employment of active monitorization techniques involving a network of sensors.

In the framework of the two-day NASA Space Apps Challenge 2018, the ARACNE student team from Politecnico di Milano faced the design of an innovative architecture aimed to monitor the external skin of the spacecraft. The proposed system consists of a sensorial network capable of exploiting waves propagation to obtain relevant energetic and kinematic measurements. Similar approaches on Earth have already been able to correlate the collected data of a group of piezoelectric sensors with the energetic level of the event and its location. Sensors remain in a standby state until a sufficiently destructive wave is detected, and are sequentially activated based on their own position. The kinematic measurements of each sensor are sent to a central node that estimates the energy of the wave and triangulates its origin. From a theoretical viewpoint, this can be done either in a deterministic way or by means of a pre-trained neural network. Despite its greater computational cost, the second approach enables an onboard training process that adapts to the evolution of the structure throughout the mission.

In order to extend the concept to complex geometries, the network must be analysed based on FEM simulations or an experimental testing campaign. This is particularly important for machine learning applications requiring large datasets. The analysis should output a topologically optimized network of sensors and a sufficiently reliable detection system. This leads to a reduction in the overall cost and mass of the system.

A preliminary study analysing the trade-offs between cost, feasibility, performance and power is presented. The baseline design is selected on the grounds of the aforementioned characteristics. The team is nowadays working on the project as an extracurricular activity supported by the University Department of Aerospace Engineering to better identify the feasibility of the final solution.