
Real-time detection of Solar and Jovian radio bursts with NenuFAR : a part of the EXTRACT project.

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Résumé

In the past decades, the increasing need for ultra-high-resolution radio observations with enhanced sensitivity has led to a surge in data volumes from next-generation radio telescopes. Efficient tools for data management, processing, and storage optimization are now crucial for helping scientific analysis. The EXTRACT project, funded by the European Commission, is developing a distributed data-mining platform for EXTREme dATA Across the Compute continuum. A key use case, Transient Astrophysics with a Square Kilometer Array pathfinder (TASKA), takes advantage of EXTRACT technologies to handle the massive data streams produced by NenuFAR, one of the SKA pathfinders.

This work presents two targeted projects, TASKA-A1 and A2, focusing on real-time detection of (A1) Solar radio spikes and (A2) Jupiter's fast-drifting radio bursts (S-bursts), in high resolution time-frequency dynamic spectra. TASKA-A1 employs the deep learning-based SpikeNet convolutional neural network (Murphy et al., 2024) to detect Solar spikes in real-time observations. TASKA-A2 adapts an existing detection pipeline based on Fast Fourier Transform (FFT) and Radon Transform (Mauduit et al., 2023) to enable real-time identification of Jovian S-bursts. Additionally, we are developing a novel convolutional neural network based on anomaly detection to enhance detection efficiency and robustness. Both algorithms are embedded within the MurMuRe pipeline (Modular Multicast Receiver), specifically developed for the NenuFAR real time data receiver, which allows to use either the real-time data flow from the instrument or stored data with various formats.

These advancements provide an important step toward smart data filtering for next-generation radio telescopes. Indeed, by enabling real-time decision-making, astronomers can dynamically store high-resolution data for only the most scientifically valuable events while preserving lower-resolution data for broader analysis. It also paves the way of "analog to information" processing, which would drastically reduce the storage needs. As a matter of fact, the

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emissions studied in this work require a high time-frequency resolution, but are often embedded within larger slowly-varying emissions that can be studied at a lower resolution. This approach helps optimizing data storage while maintaining its value for scientific analysis, thus preparing for scalable solutions in the era of the Square Kilometer Array.