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Detection of 5G Signals: Study of a Detection Method and its limitations

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The rapid expansion of fifth-generation (5G) telecommunications networks presents significant challenges for passive remote sensing for both Earth Observation (EO) and Radio Astronomy (RA) observations. As 5G infrastructure continues to proliferate globally, driven by increasing demands for high-speed mobile connectivity and the Internet of Things (IoT), the potential for creating Radio Frequency Interference (RFI) with scientific observations grows correspondingly. Of particular concern are the 5G frequency allocations in FR1 (410-7125 MHz) and FR2 (24.25-71.0 GHz) bands, which can result in RFI in two different ways: by leaking into protected science bands used for Earth Observation and by contaminating spectral line observations in radio astronomy. These degradations of the passive instrument measurements could have a significant impact on the accuracy of weather predictions and astronomical observations, necessitating the development of novel and robust detection methods for 5G signals.

Building upon previous work [1], we developed and implemented a detection method leveraging the inherent modulation characteristics and cyclic structure of 5G signals. The method was originally tested on simulated data sets and was then validated using experimental data. The measured data consist of time series of I and Q raw signals across 16 frequency bands spanning the FR1 range.
The detection algorithm specifically exploits the cyclic structure of 5G carrier signals, identifying characteristic features in the correlation function whose positions correspond to fundamental 5G modulation parameters. The initial analysis was performed using 10 ms snippets. This duration was chosen as it corresponds to typical spaceborne radiometer integration times. It was then demonstrated that the method seems successful in detecting 5G signal with a detection rate of ~90%.
The next step of this work is to understand the method limitations. To test the impact of the snippet duration on the detection rate, we conducted a preliminary sensitivity analysis using 500 random snippets for each snippet duration and vary the duration from 10 μs to 20 ms . Early results presented in Figure 1 indicate that detection rate approaches 85% when the snippet is longer than 0.5 ms at 3.49 GHz in a case of high Interference-to-Noise Ratio (INR) measurement. Once a more comprehensive analysis will be performed, this curve can be used to estimate the minimum duration of the snippet sufficient to capture the cyclic characteristics of 5G signals and produce a reliable detection. This study needs to be expanded by increasing the number of random selections and looking at other frequencies.

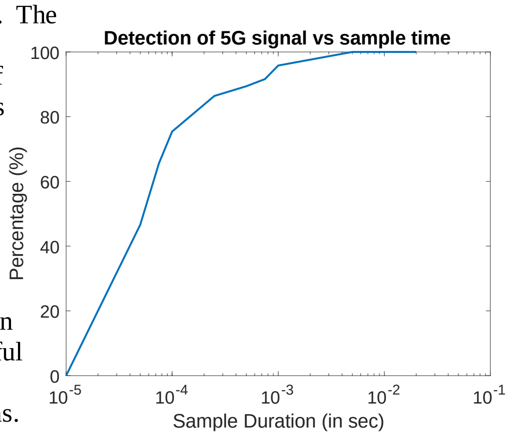

Figure 1: Detection Rate vs Duration of time series

Ongoing research focuses on comprehensive time duration and bandwidth dependency analysis and validation across diverse INR conditions. Future work will examine the minimum bandwidth requirements for reliable 5G signal detection and explore the method's robustness across various interference scenarios. Complete findings will be reported at the conference.

[1] A. Bringer, and E. Kim, "New RFI Threats for Future Microwave Sounders: Development of New RFI Detection Strategies for 5G Signals," *Proceedings of Science,* Submitted