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How Machine Learning can assist Data Analysis of Ground Based Radio Astronomy

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Abstract

Type III bursts are intense, non-thermal sporadic solar radio emissions and can be characterized by their rapid development in time and frequency in the dynamic spectrum. Produced by accelerated electron beams which propagate along open magnetic field lines during the impulsive phase of a flare via the plasma emission mechanism and generated at the local electron plasma frequency $fp \simeq 9\sqrt{n_e}$ kHz (n_e as the plasma density: number of electrons per volume cm^{-3} [1]) (the fundamental F component) and/or its harmonic $2fp$ (the harmonic H component), their frequency ranges from $\sim$ 1 GHz to $\sim$ 20 kHz thus making them observable by ground and space-borne radio telescopes respectively. Beside a fast drift from high to low frequencies, bursts duration increases simultaneously as the drift rate decreases at lower frequencies. These strong relations between features and type III bursts are very distinct to other bursts that are accompanying the periods of solar activities and represent an excellent candidate for pattern recognition by supervised machine learning. Convolutional Neural Networks (CNNs) enjoy a great success in large scale image and video recognition [2], [3], [4] and will be used in the present work to scan as a sliding window along the time axis over a dynamic spectrum, returning a time-series like classification probability for type III radio bursts. For later analysis, the classified bursts are collected in burst-probability, burst-duration and max. burst-intensity bins. Initially, the presented network was trained and tested [5] on High Frequency Receiver data from the space-borne observatory STEREO/WAVES covering a frequency range from 125 to 16025 kHz [6]. For large scale data analysis, the model was applied on ground based measurements from UTR-2 and URAN-2, covering a frequency range from 8 to 32 MHz [7] as well. By retraining the network with extended one-hot encoded training data [8], the model will classify additional radio features hence extending its range of use in modern radio astronomy.

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