A modern approach to the detection and classification of meteor radar echoes

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Millions of meteoroids enter the Earth's atmosphere every day. When these objects interact with the background atmosphere, they create long plasma trails, which can be monitored using different radar systems. Analyzing these large data sets require reliable detection and classification algorithms, which can provide reliable tools to better classify and study meteor reflections ad their impact on the composition of the mesosphere lower thermosphere region. Currently, most low power (a few kW) meteor radars instruments search for underdense meteor trails, often discarding overdense and nonspecular meteor trails. In the last decade, scientists have studied other types of meteor radar reflections such as head-echoes, non-specular echoes, low-altitude trail echoes, etc., using high power and large aperture (HPLA) radar sensors. Each of these radar reflections has various decay duration, altitudes of occurrence, power characteristics, etc. Thus, the implementation of robust detection and classification tools of meteor reflections is essential to carry out long-term meteor studies. Statistical analysis among different types of meteor trails requires a large number of samples to be identified. This process of radar meteor identification and classification has embraced machine learning tools. For example, earlier research conducted by Siming et al., 2011, using support vector machine with several radar echo attributes from ~200 samples for meteor classification. In this work, we build upon this early work and introduce a modern classification Model based on a variant of Mask Region Convolutional Neural Network (Mask R-CNN) for meteor identification and classification from radar Range time Intensity (RTI) power maps. First, the model uses adaptive signal to noise ratios threshold and K-mean clustering for segmentation. Secondly, the CNN is applied for identification and classification. The Model is trained with about 20,000 samples, achieving accuracy greater than 90%. Details concerning training set, implementation, feature extraction, and data visualization are presented and discussed using HPLA Jicamarca meteor radar and a specular meteor system located in Cerro Pachón, La Serena, Chile.

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