Analyzing Meteor Scatter Communications Through Citizen Science and Data Driven Methods

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Introduction

Meteor scatter communication uses ionized trails from meteoroids entering Earth's atmosphere to briefly reflect radio signals, enabling short long-distance contacts. Trails are classified as underdense (short reflections) or overdense (longer, stronger reflections). Amateur radio operators observe this during showers like the Perseids and Geminids using WSJT-Xon the 6-m and 10-m bands.

Methodology

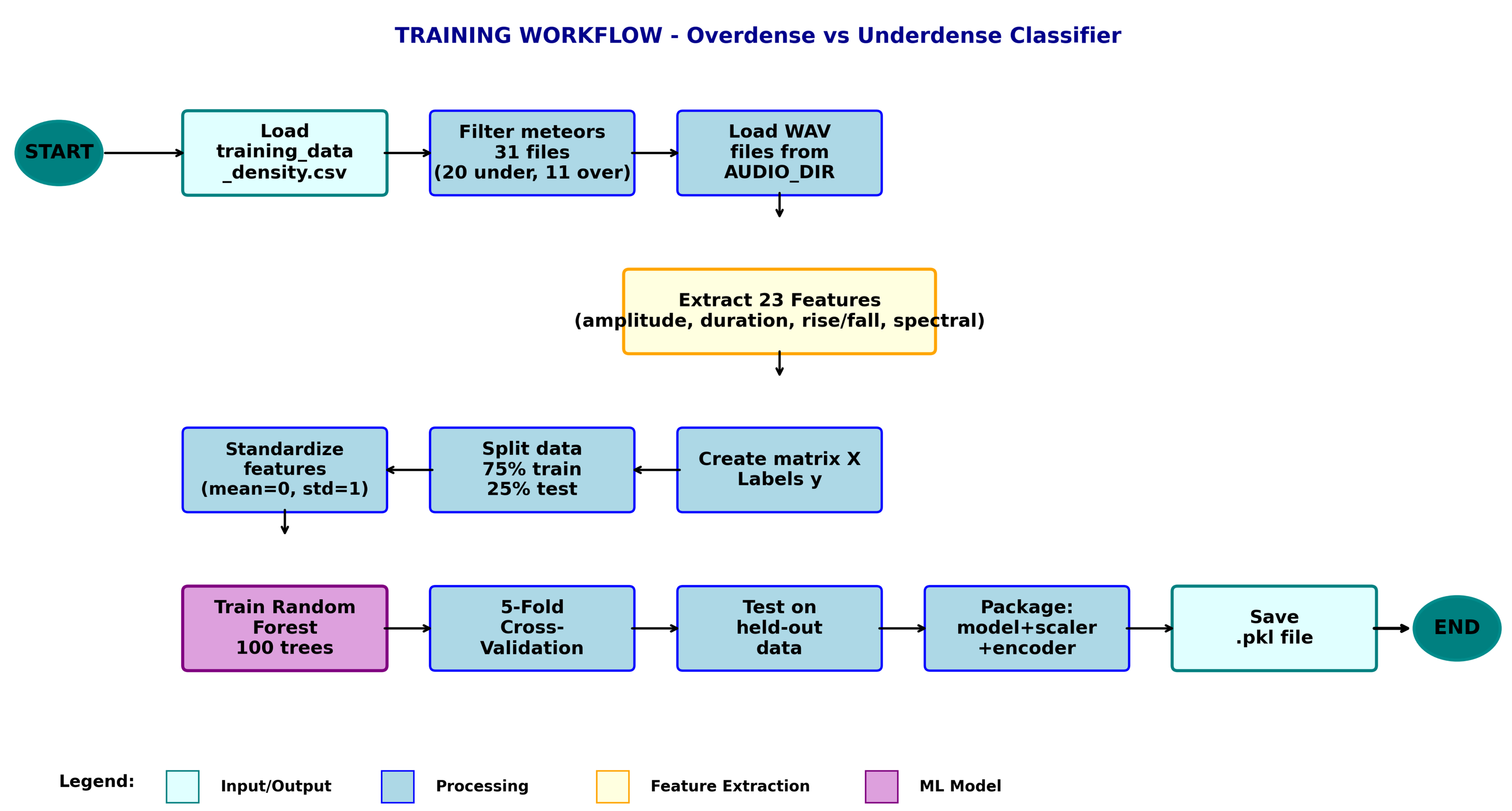

Figure 1. Workflow used to train the meteor signal classifier. Labeled WAV recordings of underdense, overdense, and aircraft scatter events were processed to extract signal features, standardized, and used to train a Random Forest model. The trained model and preprocessing parameters were then saved as a `.pkl` file for later classification.

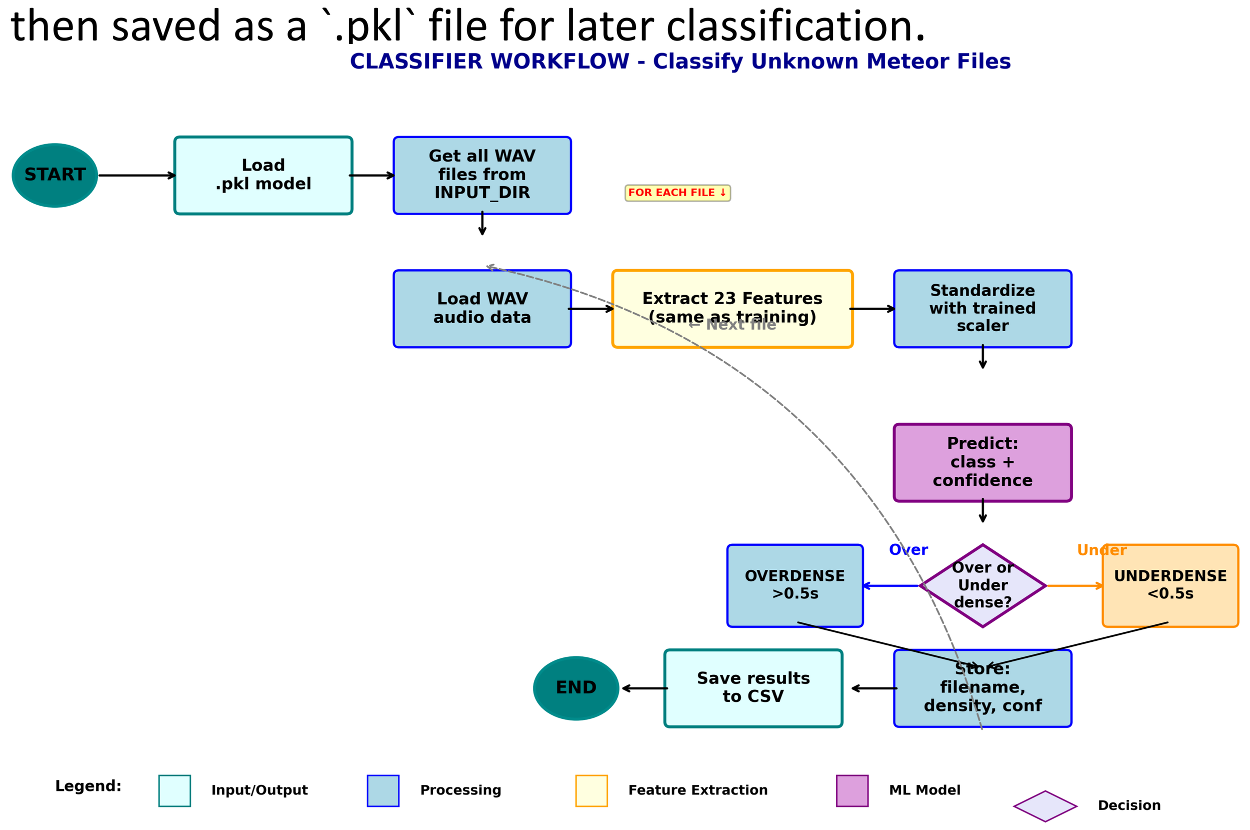

Figure 2. Workflow used to classify unknown meteor recordings. The saved classifier loads new WAV files, extracts the same signal features, standardizes the data, and predicts whether each event is underdense or overdense. Results are then exported to a CSV file for analysis and visualization.

Data/Analysis

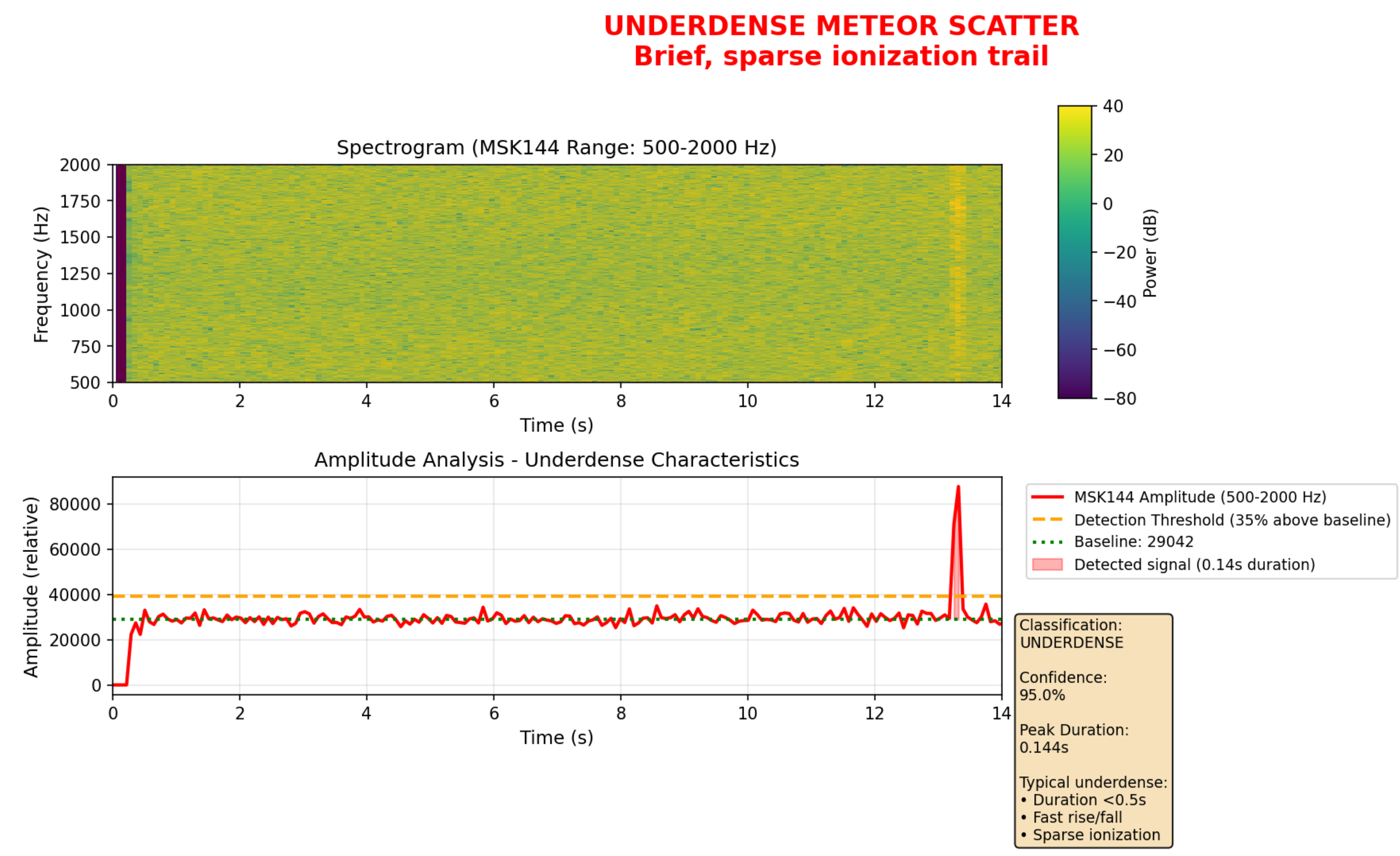

Figure 3. A brief meteor echo produced by a sparse ionization trail. The short-lived, sharp amplitude spike (≈0.14 s) reflects a rapidly diffusing plasma trail. Fast rise and fall times and lower sustained power are typical signatures of underdense meteors [2].

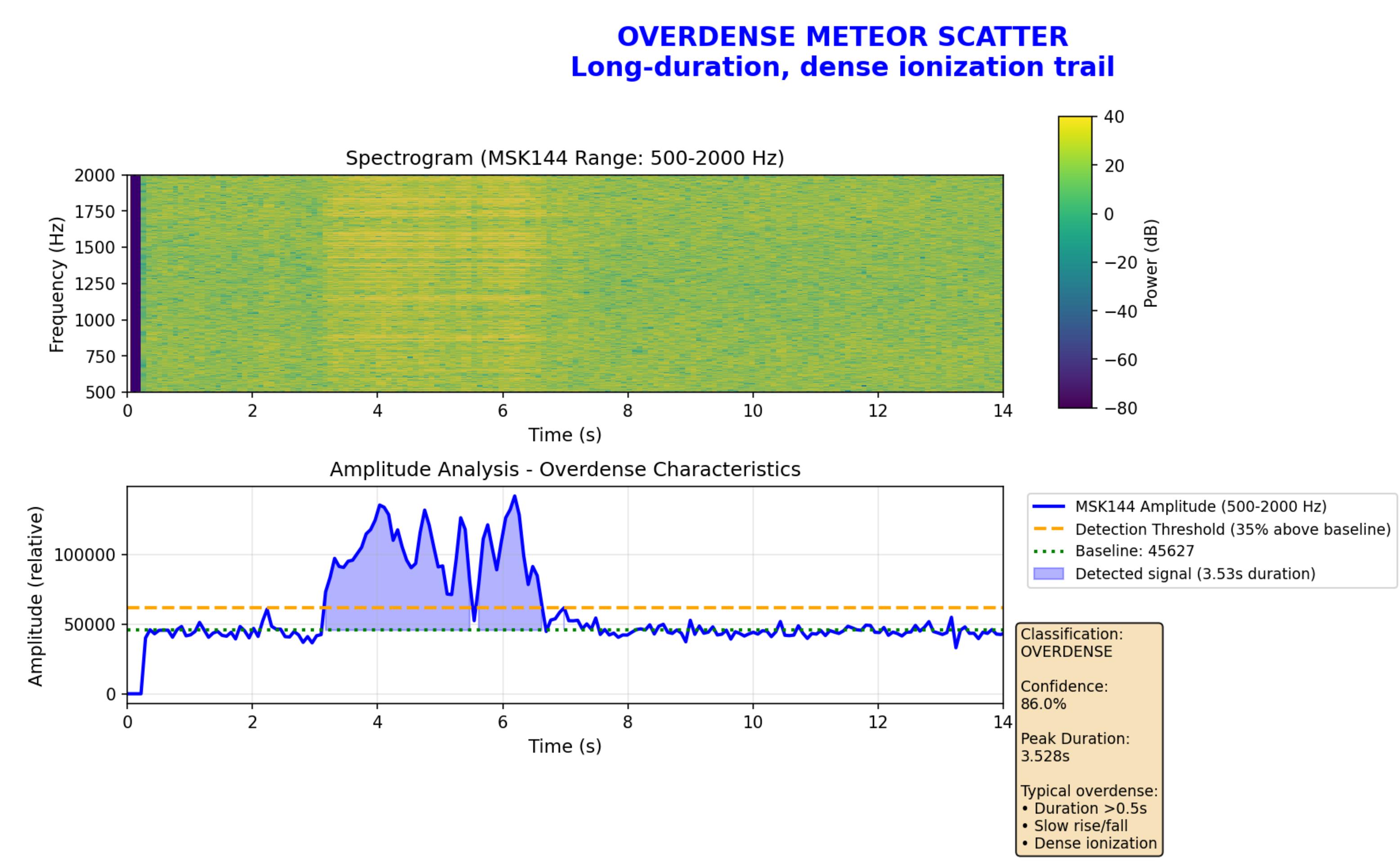

Figure 4. A long-duration meteor echo showing a dense ionization trail. The sustained, high-amplitude signal (≈3.5 s) indicates a strong capability of reflecting radio waves over an extended period. Gradual rise and fall in amplitude and stable power levels are characteristic of overdense meteor [3].

	UNDERDENSE	OVERDENSE
Electron Density		
	Lower electron density in the ionized trail	Very high electron density forming a dense plasma column
Signal Duration		
	Very brief reflections (≈ 0.05–0.5 seconds)	Longer reflections (≈ 1–10+ seconds)
Signal Strength		
	Weak to moderate signals; often faint "pings"	Stronger signals that may sound like bursts or sustained tones
Frequency Sensitivity		
	More commonly observed on higher frequencies such as the 10 m band (28 MHz)	More easily detected on lower frequencies such as the 6 m band (50 MHz); dense trails reflect longer wavelengths more efficiently

Figure 5. Key characteristics distinguishing underdense from overdense meteor scatter events based on ionization trail density, signal properties, and radio frequency sensitivity..

Equipment Variables/Impact on Data

- Frequency Band (28 MHz vs. 50 MHz), Antenna Type (Yagi vs. Omnidirectional), Transmitter Power, Receiver Sensitivity (SDR vs. Analog), Digital Software (WSJT-X).

Conclusion

This study uses amateur radio meteor scatter observations to analyze ionospheric propagation. A coding program was developed to classify meteor scatter events within large datasets. Future work will validate the classifier and compare detection of underdense and overdense events on the 6-m and 10-m bands.

References

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