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Probabilistic modeling of signal intensity on the spectrograms of microwave reflectometry for the plasma diagnostics of electron density profile

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To reconstruct the electron density profile of tokamak plasma, the phase of reflected microwave is to be captured by tracing the signal along the frequency as an imaginary pathway on the spectrogram. From the blurry and broken lines among the unwanted clutters, the actual path should be estimated as a continuation of the tone heights at each vertical slice of the wavelet transform. Thus, we pay attention to the recent idea idea of the Gaussian derivative wavelets as a measure to revive the vanished traces which are subject to nodal points of modulated amplitude. As it is critical to recognize the vanishing patterns, at which the Gaussian-derivative is better to be applied instead of the common spectral method of Morlet wavelet, we introduce a probabilistic model of spectral signal as a mixture of basis functions. At first, the bases are prepared from the ideal beat signal of sinusoidal waveform, and the feasibility of our idea is checked as a preliminary attempt to maximize the log-likelihood of spectral data with the fixed number of mixture patterns. Then, a Bayeian inference of variational mixture is developed for the phase recovery in our microwave reflectometry. After the exploration, a generative NN (Neural Network) is proposed as a surrogate model with latent parameters, which deforms the ideal bases to improve the probabilistic model, by training the network with the real data.

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