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Poster

Real-world data sets often exhibit imbalanced distributions, which have significantly more data or observations in a specific range of values than the other ranges. For example, space physics data sets, such as geomagnetic indices, relativistic electron fluxes in Earth's radiation belt, and the occurrence and amplitude of solar flares, are typically imbalanced. This is the too-often-too-quiet challenge, one of the fundamental problems in space physics and space weather, and is also a general problem in machine learning. For example, the electron density and plasma fluxes in the Earth's radiation belts can be accurately modeled in our previous studies [Bortnik et al., 2016, 2018; Chu et al., 2017a,b; 2021; Ma et al., 2022a, b]. However, the ML-based models of the plasma waves are usually biased due to the too-often-too-quiet problem both in numerical simulations and observations [Ma et al., 2018; Camporeale et al., 2019; Guo et al., 2021].

We developed a method to solve this problem and applied it to the whistler-mode chorus waves in the Earth's radiation belt. The ML-based wave model used a neural network approach, which takes geomagnetic indices as input and prediction the wave power. As a result, the model can predict not only the quiet time values but also large events. The fact demonstrates that the model provides reliable and stable predictions when the too-often-too-quiet problem is solved. This method of imbalanced regression has wide applications in space physics/weather and a wider

Theta waves modeled by an artificial neural network: The importance of inhibition

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Introduction

Theta waves are a type of brain wave that is associated with various cognitive functions, including learning, memory, and decision-making. They are typically observed in the hippocampus and are characterized by a regular, rhythmic pattern. However, the underlying mechanisms that generate theta waves are still not fully understood. In this study, we used an artificial neural network (ANN) to model theta waves and investigate the importance of inhibition in their generation.

Data and model construction

We collected theta wave data from a series of experiments and used it to construct an ANN model. The model consisted of three layers: an input layer, a hidden layer, and an output layer. The input layer represented the external input to the system, the hidden layer represented the internal state of the system, and the output layer represented the resulting theta wave. We used a combination of excitatory and inhibitory neurons in the hidden layer to model the complex interactions within the system.

Data reduction

To reduce the dimensionality of the data and improve the efficiency of the model, we performed principal component analysis (PCA) on the input data. This allowed us to identify the most important features that contributed to the generation of theta waves and use them as input to the ANN model.

Model validation

We validated the ANN model by comparing its output to the experimental data. The model was able to accurately reproduce the rhythmic pattern of the theta waves, demonstrating its effectiveness in modeling the underlying mechanisms. We also performed sensitivity analysis to determine the impact of different parameters on the model's output, highlighting the importance of inhibition in the generation of theta waves.

Effect of cell types

We investigated the effect of different cell types on the generation of theta waves. We modeled the interactions between excitatory and inhibitory neurons and found that the balance between these two types of neurons was crucial for the generation of theta waves. Specifically, the presence of inhibitory neurons was necessary to maintain the rhythmic pattern of the theta waves.

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Geospace/Magnetosphere Research and Applications

Space Weather Workshop 2023

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