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Detection of anomalies amongst LIGO's glitch populations with autoencoders

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Non-Gaussian, transient bursts of noise in gravitational wave (GW) interferometers, also known as glitches, hinder the detection and parameter estimation of short- and long-lived GW signals in the main detector strain. Glitches come in a wide range of frequency-amplitude-time morphologies and may be caused by environmental or instrumental processes, so a key step towards their mitigation is to understand their population. Current approaches for their identification use supervised models to learn their morphology in the main strain with a fixed set of classes, but do not consider relevant information provided by auxiliary channels that monitor the state of the interferometers. In this work, we present an unsupervised algorithm to find anomalous glitches. Firstly, we encode a subset of auxiliary channels from LIGO Livingston in the fractal dimension, which measures the complexity of the signal. For this aim, we speed up the fractal dimension calculation to near-real time. Secondly, we learn the underlying distribution of the data using an autoencoder with cyclic periodic convolutions. In this way, we learn the underlying distribution of glitches, and we uncover unknown glitch morphologies and overlaps in time between different glitches and misclassifications. This led to the discovery of 6.6% anomalies in the input data. The results of this investigation stress the learnable structure of auxiliary channels encoded in the fractal dimension and provide a flexible framework for glitch discovery.

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