Identifying Glitches in Gravitational Waves Using Machine Learning

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Problem Release date:	January 12, 2023
Date of Submission:	March 01, 2023

1 Introduction

Gravitational waves are bends in the space-time continuum caused by violent interactions between massive, highly dense celestial bodies. Various factors, including cosmic activities such as supernovae, may cause glitches in these waves. Based on their wave-forms, they are classified into various categories such as Chirp, Blip, High Frequency, etc, to name a few.[1] [2] [1]

2 Problem Statement

We have the glitch data of gravitational waves, categorized into twenty-two different types of glitches based on eight features. We aim to build a machine-learning model to classify a given glitch into one of the 22 glitches.

3 Data analysis

We have shortlisted the relevant features to the problem statement, which are, The Peak frequency, Central frequency, Bandwidth and duration of the waves. We have found a counterintuitive piece of information that the central frequency and Bandwidth vary linearly This observation can be used in two ways:1

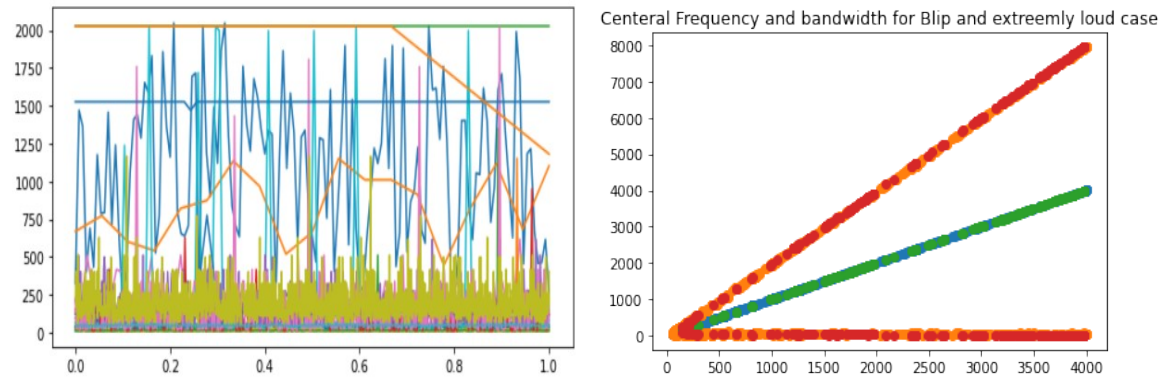

Figure 1: a: Peak frequencies for all classes b: Linear relation of central frequency and bandwidth

One is to eliminate one of the features due to its high correlation. the second is that we create different linear regression models for each class and assign a data point to a class giving the least error.

[1] https://www.ligo.caltech.edu/page/gw-sources

4 Discussions and Plans

- Evaluating relevance of "SNR" to problem statement.
- Since our data is multi-class, we are keen to test our dataset on multinomial logistic regression[3] or softmax regression.
- We plan to fit out the model using the cross-entropy loss function.
- Test with KNN and Decision tree algorithms and choose the best.
- Classify by observing peak frequency ranges for all classes.

2

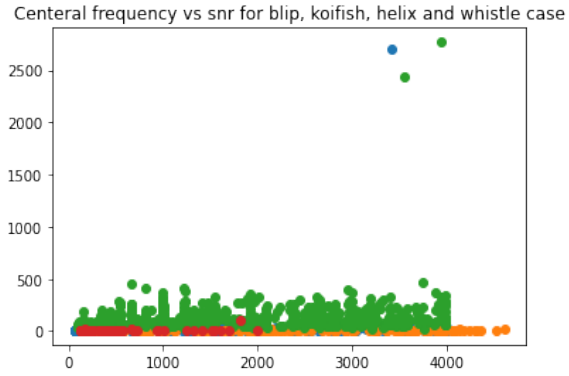

Figure 2: Concluding that SNR might not be a suitable parameter

5 Contribution

All the work has been done in an equally distributed manner and with proper discussions with my team members Parth Gupta and Prajjwal Sanskar. Specifically, I have:

- Contributed to data analysis
- Explored multinomial logistic regression method for our model
- Contributed to report writing.

References

[1] S Mukherjee. Classification of glitch waveforms in gravitational wave detector characterization. *Journal of Physics: Conference Series 243 (2010) 012006*, page 3, 2010.

[2] LIGO Caltec. Sources and types of gravitational waves. *https://www.ligo.caltech.edu/page/gw-sources*.

[3] Jason Brownlee. Multinomial Logistic Regression With Python. 2021.