Investigating the efficiency of the SPIIR pipeline in O3 offline Gravitational wave search

Md Redyan Ahmed [1,2] , SPIIR collaboration[2]

[1]Indian Institute Of Science Education And Research kolkata *[2]The University of Western Australia*

INTRODUCTION

- Gravitational waves are 'ripples' in space-time caused by some of the most violent and energetic processes in the Universe.
- K means algorithm is used in this project to investigate the distribution of False alarm rates of Gravitational waves and to classify them.
- Here, false alarm means unwanted events (not GW events) which are detected by GW detectors.
- The data has 3 time scales :2 hour, 1 day, 1 week. It refers that data was collected with the time window of 2 hours, 1 day and 1 week.
- K-means clustering is one of the simplest and popular unsupervised machine learning algorithms.
- The K-means algorithm identifies k number of centroids, and then allocates every data point to the nearest cluster, while keeping the centroids as small as possible.
- The 'means' in the K-means refers to averaging of the data; that is, finding the centroid.

METHODOLOGY

Using O4 PSD, we simulated an O4 run and ran the SPIIR pipeline to produce the FAR dataset.

Implementing K means in our False Alarm rate dataset:

Step-1: We need to choose the number of clusters k
Step-2:Select k random points from the dataset as centroids
Step-3:Assign all the points to the closest cluster centroid
Step-4:Recompute the centroids of newly formed clusters
Step 5: Repeat steps 3 and 4

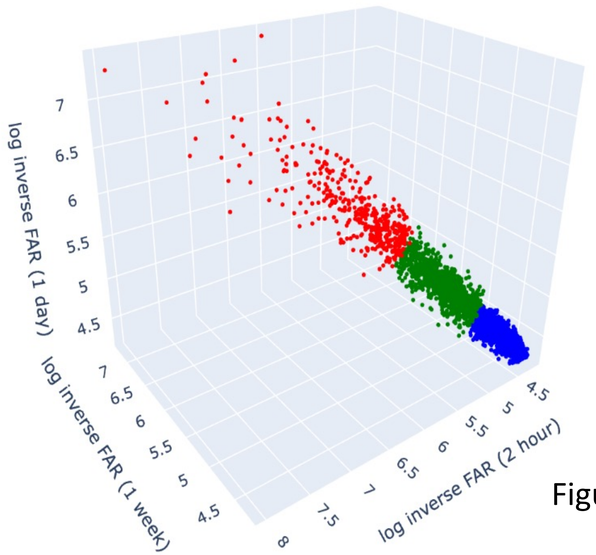

Figure-1

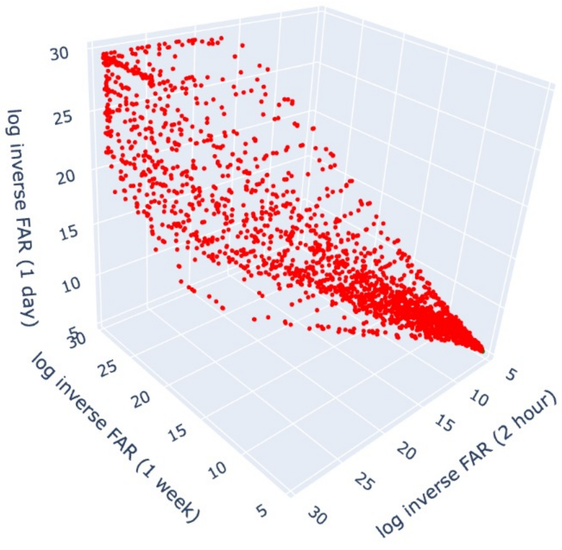

Figure-2

Fig 1:3d plot of background data of inverse far including clusters are given where 1st cluster is shown as Blue , 2nd cluster is shown as Green , and 3rd cluster is shown as Red
Fig 2: 3-d plot of injection data of inverse far including clusters are given where 2nd cluster is shown as Green and 3rd cluster is shown as Red .
In both of the plots, the red points are potentially be GW signals, Blue is likely a noise, Green could be ambiguous.

RESULTS

Clusterings of the background data of inverse FARS are given below in this table :

	ifar_1d	ifar_2h	ifar_1w	cluster	color
48037	4.312791	4.312791	4.312791	0	blue
51816	4.489428	4.489428	4.489428	0	blue
52989	5.311368	5.311368	5.311368	1	green
55603	4.711959	4.711959	4.711959	1	green
58220	4.353763	4.353763	4.353763	0	blue
...	...	...	...	...	...
19053104	4.676020	4.742496	4.674872	0	blue
19060812	5.199852	5.221358	5.190794	1	green
19062204	4.656902	4.831009	4.494729	0	blue
19067404	5.743004	5.765505	5.702971	2	red
19070404	4.525623	4.658288	4.577817	0	blue

Clusterings of the injection data of inverse FARS are given below in this table :

	ifar_1d	ifar_2h	ifar_1w	cluster	color
0	29.429491	29.625818	23.186479	2	red
1	6.626939	6.346666	6.661309	2	red
2	29.410623	29.365795	29.404005	2	red
3	17.137266	20.451085	13.383019	2	red
4	29.345164	29.089653	29.339473	2	red
...	...	...	...	...	...
9037	8.015959	11.999055	8.471357	2	red
9038	20.141793	29.453066	20.184462	2	red
9039	5.965681	5.946524	5.943210	2	red
9040	29.429491	29.625818	29.488818	2	red
9041	5.743004	6.004442	5.814653	2	red

Conclusion and future research

- Most of the time, we miss some important gravitational waves because we think that the event is a false alarm.
- Classification of false alarms will prevent it .
- The future research will be to implement this algorithm in real LIGO noise.

ACKNOWLDGEMENTS

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