Development of GNU Radio Blocks for Spectrum Sensing Based on the Analysis of the Autocorrelation of Samples

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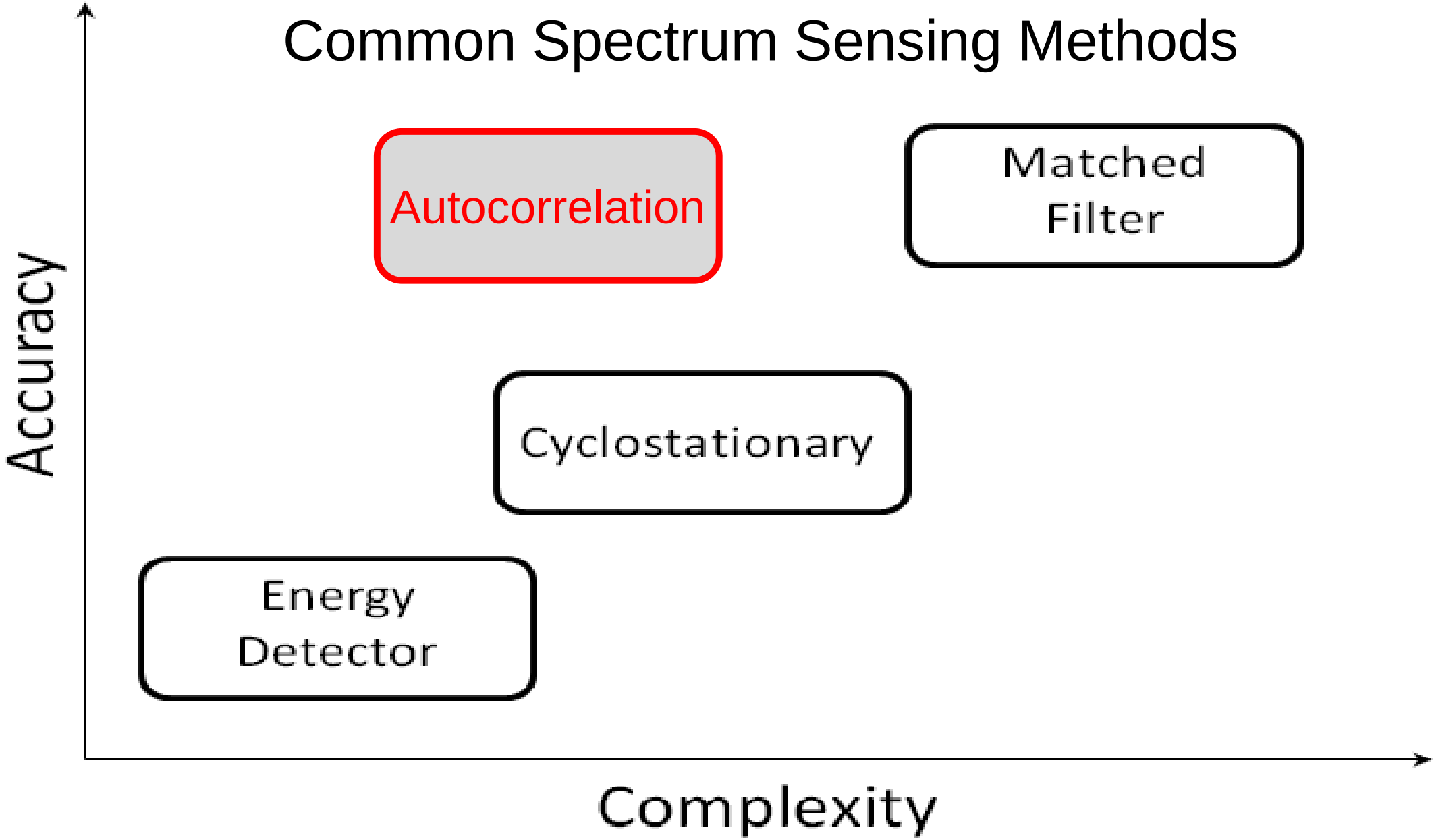
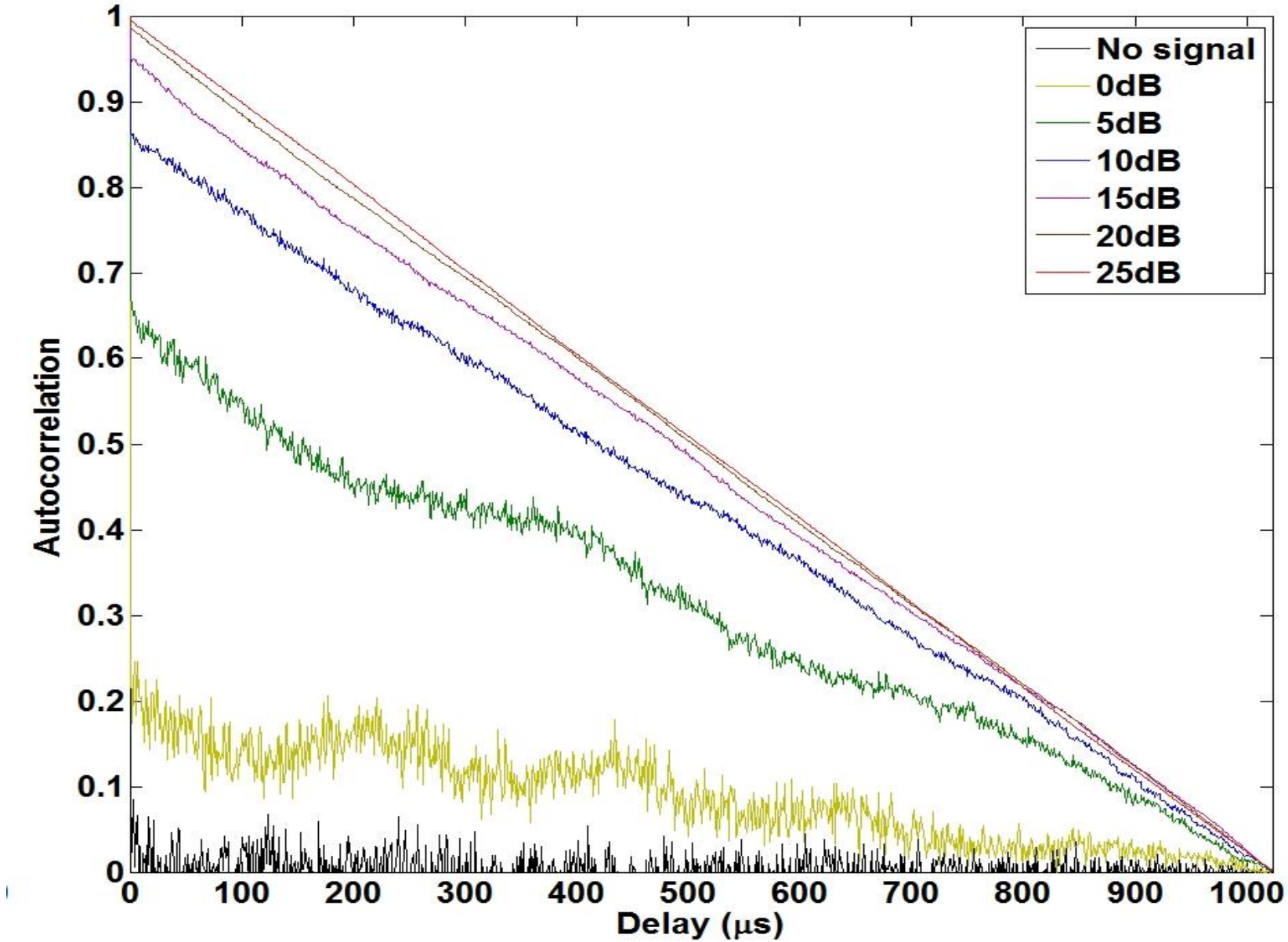
Content

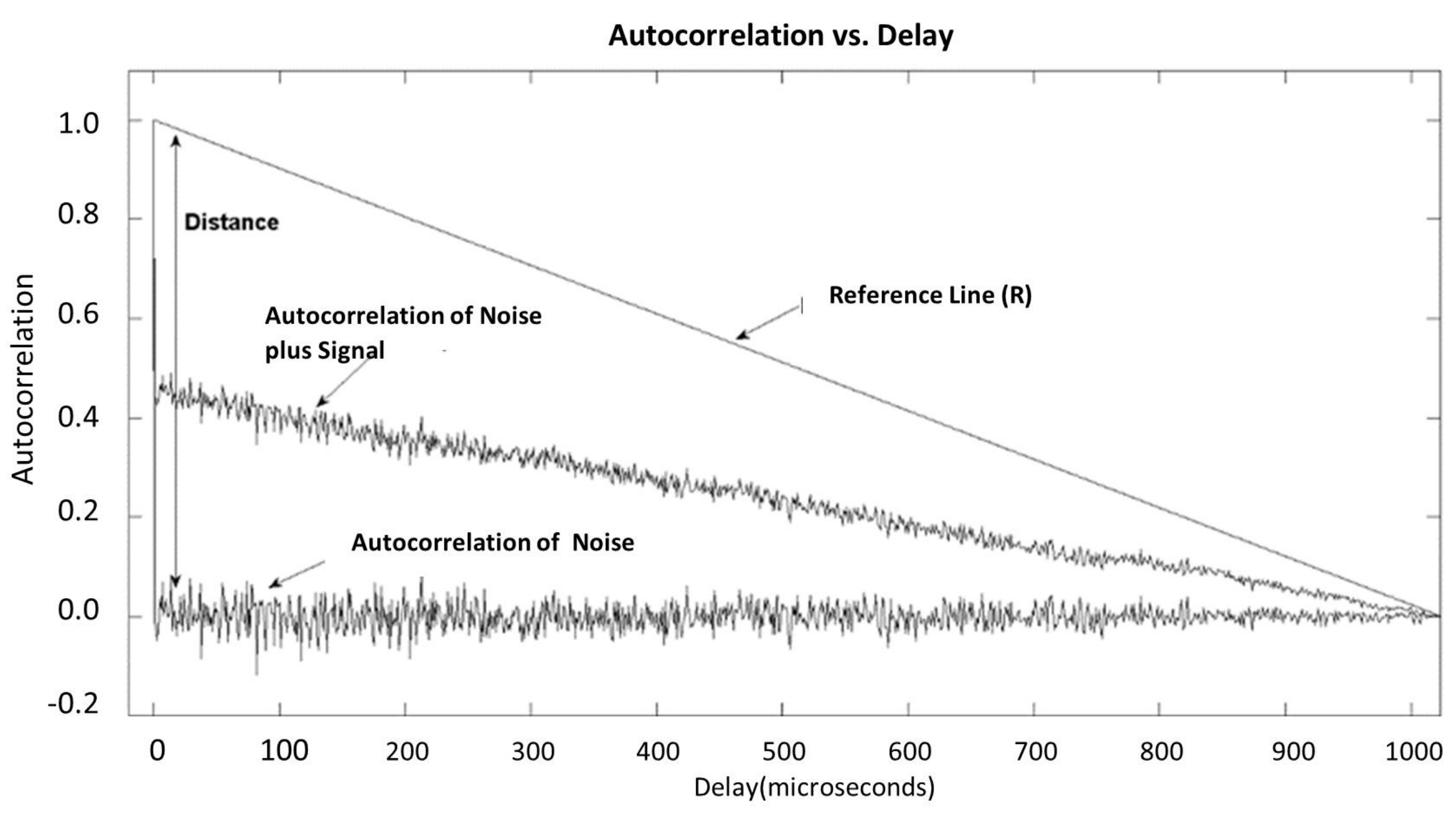
- Common Spectrum Sensing Methods
- The Euclidean method
- The Kmeans method
- The KNN method

Common Spectrum Sensing Methods



Autocorrelation for Different Conditions




Autocorrelation vs. Delay
Autocorrelation
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
Distance
Reference Line (R)
Autocorrelation of Noise
plus Signal
Autocorrelation of Noise
0
100
200
300
400
500
600
700
800
900
1000
Delay(microseconds)

Euclidean Distance Method

$$E(x, y) = \sqrt{\sum_{i=0}^{n} (x_i - y_i)^2}$$

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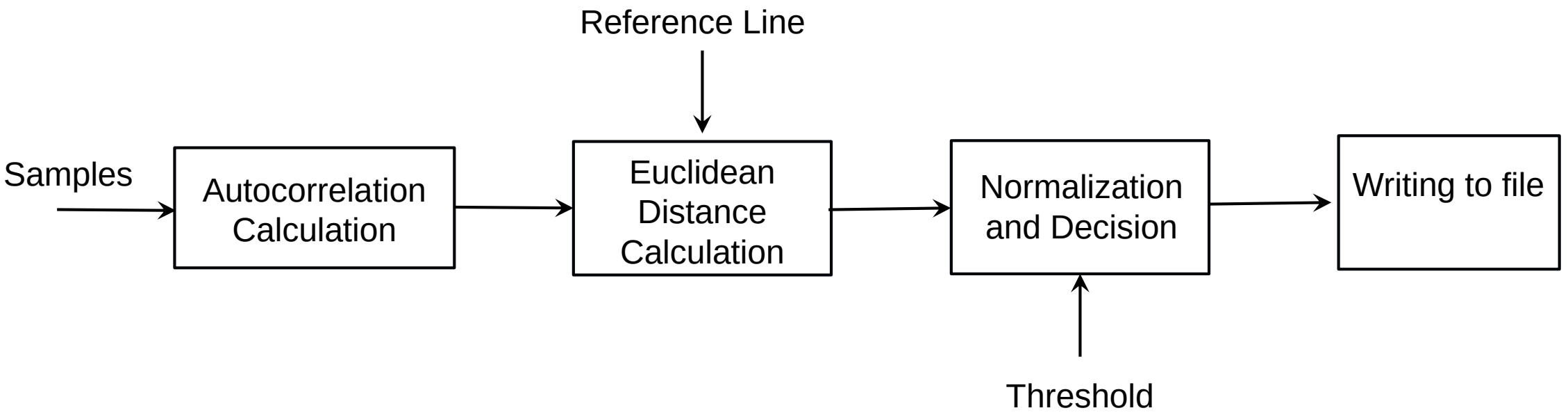
Euclidean Distance Block Diagram



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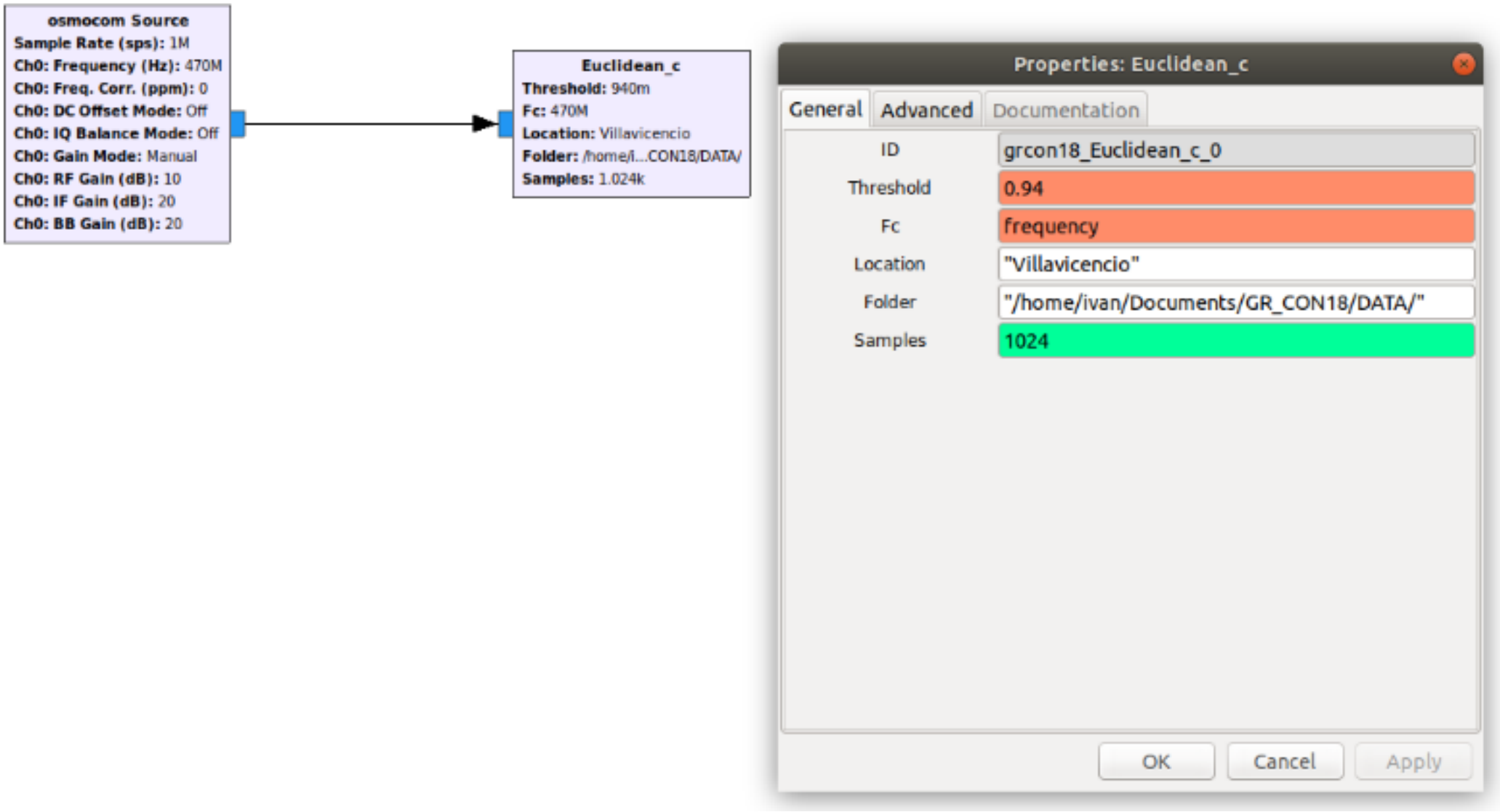
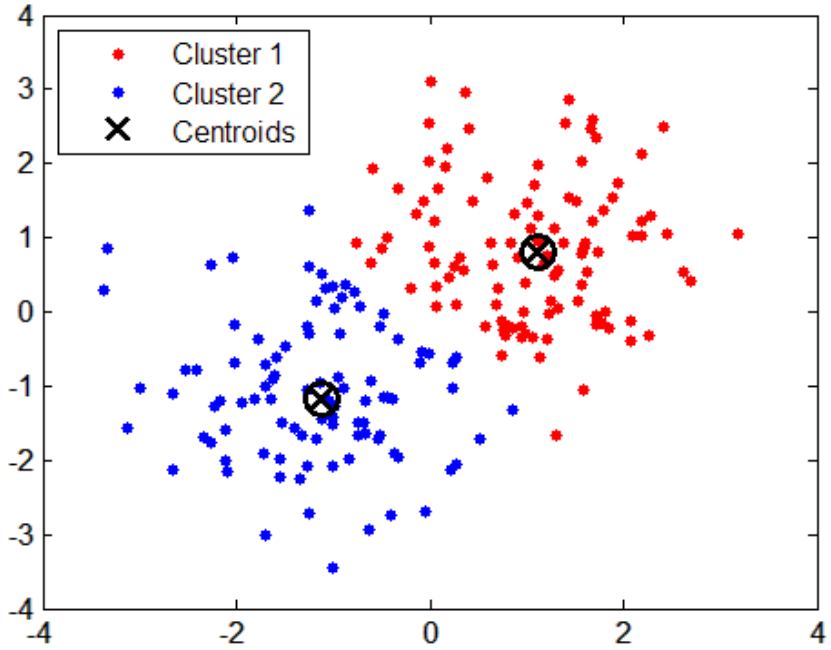
Euclidean Distance GNU Radio Block



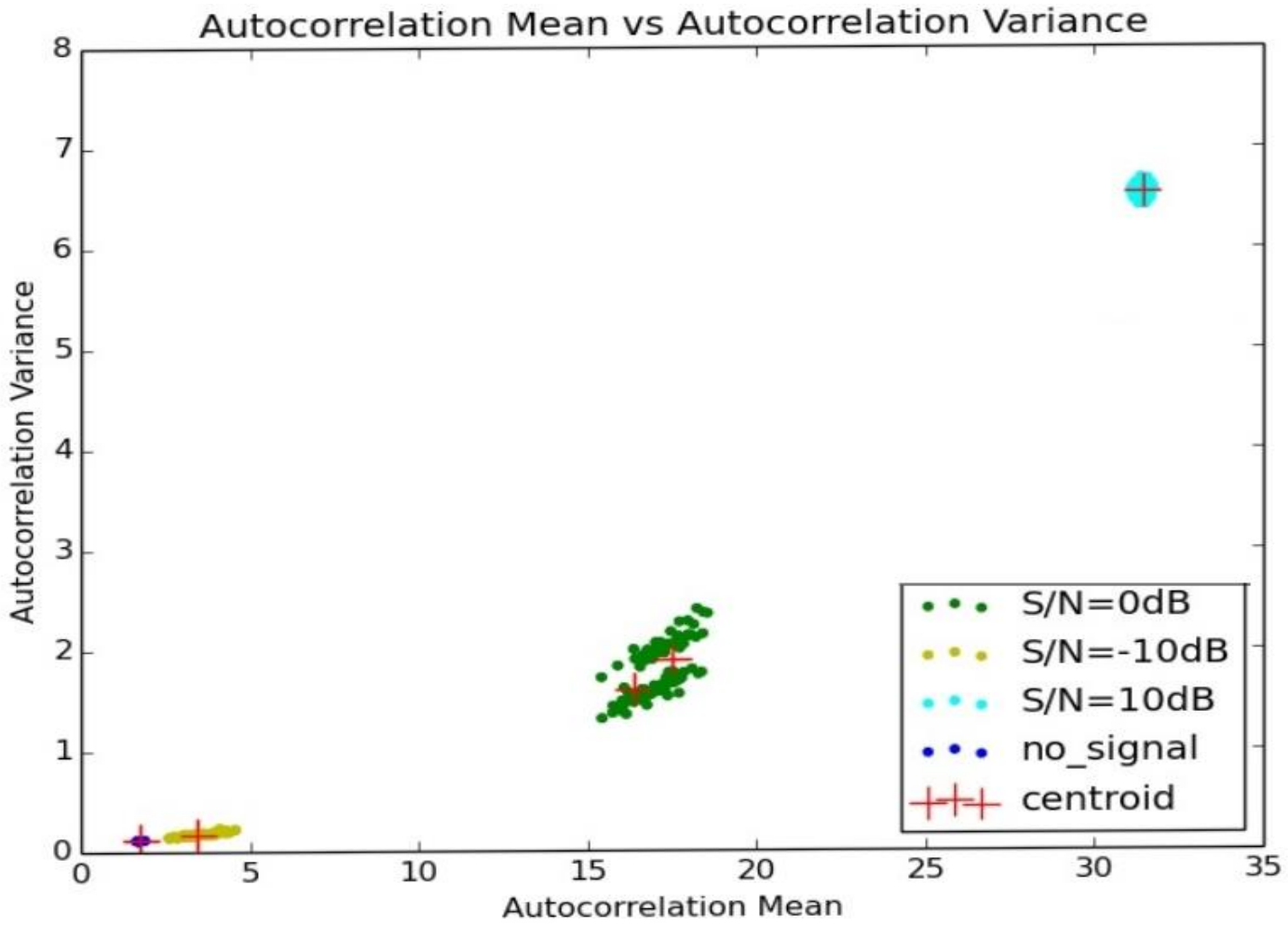
K-Means Clustering Method

$$\sum_{i=0}^{n} \min_{\mu_j \in C} (||x_j - \mu_i||^2)$$

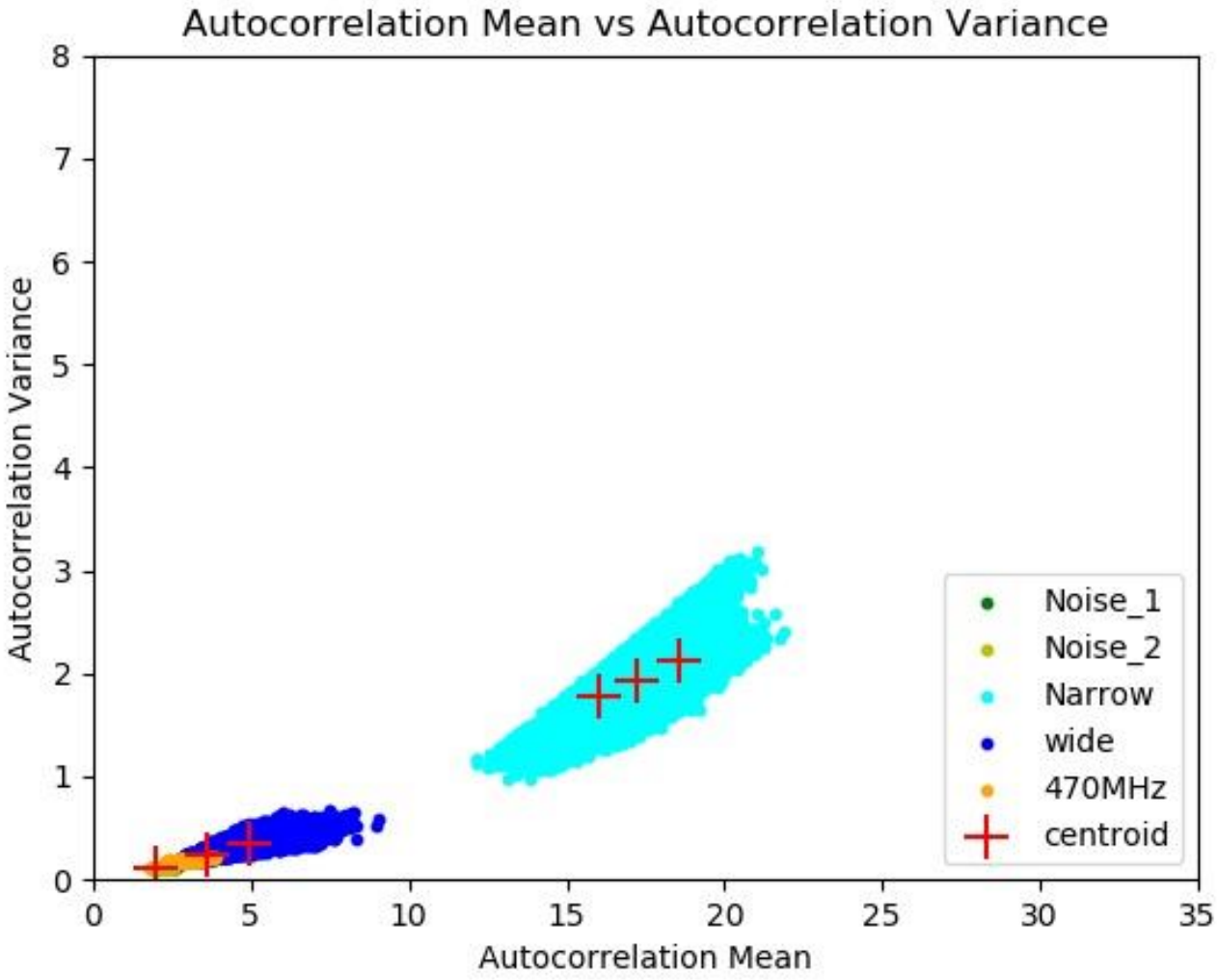
- Pick initial centroids: K samples of the dataset.
- Assign each simple to the nearest centroid.
- Calculate new centroid: mean of the cluster samples.



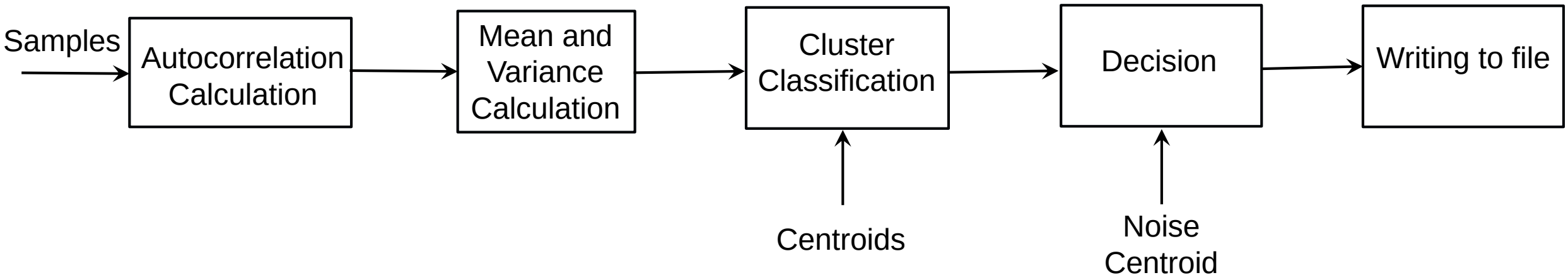
K-Means Clustering and Autocorrelation



K-Means Clustering and Autocorrelation



K-means Method



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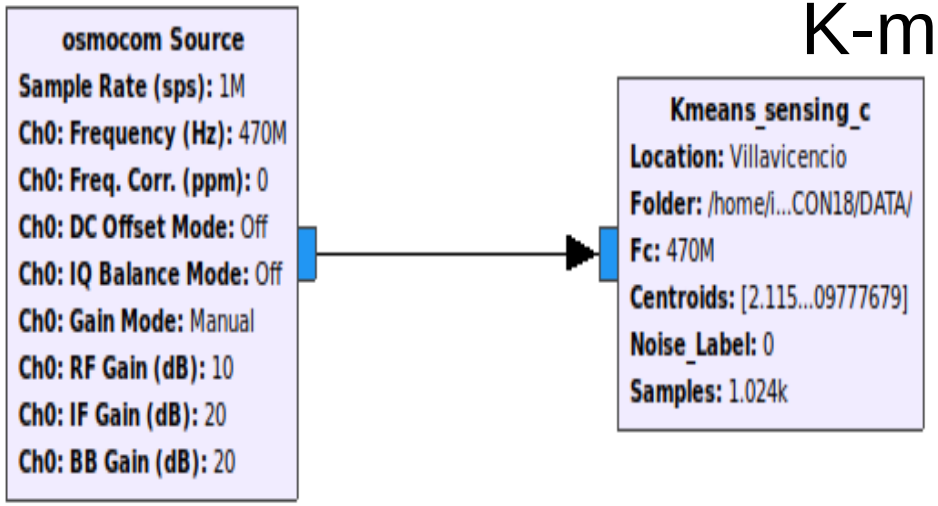
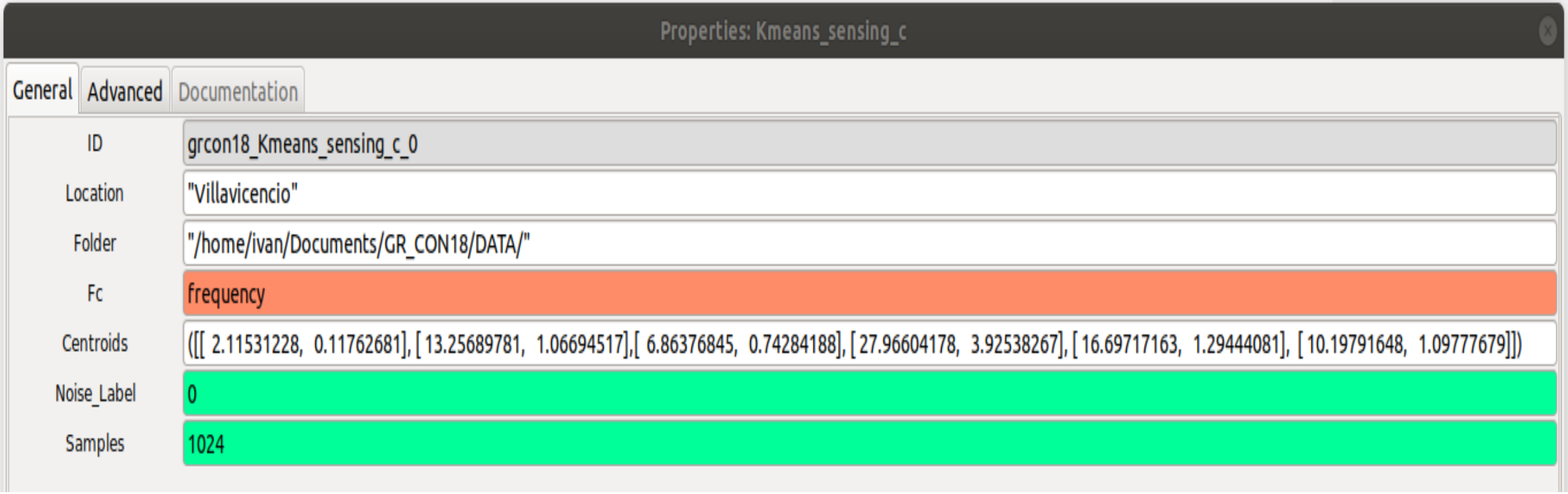
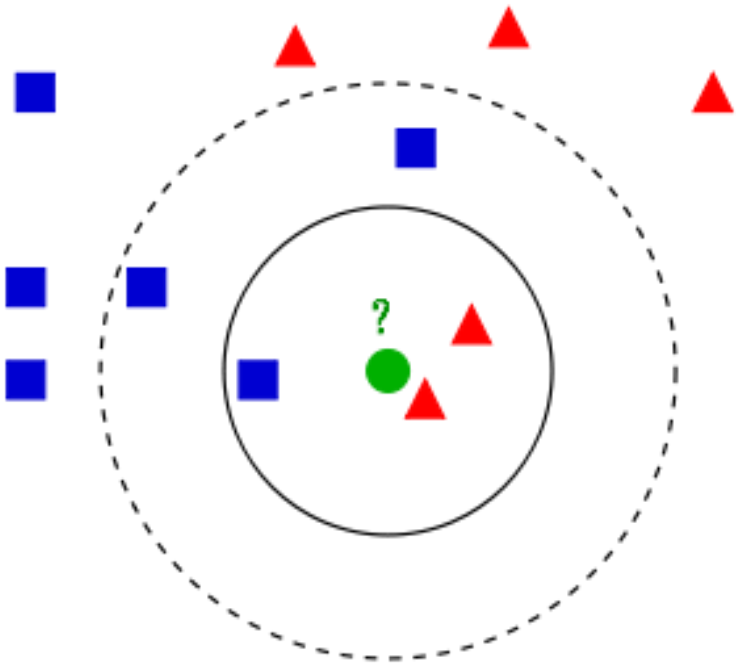
K-means GNU Radio Block





KNN Method
K- nearest neighbor method



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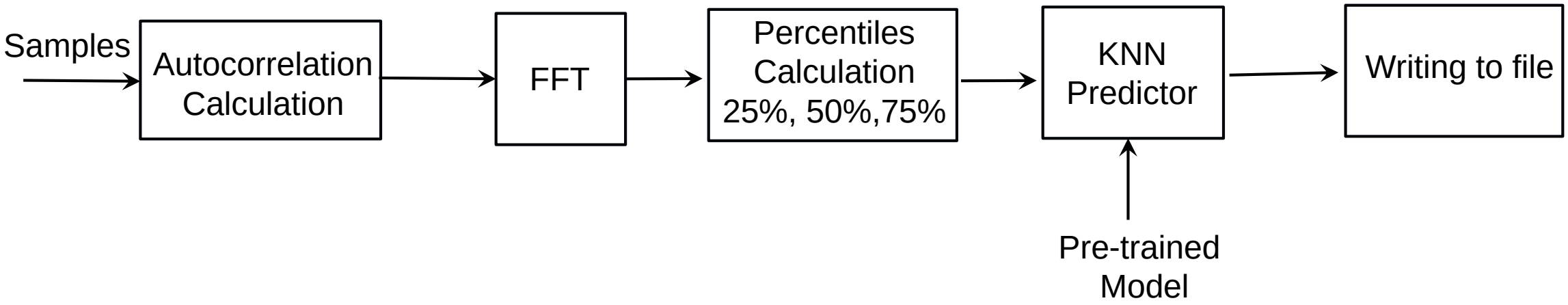
- Training samples with known labels.
- A new sample is given the most common label among its K nearest neighbors.

KNN Method



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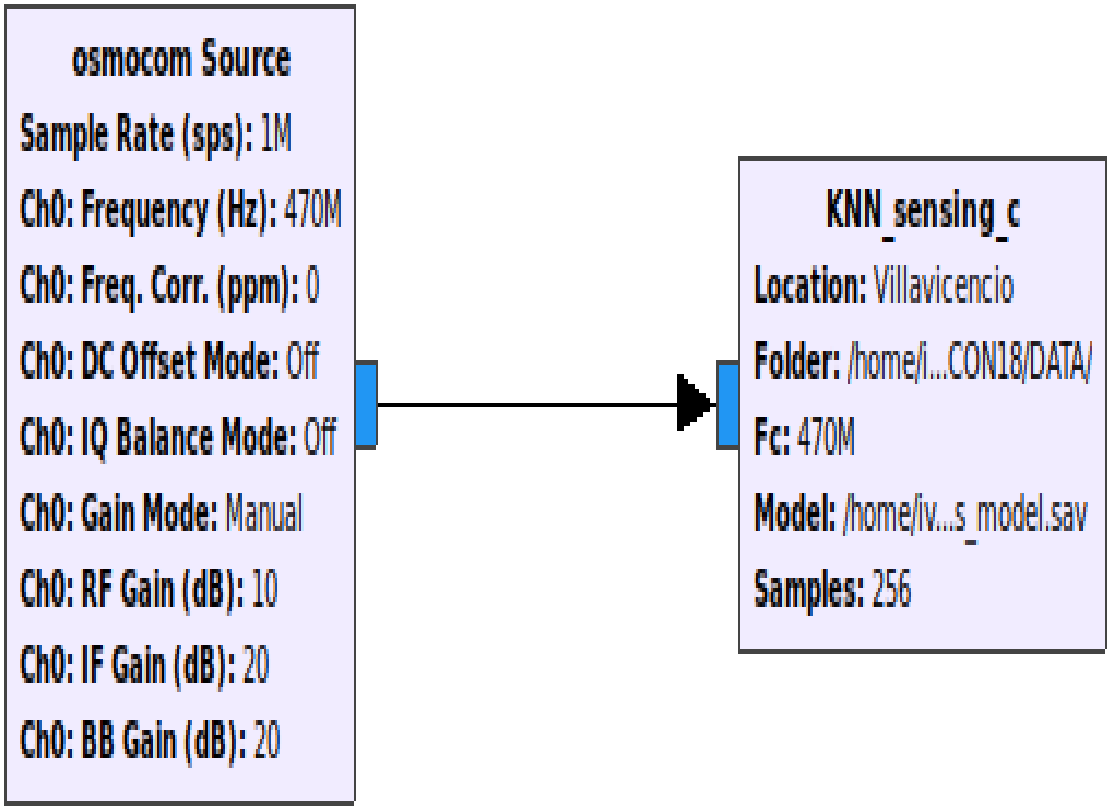
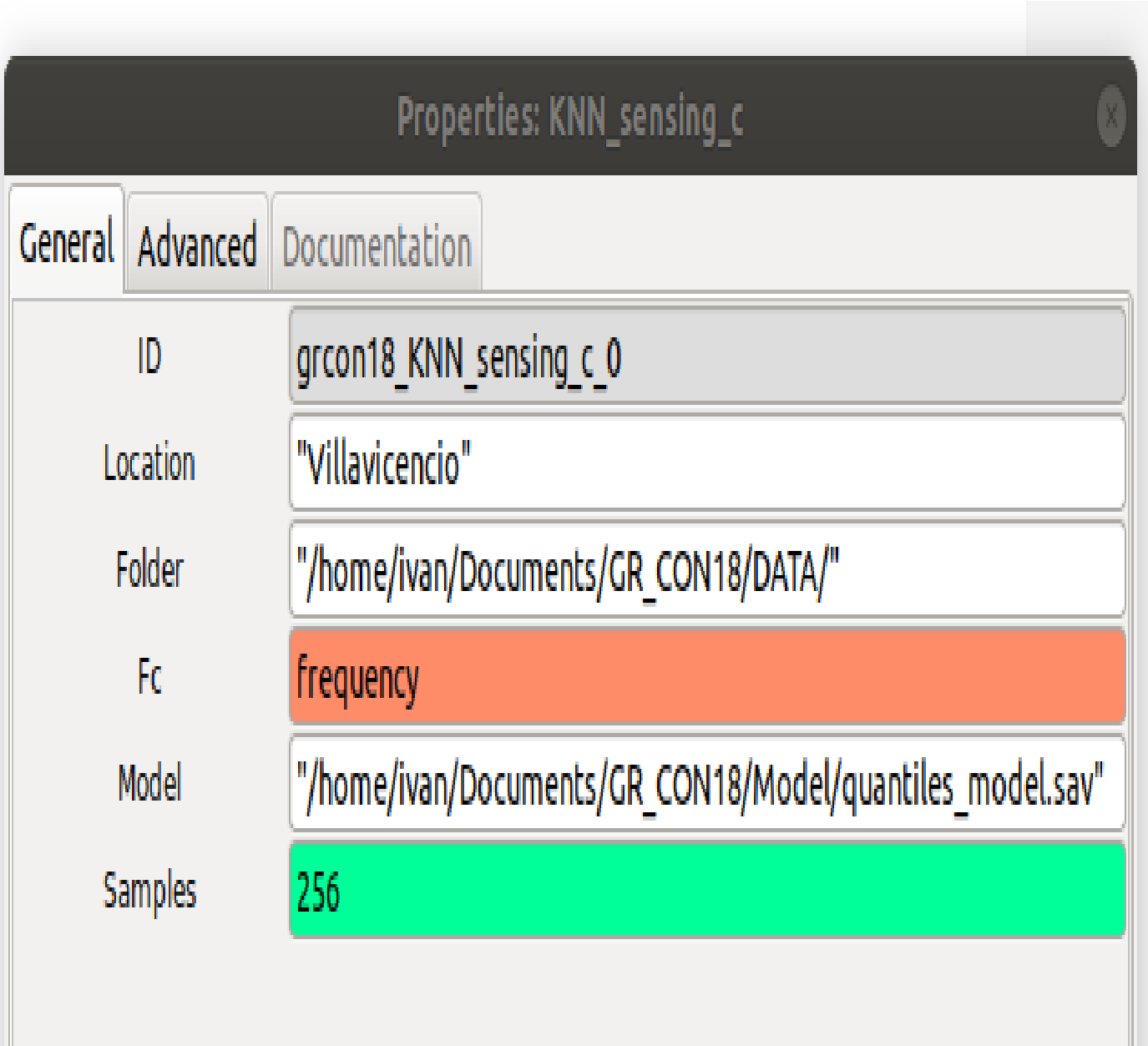
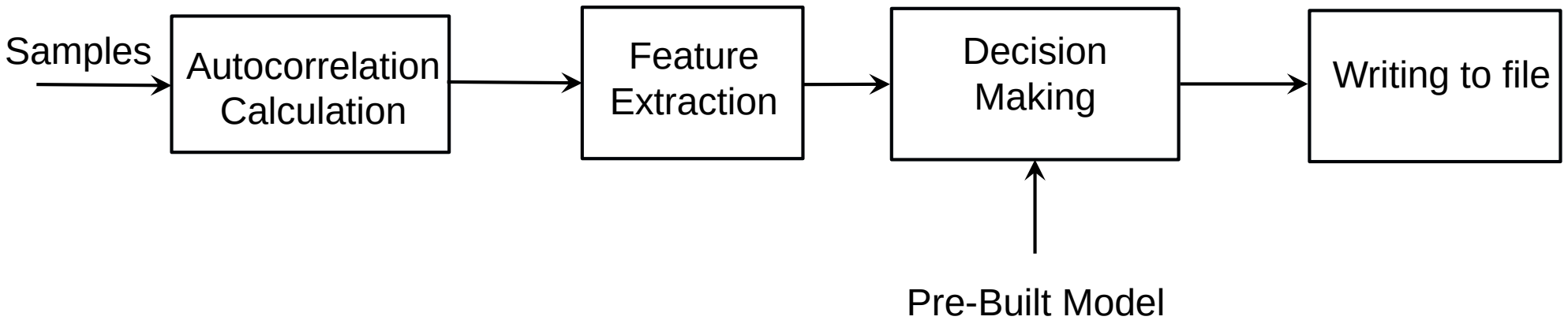
KNN GNU Radio Block





What all the methods have in common



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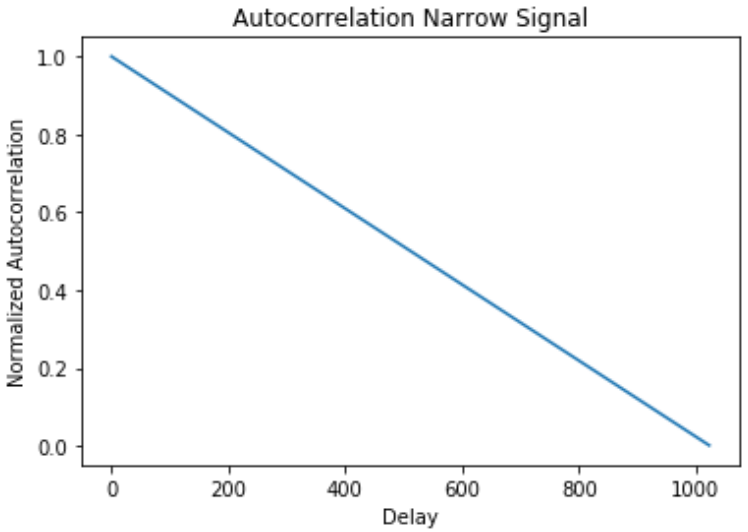
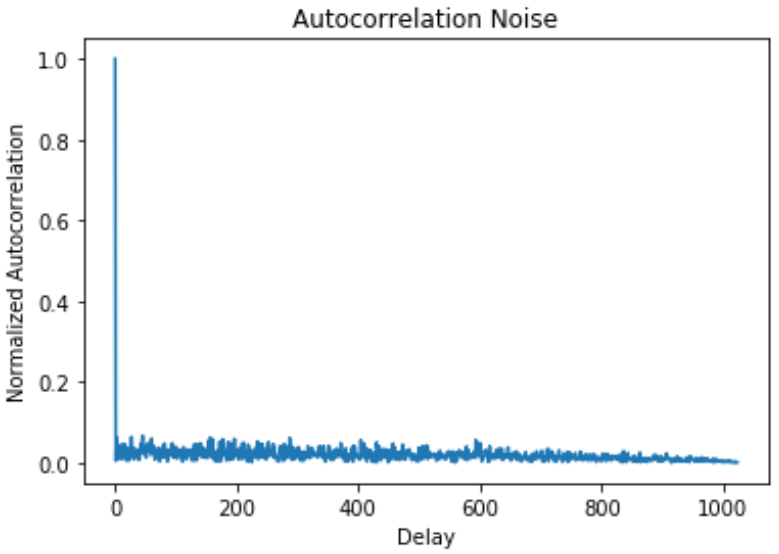
Sometimes it is easy to extract the features



Hack RF + GNU Radio signal



Noise

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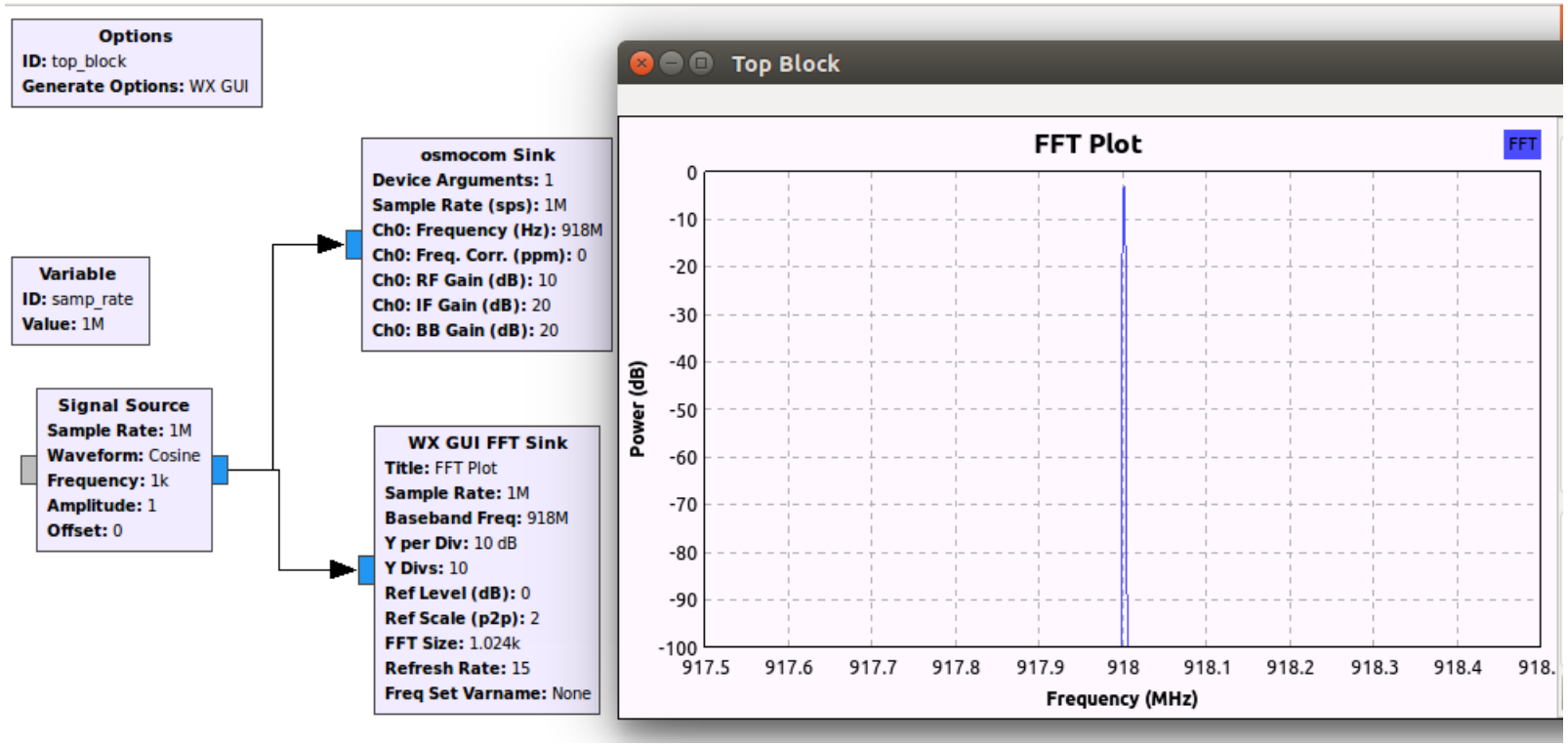
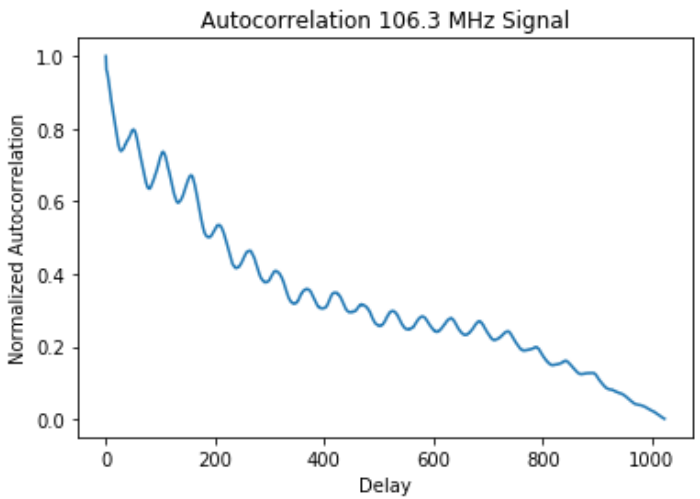
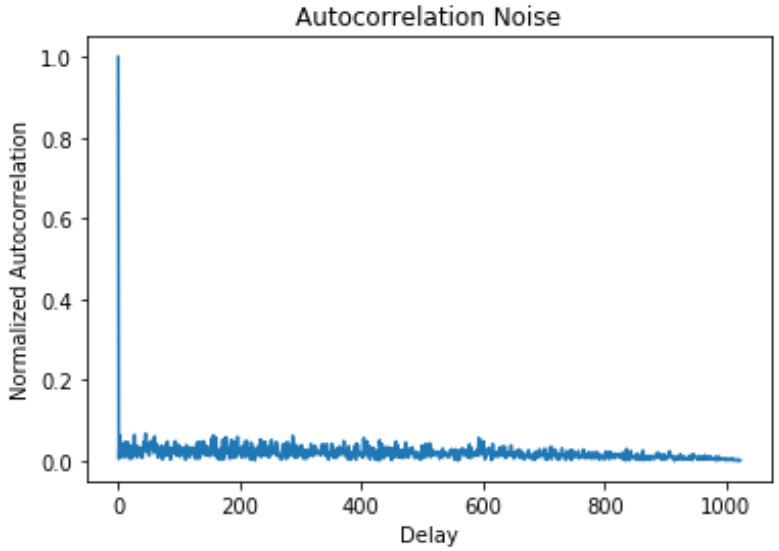
Scheme used for generating a narrow signal



Sometimes it is easy to extract the features



Hack RF + GNU Radio signal



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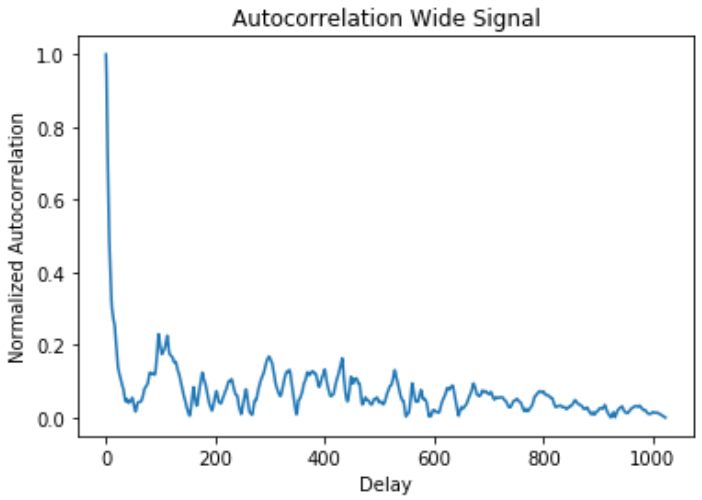
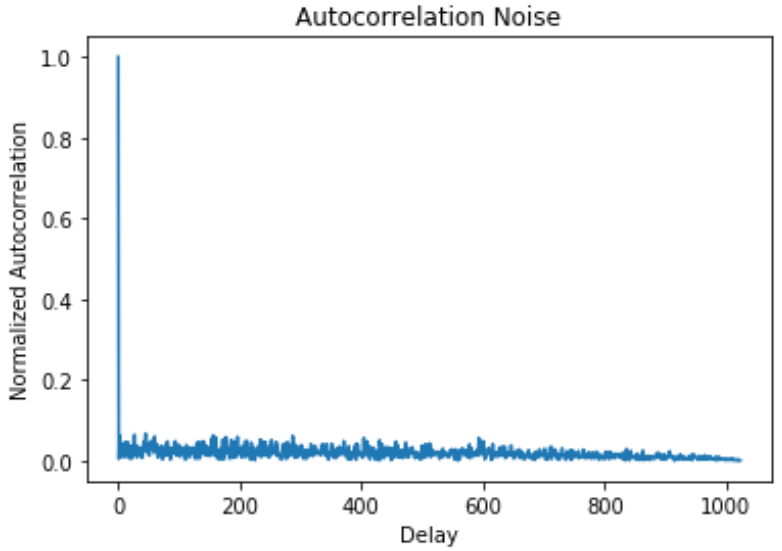
Sometimes it is a little bit difficult



Hack RF + GNU Radio signal



Noise

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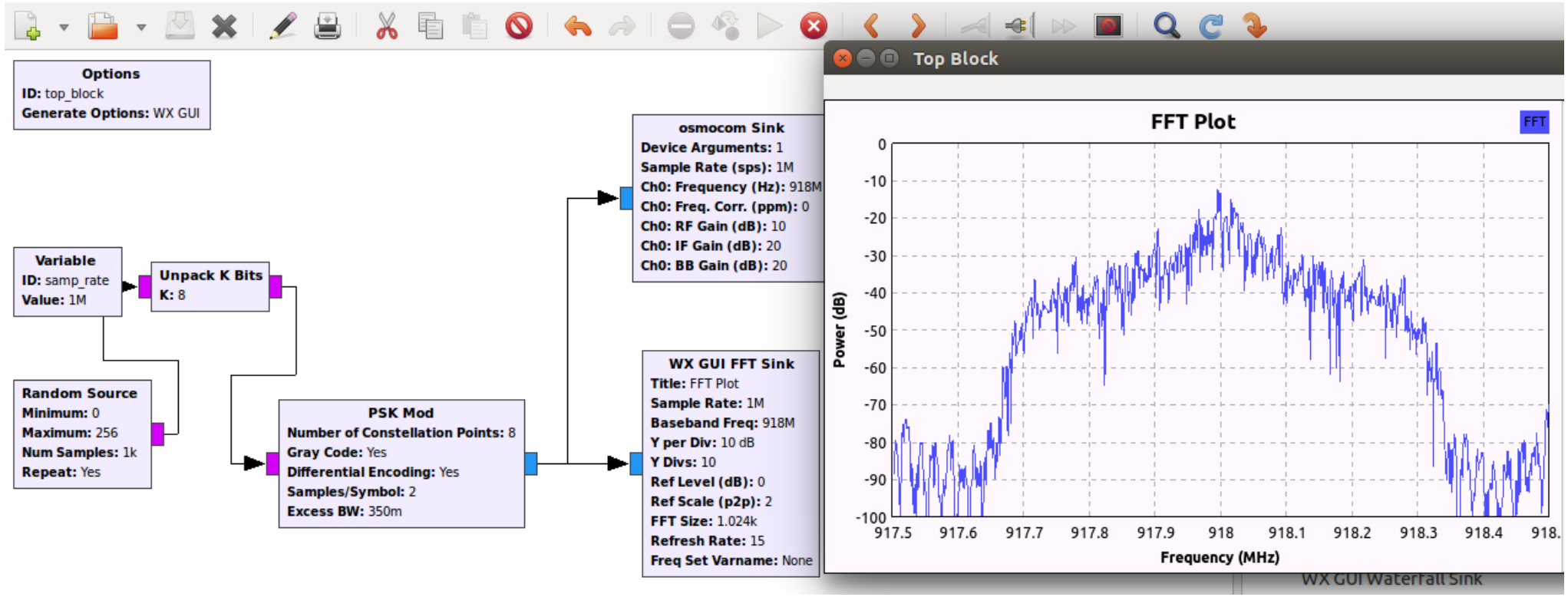
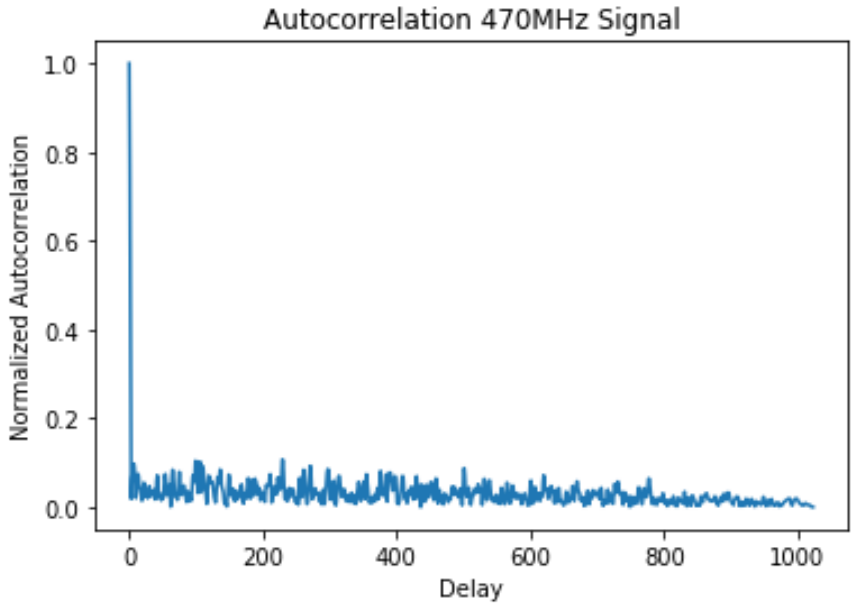
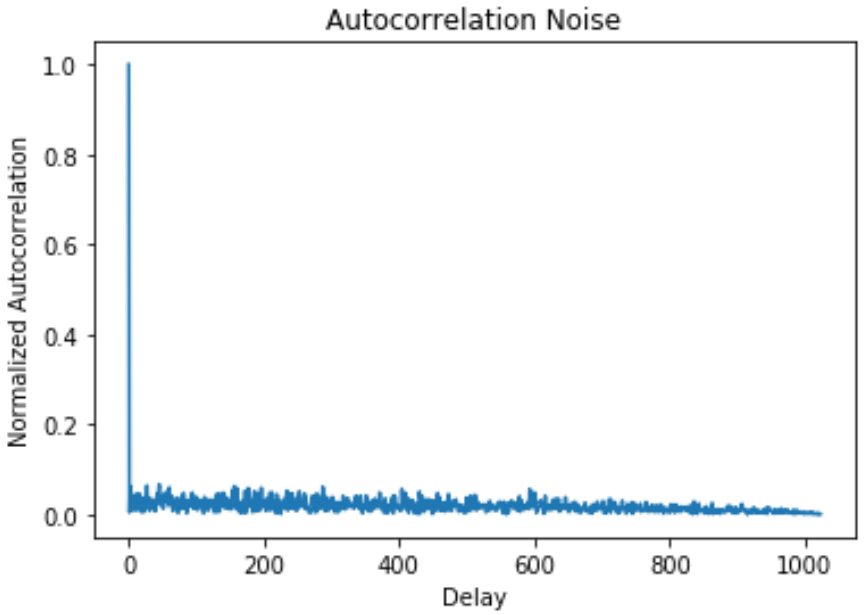
Scheme used for generating a wide signal



Sometimes it is much more difficult



470 MHz signal (Digital TV) taken from the air



Noise

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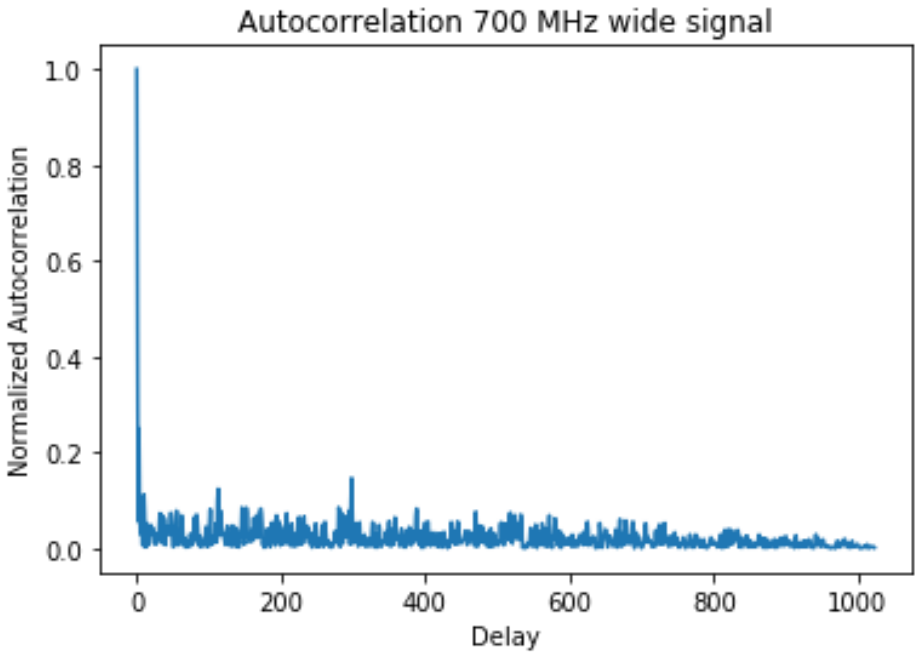
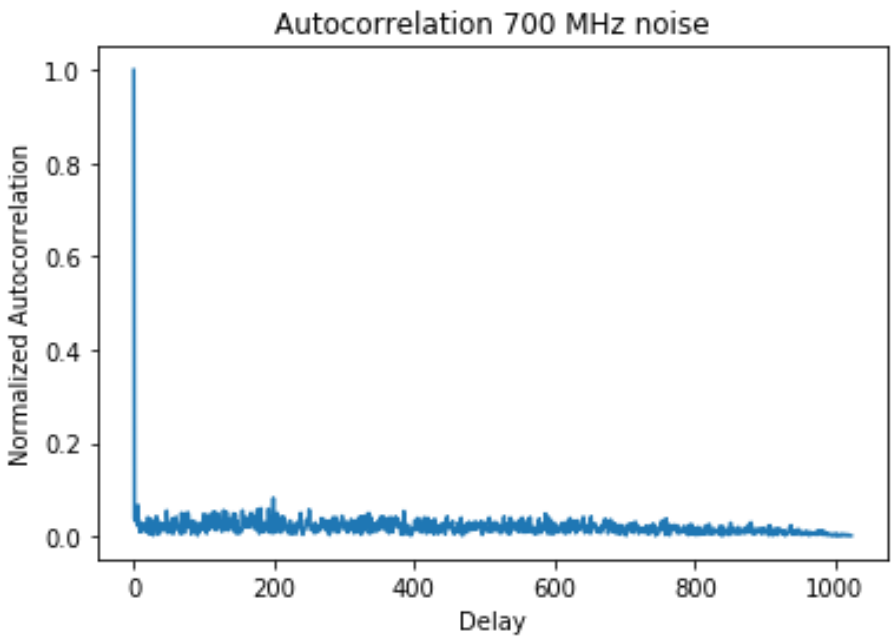
Sometimes it is a much more difficult



Hack RF + GNU Radio signal



Noise

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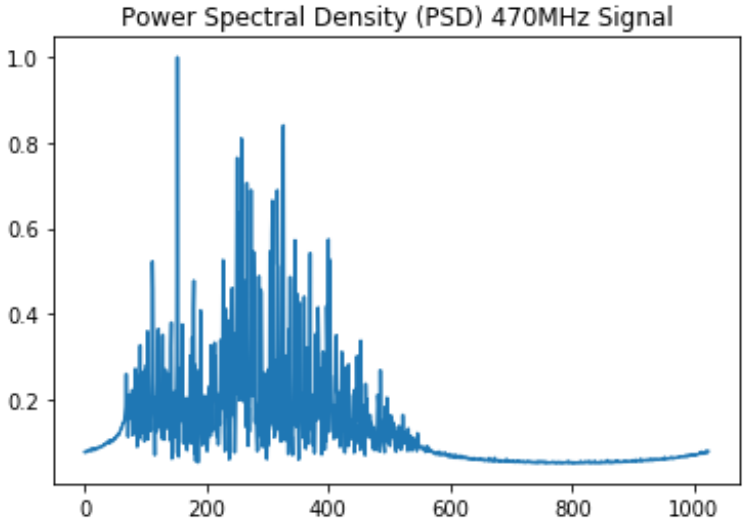
Taking the FFT of the autocorrelation makes the features more visible



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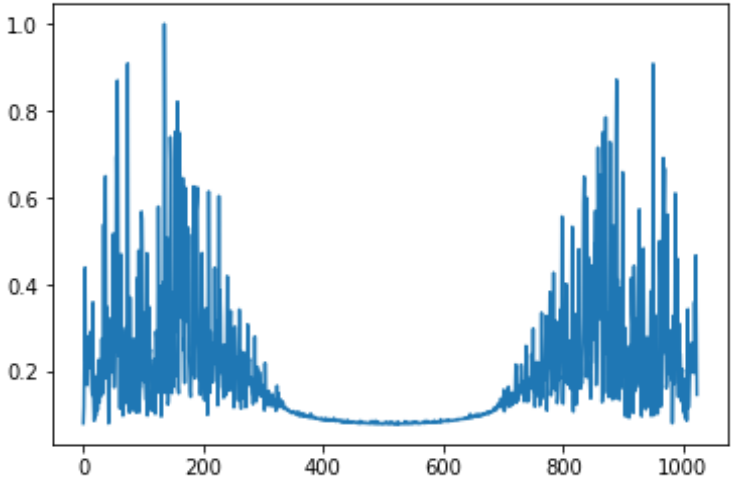

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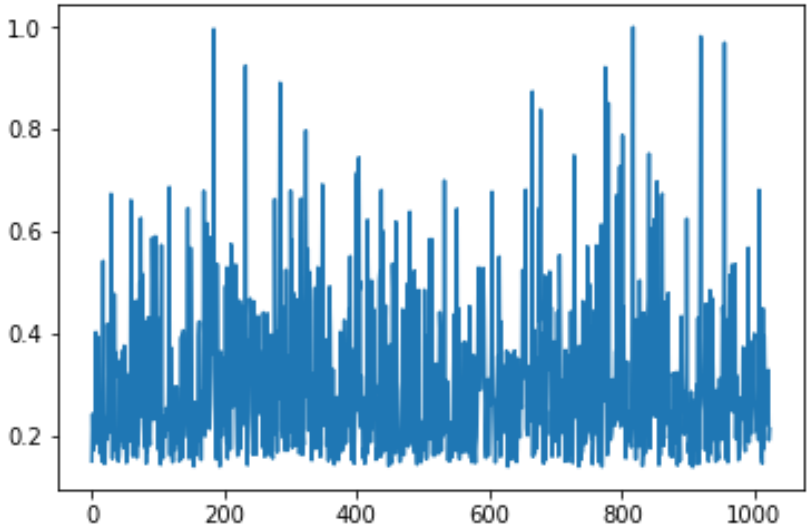
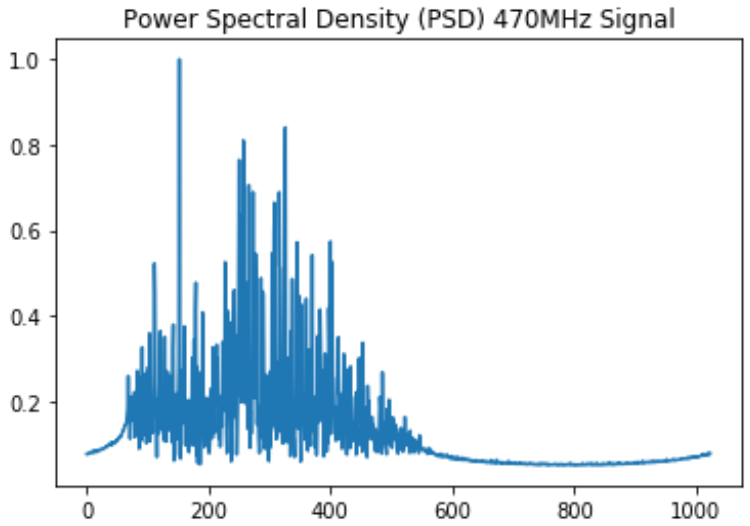


Noise

25%, 50% , 75% percentiles as features



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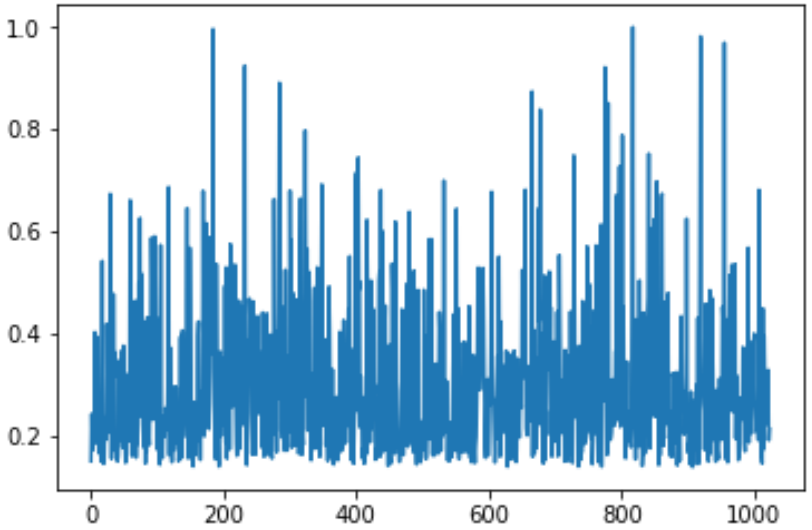

Noise

	p_25	p_50	p_75	PU
119221	0.088163	0.119343	0.193114	1.0
119222	0.067656	0.094399	0.155456	1.0
119223	0.116526	0.159822	0.233984	1.0
119224	0.091226	0.121970	0.190987	1.0

	p_25	p_50	p_75	PU
0	0.140444	0.188720	0.258878	0.0
1	0.181953	0.248563	0.342750	0.0
2	0.147883	0.193947	0.270266	0.0
3	0.176191	0.227200	0.330292	0.0

Tests

	Narrow Signals		Wide Signals	
Method	**False Alarm**	**Detection**	**False Alarm**	**Detection**
Euclidean	0%	100%	0%	80,4%
Kmeans	0%	100%	2,3%	95,1%
KNN	0%	100%	1,6%	96,2%

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Conclusions and Future Work

- The KNN method performs better than the Euclidean and K-means method; the more training data the better the performance.
- We can see the autocorrelation and the PSD as images and analyze them by means of machine- learning algorithms.
- Pre-trained models can be shared to be re-used for spectrum sensing.
- Future work includes solving the problem of overflowing (OOOOOO) when running the flowgraph.
- Future work also includes working on multi-label classification using the KNN method.
- Future work also includes calibrating the hyper-parameters of the model for better performance; trying other percentiles or looking for other features to exploit.

Thanks !

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