ECE-361

Final Project Part 3
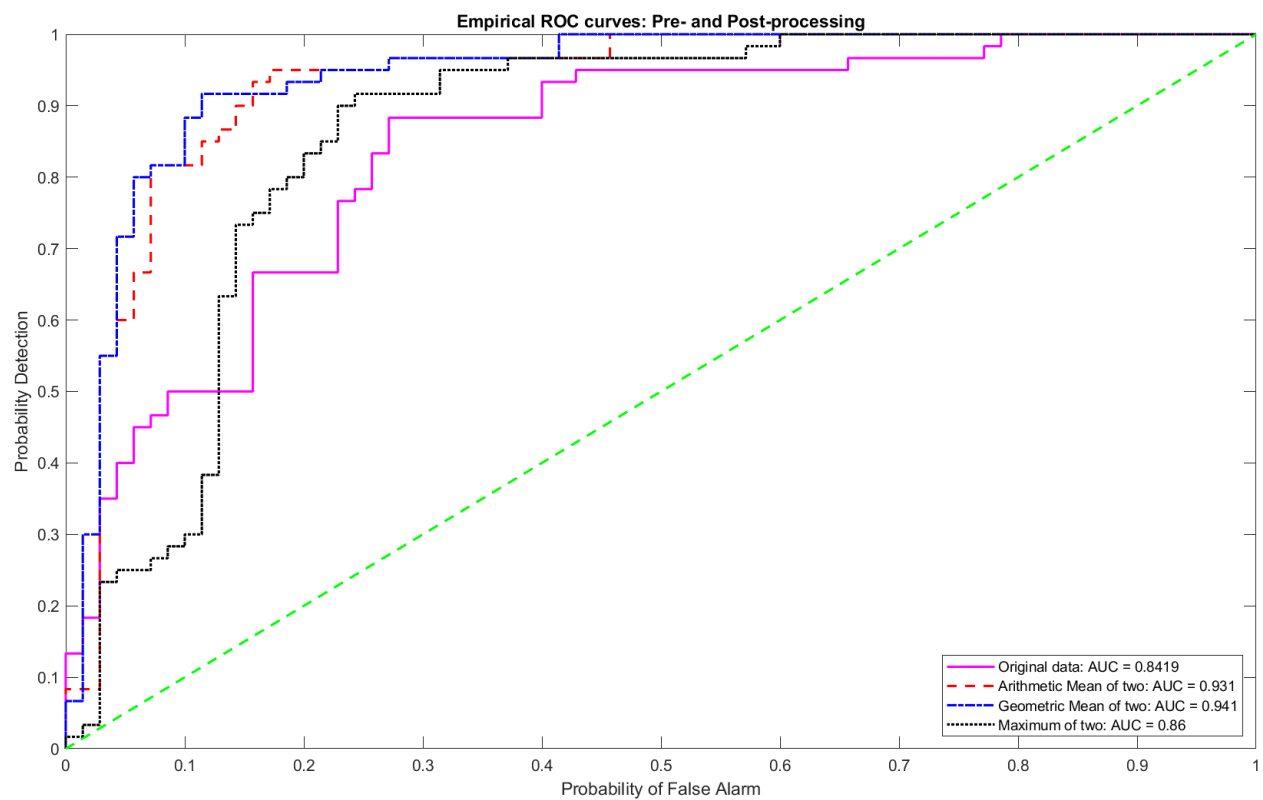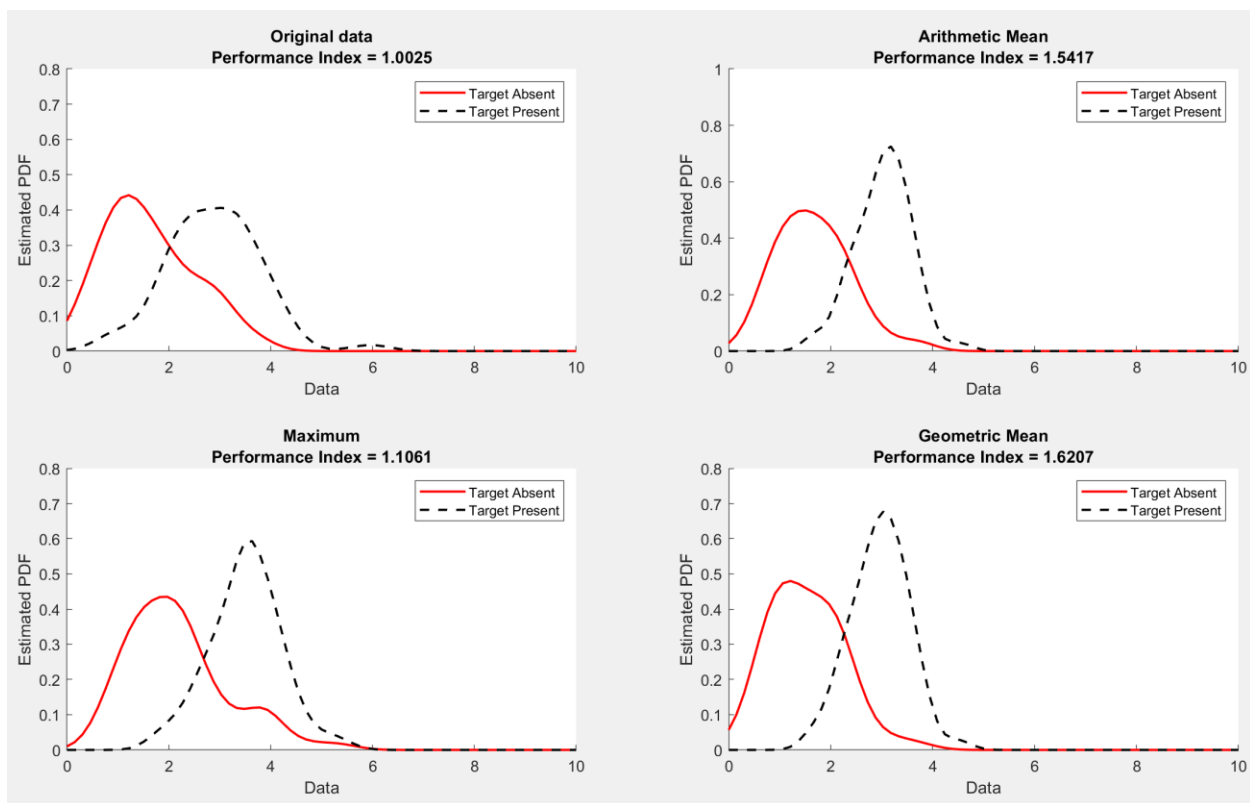
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Target Absent (sorted)

0.134	0.776	1.066	1.296	1.665	1.989	2.816
0.249	0.808	1.079	1.353	1.694	2.069	2.832
0.367	0.826	1.091	1.382	1.861	2.227	2.891
0.439	0.847	1.103	1.412	1.871	2.243	2.968
0.449	0.857	1.143	1.448	1.873	2.450	3.014
0.459	0.872	1.184	1.484	1.873	2.483	3.068
0.530	0.936	1.195	1.488	1.882	2.498	3.162
0.586	0.946	1.226	1.519	1.936	2.520	3.256
0.619	1.028	1.288	1.523	1.959	2.542	3.651
0.766	1.028	1.291	1.533	1.985	2.789	3.776

Target Present (sorted)

0.867	2.080	2.545	2.998	3.289	3.728
0.923	2.103	2.596	3.012	3.325	3.742
1.135	2.216	2.609	3.058	3.357	3.815
1.579	2.235	2.613	3.074	3.384	3.899
1.798	2.248	2.626	3.099	3.390	3.990
1.845	2.278	2.652	3.150	3.399	4.067
1.859	2.288	2.652	3.179	3.424	4.146
1.999	2.340	2.674	3.218	3.509	4.179
2.019	2.414	2.701	3.239	3.612	4.370
2.034	2.425	2.762	3.271	3.707	5.958

Original data
Performance Index = 1.0025

Estimated PDF vs Data

Legend: Target Absent, Target Present

Arithmetic Mean
Performance Index = 1.5417

Estimated PDF vs Data

Legend: Target Absent, Target Present

Maximum
Performance Index = 1.1061

Estimated PDF vs Data

Legend: Target Absent, Target Present

Geometric Mean
Performance Index = 1.6207

Estimated PDF vs Data

Legend: Target Absent, Target Present

Empirical ROC curves: Pre- and Post-processing

Probability Detection vs Probability of False Alarm

Original data: AUC = 0.8419
Arithmetic Mean of two: AUC = 0.931
Geometric Mean of two: AUC = 0.941
Maximum of two: AUC = 0.86

Performance Improvement Metrics: Dual Diversity

		Target Not Detected	Target Detected	Signal Processing Algorithm
	Target Absent	51	19	No Processing(input): PI = 1.0025
	Target Present	7	53	*Error rate = 26/130, AUC = 0.842 *Positive Predictive Value = 0.73611
	Target Absent	58	12	Arithmetic Mean: PI = 1.542
Single Iteration	Target Present	3	57	*Error rate = 15/130, AUC = 0.931 *Positive Predictive Value = 0.826
	Target Absent	53	17	Maximum: PI = 1.106
	Target Present	5	55	*Error rate = 22/130, AUC = 0.86 *Positive Predictive Value = 0.764
	Target Absent	62	8	Geometric Mean: PI = 1.621
	Target Present	5	55	*Error rate = 13/130, AUC = 0.941 *Positive Predictive Value = 0.873

*Error rate and positive predictive value estimated
 based on the Youden's index Threshold

Performance Improvement from Signal Processing(Dual Diversity)
Mean and Std. Deviation of Metrics: 100 Iterations

	Orig Data	AM	MX	GM	
AUC	0.842	0.919	0.879	0.919	**(mean)**
		0.023	0.029	0.023	**(std. dev.)**
Error Counts [out of 130]	26	18	23	18	**(mean)**
		4	4	4	**(std. dev.)**
PPV	0.736	0.832	0.781	0.835	**(mean)**
		0.048	0.059	0.049	**(std. dev.)**
Perf. Index	1.002	1.434	1.181	1.44	**(mean)**
		0.166	0.155	0.172	**(std. dev.)**

This project utilized both "Target Absent" and "Target Present" datasets to determine the most optimal thresholds using Youden's index. By applying this threshold, we identified the best-fit probability distributions for each dataset, specifically the Rayleigh and Rician distributions, to model and generate new randomized and parameterized data. Through comprehensive analysis, performance indices were calculated under different signal processing strategies, including Arithmetic Mean, Maximum, and Geometric Mean, demonstrating significant improvements in detection accuracy and predictive performance compared to raw input data. Empirical metrics, such as the Area Under the Curve (AUC), error rates, positive predictive values (PPV), and

performance indices, highlighted that the Geometric Mean approach yielded the highest AUC (0.941) and the lowest error rate (13/130), making it the most effective strategy. The study's results emphasize the value of signal processing in enhancing classification and detection capabilities within probabilistic frameworks. This project serves as a practical example of how statistical tools and probability analysis can be applied in engineering contexts to optimize decision-making processes. The ability to model, simulate, and automate such systems is invaluable, with applications spanning system diagnostics, resource management, and real-time monitoring to drive efficiency and accuracy in industrial and technological settings.