EE 201C Project 3 Final Report

High Sigma Modeling

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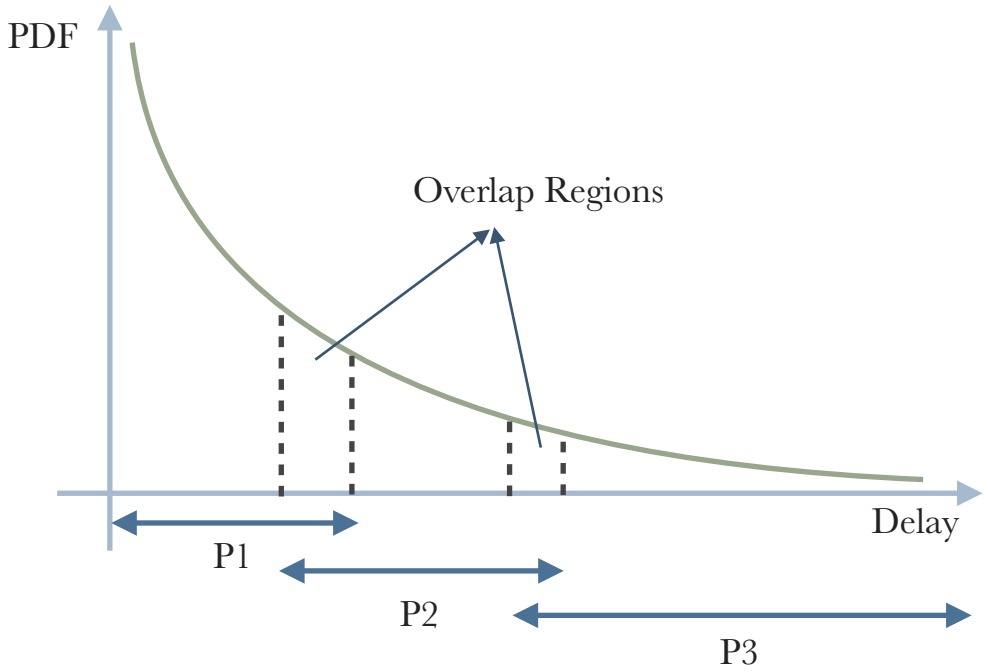
Problem Statement

For very rare events, like beyond 6σ, Monte Carlo simulation is very cumbersome. It would require large number of samples while the majority of samples provide no useful information in high sigma regions. This project seeks to use more sophisticated algorithm to sample more points in the region of interest. As of runtime and memory considerations, it is desirable to reduce the total number of runs or lookups.

Proposed Approach

For 6 sigma accuracy, it is to determine distribution up to 1.40e-10. From project 2, we have determined distribution up to 3 sigma point, which is around 1.37e-10. By important sampling, we have another distribution between 1.365e-10 and 1.38e-10. After using SVM, the third set of data is generated for delay greater than 1.375e-10.



We proposed the following workflow to achieve the goal:

1. From Table Lookup (500K Data), we plot truncated PDF P1.
2. From Important Sampling, we plot truncated PDF P2.
3. From SVM classified set, we plot truncated PDF P3.
4. By tuning the overlap regions, it is achievable to get a continuous plot.

Support Vector Machine

We use Matlab function **fitcsvm** to build the classifier. Samples over 1.37e-10 are labeled as 1 and the rest that are between 1.365e-10 and 1.37e-10 are labeled as 0. Around 1K samples within that region are used for training SVM. Meanwhile, we only select the 4th of every 6 variables in the total 360 variables, leading to a total number of 60 variables being fed to the function. As to accuracy, kernel function is specified as 'polynomial' and kernel scale is 'auto'. The fraction of coverage is about 95% with accuracy around 60%.

Important Sampling (Shifted Samples Generator)

Important Sampling is used to generate new samples near failure region. We selected outputs larger than 1.36e-10 and calculated the means of 360 variables. Then we use the means and original variance to generate shifted samples. Matlab is used to generate new input sets.

For P2, we generated 5000 shifted samples. After running HSpice and cutting 1.365e-10 ~ 1.375e-10 part, we can get P2.

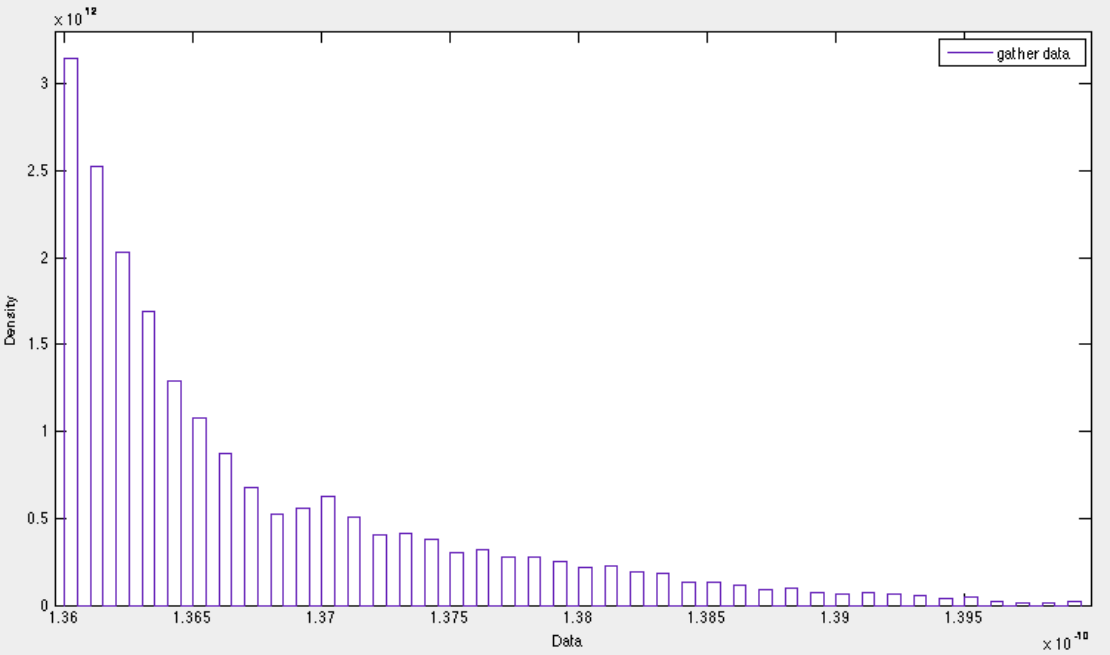
For P3, we generated 10000 shifted samples. After running SVM classifier, we got 3035 samples may be in the high sigma region (larger than 1.37e-10). After running HSpice and cutting 1.375e-10 ~ 1.4e-10 part, we can get P3.

Region	P1 [1.360e-10, 1.367e-10]	P2 [1.368e-10, 1.375e-10]	P3 [1.376e-10, 1.400e-10]
Number of Samples	**3634**	**822**	**1324**
Density	**3634/500K 7.268e-3**	**(822*0.007158)/2488 2.36e-3**	**(1324*0.007158)/4976 1.90e-3**
SPICE Run	**3634**	**5000**	**3035**

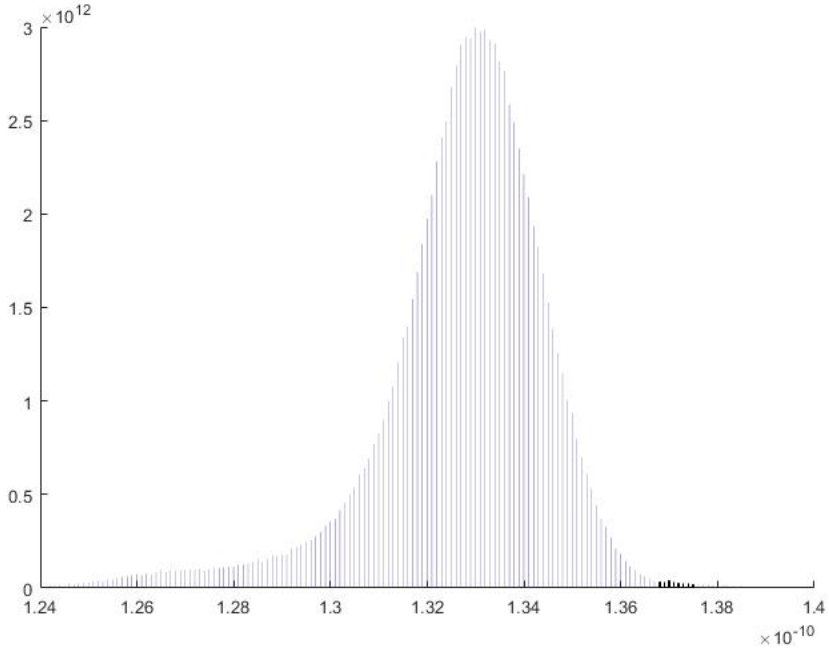
Results

This section shows the results we obtained:

PDF of High Sigma Region



PDF of Whole Region



Reference

W. Wu, W. Xu, R. Krishnan, Y.-L. Chen, and L. He, "REscope: High-dimensional statistical circuit simulation towards full failure region coverage," in Proceedings of the 51st DAC, 2014.