EE 201C Final Project Presentation

High-sigma modeling

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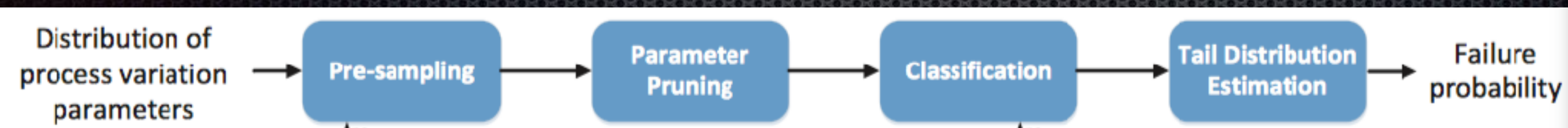
Problem Statement

- For very rare events, say 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 Solution

Distribution of process variation parameters → Pre-sampling → Parameter Pruning → Classification → Tail Distribution Estimation → Failure probability

- Sample Pruning

  - Reduce dimensionality

- Support Vector Machine(SVM)

  - Binary classifier for newly generated samples.

- HSpice

 - To run classified newly generated samples

Sample Pruning

- Object : To reduce number of dimensions needed in SVM classification

- Only choose variance with high variance

360 Variables

180	60	60
Constant	Low Variance	High Variance
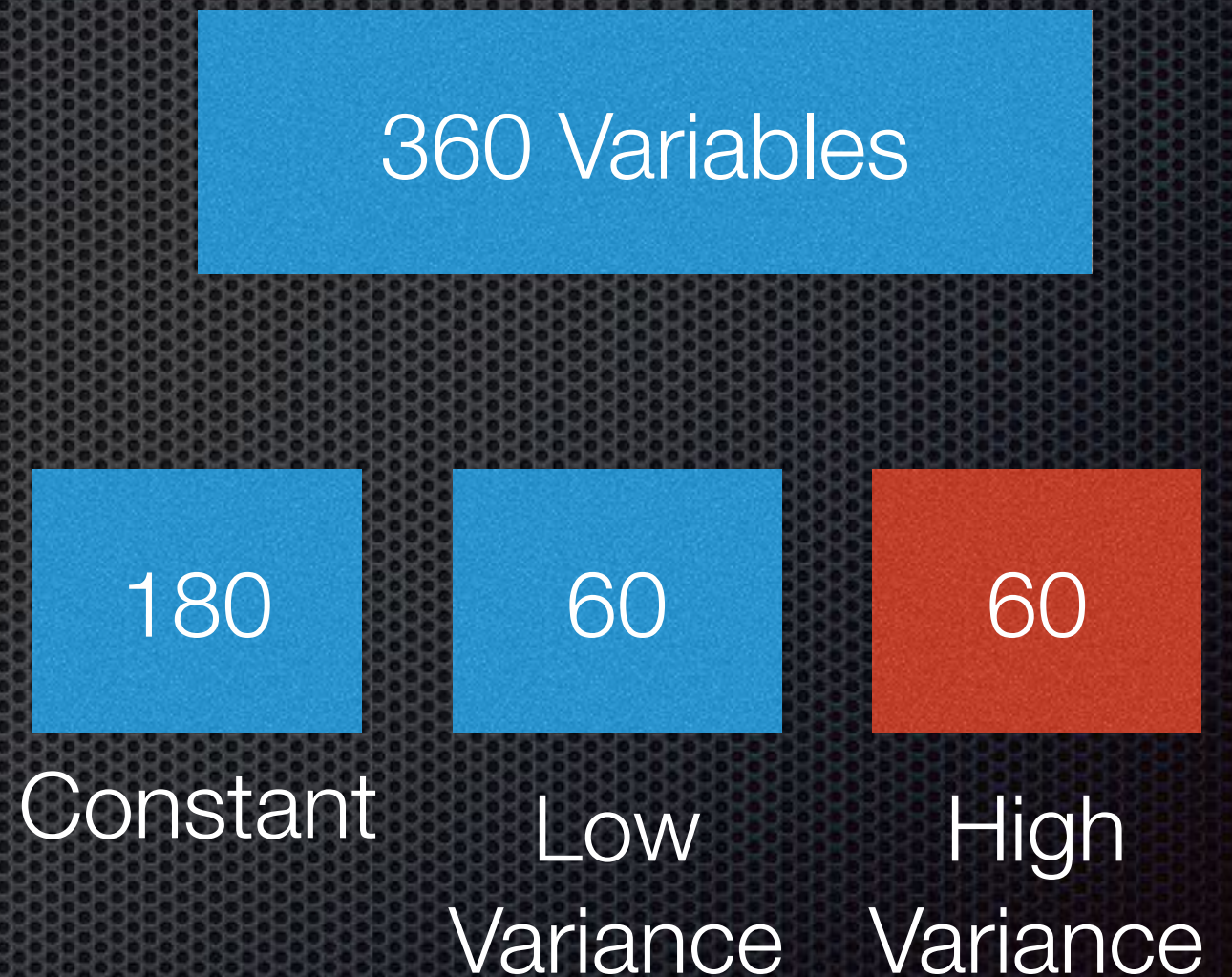
SVM Classification

- What is SVM?

  - For 2D/3D, it's a line/surface that differentiates two sets of points.

  - For more than 3D, it is abstracted as so-called Hyperplane.
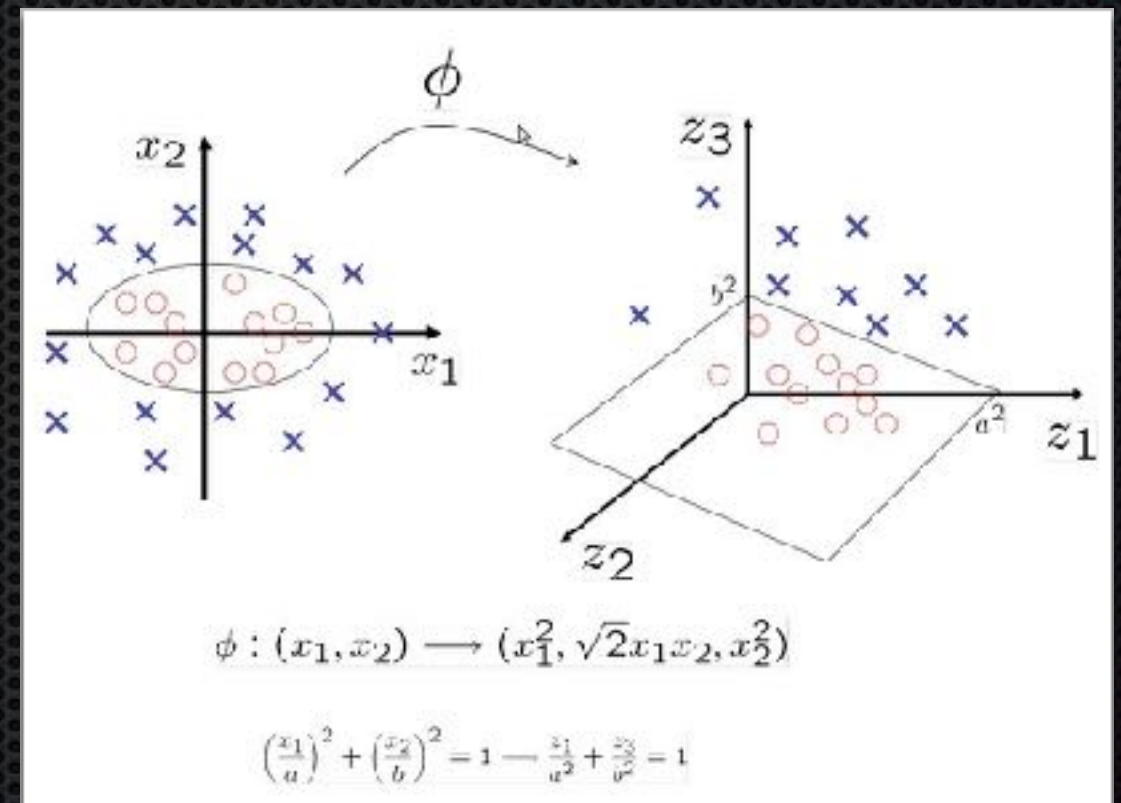
  - Typically need Kernel Functions
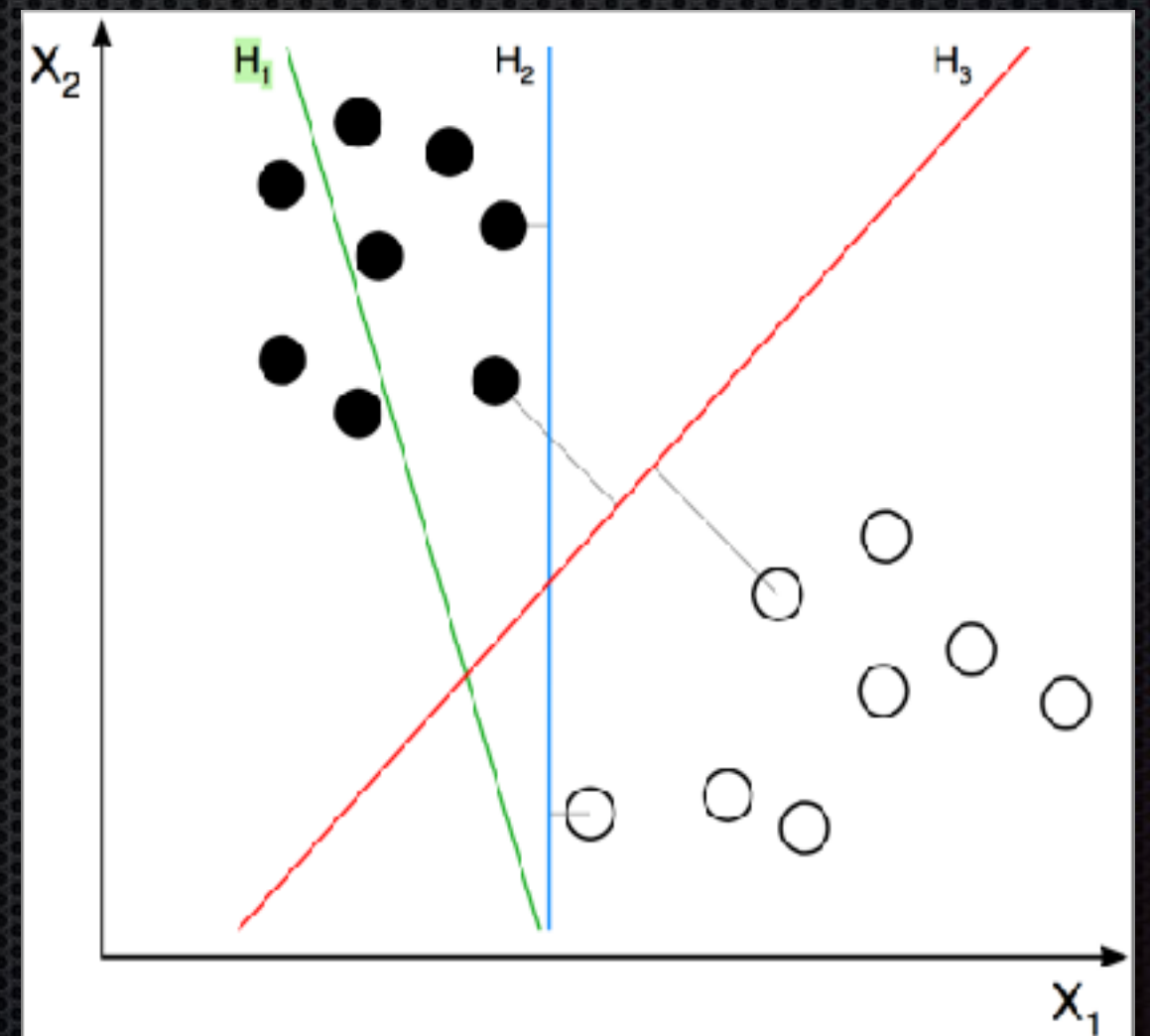
https://en.m.wikipedia.org/wiki/Support_vector_machine

Kernel Functions

- In Machine Learning, a Kernel Function is defined as a mapping function between two sets.

- In Matlab, for low to moderate dimensionality, fitcsvm provides 3 kernel function: linear, rbf, and polynomial.
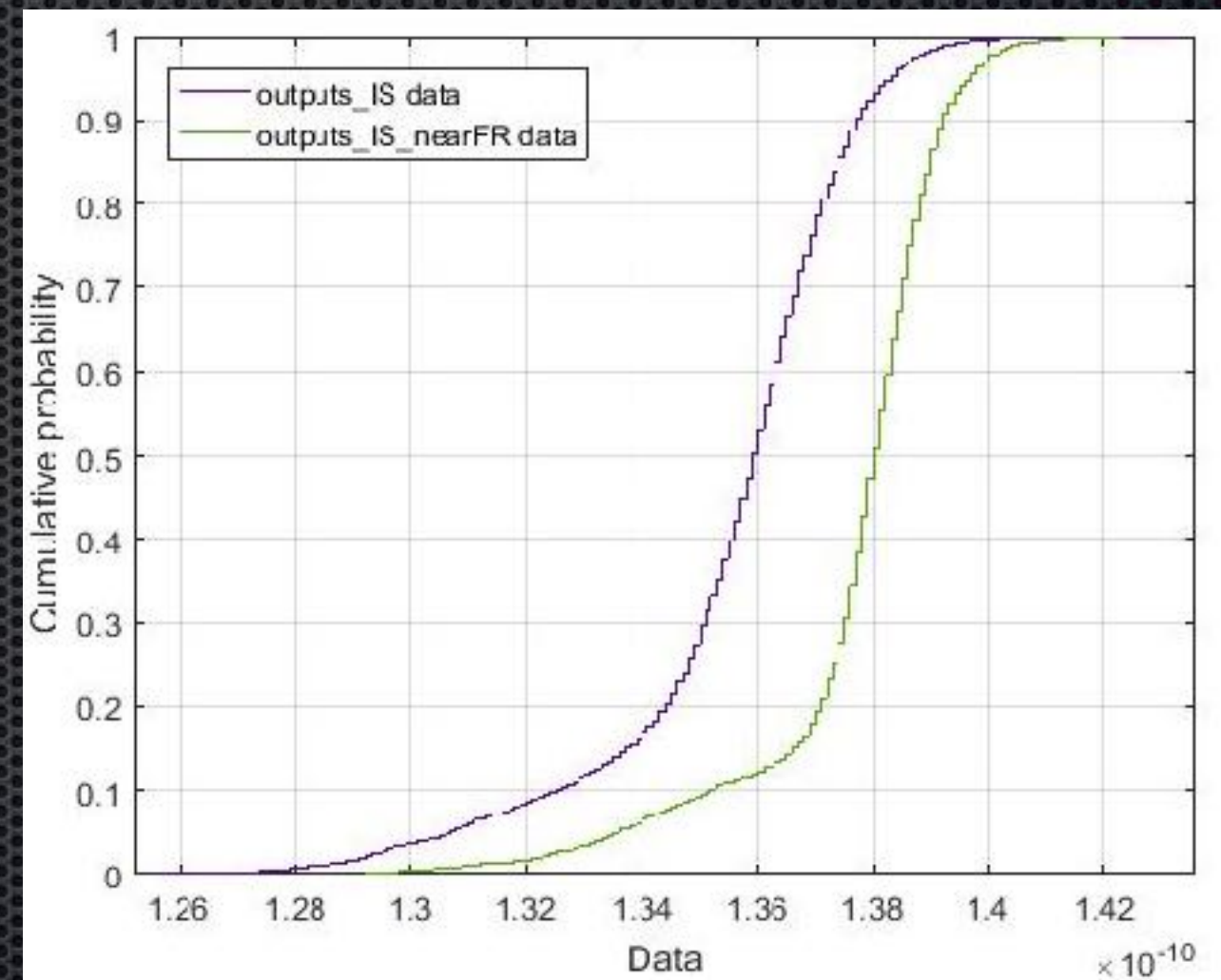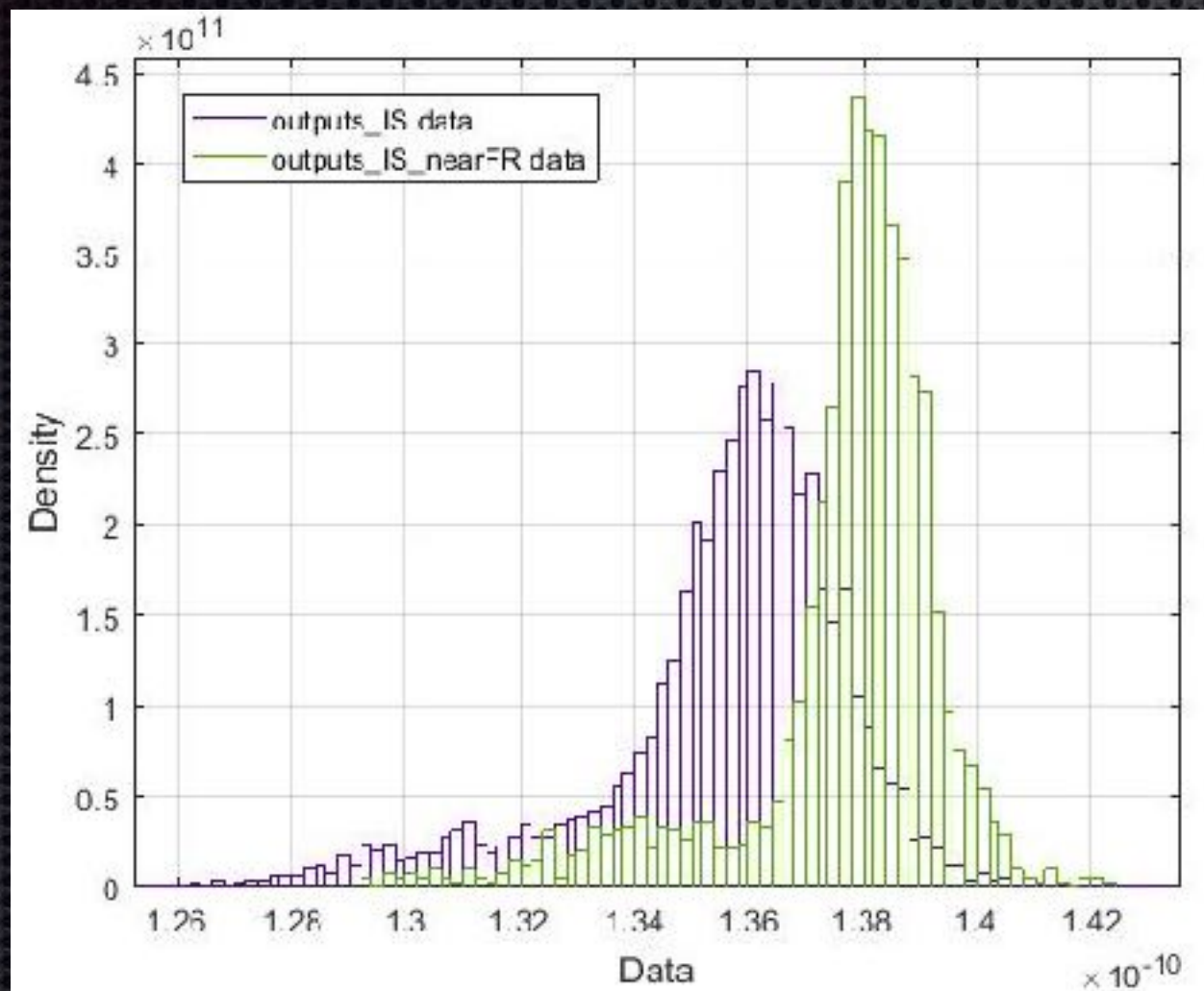

$$\phi : (x_1, x_2) \longrightarrow (x_1^2, \sqrt{2}x_1 x_2, x_2^2)$$

$$\left(\frac{x_1}{a}\right)^2 + \left(\frac{x_2}{b}\right)^2 = 1 \longrightarrow \frac{z_1}{a^2} + \frac{z_3}{b^2} = 1$$

Kernel Functions

- Test Results using Matlab:

Kernel	Linear	RBF	Polynomial
Predict Traning Samples	91.7%	99.5%	100%
Predict Original Data	---	TBD	TBD
Predict IS Data	---	413/516 out of 1069	924/1527 out of 1069

Results

New Sample

- After building SVM models, we could classify newly generated samples.

- Using selected samples for HSpice runs.

- Theoretically, we need 2M unshifted samples to reach 6 sigma region.(*2,000,000*1e-6=2*)

Reference

- https://en.m.wikipedia.org/wiki/Support_vector_machine

- 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.

Thank you