Modeling Emerging Device Characteristics Using Neural Network Approach (CM2b-15)

WANG Zixuan
Supervisor: Professor CHAN Mansun

Overview

With the development of microelectronic devices, many technologies are emerging every day, and each of them requires circuit level evaluation. Unfortunately, developing physical formulas and constructing the traditional physical models for every device consumes a large amount of time, which goes against the requirements of the high-speed development of devices. As the Artificial Neural Network is one of the powerful machine learning tools, this project discovers the method to use it to model the characteristic curves of the emerging devices, as well as find extra assisting technology to improve the performance of the modeling.

Objectives

- Using the Artificial Neural Network to learn the characteristic curves of the emerging device.
- Transforming the Neural Network to an HSpice model.
- Providing suggested sampling step during the process of collecting data.
- Finding methods to improve the ANN’s ability of generalization

Methodology

Some definitions:

- Sampling Step: 
  - Randomly Sample, 
  - Quadratic Sampling, or 
  - Logarithmic Sampling

- Modified Relative Error, $\text{MRE}(\text{prediction}, \text{target}) = \frac{|\text{prediction} - \text{target}|}{\text{target}}$

- Predictive Error, $\text{PE}(\text{prediction}, \text{target}) = \frac{|\text{prediction} - \text{target}|}{\text{target}}$

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Results

- Figure 4. The Prediction and the Real Value
- Figure 5. The Error between the Prediction and the Real Value
- Figure 6. The Marginal Appropriate Sampling Steps of Different Devices

Table 1. The Performance of the PPE Algorithm

<table>
<thead>
<tr>
<th>Sample $V_n$</th>
<th>0.085</th>
<th>0.105</th>
<th>0.257</th>
<th>0.640</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSEfective</td>
<td>0.794</td>
<td>0.789</td>
<td>0.789</td>
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Conclusion

The neural network can be used to model the characteristic curves of the emerging devices with a small error.

By adopting the logic of finding suggested sampling step, the researchers can find the appropriate sampling step for every input (not limited to $V_n$, $V_g$), which enables them to obtain the ANN model with relatively small training set.

The PPE algorithm can select the neural network with higher accuracy as well as improving the ANN’s ability of generalization, although it is not necessary to improve the performance to certain level. Furthermore, the idea of adopting one machine learning tool to another area of machine learning application may help us improve the performance of machine learning tools.