

ML Surrogate Model Tutorial - Evaluation Package

Analog Intelligent Design Inc.

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What's Included

This package provides a complete evaluation workflow with trained ML models:

- 📁 Evaluation Package
 - |
 - |— 📄 master_evaluation_script.py [Main script]
 - |— 📁 Models/ [ML model files - 12 files]
 - | |— folded_cascode_design_space_scaler_model.pkl
 - | |— catboost_folded_cascode_design_space_*.txt (11 files)
 - |— 📁 Testing/ [Optional sweep input files]
 - | |— variation_analysis_input.csv
 - | |— variation_analysis_input_temp.csv
 - | |— variation_analysis_input_voltage.csv
 - | |— ... (more sweep files)
 - |— 📄 Documentation/ [User guides]
-

Quick Start (2 Commands)

1. Install dependencies

```
pip install pandas numpy matplotlib catboost joblib
```

2. Run the evaluation

```
python3 master_evaluation_script.py --base /path/to/your/models
```

✅ **Done!** All results appear in the evaluation_results/ folder.

What Gets Generated

After running the script, you'll get files organized by input:

Plots (4 PNG files at 300 dpi per input)

- GM_vs_Vdd_*.png - Gain Margin vs Supply Voltage
- Gain_vs_Vdd_MultiCorner_*.png - DC Gain across process corners
- Temperature_Sensitivity_*.png - Temperature effects on DC Gain
- Power_Gain_Tradeoff_*.png - Power vs Gain trade-off colored by UGB

Data Files (CSV per input)

- folded_cascode_results_*.csv - Prediction results (input + outputs)
- designs_meeting_specs_*.csv - Filtered designs meeting specs
- statistics_summary_*.csv - Performance statistics (mean, std, min, max)

Generated Input Files

- custom_pvt_sweep.csv - PVT sweep (60 points: 5 voltages × 4 temps × 3 corners)
- batch_random_100.csv - Random batch designs (100 samples)

Log File

- evaluation_log.txt - Complete execution trace

Note:

- All output filenames include timestamps to avoid overwriting
- Total file count depends on configuration

Key Features

Real ML Model Predictions

- Uses trained CatBoost models with scaler
- Millisecond predictions vs hours for SPICE

- 11 performance metrics predicted simultaneously

✓ Multi-Sweep Support

- Run all tutorial examples with --run-all-sweeps
- Automatically evaluates available sweep files
- Each sweep gets timestamped outputs
- Missing files skipped automatically

✓ Flexible Command-Line Interface

- Custom inputs via --input
- Custom output directory via --outdir
- Fast mode via --no-plots
- Transform control via --no-cube

✓ Professional Outputs

- High-resolution plots (300 dpi PNG)
- Clean CSV files for Excel
- Complete execution logging
- Timestamped filenames

✓ Fast Execution

- Typical: 5-15 seconds on modern laptop
- Suitable for interactive exploration
- Model caching for performance

Note: Execution time varies based on hardware and configuration.

Tutorial Functionality Implemented

This script implements functionality from tutorial concepts:

Tutorial Concept	What the Script Does
Data import	Loads CSV, displays columns and row counts
Single-variable plotting	GM vs Vdd plots
Multi-corner comparison	DC Gain plots across corners
Statistical analysis	Computes stats; identifies best design
Design filtering	Filters by: DC_gain>80, PM>60, Power<2.5, UGB>150
PVT scenario generation	Creates 60-point sweep
Random batch generation	Creates 100 random designs
Visualization	Temperature sensitivity & power trade-off plots

System Requirements

Python: 3.8 or higher (required)

Libraries:

- pandas
- numpy
- matplotlib
- catboost
- joblib

Hardware:

- Disk Space: ~10 MB for models, ~2 MB for outputs per run
- Memory: ~200 MB during execution (approximate)
- Typical execution: 5-15 seconds on modern laptop

Operating System: Windows, Mac, or Linux

Next Steps

1. Read the User Guide

Open Master_Evaluation_Script_User_Guide.md for:

- Detailed command-line options
- Comprehensive usage examples
- Troubleshooting guide
- Input file format specifications

2. Run the Script

```
python3 master_evaluation_script.py --base /path/to/models
```

3. Review Outputs

Check the evaluation_results/ directory for:

- High-resolution plots
- CSV data files
- Execution log

4. Explore Advanced Options

Run all tutorial sweeps:

```
python3 master_evaluation_script.py --base /path/to/models --run-all-sweeps
```

Use custom input:

```
python3 master_evaluation_script.py --base /path/to/models --input my_designs.csv
```

Fast mode (no plots):

```
python3 master_evaluation_script.py --base /path/to/models --no-plots
```

Package Directory Structure

After running, your directory will look like this:

```
your_directory/
```

```
├─ master_evaluation_script.py
```

```
├─ Models/
```

- | |— folded_cascode_design_space_scaler_model.pkl
- | |— catboost_folded_cascode_design_space_*.txt (11 files)
- | |— Testing/
 - | |— (optional sweep input files)
- | |— Documentation/
 - | |— (user guides)
- |— evaluation_results/
 - |— GM_vs_Vdd_*.png
 - |— Gain_vs_Vdd_MultiCorner_*.png
 - |— Temperature_Sensitivity_*.png
 - |— Power_Gain_Tradeoff_*.png
 - |— folded_cascode_results_*.csv
 - |— designs_meeting_specs_*.csv
 - |— statistics_summary_*.csv
 - |— custom_pvt_sweep.csv
 - |— batch_random_100.csv
 - |— evaluation_log.txt

Note: File count in evaluation_results/ depends on inputs and configuration.

Support & Contact

For technical support:

Email: info@aianalog.co

Website: www.aianalog.co

For detailed error messages:

Check `evaluation_results/evaluation_log.txt`

This evaluation package provides a complete workflow with trained ML models!

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