Machine Learning in EDA

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Machine Learning Is Not New…

Machine Learning is the field of study that gives computers the ability to learn without being explicitly programmed.”

Arthur Samuel, 1959

60 Years of Research

Artificial Intelligence
Neural Networks
Big Data
CNN
Deep Learning

Super Computer Performance

High-Performance Cloud
Massive Storage
Massively Parallel

source: www.top500.org
Drivers of Machine Learning and AI

Cloud Datacenter

Automotive

Medical

Industrial IoT

Applies to All Verticals

Machine Learning
Machine Learning at Cadence (and EDA in general)

**Enablement**
- Hardware/software co-design
- Tensilica® IP for machine learning

**Inside**
- Better PPA, faster engines
- Improved testing/diagnostics

**Outside**
- Automated design flow
- Productivity improvement
What is needed to Do Well in ML / AI (Fast and Smart)

Core Engine Performance
- Signoff Accuracy
- Single-CPU Performance
- Efficient Memory Mgmt
- Cloud Ready

Compute Capacity
- Massively Parallel
- Multi-Thread
- Fully Distributed
- Cloud Ready

Smart Flows/Solutions
- Natively Shared Engines
- Smart Physically ECO
- Common UI
- PPA Closure

The Right Technology for Machine Learning
FAST Engines

Tempus™
Signoff STA

Quantus™
Signoff Extraction

Innovus™
Implementation

Joules™
RTL Power

Modus DFT
DFT and ATPG

Xcelium™
Logic Simulation

Volus™
Signoff Power

Stratus™
HLS

Palladium®
Hardware Emulation

Protium™ S1
FPGA Prototyping

Genus™
RTL Synthesis

Pegasus™
DRC, LVS, DFM

JasperGold™
Formal Verification
Conformal Smart LEC
Next-generation fast and smart logic equivalency checking

- Adaptive Proof
- Massively Parallel

RTL → Conformal® Smart LEC

Netlist

Design Size (inst):
- 1.8M: 1 day
- 5.3M: 6X
- 5.6M: 6X
- 9.4M: 22X
- 20.6M: 10X

Machine N

LEC
Smart LEC

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Project VirTUS: A Technology for True Signoff

- Fully integrated, production-proven signoff
  - Tempus™ static timing
  - Voltus™ IR drop
  - Common database and runtime model

- Smart IR-sensitive path prediction
  - Machine learning for complete coverage
  - Factory trained for signoff

- Timing/sensitivity-driven IR analysis
  - Multi-cycle, functional, vector-less
  - IR drop and timing event natively aligned
Digital Full-Flow Technology: Database and Common Engines

Design Database
Massive Parallel/Multi-Threaded Infrastructure

Core Engines
Core Infrastructure Database
Full-Flow PPA Optimization

Transforms
Optimizations
Performance, Power, Area Optimizations

Logical Opt
Physical Opt
Clock Opt
Placement Opt
Routing
Extraction
Timing
DRC
EM-IR
Common UI

Genus™
Innovus™
Quantus™
Tempus™
Voltus™
Pegasus™

Advanced-Node Features
Via Pillar Optimization
IR-Aware Placement
IR-Aware Timing
Power Grid Trimming
DRC-Aware Routing
Metal Fill
Machine Learning for Library Characterization

Challenges
• Many cells, many process corners
• Many new effects
• Millions of simulations for each new standard cell library

Machine learning improves throughput:
• Learn from previous process corners
• Smart interpolation by extracting critical measurements
• Critical corner identification
Machine Learning: Digital Implementation

- **Floorplanning**
  - Optimized power grids

- **Placement**
  - Congestion prediction

- **Clock Tree Synthesis**
  - Better clustering for latency and skew

- **Routing**
  - Improve initial routing pattern

Design Data Extraction

Machine Learning Training Set (Large Design Data Cache)

Model vs. Actual Prediction Accuracy

Design Guidance

- Optimized power grids
- Congestion prediction
- Better clustering for latency and skew
- Improve initial routing pattern
Machine Learning Is Everywhere

- Cadence invested in developing fast and accurate leading-edge engines
- Cadence technology is designed to utilize the immense compute power available today via large networks or the cloud
- Cadence full flow, based on common engines and machine learning algorithms, delivers the best PPA with the best TAT
Cadence in Brazil

• R&D office, working on different products and careers: software development, product experts, application engineers, dev ops

• Local group with focus on machine learning for verification

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