



VLSI and Hardware Research in the Era of Machine Learning

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VLSI Research and its Significance

- What is research?
 - Advancement of existing knowledge
- Why research?
 - Satiates human curiosity to know more
 - Fuels industrial development
- What is the broad scope of VLSI research?
 - Electronic devices
 - Design methodology to build complex chips
 - Improving efficiency – power, energy, performance, cost, etc.
 - Novel applications
 - ...

Machine Learning

- It is everywhere !!
- Everyone wants to do research in machine learning !!
- It is a very fast growing field !!
- Record number (>8000) of papers submitted in top ML conferences !!
- High salary and demand for ML engineers !!

Can ML grow alone ? **NO**

Can ML help other domains grow ? **YES**

Effect of ML on VLSI and Hardware Research

- Improved compute capacity and energy efficiency
 - **Novel architectures** like TPU (Tensor processing unit), DPU (DNN processing unit), etc. have evolved
 - Energy efficient and real-time ML on portable devices
- Companies like Google, Facebook, Amazon
 - Investing on ASICs, FPGAs, GPUs
 - **Hiring VLSI designers** and computer architects
- VLSI conferences are flooded with ML papers
 - DAC has **dedicated tracks** on efficient ML and DNN

DAC 2020: From EDA to Design on Cloud, Machine Learning, Embedded Systems and More

As the premier conference for the design automation of electronic systems, the 57th Design Automation Conference program has expanded to also include many verticals closely integrated with and/or dependent on cutting-edge electronic design automation. Along with a large exhibit floor featuring top EDA, design on cloud and IP companies, stellar keynote sessions and endless networking, the topics below will be represented on both the industry and academia portions of the DAC program.

Autonomous Systems ▶

Modern autonomous systems are growing at an increasingly rapid pace. These complex systems are developed to make our experiences safer, more energy-efficient and enjoyable.

Design ▶

A cross-domain interaction of researchers, designers and practitioners cover design for electronic systems and electronic design automation in both the Research Track and Designer Track.

EDA ▶

For more than five decades DAC has focused on EDA and today it is still important with the growing complexities and scaling of semiconductor devices in circuits and systems.

Embedded Systems ▶

The NEW Embedded Systems & Software (ESS) track provides a forum to discuss the challenges of embedded design. The sessions present an opportunity to exchange ideas/roadmaps for the future of this expanding area.

IP ▶

The IP Track is a forum for presenting & discussing the challenges of IP development, verification, integration and management. It provides an opportunity for leaders in the industry and tool users to exchange ideas.

Machine Learning/AI ▶

The ML/AI program will highlight advances in the field with a focus on design and design automation at the cross section between ML/AI algorithms and hardware.

Security ▶

The security of systems is essential in today's electronics. Secure, trustworthy SW and HW components, platforms and supply chains are vital to all domains including financial, healthcare, transportation, and energy.

Design on Cloud ▶

The effect of the cloud can be found in just about every industry. Design on Cloud sessions provide discussions related to hybrid cloud, EDA tools, data storage, security, and the complexity of this new era of design.

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ML publications in top VLSI conferences

Using ML to improve architectures

- PRIMAL: Power inference using *machine learning*, DAC 2019
- *Machine learning*-based pre-routing timing prediction with reduced pessimism, DAC 2019
- Accurate wirelength prediction for placement-aware synthesis through *machine learning*, DATE 2019

Designing architectures to support ML

- A camera with brain - embedding *machine learning* in 3D sensors, DATE 2019
- Real-time anomalous branch behavior inference with a GPU-inspired engine for *machine learning* models, DATE 2019
- CORN: In-buffer computing for binary *neural network*, DATE 2019
- SeFAct: Selective feature activation and early classification for *CNNs*, ASPDAC 2019

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Many more opportunities !!

Emerging Research Topics in VLSI, Hardware Design and Systems

- **Approximate** computing
- Efficient computing for **intermittent systems**
- Use of **Non-volatile memory** in computing
- Processing **in memory (PIM)/near** memory
- **Energy** and **Performance efficient** computing on **Heterogeneous** platforms (CPU, GPU, FPGA, Accelerators, etc.)
- **Neuromorphic** computing
- **Accelerators** for deep neural networks and machine learning
- Use of machine learning for **electronic design automation**
- Use of **novel device** materials
- ...

Changing Research Landscape

Boundary between industry and academia is thinning

- AssisTech, IIT Delhi
 - A complete end-to-end research and product development lab to develop products for visually impaired
- Google, Facebook, IBM, Amazon, ...
 - Lot of research papers in top ML and AI conferences are coming from industry / startups
- Incubation centers and startup culture
 - Increasing expectation for research to be useful for society
- Inter-disciplinary research becoming popular
 - Problems in real-life are inter-disciplinary
 - Potential to solve many immediate problems

Summary

- Novel applications (autonomous driving, smart systems, etc.) fuelling VLSI research –
 - Newer sensors, processor speed, cost, power improvements
- Machine learning has spawned lots of research areas in VLSI and hardware design (and also in other fields)
- Many technological advances (e.g., newer devices, cloud, mobile) fostering novel hardware research problems
- Nature is inter-disciplinary → Many newer research problems are inter-disciplinary and have huge potential to impact the society

THANKS

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