EAS 504: Applications of Data Science – Industrial Overview – Spring 2023

-Lecture by Arun Venkatachar

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Ques 1 : Describe the market sector or sub-space covered in this lecture :

The market sector or sub-space covered in this lecture is Introduction to Electronic Design Automation Industry (EDA) & Application of Machine Learning to EDA . EDA organizations invest in R&D to innovate and develop new technologies, techniques, and methods for electronic design. This may entail creating novel design processes, optimization techniques, and algorithms for electronic circuit and system modeling, testing, and verification. Manufacturing data, including fabrication and assembly data, is analyzed using ML to offer input to designers on how to improve their designs for manufacturability. Large datasets may be analyzed by ML algorithms to detect design elements that may result in production problems, yield losses, or cost increases. This data may assist designers in making design decisions that increase manufacturability, yield, and cost-effectiveness, leading in more efficient and cost-effective manufacturing processes. Machine learning methods are used to automate component placement and routing on PCBs or ICs, therefore speeding up the design process and decreasing human mistakes. Data-driven design process automation can lead to speedier time-to-market and more cost-effective product development.

Ques 2 : What data science related skills and technologies are commonly used in this sector?

Data science is growing rapidly and it is very important in the Electronic Design Automation Industry sector, and now EDA sector is recognizing the potential of data analytics to drive growth and profitability of the organization , also mitigating risks. With techniques to monitor, regulate, and manage massive amounts of data, ML and data science has opened up a plethora of opportunities in the EDA .APIs are used to create software tools and frameworks for automating many elements of electrical design. APIs may be used, for example, to create placement and routing algorithms that automatically position and route components on a printed circuit board (PCB) for best performance and manufacturability. These algorithms may be enhanced using machine learning approaches to optimize the design process based on data-driven insights. APIs and machine learning are used in circuit design to discover faults. Machine learning algorithms, for example, may examine circuit performance data and discover deviations from predicted behavior that may suggest design flaws. To allow automatic flaw identification in electronic designs, APIs may be utilized to incorporate these machine learning techniques with verification tools. To build the Synopsys API, several statistical and machine learning models, such as KNN, Regression, SVC, RandomForest and others, must be implemented.

Ques 3 : How are data and computing related methods used in typical workflows in this sector? Illustrate with an example.

Methods that are based on data and computation are crucial for Electronic Design Automation industry. These approaches let them to examine enormous amounts of data, discover patterns of human errors, machinery errors, and take preemptive steps to avoid losses. CMLP APIs establish a collection of rules, protocols, and interfaces that allow EDA tools to communicate with one another, share data, and operate on electronic designs. These APIs allow EDA tools to interface with various design components such as libraries of electrical components, models, and intellectual property (IP) blocks, all of which are necessary building blocks in the design of electronic systems. APIs can be used by designers to construct custom scripts, plugins, or workflows that automate routine tasks, alter tool behavior, or incorporate particular design processes. APIs can help in the communication of design data, design rule checks (DRC), and other vital information, allowing for easy cooperation among the many stakeholders involved in the design and production of electronic systems. Designers may modify the tools to their unique needs, allowing for better adaptability and versatility in the design process. APIs can help in the communication of design data, design rule checks (DRC), and other vital information, allowing for easy cooperation among the many stakeholders involved in the design and production of electronic systems.

Ques 4 : What are the data science related challenges one might encounter in this domain?

The increasing need for data science related skills and technologies are key to the success of the Electronic Design Automation sector to meet their increasing data size every day. They maintain large warehouses and embed huge number of transistors which leads to huge chunks of Data. Companies begin by establishing the chip's architecture, which includes the functional blocks, their interconnections, and the overall system-level design. This process assesses the chip's capabilities, performance, power consumption, and compliance with the specifications of the target smartphone. A chip architecture, for example, may have a central processing unit (CPU), a graphics processing unit (GPU), memory controllers, communication modules, and other components. Inconsistencies, mistakes, or uncertainties in data from many sources might have an influence on the trustworthiness of design solutions. EDA entails handling sensitive design data, including the designs' intellectual property (IP). It is vital to safeguard the confidentiality, integrity, and availability of design data in order to avoid data breaches, intellectual property theft, and unauthorized access. Data quality and accuracy are critical for data-driven decision-making and model training in EDA applications to provide trustworthy and efficient design outputs. Inconsistencies, mistakes, or uncertainties in data from many sources might have an influence on the trustworthiness of design outputs.

Ques 5 : What do you find interesting about the nature of data science opportunities in this domain?

Silicon chip demand is not restricted to electric cars , smart phones, but also extends to other areas of the automotive industry and many other industry. For purposes like as engine management, safety systems, entertainment, and connection, modern automobiles are outfitted with a wide range of semiconductor components, including silicon chips. The need for silicon chips in the automotive sector is likely to rise further as vehicles become more complex and include more electrical functions. The EDA industry deals with massive volumes of data created throughout the chip design, manufacturing, testing, and integration processes. Data from simulations, design files, testing findings, and production procedures are all included. Data scientists in the EDA area confront issues like as managing and analyzing huge datasets, devising algorithms to extract insights, and effectively processing and analyzing this data using big data technology. EDA is a multidisciplinary field that brings together skills from computer science, electrical engineering, physics, material science, and manufacturing processes. To comprehend the complexity and subtleties of chip design, fabrication, and testing, data scientists in EDA must collaborate with experts from multiple domains and build data-driven solutions that incorporate insights from many disciplines.

(i) Describe some of the challenges in applying machine learning approaches to this domain

EDA procedures are extremely complicated and time-critical, including large-scale designs containing billions of transistors and extensive interconnections. Using machine learning algorithms in such large-scale projects might provide scalability and efficiency problems. Machine learning models must process and evaluate massive volumes of data, which can be computationally taxing. It is a huge problem to ensure that machine learning algorithms are fast, scalable, and capable of handling the scale and complexity of EDA designs. Machine learning models employed in EDA must be interpretable and explainable in order to acquire the trust and approval of designers, verification engineers, and other stakeholders. However, many machine learning techniques, such as deep neural networks, are inherently complicated and difficult to grasp. Interpreting and explaining the judgments produced by machine learning models in EDA may be difficult, especially when working with complicated design rules, limitations, and optimizations.

(ii) Describe two illustrative use cases from this domain where ML approaches have been successfully used.

As the professor put it, "trash in, garbage out," in most situations there is no diversity in the data. Data from other chips will be inaccessible to other system architectures. The firm would need more data from a specific design. . ML methods for power optimization in chip design have been effectively applied by evaluating power consumption data from many sources, such as chip simulations, power measurements, and system-level data, to identify power-hungry locations and optimize power management algorithms. Power distribution networks (PDNs) in integrated circuits (ICs) serve an important role in providing reliable and efficient power delivery to the chip's many components. Because of their complicated topologies and the necessity to fulfill tight power supply criteria, optimizing PDNs is a difficult endeavor. PDNs have been effectively optimized using ML techniques, which estimate power supply noise and voltage drop in different parts of the chip and then optimize the PDN architecture and design parameters appropriately. Complex patterns and correlations between design parameters and PDN performance indicators may be learned by ML models trained on huge datasets of PDN performance simulations, allowing for rapid optimization of PDN designs to fulfill power integrity requirements