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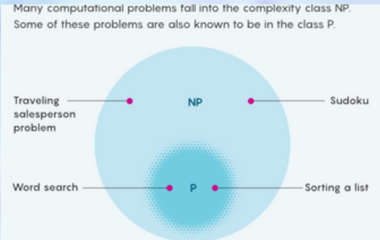
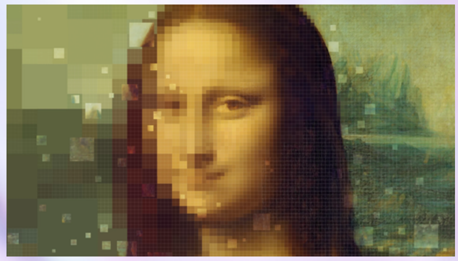
Byte Quest

Department of CSE

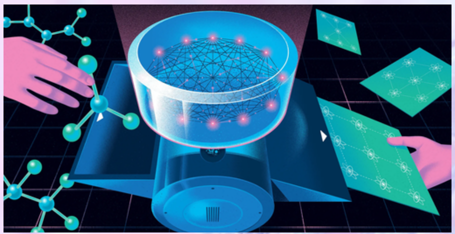


COMPLEXITY THEORY'S 50-YEAR JOURNEY TO THE LIMITS OF KNOWLEDGE



THE AI TOOLS MAKING IMAGES LOOK BETTER

ALAN TURING AND THE POWER OF NEGATIVE THINKING



MACHINE LEARNING AIDS CLASSICAL MODELING OF QUANTUM SYSTEMS

Department Vision

To be a center for academic excellence in the field of Computer Science and Engineering education to enable graduates to be ethical and competent professionals.

Department Mission

To enable students to develop logic and problem solving approach that will help build their careers in the innovative field of computing and provide creative solutions for the benefit of society.

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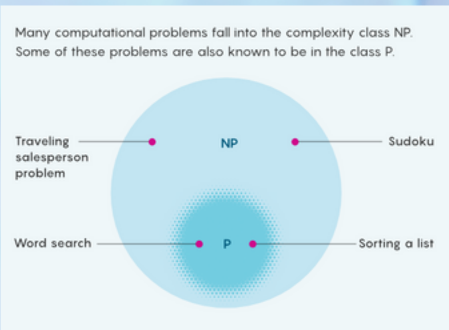
COMPLEXITY THEORY'S 50-YEAR JOURNEY TO THE LIMITS OF KNOWLEDGE

Theoretical computer science grapples with the P versus NP problem, pondering whether complex computational problems can be efficiently solved. This puzzle has resisted resolution despite extensive efforts by complexity theorists. Meta-complexity, a subfield, delves into the difficulty of proving computational hardness, linking it with fundamental questions. The problem's origins trace back to Kurt Gödel's work on the limits of mathematical reasoning and the foundational work on computation by Alan Turing.

The P versus NP problem concerns two complexity classes, P and NP, where P contains easily solvable problems and NP includes problems whose solutions can be quickly verified. The central question asks if NP problems with challenging solutions actually have hidden shortcuts (P = NP) or if they're inherently difficult (P ≠ NP). Stephen Cook, Leonid Levin, and Richard Karp's contributions identified NP-complete problems, suggesting they're all fundamentally related.

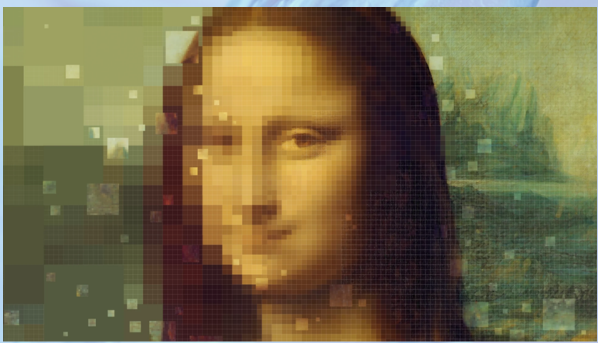
Complexity theory encountered barriers hindering approaches to solve P versus NP, like the "natural proofs barrier." Despite these hurdles, researchers remain determined to navigate this complex landscape, drawing inspiration from historical findings and exploring new perspectives like circuit complexity introduced by Claude Shannon.



Recent breakthroughs in meta-complexity, led by researchers like Marco Carmosino, have reignited interest in this field, offering new insights into the difficulty of proving computational hardness. Meta-complexity examines the intricacies of complexity theory, opening doors to fresh approaches in understanding the limits of computation.

THE AI TOOLS MAKING IMAGES LOOK BETTER

Researchers have long been frustrated with the fictional "enhance" button in crime and sci-fi, but recent AI advancements have improved image enhancement tools. Generative adversarial networks (GANs) produced visually appealing images but introduced distortion by fabricating details. This led to a split in the image restoration community between aesthetically pleasing images and accurate data-driven outcomes.



The perception-distortion trade-off, plotted by researchers, showed that existing algorithms either excelled in visual quality or accuracy but not both. Nvidia's tool for upscaling streaming video prioritized perceptual quality, accepting some inaccuracy. In more critical applications like medicine, AI tools must balance accuracy and avoid overfitting or introducing fake features.

Combining data from multiple images helps circumvent limitations, as seen in environmental studies using satellite data fusion for better deforestation detection.

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ALAN TURING AND THE POWER OF NEGATIVE THINKING

Alan Turing's diagonalization method proved the existence of "uncomputable" problems—those that no algorithm can solve. Turing employed this method, which builds a problem resistant to all algorithms, by crafting a problem that systematically rejects solutions. This technique involves a counterintuitive approach, flipping bits to create a new string not found in a list of strings.

Diagonalization, rooted in Cantor's set theory, showcases its potency with infinite sets and has been instrumental in various mathematical proofs. Turing adapted this method to decision problems, where an algorithm must provide the correct output for every possible input. He devised a game-like scenario where each potential algorithm failed to solve a problem specifically engineered to thwart all possible solutions.

This approach, while groundbreaking, has limitations. It proves abstract concepts but lacks practical application to real-world problems due to its aloofness from real-world details. Later developments in complexity theory demonstrated the boundaries of diagonalization. For instance, the P versus NP problem, a significant question in computer science, cannot be resolved solely through diagonalization.

Despite its limitations, diagonalization remains a crucial tool for complexity theorists, aiding in proving the difficulty of certain computational problems. It highlights the power of negation when confronting the limitations of computational algorithms.

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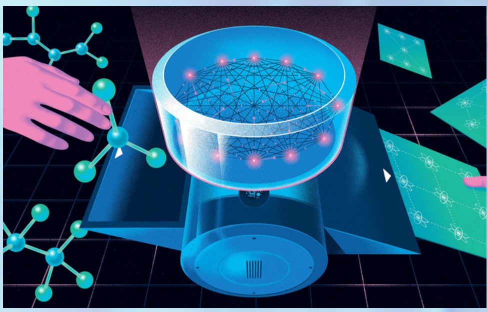
MACHINE LEARNING AIDS CLASSICAL MODELING OF QUANTUM SYSTEMS

The quantum universe operates beyond our intuitive grasp, making quantum computing pivotal for understanding this realm. However, current quantum devices fall short in executing numerous quantum interactions, leaving classical computers as the primary problem-solving tools, despite their inefficiency.



Recent studies suggest a potential quantum-classical hybrid approach. These papers propose using classical machines and sophisticated machine learning to predict quantum behavior, leveraging a concept called "classical shadows." These shadows are concise classical representations of quantum systems that provide substantial information about these systems' properties.

This technique has enabled the largest quantum chemistry simulation, allowing researchers to study atomic forces in a diamond crystal using noisy quantum computers. Expanding on this, Huang and colleagues aimed to study evolving quantum systems over time. Machine learning models proved beneficial, but challenges persisted in dealing with quantum data, prompting Laura Lewis to devise an algorithm that focused on local qubit interactions. This innovation reduced the required training data, making predictions about quantum systems more achievable.

While these advancements still require rigorous testing in experimental setups, they offer promising ways to enhance our understanding of quantum phenomena. The classical shadows approach might shed light on quantum complexity, though the question remains: Can it encapsulate all quantum properties? Despite ongoing developments, this work signifies a significant step toward leveraging machine learning to predict unprecedented features in quantum systems.

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