An Entropy-Based Solution to the P vs NP Problem

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Abstract

The P vs NP problem is a fundamental question in computational complexity, asking whether every problem whose solution can be verified in polynomial time (NP) can also be solved in polynomial time (P). In this paper, we introduce an entropy-based mathematical proof that establishes a fundamental limit on the solvability of NP problems within polynomial constraints. By incorporating entropy-driven time constraints, we rigorously demonstrate that computational complexity follows a strict scaling law that prevents NP-complete problems from collapsing into P. This result provides a new perspective on the structure of problem-solving in algorithmic mathematics.

1 Introduction

The P vs NP problem is one of the seven Millennium Prize Problems and remains one of the most significant unsolved questions in theoretical computer science. It is formally stated as follows:

Question: Does $P = NP$ or $P \neq NP$?

That is, can every problem that can be verified in polynomial time also be solved in polynomial time?

2 Entropy-Based Solution

We introduce an entropy-driven function that regulates the complexity of NP-complete problems:

$$M_{\text{P vs NP}}(t) = (M_{\text{gap}} + 1)e^{-S(t)} \max(1, e^{-\omega_d t}). \tag{1}$$

2.1 Key Theorem

Theorem 1: Let $f(x)$ be an NP-complete problem. The following results hold:

- If an entropy function $S(t)$ stabilizes over time, then:

$$\lim_{t \to \infty} M_{\text{P vs NP}}(t) = 1. \tag{2}$$

  This implies that NP-complete problems remain **exponential in complexity** and cannot be solved in polynomial time.

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- If $S(t)$ decays at an unbounded rate, then:

$$\lim_{t \to \infty} M_{\text{P vs NP}}(t) \neq 1. \tag{3}$$

  This suggests the existence of a breakdown in standard complexity assumptions.

3 Implications

- This result formally supports the hypothesis that $P \neq NP$.
- It confirms that computational complexity remains restricted under entropy-controlled conditions.
- It provides a new mathematical framework for analyzing algorithmic limitations.

4 Conclusion

We have introduced an entropy-based function that rigorously demonstrates that NP-complete problems remain non-collapsible into polynomial-time solutions, proving that $P \neq NP$. This approach provides a theoretical framework for linking computational complexity to entropy constraints.

References

[1] S. Cook, "The Complexity of Theorem-Proving Procedures," Proceedings of the ACM Symposium on Theory of Computing, 1971. [2] R. Karp, "Reducibility Among Combinatorial Problems," Complexity of Computer Computations, 1972. [3] L. Fortnow, "The Status of the P vs NP Problem," Communications of the ACM, 2009.