

Solutions to Midterm 2

1. Prove or disprove:

- (a) Let M be a deterministic Turing machine that, on inputs of length n , uses space $O(n^2)$. Then for every input x , and every configuration C of the computation of M on input x , $K(C) \leq O(|x|)$ where K is Kolmogorov complexity and $|x|$ is the length of x .
- (b) Let M be a deterministic Turing machine that, on inputs of length n , uses space $O(n^2)$ and time $O(n^3)$. Then for every input x , and every configuration C of the computation of M on input x , $K(C) \leq O(|x|)$ where K is Kolmogorov complexity and $|x|$ is the length of x .

[30 points]

SOLUTION OUTLINE:

- (a) The statement is false. Consider a machine M which simply looks at the length n of the input and then enumerates all possible strings of length n^2 on its tape. Since there is a string C of length n^2 such that $K(C) \geq O(n)$, we get a contradiction.
- (b) This statement is true. Any configuration C of the machine can be described by specifying the code of the machine, the input and the time at which the configuration occurs. Since the code of the machine is a constant, the time can be specified in $O(\log |x|^3) = O(\log x)$ bits and the input is $|x|$ bits, this gives $K(C) \leq O(|x|)$.

2. We define #SAT to be the language

$$\#SAT = \{(\varphi, k) \mid \varphi \text{ has exactly } k \text{ satisfying assignments}\}$$

Show that:

- (a) #SAT is coNP hard (recall that $\text{coNP} = \{L \mid \bar{L} \in \text{NP}\}$).
- (b) #SAT \in PSPACE.

[40 points]

SOLUTION OUTLINE:

- (a) To show #SAT is coNP hard, note that $\varphi \in \overline{\text{SAT}} \Leftrightarrow (\varphi, 0) \in \#SAT$ as $\overline{\text{SAT}}$ is the set of all the formulae which are unsatisfiable i.e. have exactly 0 satisfying assignments. This shows that $\overline{\text{SAT}} \leq_p \#SAT$ which proves the claim.
- (b) We enumerate all possible assignments to the variables and for each assignment, we can check if it satisfies the formula. We also keep a count of the satisfying assignments. Since it takes n bits to store an assignment, n bits to store the counter (as there can be at most 2^n satisfying assignments), polynomial space to check if a given assignment satisfies the formula, the algorithm uses polynomial space overall.

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Machine Learning Ryszard Stanisław Michalski, Jaime G. Carbonell, Tom M. Mitchell, 1983 **Stanford Bulletin** ,2003
Scientific and Technical Aerospace Reports ,1968 **Journal on Data Semantics VIII** Stefano Spaccapietra, Paolo Atzeni, Francois Fages, Mohand-Said Hacid, Michael Kifer, John Mylopoulos, Barbara Pernici, Pavel Shvaiko, Ilya Zaihrayeu, 2007-01-22 The LNCS Journal on Data Semantics is devoted to the presentation of notable work that in one way or another addresses research and development on issues related to data semantics The scope of the journal ranges from theories supporting the formal definition of semantic content to innovative domain specific applications of semantic knowledge *United States Air Force Academy* United States Air Force Academy, 1968 **Nuclear Science Abstracts** ,1973 *Bookseller and the Stationery Trades' Journal* ,1915 **The Bookseller** ,1892 **The English Catalogue of Books for ..** ,1880 *Reference Catalogue of Current Literature* ,1906 The Publisher ,1911 The Publishers' Circular and Booksellers' Record ,1911 *British Books* ,1911 **The Publishers Weekly** ,1911 *Mathematical Reviews* ,1998
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Table of Contents Midterm 2 Stanford Cs Theory

1. Understanding the eBook Midterm 2 Stanford Cs Theory
 - The Rise of Digital Reading Midterm 2 Stanford Cs Theory
 - Advantages of eBooks Over Traditional Books
2. Identifying Midterm 2 Stanford Cs Theory
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Midterm 2 Stanford Cs Theory
 - User-Friendly Interface
4. Exploring eBook Recommendations from Midterm 2 Stanford Cs Theory
 - Personalized Recommendations
 - Midterm 2 Stanford Cs Theory User Reviews and Ratings
 - Midterm 2 Stanford Cs Theory and Bestseller Lists
5. Accessing Midterm 2 Stanford Cs Theory Free and Paid eBooks
 - Midterm 2 Stanford Cs Theory Public Domain eBooks

- Midterm 2 Stanford Cs Theory eBook Subscription Services
- Midterm 2 Stanford Cs Theory Budget-Friendly Options
- 6. Navigating Midterm 2 Stanford Cs Theory eBook Formats
 - ePub, PDF, MOBI, and More
 - Midterm 2 Stanford Cs Theory Compatibility with Devices
 - Midterm 2 Stanford Cs Theory Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Midterm 2 Stanford Cs Theory
 - Highlighting and Note-Taking Midterm 2 Stanford Cs Theory
 - Interactive Elements Midterm 2 Stanford Cs Theory
- 8. Staying Engaged with Midterm 2 Stanford Cs Theory
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Midterm 2 Stanford Cs Theory
- 9. Balancing eBooks and Physical Books Midterm 2 Stanford Cs Theory
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Midterm 2 Stanford Cs Theory
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Midterm 2 Stanford Cs Theory
 - Setting Reading Goals Midterm 2 Stanford Cs Theory
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Midterm 2 Stanford Cs Theory
 - Fact-Checking eBook Content of Midterm 2 Stanford Cs Theory
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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