

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.

Midterm 2 Stanford Cs Theory

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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** ,1973-12 **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 *Government Reports Announcements* ,1974-11 *Mathematical Reviews* ,1998 **Government Reports Announcements & Index** ,1985
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