SymSys 100 Due: June 9, 2009, 10:00 P.M.

Take-Home Final Examination

General instructions

Answer each of the questions given below. Each of the essay questions includes a word limit, and you will be penalized for going over that number of words. Please use a word processor to enter your answers, and format your exam so that the answer to each of the six questions begins on a new page. Submit your exam by electronic mail to

symsys100-final-exam@cs.stanford.edu

Exams must be submitted by 10:00 P.M. on Tuesday, June 9.

This exam is open-book/open-notes/open-web and you are encouraged to use materials in your answers. It is, however, an exam, and you are expected to work **individually** and not consult with others.

1. Bayes' rule [short answers + 300-word essay]

Consider the following situation:

> A test for bloxtoma, a condition that can be cured by surgery, gives a positive result in 90% of patients with the condition. The test has a false positive rate of 10%—i.e., in 10% of persons who do not have the condition, the test gives a positive result. Epidemiologists have determined that only 1 person in 1000 actually has bloxtoma.

a) What is the probability that a person with a positive test result actually has bloxtoma?

b) Describe the kind of error participants often make in answering questions of this type, and discuss the explanation for this offered by Gigerenzer and colleagues.

c) Restate the problem in a way that, according to Gigerenzer *et al*., would result in improved performance.

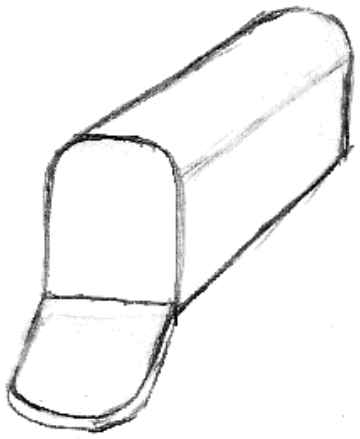
d) In 300 words, discuss how the finding that people do better in answering the reformulated version of the question bears on the question of whether people are rational, drawing on your own views as well as those presented in lectures and readings.

2. Neural stimulus and Bayesian inference [500 words total]

a) Explain how a neuron could perform Bayesian inference. Discuss what corresponds to the hypothesis, the prior, the likelihood, and the evidence.

b) Consider the ambiguous stimulus pictured at the right. Drawing on the interactive activation model of letter perception, discuss how this stimulus might be perceived as a mailbox if placed appropriately in an outdoor scene or as a loaf of bread with a slice cut from one end if placed on a kitchen countertop.

c) Finally describe how the role of context might be incorporated into a Bayesian model of the process of determining whether the pictured stimulus is a cut loaf or bread or an open mailbox.



Use no more that 500 words total. You may include a diagram if you wish in addition to the text of your answer.

3. Rules and language [300 word maximum]

The concept of "rule" has played an important role in linguistics. In the 1960s, the psycholinguist Jean Berko did an experiment that convinced many people that rules are psychologically real. She showed children the following picture, and told them "This is a wug":

Then she showed them the picture below, and said, "Now there is another one. There are two of them. There are two ___"

The children consistently answered, "wugs". Berko took this to show that the children had internalized a rule for forming regular plurals in English (basically, add –s).

a) The applicability of putative rules to novel forms is not limited to children, nor to artificially invented examples. Give two examples of rules applying to newly created expressions in English, using different rules for the two examples. [Hint: Two ways of doing this are: (i) using words of recent coinage (such as those denoting new technologies) and show that they inflect like older words, and (ii) applying a syntactic rule to a sentence that you feel confident you have never encountered before.]

b) Compare the role of the concept of "rule" in the Chomsky/Pinker position on the innateness of language and in the connectionist alternative.

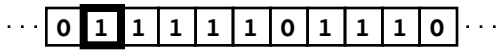
4. Linguistic relativity *vs*. universal grammars [500 word maximum]

In *Word and Object,* Quine argues for a thesis he calls "the indeterminacy of translation." He imagines a field linguist, "unaided by an interpreter, [who] is out to penetrate and translate a language hitherto unknown. . . . A rabbit scurries by, the native says, 'Gavagai' and the linguist notes down the sentence 'Rabbit' (or 'Lo, a rabbit') as a tentative translation, subject to testing in further cases." Quine then goes on for over 20 pages about ways in which the linguist's interpretation could be mistaken (with a digression about color words, which he says "are notoriously ill matched between remote languages"). "Who knows," he writes, "but what the objects to which this term ['gavagai'] applies are not rabbits after all, but mere stages, or brief temporal segments, of rabbits?...Or perhaps the objects to which 'gavagai' applies are all and sundry undetached parts of rabbits." He concludes that, "The native may achieve the same net effects through linguistic structures so different that any eventual construing of our devices in the native language and vice versa can prove unnatural and largely arbitrary."

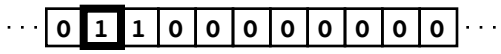
Discuss the relationships between Quine's claims as sketched above and (i) Sapir & Whorf's hypothesis of linguistic relativity; and (ii) Chomsky's notion of "Universal Grammar."

5. Turing machines

Implement a Turing machine M_{sub} that takes two integers on its input tape separated by a single **0** and subtracts the second from the first. For example, if the input tape is



executing M_{sub} should finish with the output



because 5 – 3 is 2. If the second number is larger than the first, M_{sub} should end with blank tape to indicate the value 0, because our representation for numbers on a Turing machine tape has no way to represent negative numbers.

In implementing this program, you should keep the following points in mind:

- You may assume that the input is valid. In other words, you may assume that the initial tape contains two sequences of consecutive **1**s with exactly one **0** between them. To reduce the number of special cases, you may also assume that neither of the input values is 0.
- You may assume that the tape head is initially positioned over the leftmost **1** in the first input value.
- Your program must end up with the tape head over the first **1** in the result (unless the result is 0, in which the tape head can be anywhere on blank tape).
- A correct Turing machine program is sufficient for full credit, but comments about what you are trying to do with your machine will be extremely helpful in terms of assigning partial credit on this problem.

6. The Coming Superbrain [500 word maximum]

In the "Week in Review" section of *The New York Times* from May 24, John Markoff published an essay entitled "The Coming Superbrain," which you can download from **http://www.nytimes.com/2009/05/24/weekinreview/24markoff.html**. In his essay, Markoff talks about how views of increasing machine intelligence have generated wildly diverging views about the future of such technologies, citing the positions of both Kurzweil and Joy, which you know about from the readings for this course.

Markoff's essay expresses the poles of the debate by citing two literary sources:

> There is a hot debate here over whether such machines might be the "machines of loving grace," of the Richard Brautigan poem, or something far darker, of the "Terminator" ilk.

Most of you are presumably familiar with the *Terminator* series, but Brautigan's poem is likely to be less familiar. If you're interested, you can find the poem to which Markoff refers at **http://www.brautigan.net/machines.html#28**.

Literary sources are wonderful in terms of the expansiveness of their vision, but predictions about the future are often easier to make if they are grounded in short-term extrapolations from the present day. In an essay not to exceed 500 words, discuss two specific examples from current technology, one that supports Kurzweil's utopian vision of a post-Singularity future and one that supports Joy's more dystopian view. In your essay, you should offer enough background so that your readers will understand the example and then defend why that example supports one side or the other in this debate.