SYST 664 / CSI 674: Homework Assignment 1

due January 29, 2018

Homework is due at class time on the date indicated. You may submit on paper or electronically via Blackboard. Please make sure your name is on every page of the assignment, and it is clearly marked which question you are answering. Your response will be graded for correctness and clarity.

1. Assume that the sensitivity and specificity of a routine screening polygraph are about 80% and 85%, respectively. That is, the probability that the polygraph report will indicate a concern[1] is about 80% if the individual has committed a security violation, and the probability that the exam will not indicate a concern is about 85% if the individual has not committed a security violation.
    a. Assume that about 1 individual in 1000 in a given organization has committed a security violation. What is the posterior probability that an individual whose polygraph report indicates a concern has committed a security violation? Comment on the implications of these results for the use of routine screening polygraphs for individuals working in positions requiring security clearances.
    b. Suppose an item has been stolen. Investigators have concluded that it was an inside job. A suspect has been identified and is given a polygraph exam. The polygraph report indicates a concern on the topic of the theft. Assume the same sensitivity and specificity of the polygraph as in problem 1, but assume a prior probability of 25% that the individual stole the item. What is the posterior probability that this individual committed the theft? Explain the difference between this result and Part a.

2. Consider a situation in which an individual may have committed some kind of crime or security violation. Suppose the organization must decide whether to administer some kind of sanction (arrest; remove security clearance; reprimand). Suppose we can obtain evidence that has 80% sensitivity and 85% specificity. Find the policy that minimizes expected loss. In problems such as this, it is more natural to think in terms of losses than utilities. Assume the following losses:
    - Do not administer sanction; individual is innocent   loss = 0
    - Administer sanction; individual is guilty   loss = 1
    - Administer sanction; individual is innocent   loss = 10
    - Do not administer sanction; individual is guilty   loss = 100

    For the decision of whether to administer sanctions to an individual who may have considered a security violation as described in Problem 3, find the range of prior probabilities for which considering the evidence results in lower expected loss than ignoring or not collecting the evidence. Discuss your results.

3. Experimenters performed a study in which a polygraph was administered to subjects in a simulated theft scenario. Before being polygraphed, subjects waited in a room where $50 was left on a table in open view. Some subjects were instructed to take the money, while others were asked to leave it there. Both groups were asked to tell the polygrapher that they did not take the money, and were given a monetary reward if the polygrapher believed them. Assume the polygraph sensitivity Θ has 20 equally spaced possible values ranging from 0.025 to 0.975. Assume that polygraph results for people who took the $50 are independent and identically distributed, with probability Θ of the polygraph showing a concern. Assume that all 20 values of Θ are equally likely *a priori*. Suppose the polygrapher found a concern for 12 of the 15 subjects who took the $50. Use R to make a bar plot of the posterior distribution for Θ given the results of the study.

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[1] Polygraphers prefer not to say a person "passes" or "fails" a polygraph, preferring to say there is an issue or concern.