Experimental Methods in Computer Science

2020/2021

Exercises on Hypothesis Testing

1) Your company (a big multinational company) is installing a big data centre to sell cloud services all over the world. The data centre includes more than one hundred servers and has thousands of processors and tens of thousands of cores. The memory size needed is huge, including the main memory of the servers and memory to install state solid discs (SSD) in each node. In order to reduce the cost of memory, the company has decided to use the same memory board (a 4 GByte DRAM board) for both the main memory and for the SSDs, having ordered many thousands of memory modules.

Currently, the increased scale and the constant reduction of the size of the bit cells of dynamic memory (DRAM) chips are causing manufacturing failures that are very difficult to detect by the quality control. The most noticeable example is the data-dependent retention failures that consist of memory cells that may show errors due problems in the manufacturing process. The quality tests at the end of the manufacturing lines do not guarantee that the chips are 100% free of this problem, as the time needed to test each chip with all the data pattern combinations would be months (or more). The memory manufacturers estimate by sampling the maximum number of bit cells susceptible to data-dependent retention failures in each Gbit. For the case of the chips your company has ordered, the manufacturer states average of 23 bit cells susceptible to data-dependent retention failures in each Gbit, with standard deviation of 7.53.

Considering the huge amount of memory ordered, your company decided to test exhaustively a sample of 36 modules. After several months of test, the results were the following: An average of 26 bit cells susceptible to data-dependent retention failures in each Gbit.

Based on these results, do you think your company should accept the memory modules ordered or not, considering a significance level of 0.05? Your answer should indicate the hypothesis you are testing and should explain all steps to reach your conclusion.

2) Assume that you have obtained a new navigation system. The time to find a valid GPS signal follows an unknown normal distribution with a mean of 10 seconds. In order to validate this information, you performed 9 time measurement in randomly chosen places. You have obtained a mean of 10.5 seconds and a standard deviation of 5 seconds. Would you trust on the results given by the GPS company at a significance level of 0.05?

3) A large software house established in the market of computer games wants to study in depth the reward/frustration mechanisms involved in playing computer games, in order to optimize the games to increase the motivation to play. The idea is to study the brain activity in the moments when a player makes a mistake or wins a game using a fMRI (functional magnetic resonance imaging), as the neurologists know that certain brain regions are associated to the feeling of frustration or pleasure (reward). By measuring the activity of such brain regions, it is possible identify the steps of

a computer game that produce more frustration/reward in the player. In order to achieve that the player must be inside a fMRI machine while playing the game. Knowing that the space inside the fMRI is very tight and the environment is rather artificial, the company is afraid that the fact that the player is inside the fMRI may change the conditions and lead to erroneous results. For example, it may cause the player to make more mistakes and lose the game more often. For that reason, the company has decided to perform a preliminary experiment to verify whether the fact that the player is playing the game inside the fMRI machine affects the results or not.

The experiment consists of asking a group of players to play the game (only one game) in normal conditions (i.e., in a normal room) and count the number of mistakes made during 20 minutes of game play. A total of 13 players have participated and the number of mistakes made during the 20 minutes playing the game are the following: 23, 24, 22, 39, 19, 26, 29, 32, 25, 21, 33, 36, 34.

Considering the difficulties of making experiments inside the fMRI, the company could only execute the fMRI experiments with 7 players. These players also played the same game during 20 minutes, and the number of mistakes recorded is: 34, 30, 29, 41, 23, 43, 39.

Formalize the appropriate hypotheses, test the required assumptions and consider both parametric and non-parametric alternatives. Discuss the results obtained.