UTM

MS

Laboratory No.1

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1 Problem 1

1.1 At the hospital

The psychologist Tversky and his colleagues say that about four out of five people will answer (a) to the following question:

A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital 15 babies are born each day. Although the overall proportion of boys is about 50 percent, the actual proportion at either hospital may be more or less than 50 percent on any day. At the end of a year, which hospital will have the greater number of days on which more than 60 percent of the babies born were boys?

(a) the large hospital;

(b) the small hospital;

(c) neither, the number of days will be about the same.

Assume that the probability that a baby is a boy is .5 (actual estimates make this more like .513). Decide, by simulation, what the right answer is to the question. Can you suggest why so many people go wrong?

1.2 Solution

The function 'oneDayHosp(kids)' takes as a parameter the number of babies born in a hospital and returns 1 if the probability is higher than 60% in one day.

In a for loop we iterate over 365 days, and add the returned value of the function oneDayHosp to the 2 variables 'largeHdays' and 'smallHdays', which obviously are the number of days with a probability higher than 60% in the large hospital and respectively in the small hospital.

Then we compare the results, which gives us the answer (b) most of the time.

2 Problem 2

2.1 I bet my life on this one

Are you still in mood for gambling? Why don't we get more serious then! Let's roll old school and play some Russian roulette. Here's the deal. I have a revolver with a 6 slots barrel and only 2 bullets. Now I put the bullets into the revolver in adjacent slots, spin the barrel and hand you the gun. You point the gun to your head. You pull the trigger and . . . Click! you're still alive. Congratulations but the game is not over yet. You have to pull the trigger one last time. Now you have two choices.

1. You spin the barrel afterwards you pull the trigger.
2. You pull the trigger without spinning.

Luckily you also have a computer in front of you so you're allowed to simulate the current situation such that you can make a better decision.

Your task is to find the probability for both cases. After you've computed the probability for the initial conditions please also find out what are the probabilities in case the bullets are not adjacent.

After you're done with that, compute the same probabilities only when the gun has a 5 slots barrel and 2 bullets. At the end you have to present the result for 8 different outcomes. Good luck staying alive.

2.2 Solution

First of all, imagine the barrel as a circular array ex: [1,0,0,0,0,1]

1 - bullets, 0 - empty slots, here - adjacent bullets.

The function ‘findProcent’ computes for 1000 cases the probability of being dead after the second shot, then returns the probability of being alive
(P(A) = 1 - P(A))

This function is called 8 times with different arguments, for 6 or 5 slots in the barrel, where we can have adjacent or non-adjacent bullets and with option to spin or not.

3 Problem 3

3.1 Catch them all

Assume that every time you buy a box of Chio (a moldovan brand of chips), you receive one of the pictures of the n of the members of the NOROC band. Over a period of time, you buy m $\geq$ n boxes of Chio. Write a computer program to compute the probability that you get all n members of NOROC. Use this program to find, for given n, the smallest value of m which will give probability $\geq$ .5 of getting all n pictures. Consider n = 50, 100, and 150 and show that
m = n log n + n log 2 is a good estimate for the number of boxes needed.

3.2 Solution

For any input n - number of members in Noroc band, we find the minimum 'm', m $\geq$ n, m - number of chips Chio whith 1 photo of 1 member from n members. For this, we compute for 1000 cases, with the help of the function getResult, which returns the number of boxes needed to find all photos (which is always for probability == 1, not bigger than 0.5, - disadvantage).

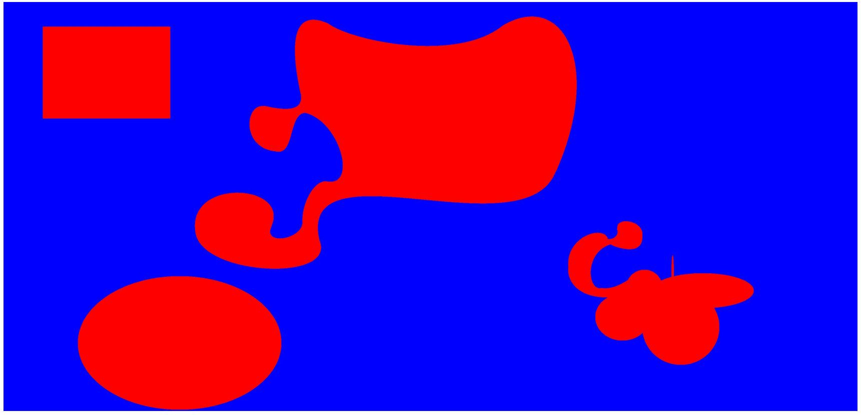
Then, we see that the number we found is almost the same as the estimated one.

4 Problem 4

4.1 Dangerous pixels

This morning CIA faxed UTM the following map scan. The total captured surface is around 42 square miles (duh . . . this imperial metric).
With red is marked the land that is mined by the guerrilla forces.
Now CIA needs to evaluate the logistics required to defuse the deadly mines.
But of course they do not have enough resources to compute the red area.
Which is why they are playing their trump card - the brilliant engineers from FAF-161.

The stakes are very high, and lots of innocent lives can be spared. So please compute the mined area a.s.a.p., using Monte Carlo method.



4.2 Solution

For this problem, I used the pillows library as sugested.

To compute the mined area, we take a a random tuple (x, y) which is a coordinate, and check if the pixel at that coordinate is red, adding 1 to areaRed if True.

It is done for 100k cases, and the returned value is the area of the dangerous zone.

The red area is 10-11 miles.

5 Problem 5

5.1 Let's get serious and crack something

This exercise aims to introduce you to very basic concept of hashing algorithms, how they work, why are they useful and what are their weaknesses.
And along the way you'll pick up the principle behind the flaw of hashing functions.

Now you're face to face with md5 hashing algorithm. Your task ahead is to find collisions for this algorithm, (only for the first 40 bits of the hash, aka first 10 hex characters). For that purpose you're going to use birthday attack, that is based on birthday paradox.

You have to write a small program that would eventually find a collision for the first 40 bits generated generated by md5 algorithm.

5.2 Solution

The concept behind this problem is really simple, but to obtain a valid result is a pain in the ass.

In this program we have to find a collision for the first 40 bits of the hashes of 2 different inputs.

I chose the uuid4 function, because it gives unique random strings.
So, when the first 10 hex characters collide (are equal) then it is a collision.

The problem is that it takes a long period of time.
For the first 8 hex chars it takes 10-30 min, while for the first 10, it takes longer than 3-4 hours.