qis-midterm

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build passing

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Specification

Hi all, Next week please complete the following coding project in python, due at the end of Friday by email. Simulate the output of a CHSH Bell test, with tunable angles. That is:

- Start with a 2-qubit Bell state: |Phi^+> = (|00> + |11>)/sqrt(2)
- Have the first qubit measure a tunable observable O(theta1) with eigenstate |theta1> = cos(theta1/2)|0> + sin(theta1/2)|1> corresponding to eigenvalue +1, and eigenstate |theta1p> = -sin(theta1/2)|0> + cos(theta1/2)|1> corresponding to the eigenvalue -1.

- Have the second qubit measure a similar observable O(theta2). However, rather than computing the expectation values directly, generate the observed random data. (See next bullet.)

- Done properly, each single measurement should return only two observed eigenvalues as a tuple, e.g., (+1,+1), such that a large number of random samples converges to the correct statistics predicted by the state. You will need to compute the correct probabilities from the state for each observation, so that you may randomly sample from the correct probability distribution. [An easy way to do this is to sample a random float from the interval [0,1] and compare that float to the outcome probabilities. i.e., if that random float is less than P(-1,-1) then return (-1,-1), else if that random float is less than P(-1,-1)+P(-1,+1) then return (-1,+1), else if that random float is less than P(-1,-1)+P(-1,+1)+P(+1,-1) then return (+1,-1), otherwise return (+1,+1).]

- Verify the correctness of your measurement implementation by generating a large set of measured data and showing that its average approximates the correct analytic expectation value of the product observable O(theta1)O(theta2).

- Generate data for the CHSH correlator. That is, generate data for 4 separate ensembles corresponding to the observable pairs A=O(0)O(pi/4), B=O(0)O(-pi/4), C=O(pi/2)O(pi/4), D=O(pi/2)O(-pi/4). Each ensemble of data should just be collections of random +1 and -1 values that were observed on each trial. Show that averaging the data for each observable separately produces seemingly reasonable results, but when those averages are added together according to the CHSH prescription (with one relative negative sign) then the total sum exceeds the classically expected bound of 2 and converges to the quantum upper bound of 2sqrt(2).

- Plot the result of the simulated correlator as a function of an added tunable angle phi for only the second qubit observable, such that the usual CHSH observables correspond to phi = 0. That is: A(phi)=O(0)O(pi/4+phi), B(phi)=O(0)O(-pi/4+phi), C(phi)=O(pi/2)O(pi/4+phi), D(phi)=O(pi/2)O(-pi/4+phi).

- Compare your simulated results to what is expected from an analytical calculation of the correlator as a function of phi. Range from phi=0 to phi=2pi in increments of pi/16.

You should turn in 1 python module (.py file) with your implementation, and 1 Jupyter notebook (.ipynb file) that demonstrates your working implementation and shows supporting plots.

Honor Pledge

I pledge that all the work in this repository is my own with only the following exceptions:

- Content of starter files supplied by the instructor;
- Code borrowed from another source, documented with correct attribution in the code and summarized here.

Signed,

Michael Seaman