Quantum Computing

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HW 5: Model Inference

- This homework does NOT have sample code
- Write a program for handwritten digit dataset
- Output a file with predictions for each data instance
- You are free to use any model or data to train your model offline
- We will only do model inference during the test
- Two scripts are mandatory:
  - compile.sh
  - run.sh <test_dataset> <output_file>

HW 5: Model Inference

- The testing dataset is a variation of mnist.t (added gaussian noise)
- We will have 10 cases where we vary the level of noises
  - N(0,0), N(0,1), N(0,2), ... N(0,9)
  - N(0,0) corresponds to no noises, i.e., plain mnist.t
- Each test case contains 10k instances.
- A test case is considered correct if the test accuracy is no less than 50%

HW 5: Model Inference

- No 3rd party code is allowed.
- 10 test cases. Each case weights 1 pt.
- The compilation is considered failed if it does not finish in 5 minute.
- A test case is considered incorrect if it does not finish in 2 minutes.
- Correct GPU solutions will get 5 pts bonus.
- The summation of the execution time across 10 cases will be used to rank correct solutions.

- Due: 11/30/2022 1:00 pm EST

Testing Environment

- ssh yourusername@granger.cs.rit.edu
- Intel(R) Xeon(R) CPU E5-2650 v4 @ 2.20GHz
- 48 threads in total (2 sockets, 12 cores per socket, 2 threads per core)
- 251 GB memory
- GPU: Tesla P4

- Testing limit:
  - 8 threads — taskset -c
  - 2 GPU

Quantum Gates

- Not
- Hadamard
- Controlled Not

- No Cloning
- No Forgetting

- Entangling

Deutsch–Jozsa algorithm

$$\frac{1}{2}(|0\rangle + |1\rangle)(|0\rangle - |1\rangle)$$

f that maps $|x\rangle|y\rangle$ to $|x\rangle|f(x) \oplus y\rangle$

$$\frac{1}{2}(|0\rangle(|f(0) \oplus 0\rangle - |f(0) \oplus 1\rangle) + |1\rangle(|f(1) \oplus 0\rangle - |f(1) \oplus 1\rangle))$$
$$= \frac{1}{2}((-1)^{f(0)}|0\rangle(|0\rangle - |1\rangle) + (-1)^{f(1)}|1\rangle(|0\rangle - |1\rangle))$$
$$= (-1)^{f(0)}\frac{1}{2}\left(|0\rangle + (-1)^{f(0)\oplus f(1)}|1\rangle\right)(|0\rangle - |1\rangle).$$

$$\frac{1}{\sqrt{2}}(|0\rangle + (-1)^{f(0)\oplus f(1)}|1\rangle)$$

$$\frac{1}{2}(|0\rangle + |1\rangle + (-1)^{f(0)\oplus f(1)}|0\rangle - (-1)^{f(0)\oplus f(1)}|1\rangle)$$
$$= \frac{1}{2}((1 + (-1)^{f(0)\oplus f(1)})|0\rangle + (1 - (-1)^{f(0)\oplus f(1)})|1\rangle)$$

CHSH Game

- John Clauser, Michael Horne, Abner Shimony, and Richard Holt in 1969
- C: Random generate x, y
- A gets x and generates a
- B gets y and generates b
- A and B wins if $x * y = a + b$

Shor's Algorithm

1. Pick a random number $1 < a < N$.
2. Compute $K = \gcd(a, N)$, the greatest common divisor of a and N. This may be done using the Euclidean algorithm.
3. If $K \neq 1$, then K is a nontrivial factor of N, so we are done.
4. Otherwise, use the quantum period-finding subroutine (below) to find r, which denotes the period of the following function:

   $$f(x) = a^x \bmod N.$$

   Equivalently, r is the smallest positive integer that satisfies $a^r \equiv 1 \bmod N$.
5. If r is odd, then go back to step 1.
6. If $a^{r/2} = -1 \bmod N$, then go back to step 1.
7. Otherwise, both $\gcd(a^{r/2} + 1, N)$ or $\gcd(a^{r/2} - 1, N)$ are nontrivial factors of N, so we are done.

https://en.wikipedia.org/wiki/Shor%27s_algorithm