# Identifying Gamma Radiation Anomaly Signals Using Quantum Computation Methods

By Joshua Foate in collaboration with Luis Valdez and Dr. Alamaniotis

CONNECT
UTSA • STMU • UNLV
CONsortium of Nuclear sECurity Technologies
In Collaboration w/
Los Alamos National Laboratory
Argonne National Laboratory

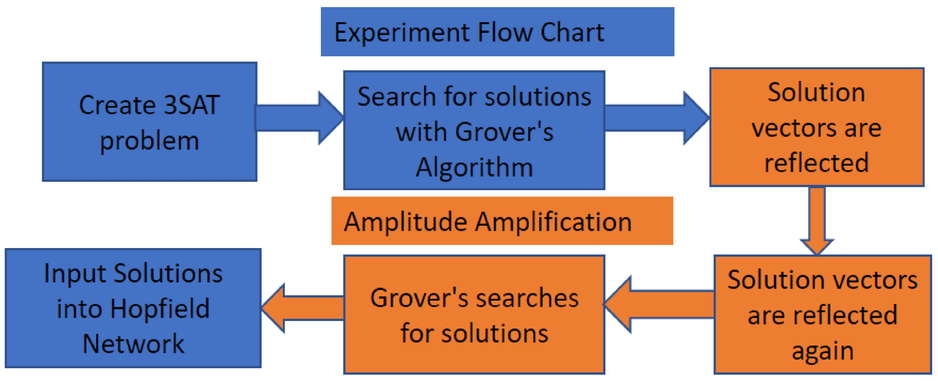

## Abstract:

- Collected data using a radiation detector to identify anomalies in the presence of naturally occurring radioactive material.
- Samples of the anomaly signals were put into a Hopfield neural network to train the network to identify whether data from the detector was an anomaly or background radiation.
- Converting our data into a 3SAT (3- Satisfiability) problem and use Grover's algorithm to find the solutions for Hopfield Artificial Neural Network memory.

$$f(v_1, v_2, v_3) = (\neg v_1 \vee \neg v_2 \vee \neg v_3) \wedge (v_1 \vee \neg v_2 \vee v_3) \wedge (v_1 \vee v_2 \vee \neg v_3) \wedge (v_1 \vee \neg v_2 \vee \neg v_3) \wedge (\neg v_1 \vee v_2 \vee v_3)$$

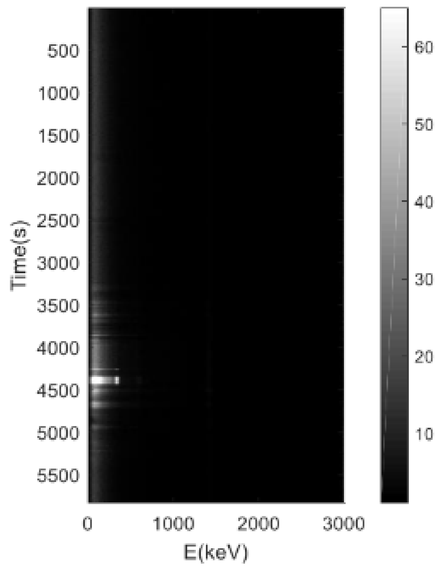

## Background:

- To simulate a quantum computer, we imported Qiskit libraries, which contained the functions and tools needed to use quantum algorithms.
- The tools we used include Grover's algorithm and a Hopfield Neural Network.
- The Hopfield neural network, created in MATLAB, is used to identify whether data from the radiation detector is an anomaly or background radiation.
- Grover's algorithm is a quantum algorithm used to speed up an unstructured search problem quadratically by amplifying the data that we are looking for so the probability of finding the solutions are higher.




## Experiment:

- Using the data from the radiation detector, we created a grayscale image using MATLAB.




- The white in the grayscale image represents the anomaly signals and the black is background data.
- Sample from this image were used to create the 3SAT problem, and Grover's algorithm is used to search for the solutions.

## Results:

- The accuracy at which the Hopfield neural network recognized anomaly signals and background data was used with the equations below.

$$Precision = \frac{tp}{tp + fp}$$

$$Recall = \frac{tp}{tp + fn}$$

$$F_1 = 2 * \frac{precision * recall}{precision + recall}$$

- 100% of the solutions from the 3SAT problem were tp (true positive).
- 40% of the non-solutions were fp (false positive).
- There were no fn (false negatives).
- The accuracy of the Hopfield neural network was calculated as 75%.

## Conclusion:

- Grover's algorithm sped up the search for solutions in our data set by turning the run time into O(√N), as opposed to O(N) (N being the number of items in a data set).
- Grover's algorithm outperforms classical search algorithms with an accuracy of 75%.
- Future work would be done by exploring ways to improve Grover's Algorithm for better accuracy.

## References:


- Team, T. Q. (2022, July 6). *Grover's algorithm*. qiskit.org. Retrieved July 21, 2022, from https://qiskit.org/textbook/ch-algorithms/grover.html
- Valdez, L., & Heifetz, A. (2021). Preliminary assessment of Qiskit Quantum Simulator capabilities for development of Quantum Hopfield neural network for Anomaly Detection Applications (Q4 report). https://doi.org/10.2172/1832153
- Ventura, D. (2000). Quantum associative memory. *Information Sciences*, *124*(1-4), 273–296. https://doi.org/10.1016/s0020-0255(99)00101-2