**Womanium Quantum + AI Climate Project**

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In this project we suggest a quantum-based method that aims to improve the accuracy of weather forecasting, specifically temperature forecasting –other possible weather variables are suggested as well.

It is a known fact today that temperatures are continuously rising. According to an [ongoing temperature analysis](https://data.giss.nasa.gov/gistemp/) led by scientists at NASA’s Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by at least 1.1° Celsius (1.9° Fahrenheit) since modern recordkeeping began in 1880.The past nine years alone have been the warmest years ever since. And it is expected that the global average temperature will reach or exceed 1.5° C (about 3° F) within the next few decades.

We are already witnessing the casualties of such an augmentation and the future consequences are assumed to be graver. Heat-related deaths, drought, widespread wildfires, endangered ecosystems are all now an organic part of our reality and they’re worsening every day. Safety protocols, economic plans and health schemes should remain up to date with these environmental changes to ensure their efficiency. And that’s where the necessity of having accurate and fast weather forecasting technologies arises, making even the smallest contributions in the field important. That is the primary motivation behind the pick of research topic for this project. An urge to make a change or inspire one that helps us take a step forward in preserving our lives and Earth.

Background research and literature reviews:

There is an ongoing effort in updating and developing existing methods and technologies as well as creating new ones that excel on different levels.

One of the most widely used one is numerical weather prediction (NWP) that proved to be rather effective despite having a high computational cost. Many machine learning and deep learning models are considered to be a great improvement in forecasting various weather variables like SVM and LSTM -typically useful for classification and regression problems- and artificial neural networks –for recognizing intricate patterns in data. Still, capturing complex relationships in data especially as the dimensional space increases and exploiting parallel processing capabilities efficiently are some of the weakness points of such approach that undergo constant improvement.

As quantum computing technologies continue to show promising results, scientists thought of incorporating the quantum advantage into their models. Some do this through quantum machine learning models/algorithms like QBoost, Quantum AutoReg, Model-B QNN…ect. While others focus on merging both classical and quantum methods creating hybrid models that benefit from their complementary capabilities to different extents. Managing decoherence time and the large number of qubits demanded for calculations remain to be challenges researchers strive to overcome.

Quantum Method Suggestion:

The suggested approach is inspired by the change of basis method, a well-known mathematical approach for solving complex problems by changing the standard perspective of presenting the problem into one that either makes it relatively easier to solve or takes it to another space where the solution to such problems is already established. The thought presented itself while comparing the classical Monte Carlo method and its quantum version.

While they’re both computational methods that depend on random sampling to solve complex problems, the types of the latter differ for each. Quantum Monte Carlo method with its many versions is considered a powerful computational tool in studying – many-body - quantum systems. Its main applications are simulations, modeling and predictions in quantum chemistry, condensed matter physics and nuclear physics.

The core of our suggestion is a Quantum Monte Carlo method called the Time-dependent Variational Monte Carlo (TDVMC) which uses time dependent trial wave functions that evolve according to the Schrödinger equation. It’s a highly accurate computational method when used with the right wave function, and it was proved to be so through many works like Casula et al. (2004) and Giorgini et al. (2008) where it accurately predicted ground state properties and energy levels in helium clusters and Bose-Einstein condensates.

Based on the findings mentioned above, we propose encoding temperatures data –precipitation is assumed to work too- as energy levels which means presenting them as qudits and then apply TDVMC, by choosing a fitting wave function according to the specific data used, to study the evolution of energy levels under the influence of the time-dependent constraints/interactions formulated trough the chosen wave function.

The TDVMC is applied to simulate the dynamic response of molecules to external fields and proved to be efficient in the study of nonequilibrium strongly correlated electron systems. We, therefore, suggest that it might be useful to study the relationship of temperature changes –or precipitation- and phenomena like drought and make better predictions about the latter as well. Further research could be to investigate the possibility of studying the interactions between many qudit systems presenting different weather variables.

References:

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