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REPLICATING THE BRAIN MOLECULAR AND SYNAPTIC STRUCTURE BY QUANTUM COMPUTING SIMULATION

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Abstract - *The Brain is the most fundamental and complex part of the living organism, which differentiates one organism to another organism & species. The consciousness is trapped by the organism's physical body. Replicating this consciousness in the digital platform is making the Brain immortal, and this can be achieved by making use of Quantum Computer. Quantum computer makes use of Quantum principles in order to make task possible with greater accuracy. In this paper we try to know how the Quantum Computer performs the Quantum Simulation on the brain's Quantum information (Molecular Structure) which is a combination of complex neuron synaptic connections.*

Key Words: **Quantum Computer, Entanglement, Brain, Simulation, Brain sequence, Synaptic connections, Qubits, Consciousness, Neurons**, etc

1. INTRODUCTION

1.1 Brain

We achieved significant landmarks in every field like unlocking the theories, how the universe work, and we even exploring the fields where we can't even see with our necked eye. But as the brains which made this possible, we still don't know it actually work.

The Brain is the most fundamental and complex part of the living organism which differentiates one organism to another & species. Each individual have their own consciousness & intelligence which is different from others (the way we think & implement). The consciousness & knowledge in brain is encoded in the structural and functional connection between Neurons. The Neurons are the basic synaptical connection structures that make the whole Brain functioning. There are 100 billion neurons in human brain and each neuron is connected to thousands of other neurons, which makes up 100s of trillions of synaptic connections. Each neuron state is dependent on other neuron state. The human brain keeps on changing, from the time we born the brain keeps on changing as we interact with the process of development and learning. The brain builds new neurons, and also shaping the neuron connections as we grow older. This make even more complex to study (scan) the brain.

But the organisms have a limited life period, one day all organisms die and their consciousness and intelligence decay with their brain. But is there any way to ensure accurate digital simulation of the Brain?

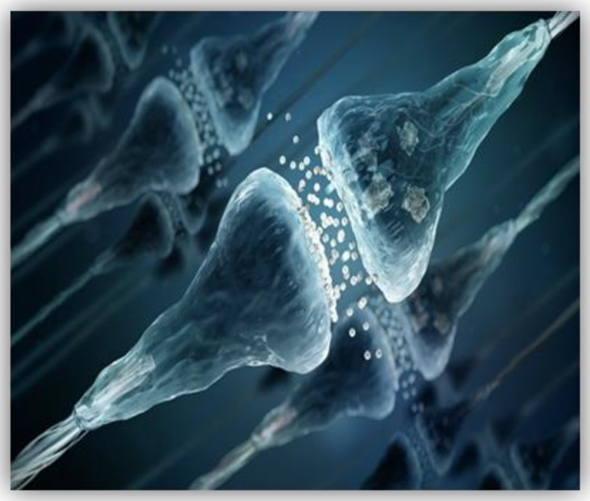

Fig 1: The Synaptic Connection of Neurons.

1.2 Quantum Computer

As the years goes by the computational power of computers increased exponentially and size of the computer (CPU) decreased in the order of nanometers (present 5 nm). The classical computer met the physical limitation, if the size of CPU is further reduced in the order of few atoms (less than 5 nm). Because as the size of the CPU further (transistor channel length) decreases the gate in transistor cannot hold the flow of current anymore, this property is called "Quantum tunneling".

The Quantum Computer is a result of using these quantum properties in our favor to improve the computational power. We make use of quantum properties such as "Quantum Superposition" and "Quantum Entanglement" in our favor to perform the computations. The classical computer uses the classical bits which either be 0 or 1, but in Quantum Computer, we use "Quantum bits" (Qubits) which can be 0 & 1 simultaneously but if we measure the value of qubit, it resides in one of the definite state.

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The "n" number of Qubits can exist in "2^n" possible combinations at a same time. Example: 3 qubits can exist in all of those eight (8) possible combinations simultaneously. Another interesting property of Quantum Computer is "Quantum Entanglement" which means the state of one qubit is dependent on another qubit (irrespective of distance between them), when we measure the state of one qubits we can determine the state of corresponding entangled qubit without even measuring it.

Unlike the logic gates we use Quantum gates in Quantum computer which takes the input of superposition qubits and manipulate it based on the gate probability, it produces a resultant output. The output we get is a superposition output but the instance we measure it, the superposition is collapsed and resides into one of the definite combination. These Quantum properties help us to map & simulate the quantum information of brain by Quantum Computer.

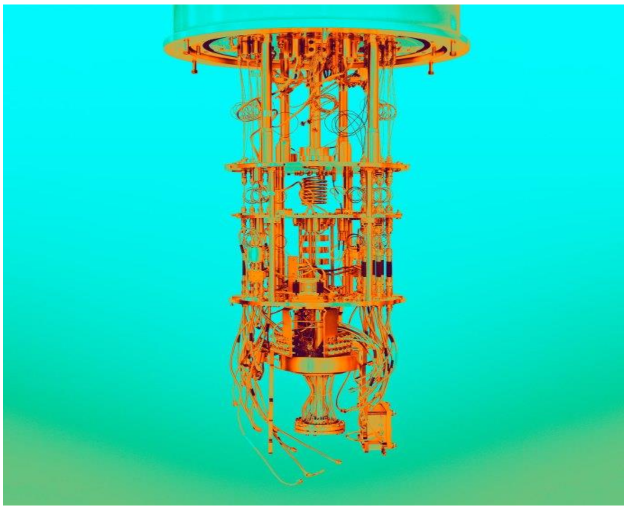

Fig 2: The Quantum Computer Photo by Justing Fantl

2. OVERVIEW

The replication of Brain actually refers to scan the synaptic connections between the Neurons (CONNECTOME) and transfers it to into a computer to run a simulation of consciousness. The main challenge that arises is scanning the brain in accurate detail and preciously recreating and simulating it in a digital world. The volume of the Neurons are huge at a range of 100 billion, and the connections between will be in range of 100s of trillion as mentioned earlier and all the connections between the Neurons are not same, to scan and map this huge volume and variety of data there will meet the huge scanning & computational challenge. By considering the current technology this is far away to reach.

The complete brain ever scanned is a brain of a worm with 302 Neurons and made a simulated brain into a robot. The Allen institute in Seattle, Washington in 2019, reconstructed a cubic millimeter of mouse brain, this is the largest scanning of brain (size of a single sand grain), consist of 100,000 neuron and over billion synaptic connections to scan it they made it into 25,000 slices with each 40 nm wide. Researchers took 100 million of images and 2 Petabyte of data. If this is very huge then image the human brain.

The scanning at Synaptic level of Brain are more and more complex but to get even more accurate consciousness simulation the scanning is not sufficient for synaptic level, instead we require scanning at a molecular level, we even have to map basic sub-building blocks like molecules and protein, which results even more data to replicate.

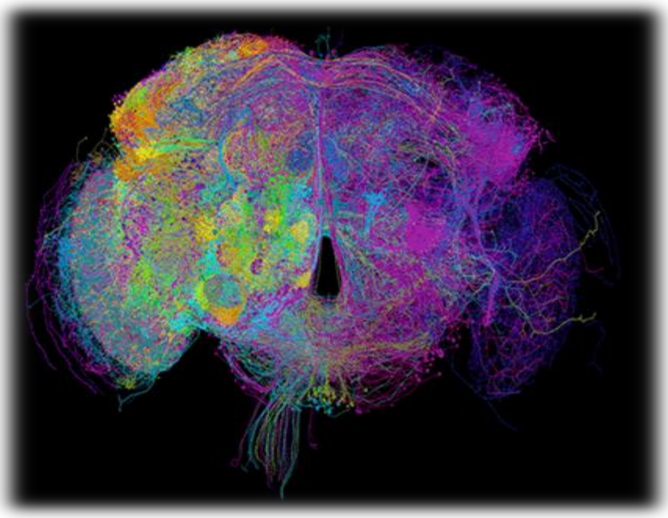

Fig 3: An adult fruit-fly brain in all its glory

Let us considering the molecular level of brain, at most fundamental level all the consciousness ultimately depends on molecular level within neurons. Every protein that responsible for fundamental functioning of neurons is governed by the interactions of 1000s of molecules.

In this level the main focus is done on cellular signaling (the process of cellular communication). The researchers focusing on cellular signaling in Dopamine 1 Receptor (D1R)-containing Medium Spiny Neurons (MSN), which are one of the cells types used to simulate the brain. The responses of these MSN are controlled by the protein called adenylyl cyclase type 5 (AC5), by scanning and mapping the structure of this protein we can simulate the corresponding neuron with greater accuracy. This molecular model helps us to simulate the brain in most desirable way because of the molecules in neurons are responsible for functioning of consciousness rather than neurons itself.

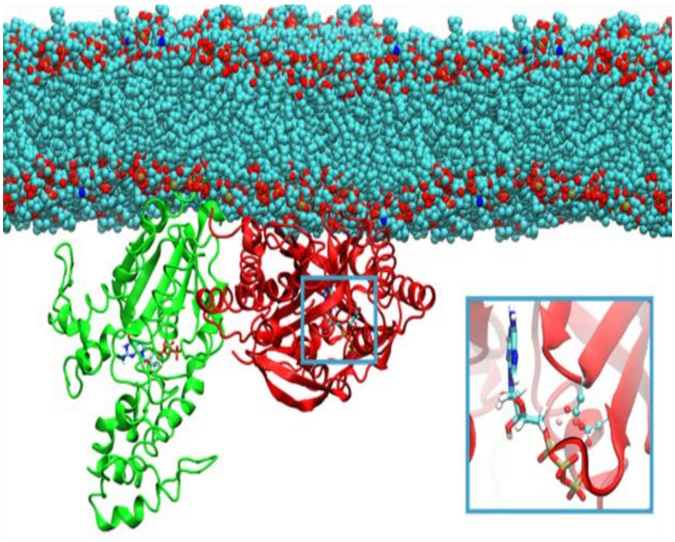

Fig 4: Protein interactions and dynamics in Neuronal signaling

3. QUANTUM COMPUTING SIMULATION OF BRAIN

To replicate the brain synaptic sequence, the quantum computer makes it a step further. Before mapping the connections we have to scan the synaptic sequence, but scanning the entire synaptic connections is an ideal approach but in practical approach we have make use of probabilistic approach, where we only scan the relevant parts of connections (with more probability) which makes up the major consciousness of the that individual.

After scanning, the role of Quantum Computer comes into the picture. We know that each neuron state is entangled with other neurons state, which means the state of each neuron is effected by the other (each neuron state is dependent on other), this is a Quantum Property called "Quantum entanglement". The Quantum computer works under the Quantum principles such as "Superposition" and "Entanglement" by these properties we can simulate the brain even more accurately.

By using entanglement property we measure only relevant neuron connection, and we can determine the state of other neurons which are entangled with it, and we can also determine the state of one connection simply by measuring the state of entangled synaptic connection. By this we can improve the computational complexity by some extent and gives the accurate output simulation. But in classical computer, the classical bits do not obey entanglement property, the classical bits are not entangled with other classical bits. But in Quantum computer this is a fundamental property, we can ensure that neurons states in simulation are entangled.

To replicate the brain with greater accuracy we perform molecular simulation with Quantum computer. We know that molecules are the Quantum particles which obey the Quantum principles, since each molecular state is entangled with other molecular states, we can determine the state of one molecule just by measuring the state of entangled molecule without even measuring it. Since the simulation is in molecular level, every basic function is taken in to count, and we can simulate the brain with even more accuracy.

We know that in Quantum Computer "n" Qubits can exist in "2^n" states simultaneously, due to which every combination of neuron sequence can exist in the given qubits, this makes the simulation a bit easy by reducing the computational step "it reduces the steps required to reach the output compared to classical computer", in Quantum computer the step are Square root of the step required that of classical computer, e.g.: a Quantum computer does the task in just 10 steps while the classical computer takes 100 steps (square root (100) = 10).

Simulating the brains sequence, the Quantum Computer takes fewer steps to reach the simulation output. The quantum compute makes a huge difference while searching of large scanned neuron sequence data because it takes fewer steps to get the desired outcomes.

By using the Quantum Computer we simulate the Quantum Physics with actual Quantum properties.

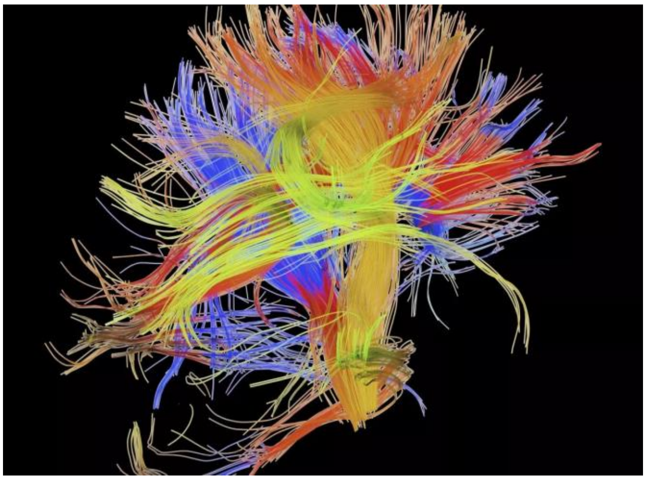

Fig 5: A colored 3D diffusion spectral imaging scan made using data and software from the human connectome

4. CONCLUSIONS

This technique of replicating or simulating the brain gives us an optimal results as compared with classical approach because the quantum computer is a better solution when dealing with the quantum information which obeys the quantum principles such as "Quantum Entanglement"(where the state of one Neuron effect the others). It's not possible and necessary to simulate each and every connection and structure in brain instead we simplify the simulation based of probability function that makes up major part of the individual. Simulating the whole sequence with quantum computer is “easier said than done”, by the Scaling the Quantum system can increase the computational power.

We are limited by the current technology but one day we can make this approach possible.

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