IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Quantum Computers - Not a fiction but a future reality to save mankind

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Abstract

In the modern world, healthcare plays a major role that is of a big concern. The present models in health care may not be very compatible for the future trends. A new revolution called quantum age is evolving faster and will not only change the worlds in all field but will play a major role in healthcare field. Quantum computers are hard wired physical machines that use the properties of quantum physics. They can be used extensively to store data and perform large and complex computations that will outperform the best supercomputers. Traditional computers or even super computers, which include smartphones and laptops work on binary digits "bits" that can either be 0s or 1s but a quantum computer works on the basic unit of memory called quantum bit or qubit. The qubits encode 0s, 1s, or both at the same time. The superposition, entanglement and tunneling properties enable quantum computers to manipulate enormous combinations of states at once. Qubits are made using physical systems, such as the spin of an electron or the orientation of a photon that are intrinsically linked together. They work on two concepts called superposition and entanglement. Quantum computers has to protect qubits from external interferences like radiation and temperature. This can be achieved by either isolating them physically or keeping them cool. Additional qubits can be added if needed to correct the errors that creep into the system. Quantum computer working is called quantum computing. It returns various very good answers in a very short amount of time. This paper reviews mainly on healthcare applications and how quantum computing can solve a problem or find a best medicine for a given health problem.

Keywords: Quantum, superposition, entanglement, qubit, atomwise, atomnet, tunneling

A quantum is a smallest unit of mass or energy or it can be a measurement of any physical quantity. It can be applied to computers as well to perform parallel computing ie performing multiple operations simultaneously. A normal computer may take several years to solve a complex problem, where as a quantum computer just takes few seconds. A normal computer works on binary digits 0 & 1 as the smallest unit where as a quantum computer uses qubits

which can be set to one of values 0 or 1 or both. E.g. when a photon is travelling, it has both horizontal and vertical polarization, 0 / 1 can be given to any of the polarization for a quantum computer but once it is filtered or processed it will take either 0 / 1. Superposition and Entanglement are the 2 positions of a qubit. In super position, the qubit can represent either a 0 / 1/ both at the same time. Entanglement happens when 2 qubits in superposition are associated with one another i.e. the state of one qubit is either 0 / 1 / both depends on the state of another. This concept can be used to solve complex problems that are impossible to solve even by super computers. A quantum computer transistor size is 14nm which is 8 times less than the HIV virus diameter and 50 times small than a Red Blood Cell. Operations performed by a quantum computer is called quantum computing. Some of the real world applications that can performed in very little time when compared to the normal or super computers would be

1. Telepathic signals between twin babies can be identified like when one smiles, the other feels happy, this may be inseparable and non clonable which are essential for quantum communication. A unique private key is created to secure information transmission.
2. When there are 4 bits of 0's and 1's, 16 combinations can be made out of it in a small time.
3. Searching a data in DB, it uses root n searching
4. It is used in IT security, E-mail and banking where data is secured using encryption system by providing public key where only the user can decode.
5. Used to reconstruct molecules which is one of the most difficult thing to do by mankind, quantum simulations can be used to simulate proteins that may revolutionize medical sector.
6. Solving a maze, a classical computer game traverses each path and then comes to a conclusion which may take some time, whereas a quantum computer tries all paths simultaneously and arrives at a solution within few seconds.
7. A classic computer can solve 2n and 2^n to some extent where as a quantum computer has the capability to solve 2^{50} simultaneously within few seconds.
8. Helps in financial service sector to make better investments by finding new ways to model financial data
9. Find new supply chains by finding optimal path to reach the destination

Apart from the above mentioned fields, quantum computing plays a vital role in the health care sector, which may revolutionize the world and bring a better tomorrow.

Quantum Computing in health care:

1. Sequencing DNA with more comprehensive analysis by comparing a bench mark quantity with results of millions of other samples of patients with same food and life style.
2. Helps to find new medicines with new compositions by helping in entangling and restructuring the molecular and chemical bonding.
3. Patients can treat themselves or get treatments where ever they are by themselves by analyzing data using sensors.

4. Arriving at the perfect decision for any support system – they can find diagnosis and treatment options that human cannot find
5. Drug design – molecule restructuring and new compositions of chemicals are designed to fit in the protein in the body in a faster way providing accurate results within few hours.
6. Creating the safest medical data – quantum data is highly secured. Hackers should have complete knowledge on the laws of quantum physics to hack the health record which is next to impossible.

1. Supersonic drug design

Inventing and developing new medicines with different compositions is a lengthy and costly clinical trial. Scientists and chemists are working with alternate ways such as artificial intelligence, machine learning and human organs-on-chips to make the drug discovery and development cost-effective and speed up the process. For example, Atomwise is a process of investigating drugs with small molecules. It uses supercomputers to manipulate therapies from a database of many molecular structures. A neural network, AtomNet is a neural network model that works on quantum mechanics, screens more than 100 million compounds every day. In 2015, Atomwise process was redesigned to treat the Ebola virus where two drugs were found in less than a day. This can be achieved faster by running many searches on quantum computers. This search will try all possible molecular combinations at an unimaginable speed. The drug is tested in different cell models and human tissues in a very small amount of time. This process will help to discover antidotes to many diseases like cancer and Alzheimer's.

2. Reaching the age of in silico clinical trials

A silico clinical trial is the use of computer models to simulate and develop new drugs and test them before being tested in live clinical trials or patients. It requires no humans or animals to be tested but the entire process runs only by simulation and then send to regulatory evaluations. However, this cannot be achieved with the current technology. Quantum computing actually simulates on virtual humans which operates on more than 1500 equations and 6500 variables like blood circulation, body fluids, hormones, electrolytes, metabolism, body and skin temperature and finds a solution within a short span of time.

3. Sequencing and analyzing DNA full speed

A Quantum computer works on super position and entanglement. This process is taken for processing or restructuring a DNA. Biologically a DNA changes in every generation of human birth. It has taken around 15 years to crack the code of the human DNA that costed billions of dollars. Genetic tests are used to learn a patients genetic risks for disease and also help the healthcare professionals to diagnose illness precisely. Quantum computing could give a hand in this as it can do the complete process with few hours. It can do faster sequencing of DNA for faster analysis and keep track of every genomic data in the health records.

4. Making patients truly the point of care

Huge health data in the measure of gazillions are collected everyday across the world. The data may be through wearable, sensors, medical gadgets etc. These data are sent and stored in cloud which may be around 44 zeta bytes annually. A new level of understanding in health care system is to move from preventive to predictive health which predicts the patients' future health. For example, an ophthalmology app shows how a patient's vision would change if he is affected by cataract. Quantum computer are fed with large amount of health parameters data like genetic information, sensory data, other health information which gives a comprehensive idea about the patients future health.

5. Radiotherapy

Radiation therapy is mainly used to treat cancer where it uses beams of intense energy to kill the cancer cells or stop them from multiplying. This will minimize damage to surrounding healthy tissue. This is could be achieved by many simulations until a positive result is obtained. With the help of a quantum computer, detection and diagnosis of cancer can be done at the early stage and discover new drugs rather than waiting for biopsis result which is a traditional method. With this innovative approach, designing the scans and diagnose disease accurately is a boon to the oncology doctors

6. **Drug Research**

Studying molecular structure and restructuring them to invent new medicines and their compositions precisely has helped the pharmaceutical sector to cure a range of diseases. This could be achieved in a short time when compared to traditional computers. Quantum computing simulates on models of complex molecular structures at an atomic level that is very crucial for medical research and drug discovery

7. Disease Screening

Quantum technology is a promise for health care because many cell processes take place at the nano or atomic and subatomic particles level. At this level matter stops behaving according to the laws of physics and starts demonstrating the unique properties of quantum mechanics. Using a method known as the bio-barcode assay, we can detect disease specific "biomarkers," in blood using gold nanoparticles, which are visible using MRI scan. They attach themselves to disease-fighting cells which are completely safe for human use. This method is cheaper, flexible, and more accurate than conventional alternatives. Another application of quantum-based technique to treat diseases are usage of gold nanoparticles programmed to build to attach themselves only to tumor cells. This allows accurate imaging as well as laser destruction of the tumor, without harming the healthy cells.

8. **Protect Healthcare Data**

The healthcare sector is adopting the Information Technology to assist both doctors and patients to improve the delivery of healthcare services. The most important section is to protect the Health Record electronically where patient

information is stored. Security Rules are imposed appropriately to protect the data confidentiality and integrity. Here Quantum cryptography refers to cryptographic algorithms also called public-key algorithms is the only known method for transmitting a secret key on the laws of physics. It enables both the parties to produce a shared random secret key known only to them, which can then be used to encrypt and decrypt messages.

9. **Protein Folding**

Proteins are the basic building blocks of any living being. Protein folding is the process of enabling each protein to perform its job within the cell. All protein molecules are heterogeneous chains of amino acids. The proteins perform their biological functions by coiling and folding into a specific three-dimensional shapes. Malfunction can happen if any one protein is wrongly folded. A more detailed knowledge of the different ways proteins are folded can lead to the development of new therapies and medicines. A quantum computer will be able to simultaneously test a huge number of possible protein fold structures and identify the most promising ones. This method is successfully carried on by an IBM Q 20-qubit quantum computer.

10. Quantum computer in Aircraft modelling

Quantum computing is not only a boon to medical field but also plays a vital role in aerospace industry by showing great potential to solve computational challenges like aircraft modelling, simulation, speeding up aircraft design, programming and debugging millions of lines of software code and assess the optimal amount of fuel and speed at which to operate a commercial aircraft. To solve this, the modern computers require more electricity and processing power to maintain its sustainability performance. It may require around 120 million lines of code to design and program an aircraft. Verifying and validating this code is time-consuming and a very complex process. However quantum computing will ease the process by accelerating the verification and validation process, improve production efficiency, speed up the aircraft designing process and ensure flight operations thereby reducing the time and cost significantly by enabling parallel computations. Quantum communication between ground station and the aircraft and between aircraft to aircraft can be made using cryptographic algorithms via asymmetric keys. Quantum sensors are also used for different applications, such as climate dynamics from satellites and weather forecasting.

Quantum computer vs Traditional computer / Super computer

A supercomputer works with the basic principle of bits 0's and 1's with 0 the off state and 1 the on state. It has other parameters like multiple wires and high number of processors which allow parallel processing and robust design where as an Adiabatic quantum computer works on quantum bits called qubits that exhibit quantum properties like superposition and entanglement which involves immense parallelism. A nondeterministic computer can enter into multiple states at once, and only succeeds if any state reached finds a solution. A quantum computer has the capacity to put the state bits into superposition, but only succeeds if it produces a measurable result which gives the right answer for more than 2/3 of the time. A quantum computer works on quantum mechanics. E.g.1. Flip a coin, it either falls as

head or tail. Superposition and entanglement is like a spinning coin and it's one of the things that makes quantum computers so powerful. A qubit allows for uncertainty. E.g.2. If a normal computer has to figure its way out of a maze, it will try every single branch and finally arrive at the destination consuming a large time. A quantum computer can go to every path of the maze at simultaneously and solve the problem within a short span of time. Physicists still don't completely understand how it works. You can take the spinning coin concept and use it to perform many complex calculations and if multiple qubits are stringed together then the problem can be solved which the super computers take millions of years to solve. Quantum computers not only does things faster or more efficiently it also does things which human have not dreamt of. They are gradually used in the development of artificial intelligence like improving the software design model of self-driving cars. Super computers can only analyze the most basic molecules. But quantum computers operate using the same quantum properties as the molecules and protein folding and discover new medicines to treat complex diseases like Alzheimer's. Quantum computers or quantum computing are used in predicting the financial markets, improve weather forecasts, study and create models on different behavior of individual electrons to understand quantum physics. A classical computer takes several years to break a large prime number to decrypt an encrypted data whereas for a quantum computer cryptography will be another key application where encryption keys cannot be copied or hacked. They would be completely unbreakable. Google announced it has a quantum computer that is 100 million times faster than any classical computer in its lab. Every day, we produce 2.5 exabytes of data. The huge difference between a super computer and quantum computer is in the vector of length 2^n complex values where n is the number of qubits in that quantum computer. For example:

1 qubit = 2 values in the state vector
2 qubits = 4 values in the state vector
3 qubits = 8 values in the state vector
... ...
16 qubits = 65,536 values in the state vector
... ...
100 qubits = 1,267,650,600,228,229,401,496,703,205,376 values in the state vector
... ... and so on.

Conclusion

Our modern computers, even though they are powerful in many ways they are limited in terms of the size and complexity when compared to quantum computer. A quantum computer plays a vital and crucial role in various fields. It can simulate and process an atom for drug development, fraud detection, improve machine learning with AI, high resolution screening process of diseases using pattern matching techniques. Provide patch models to diabetic patients who are injection phobia and minimize radiation damage to healthy tissue. They are not only used in the field of medicine but also used in various other fields to improve the world's economy. They are used in marketing by analyzing huge volumes of consumer data from different varieties of sources, use of complex algorithms to automatically trigger

the share market dealings based on a wide variety of market variables and incur the best way of investment called as Algorithmic trading. Finally logistics, the most important supply chain that keeps the life and world running by optimizing the workflows associated with logistics, fleet operations, traffic management, air traffic control, freight and distribution. Quantum computer is not a science fiction any more, but is a fantasy coming true.

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