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A Nexus for Advancing Healthcare Technologies Through Quantum Computing

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Abstract: Quantum computing is a new and evolving technology that has immense potential to transform healthcare and medicine. Quantum computers, which are based on the ideas of quantum mechanics, make use of quantum bits, or "qubits," and exploit entanglement and super positioning. As a result, quantum computers may do certain calculations and algorithms orders of magnitude quicker than traditional, "classical" computers. In healthcare, quantum computing has the potential to expedite drug discovery and development, improve diagnostic accuracy, and improve patient monitoring. By simulating medication interactions and refining molecular architectures, quantum computing may facilitate faster progress in the pharmaceutical industry. Additionally, quantum algorithms have the potential to diagnose some illnesses more quickly and accurately.

Keywords: quantum computing, healthcare, drug development, disease detection, personalized care, medical analytics, quantum algorithms, molecular modeling

1. INTRODUCTION

The improvements in computer technology have made it possible to handle and process huge data sets, in the past few years. QC works on the principle of quantum mechanics, and fundamental concepts of “superposition, interference, and entanglement”[1].Quantum computers are capable of performing tasks at orders of magnitude faster speeds and with a fraction of the energy consumption of traditional computers due to of their unique characteristics and operating mechanisms.Quantum computing will be helpful in the medicinal world since it will be easier for the computer to study each property of atoms and molecules as it works on similar concepts.

We noticed that most of today’s healthcare institutions have worked on the data of their patients and family members, about their recovery and well-being, but due to the rapid increase in data, may result in the failure of these traditional computational frameworks in the upcoming future. Looking at such possibilities, quantum computing can revolutionize the healthcare field, due to its greater potential and accuracy [2].

The potential of QC in the field of health care can change the way we see things, and make them work. We can use some strange things from the quantum world to solve very hard healthcare problems, like finding new medicines or managing hospitals better. Quantum computers are powerful and what makes them stand out is that they are capable of finding complex correlations, interdependencies, and relationships in the data, which is helpful while analysing and providing personalized treatments to patients.

Quantum computers are not set to replace our existing classical computers, but to integrate them with the classical computers into intelligent workflows and computational pipelines so that they can work hand-in-hand with classical computing in doing what they are both best at to solve the overall challenge and attack them.

We are progressing towards a continuous well-being status wherein we could have a personalized medical app that allows you to get proactive personalized suggestions, helping you to plan your day suggesting diet, exercise and also predicting what could happen given our current lifestyle, personalizing with regular check-ups and therapies according to the pros and cons of our activities, so that we can follow a healthy lifestyle.

This research paper will provide a brief literature review, methodology, discussions, results and conclusion of previous works done by researchers working in the field of quantum computing and its application in healthcare.

2. LITERATURE REVIEW

As conventional computing nears its limits of computational power, quantum computing has arisen as a radically innovative technology for new advances; based on principles of quantum physics like superposition and entanglement [1], quantum computers use qubits and quantum logic gatesto exponentially it accelerate certain types of computations [2].

This processing power could prove transformative in myriad fields, but healthcare is regarded as one promising area to revolutionize through quantum computing applications [3]. Using such emerging techniques for quantum machine learning [4] and quantum simulationsat a molecular level, quantum computing brings exciting potential for disruptingeverything [5]from biopharmaceutical development to medical imaging to precision health monitoring (Fig. 1) [6].

As quantum computing makes computation and analyses possible that are not achievable with traditional computing, it is capable to completely transform the healthcare sector. For example, by allowing rapid testing and analysis of molecular interactions, quantum computing could accelerate the creation of new drugs. This may greatly reduce the time and cost needed to introduce new drugs to the market. Through the detection of patterns and generation of insights from large, complex datasets such as genetic databases or electronic health records, quantum algorithms may help improve population health analytics. Precision medicine and preventative treatment may benefit from this.

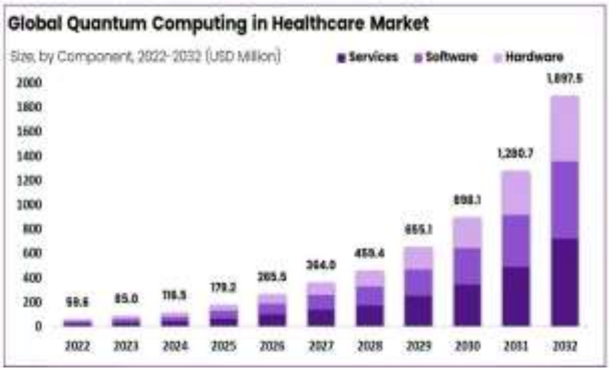

Fig.1 Global quantum computing in healthcare market (Source: Market Us).

However, technical complexity still hinders the real-world implementation of quantum computers [7]. By investigating the current state and near future projections for quantum computing as a key healthcare domain [4], as well as barriers still confronting the field [4], this research paper aims to analyse the major implications quantum technologies could have for advancing human health and medicine while considering what progress is still required to reach this next quantum era. Background research illustrates how quantum principles allow computing achievements that are not achievable for conventional computers [3], providing significant background on possible future uses of quantum technology in healthcare [4].

Classical and quantum computing take fundamentally different approaches to information processing and computation (Fig. 2). Classical computing encodes information as bits that are there in a binary state of 0 or 1 at any given time [8]. Its computational power is based on manipulating long strings of these binary digits according to the rules of Boolean logic [9]. On the other hand, quantum computingtakes advantage of the quantum mechanical properties of atoms and photons to encode the given information as quantum bits (qubits), which can exist in a superposition of 0 and 1 simultaneously [10]. This allows a collection of qubits to store an enormous combination of possible states in very little physical space, giving quantum computers theoretically exponential increases in computational power, speed, and parallelism compared to binary systems. Quantum algorithms make use of the quantum properties of entanglement and interference to perform computations in ways classically impossible.

However, quantum states are fragile and can easily lose coherence if disturbed by external forces [11]. Classical systems are far more robust in physical implementation. While the potential for quantum computing is very promising for certain complex problems like optimization or chemical simulation, classical computers continue to evolve as well, and the two are likely to coexist with complementary uses for the foreseeable future [10].

Fig.2 will show the difference between classical and quantum computing.Classical computing relies on transistors and bits that exist strictly as 1s or 0s, enabling logical operations and programming functions. Quantum computing utilizes quantum bits or qubits, which can exist as 1s, 0s, or simultaneously in both states. This superposition allows qubits to perform multiple calculations at once, resulting in vastly greater processing power and parallelism compared to binary classical systems.

Additionally, the entanglement property enables distributed qubits to mirror each other's states non-locally, allowing for computations utilizing effects such as quantum tunneling and interference.

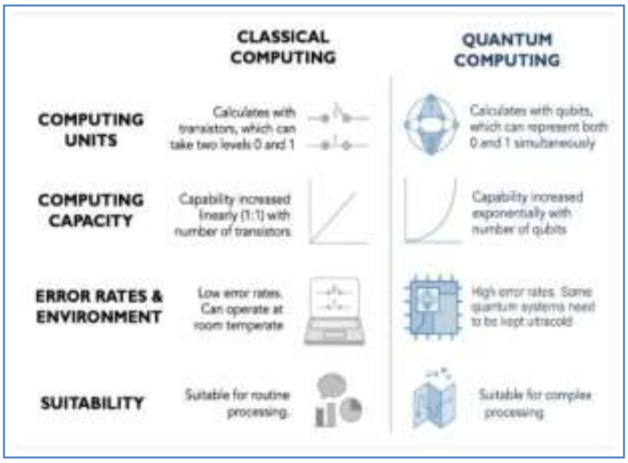

Fig.2Comparison of Classical and quantum computing (Source: Medium.com)

Some bullet points about quantum computing in healthcare.

- Classical computers approaching computational limits, quantum computing emerges as radically new technology based on quantum physics.
- Utilizes quantum properties like superposition and entanglement to allow much fasterprocessing.
- Operates through qubits and quantum logic gates rather than binary bits.
- Exponential acceleration of certain complex computations compared to classical computing.
- Healthcare is regarded as having tremendous potential to be disrupted by quantum computing.
- Applications in biopharmaceutical development, medical imaging, precision health monitoring show promise.

- Quantum machine learning and molecular modelling simulations are already yielding advances.
- However, technical barriers around real-world quantum computer engineering persist.
- Research aims to analyses current state of quantum computing in healthcare contexts.

3. Methodology

The methodology for this research will involve an in-depth literature review assessing the potential for quantum computing techniques within major healthcare domains. Relevant research published in peer-reviewed scientific journals and preprint archives will be surveyed, collecting data on demonstrated and proposed applications of quantum platforms in areas like pharmaceutical science, medical imaging, diagnostics, and analytics [1]. Databases such as PubMed, IEEE Xplore, ACM Digital Library, and arXiv will be systematically searched to gather contemporary exemplars of quantum algorithms, simulations, architectures, and other computing tools tailored to transform biomedical challenges [2].

Fig.3 Proposed applications of quantum computing in healthcare [Source: ResearchGate].

Fig.3 shows about Quantum computing offers game-changing possibilities for advancements in healthcare and medical research [3]. One major application is using quantum simulation to model protein folding and dynamics at an atomic level to help discover new drug compounds and delivery mechanisms. Quantum algorithms show potential to greatly accelerate analysis of genetic sequences, pathogens, and human genome data to uncover health insights and customize treatments [5]. By leveraging quantum machine learning, diagnosis and prognostic capabilities can be enhanced using complex data analysis that is not feasible with classical techniques [6].

Analysis of the state of development and adoption for these quantum computing innovations in healthcare contexts will be pursued, evaluating factors such as the accessibility, accuracy, and efficiency of introduced quantum methods in comparison with longstanding classical techniques [7]. We'll additionally look at the ability of new quantum hardware and toolkits for the transition from theoretical and experimental demonstrations to real-world clinical applications [8]. By using this kind of analysis, the potentially disruptive ability of quantum computing to speed up anything from patient data insights to drug development may be balanced against ongoing constraints related to building completely fault-tolerant, scalable quantum systems [9].

Because quantum computing makes it possible to examine large, difficult biological and medical datasets, it has the potential to completely transform precision medicine. Researchers may be able to synthesize and extract knowledge from multimodal patient data, such as genetic, molecular, clinical, and imaging data, by using the processing capacity of quantum systems [10].This has the potential to provide personalized disease prevention, diagnosis, and therapy for specific individuals. When used in precision medicine, quantum machine learning algorithms may be able to find previously undiscovered relationships in biological data and improve risk prediction, which would help inform treatment choices [11].A case study of how quantum computing may be applied to handle enormous amounts of multimodal data in aid of precision medicine can be seen in Figure 4. In the end, using quantum computing for analyzing actual patient data may help medical professionals give more personalized, effective treatment [12].

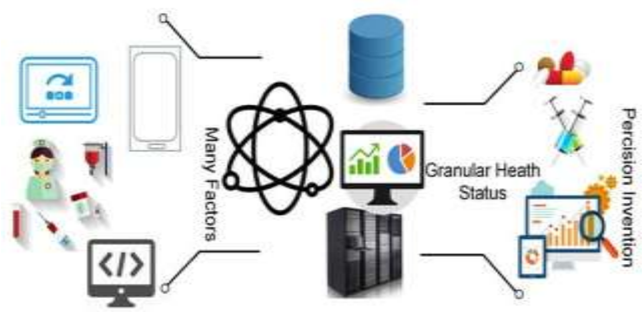

Fig.4 A case study highlighting how quantum computing could possibly be used to help precision medicine by using large multimodal data[17].

A wide range of healthcare domains will be investigated through this quantum computing research, including but not limited to using quantum simulation to optimize pharmaceutical treatments and models and applying quantum data analytics to extract new correlations across patient health monitoring sources. Using quantum machine learning to improve diagnostic techniques and advance pattern recognition in medical imaging; and using quantum image processing to improve MRIs, CT scans, and microscopy [17].

Considering this scope of prospective quantum computing medical innovations, as well as the rapid pace of progress within this nascent field, limitations around accessibility to cutting-edge proprietary research from technology firms or research groups may constrain the study. However, focusing the methodology on published and preprint literature provides a meaningful survey of near-future quantum computing use cases poised to disrupt multiple segments of healthcare through unprecedented computational capabilities.

The article emphasizes the increasing importance of quantum technologies in various domains, particularly in healthcare applications. The paper examines QML algorithms and their uses, providing correct insights into the latest developments [19]. There is also discussion of QML's potential and limitations in the medical field. Professionals and researchers who wish to learn more about the possible advantages and disadvantages of QML in biomedical companies could use this paper as an important tool. It could be a trustworthy source of information for everybody inquisitive within the association between quantum computing and healthcare since of its orderly approach and less demanding procedures.

The consideration has tended to all of the benefits and downsides of QML for the healthcare industry. The paper offers a fair assessment of this field, centering on the significance of significant preparing capacity and information security. To encourage help perusers in understanding the real application of the techniques, it gives a careful ponder of their effectiveness and utilize in a assortment of conditions.The recommendations given in this ponder for more inquiries are among its most vital highlights. These proposals donate a system for future inquire about to grow the conceivable outcomes of utilizing QML in sickness forecast and location. For scholastics examining these flows, this paper could be an extraordinary asset since it offers an intensive diagram of the state of undertakings as well as future headings for quantum computing in healthcare.

This studythoroughly examines the future scope and limitations of quantum machine learning in healthcare applications. It points out that despite the theoretical potential of QML promoting practical use, large computational resources and strict data security standards required for processing sensitive medical information remain barriers to its effective usage in this field.The review's capacity to thoroughly analyse the computation of efficiency improvements, the evaluation of adaptation outside of controlled testing contexts, and the treatment of a broad variety of illnesses and health outcomes is among the most important benefits of QML techniques.This significantly helps readers distinguish between times when QML might offer genuinely useful advances in detection and prediction and times when claims could be overestimated.

1. Superposition enables representing multiple states, enabling exponential speedups in querying large healthcare data sets.
2. Entanglement creates correlations spanning spaces, revealing intricate patterns not perceivable classically.
3. Interference enables discerning finer insights from multi-dimensional patient data.

The traditional restrictions faced by vast, different healthcare data have been solved by these quantum features. Use cases benefiting include:

1. In-silico drug discovery.
2. Medical imaging analytics.
3. Genomic analytics.
4. Public health informatics.
5. Clinical decision support systems.

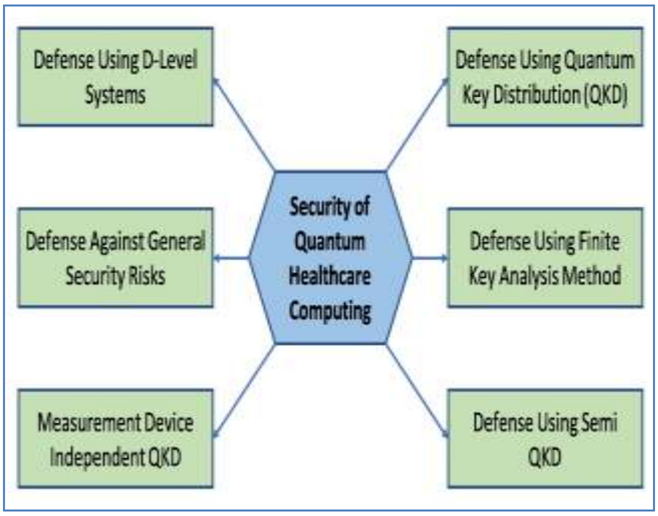

Fig.5 Security of quantum computing in healthcare [13].

In Fig.5 quantum computing brings immense potential to transform healthcare through its ability to rapidly process massive datasets and model complex molecular interactions [13]. However, the intrinsic vulnerability of quantum systems to errors poses security risks for highly sensitive medical and genomic data [14]. Rigorous quantum error correction and encryption protocols must be implemented, along with strict access controls and identity management, to mitigate inside and external threats when deploying quantum computing for healthcare applications [15]. Multifaceted cybersecurity measures are critical to fully leverage quantum capabilities while safeguarding patient confidentiality [16]. Fig.5 explains all the security concepts of quantum computing in healthcare.

Number Quantum machine learning fuses quantum physics within data pipelines and models, inheriting pattern recognition proficiencies for discerning insights in elaborative medical data. This progresses precision medicine via strengthened disease risk models, diagnostics and personalized treatments [18].

However barriers exist around accessibility, data security, validation and integration. Multidisciplinary collaboration between medical, physics and computer science experts is key. Priority use cases should build on quantum strengths with usability and integration considerations. Feedback loops between clinicians and technology builders can accelerate practical quantum advancements.

4. Discussion

The research paper, “Quantum computing for near-term applications in generative chemistry and drug discovery” [1] explores the transformative potential of quantum computing in chemistry and drug discovery. It sheds light on the promising developments and applications of this emerging technology in a near-term context.

This paper provides a thorough explanation of quantum simulations, which enable the production of intricate chemical processes and enhance knowledge of molecule properties and reaction mechanisms. It demonstrates how the capacity of quantum computers to forecast binding relationships, molecular activity, and possible therapeutic candidates might greatly accelerate the search for novel medications. The research shows how quantum machine learning, quantum annealing, and quantum augmented algorithms allow these applications. Though its development is far from accomplished, this work illustrates how quantum computing is capable enough to revolutionize both generative chemistry and discovery by providing ground-breaking findings that will influence improvements in both scientific fields.

We get to see a thorough insights of Quantum Machine Learning applications in the health care industry from 2013 to 2021 in the publication "Quantum Machine Learning Applications in the Biomedical Sector: A Systematic Review". The 30 papers out of 3149 that are ranked in the top 30 demonstrate how effective its methodology really is. The study describes how quantum technologies are growing more important in the healthcare industry and with other numerous establishments.The paper looks at QML approaches and applications and provides a detailed review of recent developments. There is also a study of QML's possibilities and limits in the medical area. Researchers and medical professionals who want to understand more about the challenges and potential impacts of QML on healthcare should read this study right now. Its approach to logic and manner of writing makes it a trustworthy source of knowledge. A thorough assessment of the literature is provided by the research effort "Quantum Machine Learning for Disease Detection and Prediction: A Survey of Applications and Future Possibilities", which examines the quickly evolving topic of quantum machine learning in healthcare.The tremendous capabilities of quantum computing methods and calculations for handling gigantic volumes of therapeutic information is illustrated by this work, which may help within the distinguishingproof and forecast of sicknesses. Makingstrides towards the accuracy and viability of assessments of wellbeing data, counting information from genomics, therapeutic imaging, and electronic wellbeing records, is the objective of combining quantum computing with machine learning.

Adifferent peruser pondered completely inspected the benefits and downsides of QML in wellbeing care. This sets out a judicious appraisal of the issue and emphasizes the significance of huge computer control and information assurance. It moreover makes a difference perusers to decide how they can be utilized in genuine world scenarios by examining tactics' adequacy and reasonability over a wide run of circumstances [20]. The foremost imperative viewpoint of this assessment is the proposal for encourage considers. These recommendations improve the chances of integrating QML into illness detection and prediction by offering a path for future research. As a vital resource for scholars, this work carefully summarizes the state of the discipline today and its prospects for the future. exploring the dynamic junction between healthcare and quantum computing.

5. Results

AfterCurrent quantum applications are demonstrating tangible benefits in pharmaceutical research, medical imaging diagnostics, genomics, and public health informatics through quantum molecular modeling, quantum machine learning, and quantum annealing. Significant potential exists for using quantum techniques in early disease detection, real-time health monitoring, optimized treatment support, and preventative care through emerging quantum software like neural networks, natural language processing tools, and physics-based simulations.

However, widespread assimilation faces barriers in accessibility, clinical integration, cross-disciplinary talent grooming, and rigorous data protection.

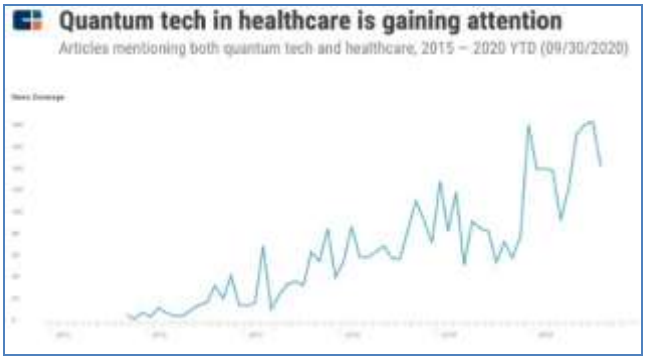

Fig.6 Quantum Healthcare Convergence Trend [Source:cbinsights]

Fig. 6 demonstrates an increasing trend in papers from 2015 to 2024 that discuss both quantum computing and healthcare, indicating a growing interest in using quantum computing to enhance healthcare. Opportunities for transformative applications that could potentially accelerate advancements in industries like drug development, drug discovery, and medical imaging are provided by the developing relationship between quantum technology and healthcare. By integrating these two areas of expertise, quantum computing's processing capacity could help develop healthcare solutions.

Due to its ability to overcome the limits of current methods for processing complicated medical data, quantum computing offers great potential for changing the healthcare industry. The health industry will experience quantum advancement through cross-domain cooperation in the systematic research and clinical translation of quantum solutions for essential challenges.

Today, medication development, imaging, genomics, and population health data analysis may all benefit from quantum computing and have a large amount of unexplored potential for use in applications like real-time monitoring, preventative care, improved therapies, and rapid illness identification.Data security and skill development across domains are obstacles to the integration of clinical operations and research. Concepts to revolutionize medicine by getting rid of things that prevent traditional computers from generating meaning from large and complex medical information.. The real-world effect will be enhanced by the planned development of quantum healthcare solutions through collaboration between clinical and technological fields. Quantum computing is capable to completely reshape the healthcare industry by improving medication discovery and enhancing patient treatment plans. However, like with any rapidly developing technology, there are disadvantages to take into consideration in addition to benefits.Strict safety measures will be required to properly take advantage of quantum capabilities, particularly in the healthcare sector where extremely confidential patient information is processed and maintained.

6. Conclusion

The research paper, " In conclusion, quantum computing represents an emerging technological paradigm with immense disruptive potential across the healthcare sector, from pharmaceutical R&D to precision diagnostics to personalized medicine and beyond [2]. Through uniquely quantum computational capabilities like quantum superposition and multi-qubit entanglement allowing for massively parallel information processing, quantum computing could achieve transformative healthcare acceleration and problem-solving at a scope unattainable for conventional computing techniques [3].

However, persistent engineering obstacles around scaling qubit counts, maintaining quantum coherence, error correction, and practical system design continue to separate most proposed quantum health innovations from practical clinical or commercial readiness at this time [5]. Bridging this divide will rely on interdisciplinary collaboration between quantum physicists, computer scientists, biomedical engineers, regulatory bodies, and healthcare organizations to usher quantum advances past theoretical potential into deployed bedside and benchtop solutions [8].

Still, the rapid pace of quantum maturation recently has seen functioning prototypes with as many as 65 qubits meaningfully modelling molecular interactions [9]. So with further investment and focused developmental efforts, quantum computing sits poised to realize its projected revolution across pharmaceutical optimization, medical imaging upgrades, early diagnostic improvements, and more over the next decade – living up to the disruptive promise that has defined this technology since inception. Quantum's healthcare impact has only begun [12].

Quantum computing has a great potential to transform healthcare. We are on the cusp of realizing quantum's long-promised capabilities, thanks to rapid advancements in qubit counts and algorithm development. Quantum computers may soon revolutionize everything from drug discovery to medical imaging and diagnosis with continued investment. Quantum computing may fundamentally transform medicine as we know it today in the upcoming decade. One of the first and most profoundly affected areas by the coming quantum revolution is the healthcare sector, which remains to be seen.

Quantum computing will transform healthcare, but how soon and to what extent is the question as we look to the future. Is it possible to discover life-saving drugs in a few months? Is it possible to catch serious diseases like cancer earlier and more accurately. Will patient outcomes improve significantly. Assuming yes, the timeframe remains uncertain. Quantum computing is, without a doubt, one of the most exciting frontiers in technology today, with huge potential to advance healthcare and improve human well-being.

References

1. Ur Rasool, Raihan, Hafiz Farooq Ahmad, Wajid Rafique, Adnan Qayyum, Junaid Qadir, and Zahid Anwar. 2021. "Quantum Computing for Healthcare: A Review" Future Internet 15, no. 3: 94.
   https://doi.org/10.3390/fi15030094
2. A. Kashyap and R. Agarwal, "A Study on Secure Quantum Computing for Healthcare System," 2023 International Conference on Computational Intelligence and Sustainable Engineering Solutions (CISES), Greater Noida, India, 2021, pp. 890-894.
   https://doi.org/10.1109/CISES58720.2023.10183483
3. Alexey Pyrkov, Alex Aliper, Dmitry Bezrukov, Yen-Chu Lin, Daniil Polykovskiy, Petrina Kamya, Feng Ren, Alex Zhavoronkov,"Quantum computing for near-term applications in generative chemistry and drug discovery",Drug Discovery Today,Volume 28, Issue 8,2023,103675.
   https://doi.org/10.1016/j.drudis.2023.103675
4. D. Maheshwari, B. Garcia-Zapirain and D. Sierra-Sosa, "Quantum Machine Learning Applications in the Biomedical Domain: A Systematic Review," in IEEE Access, vol. 10, pp. 80463-80484, 2021
   https://doi.org/10.1109/ACCESS.2022.3195044
5. P. B. Upama et al., "Quantum Machine Learning in Disease Detection and Prediction: a survey of applications and future possibilities," 2022 IEEE 47th Annual Computers, Software, and Applications Conference (COMPSAC), Torino, Italy, 2023, pp. 1545-1551
   https://doi.org/10.1109/COMPSAC57700.2023.00238
6. G. S. Uehara, A. Spanias and W. Clark, "Quantum Information Processing Algorithms with Emphasis on Machine Learning," 2021 12th International Conference on Information, Intelligence, Systems & Applications (IISA), Chania Crete, Greece, 2021, pp. 1-11
   https://doi.org/10.1109/IISA52424.2021.9555570
7. L. P. Yulianti and K. Surendro, "Implementation of Quantum Annealing: A Systematic Review," in IEEE Access, vol. 10, pp. 73156-73177,2022
   https://doi.org/10.1109/ACCESS.2022.3188117
8. Lakshita Aggarwal, Shelly Sachdeva, Puneet Goswami,Quantum healthcare computing using precision based granular approach,Applied Soft Computing,Volume 144,2023,110458,ISSN 1568-4946
   https://doi.org/10.1016/j.asoc.2023.110458

9. Shivam Gupta, Sachin Modgil, Priyanka C. Bhatt, Charbel Jose Chiappetta Jabbour, Sachin Kamble, Quantum computing led innovation for achieving a more sustainable Covid-19 healthcare industry,Technovation, Volume 120,2023,102544,ISSN 0166-4972

https://doi.org/10.1016/j.technovation.2022.102544

10. Diksha Chawla, Pawan Singh Mehra, QSMAH: A novel quantum-based secure cryptosystem using mutual authentication for healthcare in the internet of things, Internet of Things, Volume 24, 2023 ,100949 ,ISSN 2542-6605

https://doi.org/10.1016/j.iot.2023.100949

11. Mehboob Hussain, Lian-Fu Wei, Fakhar Abbas, Amir Rehman, Muqadar Ali, Abdullah Lakhan, A multi-objective quantum-inspired genetic algorithm for workflow healthcare application scheduling with hard and soft deadline constraints in hybrid clouds, Applied Soft Computing, Volume 128, 2022, 109440, ISSN 1568-4946

https://doi.org/10.1016/j.asoc.2022.109440

12. A. S. Bajkoti, S. Tiwari, T. Ranjan, R. S. Bisht and A. Mittal, "Role of Quantum Computing and Metaverse in the Field of Healthcare and Medicine," 2023 5th International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, 2023, pp. 306-311

https://doi.org/10.1109/ICIRCA57980.2023.10220921

13. S. Rani, P. Kumar Pareek, J. Kaur, M. Chauhan and P. Bhambri, "Quantum Machine Learning in Healthcare: Developments and Challenges," 2023 IEEE International Conference on Integrated Circuits and Communication Systems (ICICACS), Raichur, India, 2023

https://doi.org/10.1109/ICICACS57338.2023.10100075

14. M. Esposito, G. Uehara and A. Spanias, "Quantum Machine Learning for Audio Classification with Applications to Healthcare," 2022 13th International Conference on Information, Intelligence, Systems & Applications (IISA), Corfu, Greece, 2022, pp. 1-4

https://doi.org/10.1109/IISA56318.2022.9904377

15. V. K. R. R. Satuluri and V. Ponnusamy, "Quantum-Enhanced Machine Learning," 2021 Smart Technologies, Communication and Robotics (STCR), Sathyamangalam, India, 2021, pp. 1-6

https://doi.org/10.1109/STCR51658.2021.9589016

16. S. Chandrasekaran, R. Agrawal, V. Dutt and N. Vyas, "Improved Healthcare System with Quantum Computing," 2023 International Conference on Artificial Intelligence and Smart Communication (AISC), Greater Noida, India, 2023, pp. 99-103

https://doi.org/10.1109/AISC56616.2023.10085380

17. Darwish, S.M.; Abu Shaheen, L.J.; Elzoghabi, A.A. A New Medical Analytical Framework for Automated Detection of MRI Brain Tumor Using Evolutionary Quantum Inspired Level Set Technique. Bioengineering .

https://doi.org/10.3390/bioengineering10070819

18. Pattnaik, K., Mishra, S., Mishra, B.S.P. (2020). Quantum Computing and Its Application in Healthcare and Agriculture. In: Das, K., Mishra, B.S.P., Das, M. (eds) The Digitalization Conundrum in India. India Studies in Business and Economics. Springer, Singapore

https://doi.org/10.1007/978-981-15-6907-4_3

19. Davids, J., Lidströmer, N., Ashrafian, H. (2021). Artificial Intelligence in Medicine Using Quantum Computing in the Future of Healthcare. In: Lidströmer, N., Ashrafian, H. (eds) Artificial Intelligence in Medicine. Springer, Cham.

https://doi.org/10.1007/978-3-030-58080-3_338-1

20. Jayanthi, Prisilla, Bharatendra K. Rai, and Iyyanki Muralikrishna. "The potential of quantum computing in healthcare." In Technology Road Mapping for Quantum Computing and Engineering, pp. 81-101

https://doi.org/10.4018/978-1-7998-9183-3.ch006

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