ADI Journal on Recent Innovation (AJRI)
Vol 3 No. 2 March 2022

p-ISSN : 2685-9106
e-ISSN : 2686-0384

Quantum Computing and AI: Impacts & Possibilities

Author Notification
10 January 2022
Final Revised
25 January 2022
Published
29 January 2022

Bhupesh Rawat[1], Nidhi Mehra[2], Ankur Singh Bist[3], Muhamad Yusup[4], Yulia Putri Ayu Sanjaya[5]

Graphic Era Hill University[1,2,3], University of Raharja[4,5]
Road Society Area, Oghal Bhatta, Clement Town, Dehradun, Uttarakhand 248002[1,2,3],
Cikokol, Tangerang/(021) 55295863[4,5]
India[1,2,3], Indonesia[4,5]
e-mail: bhr222@gmail.com[1], nidhigehu@gmail.com[2], ankur1990bist@gmail.com[3],
yusup@raharja.info[4], yulia.putri@raharja.info[5]

To cite this document:
Rawat, B., Mehra, N., Bist, . A. S., Yusup, M., & Sanjaya, Y. P. A. (2022). Quantum Computing and AI: Impacts & Possibilities. ADI Journal on Recent Innovation, 3(2), 202–207.
DOI : https://doi.org/10.34306/ajri.v3i2.656
Hash : ABClJyPX3sRtPMItB2r6jBI3W2jZGnoc3BuskRbOqdSS2JiIwNSqXSQjbyLKDjOG

Abstract

Quantum computing is one of the emerging technologies. Different communities and research organizations are working to bring quantum computing applications into reality. Artificial Intelligence is another emerging area and getting stable with time. This paper, the main objective is to find out the impact of quantum computing research growth for AI applications. Thus, the method used in this study uses computational methods. so that this research can be concluded regarding the growing impact of quantum computing research for a given AI application. This paper also presents the impact and possibilities of quantum computing in the field of artificial intelligence.

Keywords: Quantum Computing, Blockchain, Artificial Intelligence.

1. Introduction

Honeywell, among others, has started investing in this technology. In many ways, quantum computing is like classical computing, storing data in the form of bits, i.e. 0 or 1. [1] However, quantum computing encodes information in the quantum bit or qubit, making it possible to store multiple states of data simultaneously. This is where the role of quantum mechanics concepts such as superposition and entanglement comes. Quantum computing works differently from traditional computing because it follows the same physical rule that an atom follows to manipulate information [2]. It is reported that quantum computing can help artificial intelligence in many ways, such as processing huge complex datasets and evolving algorithms to allow better learning, reasoning, and understanding. Several possibilities are there for machine learning algorithms and natural language processing in quantum computing. For example, recently, a natural language processing algorithm has been executed on quantum computing, which results in a "meaning aware" algorithm [3]. The meaning of meaning awareness is that now the computer can understand the individual words and the whole sentence. This awareness can be expanded to entire phrases that result in real-time speech without requiring guesswork, which is state of the art today. With the help of quantum computing, it is also possible to run machine learning and deep learning algorithms faster than their classical computers. Quantum computers using quantum physics can have computer results more accurately than their counterparts [4].

This paper discusses the impact and possibilities of integrating quantum computing with artificial intelligence in detail. How can we reduce the error further with their integration is the focus of this paper? [5]

2. Research Question

- RQ1 : How will quantum computing improve and transform machine learning and artificial intelligence capabilities?
  Answering this question will provide deep insight to researchers and scientists about what aspect of quantum computing can help improve the performance of AI applications.[6]
- RQ2 : What are the possibilities of quantum computing that can be analyzed and explored for the overall growth of AI applications
  Answering this question will give a new perspective to the research community about unexplored areas of quantum computing that will help efficiently solve AI problems.[7]

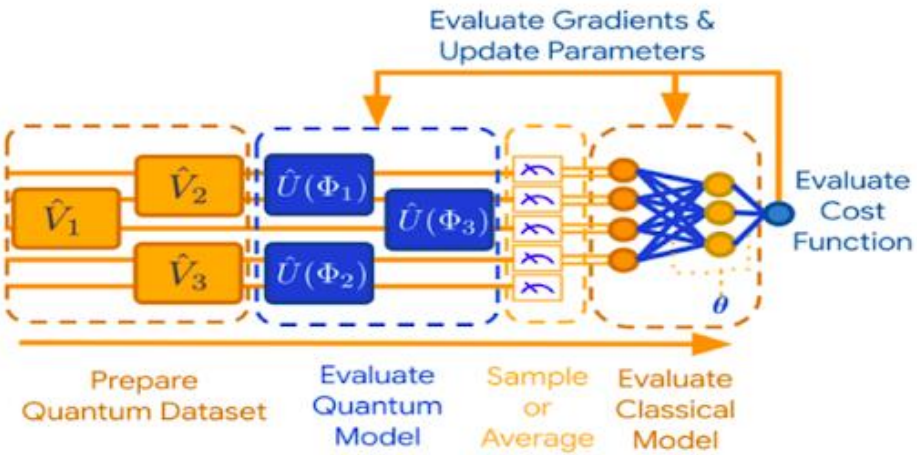
3. AI transformation with Quantum Computing

Quantum computing and AI will be merged to get an optimized solution that can generate world-class results. There are various possibilities with Quantum AI. Many research articles are popping out to show the significance of this combination [8]

There are the following possibilities with Quantum AI. Different libraries are on the way to support this innovation for developers. [9]

1. AI Learning process enhancement with Quantum algorithms.
2. AI neural search enhancement with Quantum algorithms.
3. Quantum computing and game theory touch AI for dealing with stochastic scenarios

p-ISSN : 2685-9106
e-ISSN : 2686-0384



Picture 1. Quantum Computing and AI [10]

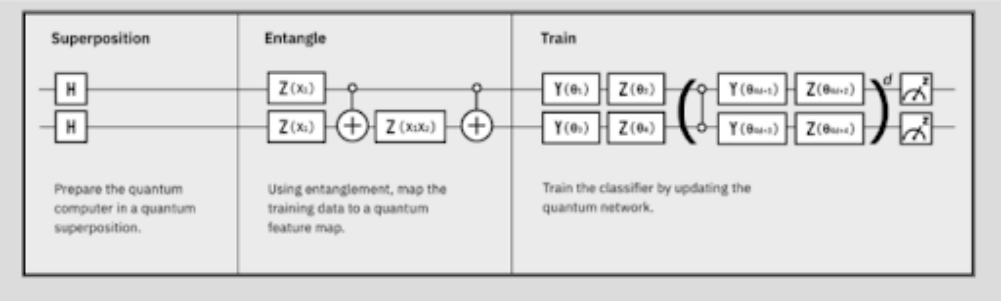
```
# A hybrid quantum-classical model.
model = tf.keras.Sequential([
    # Quantum circuit data comes in inside of tensors.
    tf.keras.Input(shape=(), dtype=tf.dtypes.string),

    # Parametrized Quantum Circuit (PQC) provides output
    # data from the input circuits run on a quantum computer.
    tfq.layers.PQC(my_circuit, [cirq.Z(q1), cirq.X(q0)]),

    # Output data from quantum computer passed through model.
    tf.keras.layers.Dense(50)
])
```

Picture 2. TensorFlow Quantum Library [11]

In the coming time, designing quantum-based AI learning algorithms will allow us to solve typical problems more quickly and help to speed up areas like AI training, pattern recognition, and fraud analysis[12]. Qiskit is an open-source quantum computing framework developed by the IBM Quantum community[13]. The purpose is to test AI and quantum computing for each other. Researchers can decode machine learning situations into inputs for QiskAqua algorithms and execute them on real quantum machines[14].



Picture 3. Quantum Classifier [15]

4. Optimization

It is a well-known fact that classical or traditional computing methods are not able to solve complex machine learning problems efficiently. To address this issue, quantum computing has come into the picture[16]. According to reports, the performance of machine learning algorithms dealing with a dataset of high dimensional vector space suffers in performance using classical computers[17]. Quantum computing gives two very important techniques, quantum parallelization, and quantum associative memories, which are said to speed up the performance or reduce the computation time and can be used to solve complex machine learning tasks both for optimization and learning[18]. It is worth noting that quantum computers are good at dealing with tensor and dot matrices in a higher dimension. This feature turns out to be very useful in reducing the time of machine learning algorithms[19]. In one of the reports, it is found that quantum computers can factor integers in polynomial time, which is normally not possible by classical computers[20]. In machine learning, there are several problems that can not be solved in the given time frame and are intractable[21]. Heuristics techniques are used to solve such intractable problems with given available resources[22]. This is where quantum computing can be used to speed up the computation time[23].

Picture 4. Quantum Computing.

5. Simulation

Quantum simulators are software programs that run on classical computers and make it possible to run and test quantum programs in an environment that predicts how qubits react to different operations[24]. There are a variety of problems, ranging from the simulation of materials or chemistry processes to optimization, for which very efficient quantum algorithms have been developed so that they can be solved by quantum computers way faster than by any other classical one[25]. They have a wide range of applications, including drug, material design, industrial process, and data processing, among others. There are a few problems where quantum computing can provide significant speed, in other words, as a function of qubits, while in some other problems, it can yield modest results[26].

6. Conclusion

Artificial Intelligence and Quantum Computing are both appliances of science and engineering[27]. The use of computational capabilities of Quantum computing in the processing of large and complex datasets of Artificial intelligence is popular as Quantum Artificial Intelligence. When technology giants succeed in building quantum computers, it will tremendously change the computational power, time, and speed [28].

On the other hand, there are several challenges in implementing quantum computing in AI applications – Mapping of a qubit, Maintaining qubit quality, Scalability, Noise

distortion, Skilled developer and Substantial ecosystem, open-source modeling, and training framework, etc [29]. For AI researchers, optimization and sampling are especially important because they enable machine learning models to be trained faster and with greater accuracy and also develop a quantum algorithm for learning and decision problems that perform better than classical AI algorithms. So quantum computing and AI need to meet various milestones to increase potential in quantum computing AI.

In this paper, a brief discussion on the impact of quantum computing research growth for AI applications is given. This paper also presents the impacts and possibilities of quantum computing in the field of artificial intelligence [30].

References

[1] C. Jones, "AI, Big data, Quantum Computing and Financial Exclusion: tempering enthusiasm and offering a human centric approach to policy.," 2021.

[2] G. Kim, "A QUANTUM-AI FRAMEWORK FOR EXTREME WEATHER PREDICTION," AI4ESP, 2021.

[3] C. Chambers-Jones, "11 AI, big data, quantum computing, and financial exclusion," *FinTech, Artificial Intelligence and the Law: Regulation and Crime Prevention*, p. 125, 2021.

[4] A. Moin, M. Challenger, A. Badii, and S. Günnemann, "MDE4QAI: Towards Model-Driven Engineering for Quantum Artificial Intelligence," *arXiv preprint arXiv:2107.06708*, 2021.

[5] A. Lele, "Quantum Computers," in *Quantum Technologies and Military Strategy*, Springer, 2021, pp. 25–38.

[6] H.-Y. Huang *et al.*, "Power of data in quantum machine learning," *Nature communications*, vol. 12, no. 1, pp. 1–9, 2021.

[7] G. Purushothaman and N. B. Karayiannis, "Quantum neural networks (QNNs): inherently fuzzy feedforward neural networks," *IEEE Transactions on neural networks*, vol. 8, no. 3, pp. 679–693, 1997.

[8] M. Schuld, I. Sinayskiy, and F. Petruccione, "An introduction to quantum machine learning," *Contemporary Physics*, vol. 56, no. 2, pp. 172–185, 2015.

[9] R. Jozsa and N. Linden, "On the role of entanglement in quantum-computational speed-up," *Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences*, vol. 459, no. 2036, pp. 2011–2032, 2003.

[10] J. I. Cirac, "Quantum computing and simulation," *Nanophotonics*, vol. 10, no. 1, pp. 453–456, 2021.

[11] J. B. Rahmad, S. Suwandi, C. K. T. Soedaryono, L. F. D. Aryanti, and D. Aprialiasari, "Analysis of The Effect of Community's Role in CSR Activities on The Image of The Company of Minarak Brantas Gas, Inc.," *ADI Journal on Recent Innovation*, vol. 3, no. 2, pp. 153–171, 2022.

[12] L. A. Faza, P. M. Agustini, S. Maesaroh, A. C. Purnomo, and E. A. Nabila, "Motives For Purchase of Skin Care Product Users (Phenomenology Study on Women in DKI Jakarta)," *ADI Journal on Recent Innovation*, vol. 3, no. 2, pp. 139–152, 2022.

[13] S. Azizah and B. P. K. Bintoro, "Determining Factors of Continuance Intention to Use QR Code Mobile Payment on Urban Millennials in Indonesia Empirical Study on Mobile Payment Funds," *ADI Journal on Recent Innovation*, vol. 3, no. 2, pp. 121–138, 2022.

[14] S. Atmadja, "A New Method for Obtaining Global Estimates of Maternal Mortality," *ADI Journal on Recent Innovation*, vol. 3, no. 2, pp. 115–120, 2022.

[15] A. Dudhat and M. A. Abbasi, "Discussion of Agile Software Development Methodology and its Relevance to Software Engineering," *ADI Journal on Recent Innovation*, vol. 3, no. 1, pp. 105–114, 2021.

[16] U. Rahardja, A. Moein, and N. Lutfiani, "Leadership, competency, working motivation and performance of high private education lecturer with institution accreditation B: Area kopertis IV Banten province," *Man India*, vol. 97, no. 24, pp. 179–192, 2018.

[17] U. Rahardja, E. P. Harahap, and S. R. Dewi, "The strategy of enhancing article citation and H-index on SINTA to improve tertiary reputation," *Telkomnika (Telecommunication Computing*

Electronics and Control), vol. 17, no. 2, pp. 683–692, 2019, doi: 10.12928/TELKOMNIKA.V17I2.9761.

[18] Q. Aini, M. Budiarto, P. O. H. Putra, and U. Rahardja, "Exploring E-learning Challenges During the Global COVID-19 Pandemic: A Review," *Jurnal Sistem Informasi*, vol. 16, no. 2, pp. 57–65, 2020.

[19] Sudaryono, U. Rahardja, and E. P. Harahap, "Implementation of Information Planning and Strategies Industrial Technology 4.0 to Improve Business Intelligence Performance on Official Site APTISI," *Journal of Physics: Conference Series*, vol. 1179, no. 1, pp. 0–7, 2019, doi: 10.1088/1742-6596/1179/1/012111.

[20] U. Rahardja, Q. Aini, Y. I. Graha, and M. R. Tangkaw, "Gamification Framework Design of Management Education and Development in Industrial Revolution 4.0," *Journal of Physics: Conference Series*, vol. 1364, no. 1, pp. 0–13, 2019, doi: 10.1088/1742-6596/1364/1/012035.

[21] I. Maulid and A. Amirsyah, "Analysis of the Hajj Fund Management Based on the Fatwa of the National Sharia Council (DSN) Number 122 Concerning the Management of BPIH Fund and Special BPIH Based on Sharia Principles," *ADI Journal on Recent Innovation*, vol. 3, no. 1, pp. 21–35, 2021.

[22] M. W. Akira, H. Haritsah, A. Zulfia, and E. Prajatelistia, "Mechanical and tribological properties of nano-sized Al2O3 particles on ADC12 alloy composites with Strontium modifier produced by stir casting method," *ADI Journal on Recent Innovation*, vol. 3, no. 1, pp. 9–20, 2021.

[23] A. Hayat and A. H. Arribathi, "Multicam Studio Design Using Vmix As A Learning Media In SMK Bina Am Ma'mur: Leon Yudi Haryanto," *ADI Journal on Recent Innovation*, vol. 3, no. 1, pp. 1–8, 2021.

[24] Q. Aini, U. Rahardja, and A. Khoirunisa, "Blockchain Technology into Gamification on Education," *IJCCS (Indonesian Journal of Computing and Cybernetics Systems)*, vol. 14, no. 2, pp. 147–158, 2020.

[25] Q. Aini, A. Badrianto, F. Budiarty, A. Khoirunisa, and U. Rahardja, "Alleviate Fake Diploma Problem In Education Using Block Chain Technology," *Journal of Advanced Research in Dynamical and Control Systems*, vol. 12, no. 2, pp. 1821–1826, 2020, doi: 10.5373/JARDCS/V12I2/S20201225.

[26] U. Rahardja, T. Hariguna, and Q. Aini, "Understanding the impact of determinants in game learning acceptance: An empirical study," *International Journal of Education and Practice*, vol. 7, no. 3, pp. 136–145, 2019, doi: 10.18488/journal.61.2019.73.136.145.

[27] P. A. Sunarya, U. Rahardja, L. Sunarya, and M. Hardini, "The Role Of Blockchain As A Security Support For Student Profiles In Technology Education Systems," *InfoTekJar: Jurnal Nasional Informatika dan Teknologi Jaringan*, vol. 4, no. 2, pp. 203–207, 2020.

[28] E. Guustaaf, U. Rahardja, Q. Aini, H. W. Maharani, and N. A. Santoso, "Blockchain-based Education Project," *Aptisi Transactions on Management (ATM)*, vol. 5, no. 1, pp. 46–61, 2021.

[29] Q. Aini, S. Riza Bob, N. P. L. Santoso, A. Faturahman, and U. Rahardja, "Digitalization of Smart Student Assessment Quality in Era 4.0," *International Journal of Advanced Trends in Computer Science and Engineering*, vol. 9, no. 1.2, pp. 257–265, Apr. 2020, doi: 10.30534/ijatcse/2020/3891.22020.

[30] R. Mitchell, L. Schuster, and J. Drennan, "Understanding how gamification influences behaviour in social marketing," *Australasian Marketing Journal*, vol. 25, no. 1, pp. 12–19, 2017.