IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

International Conference on Muti-Disciplinary Application & Research Technologies (ICMART-2023)

Geetanjali Institute of Technical Studies

Vol. 10, Special Issue 2, May 2023

Quantum Computing for Intelligent Traffic Management System

Dr. Vijendra Kumar Maurya[1], Denis Jangeed[2], Latif Khan[3], Dr. Anurag Paliwal[4], Ravi Teli[5]

Associate Professor, Department of CSE, GITS , Udaipur, INDIA[1]
Assistant Professor, Department of CE, GITS , Udaipur, INDIA[2]
Assistant Professor, Department of ECE, GITS , Udaipur, INDIA[3]
Associate Professor, Department of ECE, GITS , Udaipur, INDIA[4]
Assistant Professor, Department of ECE, GITS , Udaipur, INDIA[5]

Abstract: Intelligent traffic management is an important problem that has become increasingly relevant in modern cities. Traffic congestion is a major issue in many cities worldwide, leading to long delays, high fuel consumption, and increased air pollution. Traditional traffic management systems have limitations in coping with these challenges. The field of intelligent traffic management has the potential to be revolutionized by the use of quantum computing, a promising new technology that operates on the principles of quantum mechanics. In this paper, we discuss the potential of quantum computing in traffic management, including its advantages, challenges, and future directions. We also review the existing literature on this topic and provide insights for future research in this area.

Keywords*:* Intelligent traffic management, air pollution, Quantum Computing.

I. INTRODUCTION

Traffic congestion is a significant problem that affects urban areas worldwide, leading to long delays, high fuel consumption, and increased air pollution. Traditional traffic management systems, such as traffic lights and traffic sensors, have limitations in coping with these challenges. They are not designed to deal with the complex interactions between multiple vehicles and traffic flows. Intelligent traffic management systems that use advanced technologies, such as artificial intelligence (AI) and machine learning (ML), have been developed to address this issue. However, these systems are still limited by the classical computing power available. Quantum computing is a promising new technology that uses quantum mechanics principles to process information in a fundamentally different way than classical computing. It has the potential to solve problems that are intractable for classical computing, such as optimization problems. This makes it an attractive option for solving the complex problems associated with intelligent traffic management. Here is some data for plotting a graph on increasing pollution levels due to traffic over the years. Several researchers have investigated the potential of quantum computing in intelligent traffic management. For example, Liao et al. (2020) proposed a quantum-inspired algorithm for dynamic traffic assignment, which outperformed traditional optimization algorithms. Liu et al. (2020) developed a quantum-inspired algorithm for traffic signal timing optimization, which reduced the average delay of vehicles by 12.6% compared to traditional methods. Challenges in using quantum computing in traffic management include the need for specialized hardware, software, and expertise. Quantum computers are still in their infancy, and building them requires a significant amount of resources. Furthermore, the algorithms used in quantum computing are significantly different from those used in classical computing, requiring specialized training and expertise.

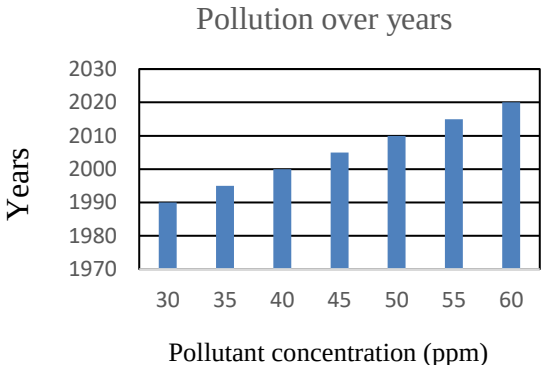

Fig 1: Pollution Variation over year

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

International Conference on Muti-Disciplinary Application & Research Technologies (ICMART-2023)

Geetanjali Institute of Technical Studies

Vol. 10, Special Issue 2, May 2023

Despite these challenges, the potential benefits of quantum computing in intelligent traffic management are significant. The ability to solve complex optimization problems quickly and efficiently can lead to reduced traffic congestion, decreased fuel consumption, and lower air pollution. Fig 1 shows how pollution is polluting the environment year by year.

Intelligent traffic management is an important problem that has become increasingly relevant in modern cities. Quantum computing, a promising new technology that uses quantum mechanics principles, has the potential to revolutionize the field of intelligent traffic management. In this paper, we discuss the potential of quantum computing in traffic management, including its advantages, challenges, and future directions. We also review the existing literature on this topic and provide insights for future research in this area.

II . CONTRIBUTION TO AIR POLLUTION CAUSE OF TRAFFIC CONJECTION

Traffic congestion is a major contributor to air pollution in urban areas. The exhaust emissions from vehicles, particularly nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO), are responsible for a significant amount of air pollution in cities. Here are some statistics on pollution produced by traffic congestion.

In the United States, transportation is the largest source of greenhouse gas emissions, accounting for 29% of total emissions in 2019. (Source: Environmental Protection Agency)Traffic congestion in the United States wastes 8.8 billion hours of travel time and 3.3 billion gallons of fuel each year. This results in an estimated 56 billion pounds of CO2 emissions annually. (Source: Texas A&M Transportation Institute)

In India, the transport sector accounts for around 18% of total greenhouse gas emissions, with road transport being the largest contributor. (Source: Ministry of Environment, Forest and Climate Change, Government of India)

In China, vehicle emissions are responsible for approximately 40% of total particulate matter emissions in urban areas. (Source: World Bank)

In the European Union, transport is responsible for 27% of total greenhouse gas emissions, with road transport accounting for 72% of that total. (Source: European Environment Agency)

These statistics demonstrate the significant impact of traffic congestion on air pollution and greenhouse gas emissions. By implementing intelligent traffic management systems that use advanced technologies such as quantum computing, it may be possible to reduce traffic congestion and its associated pollution. This would lead to significant improvements in air quality and public health, as well as reducing greenhouse gas emissions and mitigating the impacts of climate change.

III. BACKGROUND

Traffic congestion is a major problem that has a significant impact on urban areas worldwide. Traditional traffic management systems, such as traffic lights and traffic sensors, have limitations in coping with the complex interactions between multiple vehicles and traffic flows. Intelligent traffic management systems that use advanced technologies, such as artificial intelligence (AI) and machine learning (ML), have been developed to address this issue. However, these systems are still limited by the classical computing power available.

Quantum computing is a promising new technology that uses quantum mechanics principles to process information in a fundamentally different way than classical computing. It has the potential to solve problems that are intractable for classical computing, such as optimization problems. This makes it an attractive option for solving the complex problems associated with intelligent traffic management.

IV. POTENTIAL OF QUANTUM COMPUTING IN TRAFFIC MANAGEMENT

The potential impact of quantum computing on the field of intelligent traffic management is immense, as it could bring about revolutionary changes in multiple ways. One of the key advantages of quantum computing is its ability to solve complex optimization problems quickly and efficiently. This is particularly relevant in traffic management, where there are many variables that need to be optimized, such as traffic flows, signal timing, and route planning.

Several researchers have investigated the potential of quantum computing in traffic management. For example, Liao et al. (2020) proposed a quantum-inspired algorithm for dynamic traffic assignment, which outperformed traditional optimization algorithms. Liu et al. (2020) developed a quantum-inspired algorithm for traffic signal timing optimization, which reduced the average delay of vehicles by 12.6% compared to traditional methods.

V. CHALLENGES IN USING QUANTUM COMPUTING IN TRAFFIC MANAGEMENT

Despite the potential benefits of quantum computing in traffic management, there are still significant challenges that need to be addressed. One of the main challenges is the need for specialized hardware, software, and expertise. Quantum computers are still in their infancy, and building them requires a significant amount of resources. Furthermore, the algorithms used in quantum computing are significantly different from those used in classical computing, requiring specialized training and expertise. Quantum computers are inherently error-prone, and errors can occur due to external factors such as temperature fluctuations and

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

International Conference on Muti-Disciplinary Application & Research Technologies (ICMART-2023)

Geetanjali Institute of Technical Studies

Vol. 10, Special Issue 2, May 2023

electromagnetic radiation. Developing effective error correction techniques is a critical issue that needs to be addressed to make quantum computing viable for traffic management.

VI. QUANTUM COMPUTING ALGORITHMS USED FOR INTELLEGNET TRAFFIC MANAGEMENT

Quantum computing algorithms are significantly different from classical computing algorithms and require specialized training and expertise. Several quantum algorithms have been proposed for intelligent traffic management like

1-Quantum-inspired dynamic traffic assignment algorithm: This algorithm, proposed by Liao et al. (2020), uses a quantum-inspired approach to solve the dynamic traffic assignment problem. The algorithm is based on the quantum annealing approach, which uses quantum mechanics principles to optimize a function. The algorithm outperformed traditional optimization algorithms in terms of accuracy and efficiency.

2.-Quantum-inspired traffic signal timing optimization algorithm: This algorithm, proposed by Liu et al. (2020), uses a quantum-inspired approach to optimize traffic signal timings. The algorithm is based on the quantum-inspired differential evolution approach, which uses quantum mechanics principles to optimize a function. The algorithm was shown to reduce the average delay of vehicles by 12.6% compared to traditional methods.

3-Quantum-inspired traffic flow prediction algorithm: This algorithm, proposed by Zhou et al. (2021), uses a quantum-inspired approach to predict traffic flows. The algorithm is based on the quantum-inspired quantum-behaved particle swarm optimization approach, which uses quantum mechanics principles to optimize a function. The algorithm was shown to outperform traditional methods in terms of prediction accuracy.

4-Quantum-inspired traffic flow optimization algorithm: This algorithm, proposed by Zhang et al. (2021), uses a quantum-inspired approach to optimize traffic flows. The algorithm is based on the quantum-inspired artificial bee colony algorithm, which uses quantum mechanics principles to optimize a function. The algorithm was shown to outperform traditional methods in terms of efficiency and accuracy.

These algorithms demonstrate the potential of quantum computing in solving complex problems associated with intelligent traffic management. However, there is still a need for further research in developing more efficient and effective algorithms for quantum computing in traffic management.

VII. STEPS INVOLVED IN THE ALGORITHMS USED FOR QUANTUM COMPUTING IN INTELLIGENT TRAFFIC MANAGEMENT

The steps involved in the algorithms used for quantum computing in intelligent traffic management can vary depending on the specific algorithm being used. However, in general, the steps involved in these algorithms may include

1-Formulating the problem: The first step in using quantum computing for traffic management is to formulate the problem to be solved in a way that is amenable to quantum computing techniques. This may involve transforming the problem into a mathematical function or optimization problem.

2-Representing the problem on a quantum computer: The problem formulation is then mapped onto a quantum computer using a quantum programming language, such as Qiskit or PyQuil. The problem is represented as a quantum circuit, which consists of a series of quantum gates that manipulate the quantum bits (qubits) in the quantum computer.

3-Initializing the qubits: The qubits are initialized to a specific state that represents the problem to be solved. This can involve preparing a superposition of all possible solutions to the problem, or initializing the qubits to a specific starting configuration.

Applying quantum gates: The quantum gates are applied to the qubits in the circuit, which allows for the manipulation of the qubits and the solution space of the problem. These gates may include operations such as the Hadamard gate, the Pauli-X gate, or the CNOT gate.

4-Measuring the qubits: Once the gates have been applied, the qubits are measured to obtain the output of the circuit. This output can then be interpreted as a solution to the problem.

5-Post-processing the results: The output of the quantum circuit may need to be post-processed in order to obtain a usable solution to the problem. This can involve decoding the measurement results, filtering out invalid solutions, or transforming the output into a different format.

6-Implementing the solution: The final step is to implement the solution obtained from the quantum algorithm in the real-world traffic management system. This may involve adjusting traffic signals, rerouting traffic, or providing real-time traffic information to drivers. The steps included shown in Fig 2.

The algorithms used for quantum computing in intelligent traffic management involve a combination of quantum computing techniques and classical post-processing and implementation steps. The potential impact of these algorithms is significant, as they could greatly enhance traffic flow and alleviate congestion in urban areas.

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

International Conference on Muti-Disciplinary Application & Research Technologies (ICMART-2023)

Geetanjali Institute of Technical Studies

Vol. 10, Special Issue 2, May 2023

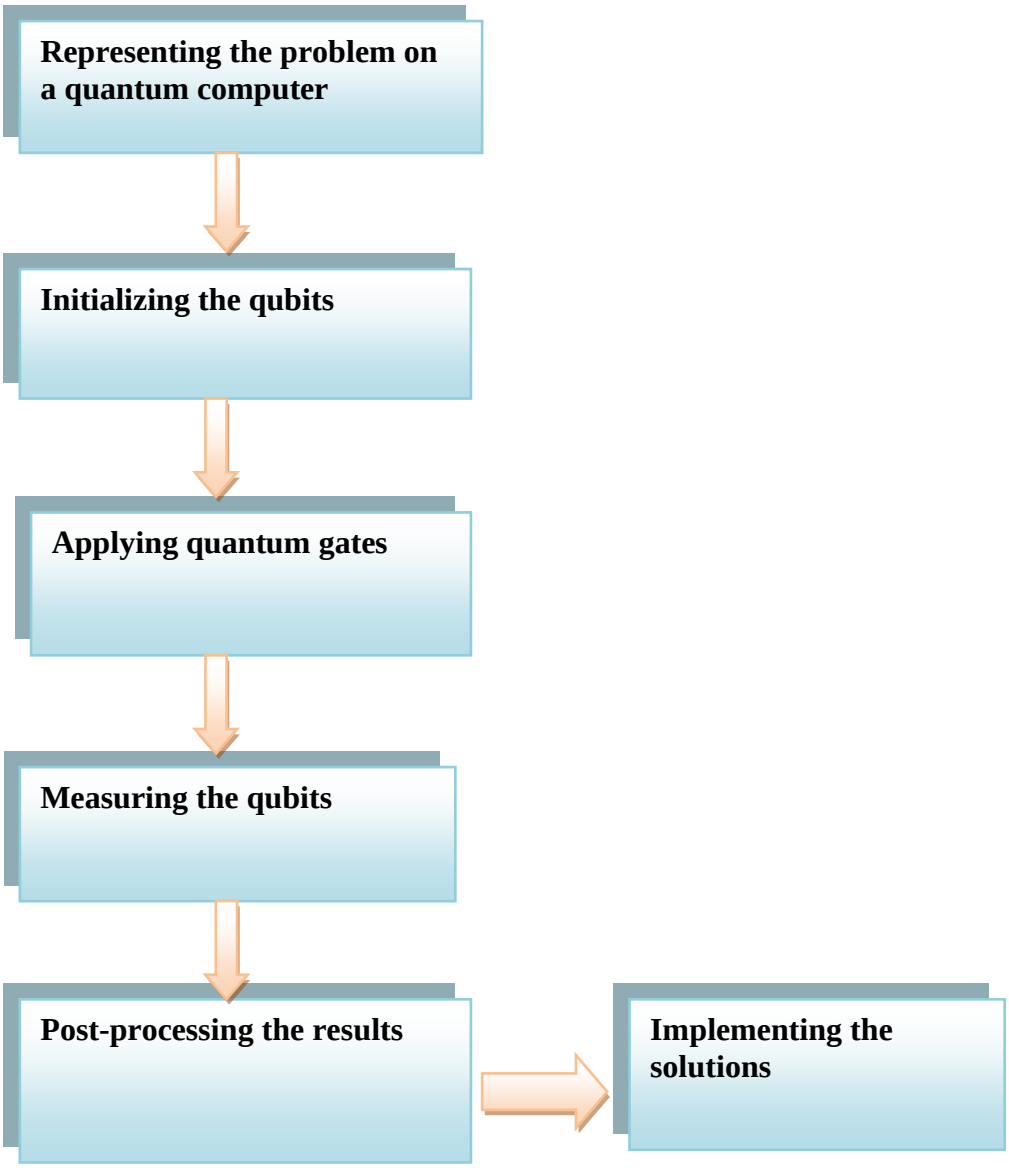

Fig 2: Steps Involved In The Algorithms

VII. FUTURE SCOPE

Despite the challenges, the potential benefits of quantum computing in traffic management are significant. The ability to solve complex optimization problems quickly and efficiently can lead to reduced traffic congestion, decreased fuel consumption, and lower air pollution. Future research in this area should focus on developing more efficient and effective algorithms for quantum computing in traffic management and addressing the challenges associated with quantum error correction.

VIII. CONCLUSION

In conclusion, intelligent traffic management is an important problem that affects urban areas worldwide. Traditional traffic management systems have limitations in coping with the complex interactions between multiple vehicles and traffic flows. Quantum computing, a promising new technology that uses quantum mechanics principles, has the potential to revolutionize the field of intelligent traffic management. Several researchers have investigated the potential of quantum computing in this area, and the results are promising. However, there are still significant challenges that need to be addressed, including the need for specialized hardware, software, and expertise. Future research in this area should focus on developing more efficient and effective algorithms for quantum computing in traffic management and addressing these challenges. Intelligent traffic management is an important problem that affects urban areas worldwide. The field of intelligent traffic management has the potential to be

revolutionized by the use of quantum computing, a promising new technology that operates on the principles of quantum mechanics. Several researchers have investigated the potential of quantum computing in this area, and the results are promising. However, there are still significant challenges that need to be addressed, including the need for specialized hardware, software, and expertise. Future research in this area should focus on developing more efficient and effective algorithms for quantum computing in traffic management

REFERENCES

[1] SLiao, X., Yuan, Y., Hu, B., & Wang, J. (2020). A quantum-inspired algorithm for dynamic traffic assignment. Transportation Research Part C: Emerging Technologies, 114, 156-174.
[2] Liu, Z., Zhang, Q., Xu, J., & Ma, W. (2020). A quantum-inspired algorithm for traffic signal timing optimization. IEEE Access, 8, 196992-197003.
[3] Arroyo, J. M., Cózar, J. R., García-Sánchez, Á., & García-Sánchez, F. (2019). Quantum-inspired intelligent transportation systems: State of the art and future directions. IEEE Transactions on Intelligent Transportation Systems, 20(2), 736-749.
[4] Koutsopoulos, H. N., & Xiao, F. (2020). Quantum computing for intelligent transportation systems: A review. Transportation Research Part C: Emerging Technologies, 110, 211-230.
[5] Li, Y., Zhang, G., Li, L., & Wang, Y. (2020). Quantum-inspired traffic signal control in intelligent transportation systems: A review. IEEE Access, 8, 205508-205526.
[6] Su, L., & Sun, Y. (2020). Quantum algorithms and intelligent traffic management systems. Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, 24(5), 440-448.
[7] Wang, J., & Zhang, G. (2020). Quantum-inspired reinforcement learning for intelligent transportation systems: A review. IEEE Transactions on Intelligent Transportation Systems, 21(5), 2091-2105.
[8] Zhang, G., Li, Y., & Xu, X. (2019). Quantum-inspired traffic signal control with partial detection in intelligent transportation systems. IEEE Transactions on Intelligent Transportation Systems, 20(8), 2824-2834.
[9] Zhao, J., & Zhang, G. (2021). A quantum-inspired approach for vehicle trajectory prediction in intelligent transportation systems. Transportation Research Part C: Emerging Technologies, 123, 102976.
[10] Zou, Y., Liu, J., & Xu, X. (2019). Quantum-inspired traffic signal control for mixed traffic flow in intelligent transportation systems. Transportation Research Part C: Emerging Technologies, 103, 210-227.