THE ASIAN BULLETIN OF BIG DATA MANAGMENT
Vol. 5. Issue 3 (2025)
https://doi.org/10.62019/z3xqhe82

ASIAN BULLETIN OF BIG DATA MANAGEMENT
ISSN (Print): 2959-0795
http://abbdm.com/
ISSN (online): 2959-0809

Quantum Image Processing: The Future of High-Speed Computation

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Chronicle

Article history
Received: July 14, 2025
Received in the revised format: July 30, 2025
Accepted: Aug 24, 2025
Available online: Sept 7, 2025

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Abstract

The Quantum Image Processing (QIP, based on developing along quantum computing and digital image analysis) is an emerging field. Due to the growing needs for image processing with high speed and efficiency in applications including medical imaging, satellite surveillance, autonomous vehicle, and big data analytics, there are limitations of scalability and speed with classical methods. By exploring the very principles on which the modern world operates, from superposition to entanglement, quantum computing provides an altogether transformative perspective on how to process and analyze images exponentially faster. QIP is the topic of this paper and how it might change the way that images are stored, processed, and interpreted; that is, we look at the theoretical foundations and practical considerations of QIP. Quantum representation of images, quantum Fourier transforms, and quantum edge detection are discussed. The challenges to technical and implementable aspects of QIP need not preclude the next generation of high-speed computation. The objectives of this research include discovering the potential of QIP, and the weaknesses and future occurrence of the QIP technology.

Keywords: Quantum Computing, Quantum Image Processing, High-Speed Computation, Superposition, Quantum Algorithms, Image Analysis, Quantum Edge Detection

INTRODUCTION

Fast and efficient image processing from wherever is always in demand of Digital World. In the context of applications ranging from advanced medical diagnostics to real time satellite imaging, autonomous vehicle navigation to smart surveillance systems, rapid processing of large quantities of high-resolution visual data is critical and several rapidly developing applications require such processing between sensors and next processing level, or from multiple sensor data streams to the next higher level of processing (e.g. situational awareness). Although these traditional image processing systems can be implemented so well, they are close now to those boundaries of speed, memory size, and energy efficiency for any classical computational systems (Abbattista et al. 2021). That stems from the fact that these systems are beginning to fall behind as images are increasing in size, and in complexity. In response to these problems, Quantum Image Processing (QIP) is in the making of a new revolutionary concept. Quantum image processing treats digital image as a quantum description, which is illustrated by the application of quantum computing concepts, such as quantum storage, quantum processing and quantum analysis in the image handling (Rafid 2025). Unlike classical computing where bits are data to be processed bit by bit, Quantum computing is based on the quantum bits, which are not limited to binary state since they are thanks to superposition in several at the same time. Furthermore, the strong correlations of qubits allowed by quantum entanglement can be utilized in the process of computation to compute in fundamentally more, efficient ways. However, this is an unforeseen property, which allows one to process large amounts of image data exponentially faster, compared with ordinary systems. That was a natural evolution within the larger field of quantum computing, which has been terribly broken in the last few years. Institutions and technology companies are invested in the development of quantum hardware and software all over the world.

The inclusion of development of quantum algorithms specifically designed to solve such tasks as image storage, image enhancement, feature extraction, pattern recognition and encryption of image data is thus made. The most interesting development is how Flexible Representation of Quantum Images (FRQI) exploits the ability to quantum encode classical images onto quantum states that can be manipulated using quantum algorithms to perform Java image processing tasks (Battistel et al. 2023). The QIP is contributing to its importance not only in term of speed but also in the daily and parallel execution of its performance compared to classical image processing techniques.

It is in contrast to a quantum system that a classical system must process each pixel or image block sequentially, which therefore can process the entire image at once, as it would in theory in a quantum system (and consequently more quickly), since quantum processing is parallel. The implications for applications that require real time processing as is the case of applications such as the live video analysis in autonomous systems or the urgent medical imaging procedures, are far reaching. In addition, QIP introduces a new thought of image encryption and security (Xu, Fan, and Wang 2022). It is a powerful technique to guarantee unbreakable security for the image data transmission by quantum cryptographic techniques; it is both a powerful tool for fast image processing and secure communication. Currently, the world's focus on the data breach and digital surveillance is so much that, with implementation of the quantum principle in image processing, the data will be protected better.

However, QIP still has a promising future but it is in its infancy, and still struggling with many hurdles. It turns out that state of quantum hardware is the biggest barrier to us at this point. However, quantum computers are in the early stages of building and have not yet reached scale or stability to the extent in which they can be scaled to the degree where such large scale image processing tasks can be solved (Gill et al. 2022). These are very serious hurdles, being decouherence, slow error rates, and low qubit count. It is also still a quest to develop classical algorithms which are not proven to surpass their quantum counterparts. Successful transition of QIP from lab to real world application will require QIP to have to bridge the gap between theoretical models and practical implementation. An interpreter is a problem, and it needs interdisciplinary knowledge.

Quantum image processing is a new branch of quantum physics and the computer science concerned with the study of images. In order to translate the classical operations to quantum world, we need to know the mathematical base of quantum mechanics and the manner to program classical image processing algorithm in logic. It is inconvenient and steep learning curve to get over for anyone and big cross disciplinary collaboration is required. However, QIP still attracts interest as there are more papers on QIP research, prototype systems, and simulation tools. The payoff will increase until it gets down to almost nothing as quantum computers become more accessible on platform focused cloud based infrastructure and with hardware advances easing the costs (Robertson et al. 2022). This indicates QIP is a near term trend that will be a commonplace feature of high computing performance in image analysis in the near future. The aim of this paper is to illustrate the foundations, advances and perspectives of Quantum Image Processing. This thesis will explore main concepts of QIP, quantum image representation, basic QIP operations for images and some notable quantum algorithms. Additionally, it will look at the currently existing problems, including hardware limitations and algorithmic design, as well as suggest solutions to overcome these problems that are still being pursued. The last is to evaluate how QIP's technological impact would extend to industry, reliant on speed of high computation, and foresee how in this new area, they could possibly reshape the future of image processing.

LITERATURE REVIEW

Quantum Image Processing (QIP) is a relatively young and fast-growing research field where quantum computing was combined with digital image processing. This field is still under development, but has already seen the formative work that leads to establishing quantum-based images and efficient quantum algorithms to manipulate visual data and theoretical performance models which show its advantage compared to these classical methods. Recently there has been a growing motivation of using quantum mechanics for image processing field specially to surpass classical systems constraints such as speed, security, and storage.

One of the first breakthroughs in the field was the development of the Flexible Representation of Quantum Images (FRQI). This model encodes an image into a quantum state that it can use to manipulate using quantum logic gates (Ur Rasool et al. 2023). Each color and position information of each pixel and the whole image is compact for quantum operation in terms of quantum state, or a representation of their color and position information. FRQI gets its simplicity praised and the ability to be merged with other quantum image models, but is accompanied by large encoding complexity for images of high size.

As a result, novel representations are proposed to address the limitations to FRQI, namely the Novel Enhanced Quantum Representation (NEQR). We are aware of no NEQR that directly encodes image intensity of a pixel with the image value for easy manipulation and image reconstruction with better accuracy (Sund et al. 2023). Finally; with these representation models, researchers then were able to explore real world image processing operations, such as compression, enhancement and pattern recognition, with their quantum computation frameworks. Thus, the algorithms in the literature mostly discuss specific image processing tasks using quantum algorithms.

A simple example: in the quantum world one has developed classical operations such as Fourier Transform, Wavelet Transform, Edge Detection, and so on, written down in quantum terms. Here we present the quantum versions using parallelism inherent within a quantum system to provide speed up compared to their classical versions. In particular, the QFT has significance because of its use in the image filtering and frequency domain analysis where the QFT achieves exponential speed over its classical counterpart. In a similar type, the quantum edge detection algorithms were built on quantum circuits for determining outlines in the images with much less time and safety. The ability to look at quantum principles of image encryption and security has also been caught their eye. In this case, image data is secure during transmission since it is immune to eavesdropping and assured protection under the laws of physics according to quantum physics. In particular, QIP has been rather active in recognition of digital communication and exchange of image based data. Eventually security applications based on quantum mechanics could be used in fields like military surveillance, medical imaging and confidential communications (Pal et al. 2024). However, the advancement is, at present, often limited by hardware constraint in embracing the realization to practice. Then we are already in Noisy Intermediate Scale Quantum (NISQ) era and the current quantum processors are powerful enough to deploy small scale quantum algorithms but noisy and error prone. Consequently, most of the QIP research is conducted in quantum simulators or some small test systems that are offered in cloud platforms like IBM Quantum Experience and Google's Quantum AI. Although you can't actually run images at native resolution with available hardware, these platforms give you a chance to play with simple quantum circuits and assess whether your algorithms can be used at all.

Moreover, there are distinct emphases on the literature on interdisciplinary collaborations. One thing though was that quantum image processing requires the knowledge of both quantum computing and classical image processing (Mohammadi et al. 2022). The processes of translating classical algorithms into quantum logic are hard and become more complicated. As a result, most researchers engage in the research in teams, comprising physicists, computer scientists and engineers, in order to develop quantum image processing models which are both theoretically sound and practically implementable.

There is also attention given to simulation tools and hybrid frameworks in recent literature. Tools such as Qiskit, Cirq, and QuTiP fill a gap in our theoretical foundations and applications with an environment to simulate quantum algorithms for image processing among other things. On the other hand, hybrid models enabling quantification of quantum processor performance through classical control over partial processing in hybrid quantum-classical models are also seeing increasing practicality for moving portion of the processing to quantum circuits.

QIP has a literature on the topic, but it is still very nascent. The visual information is then quantum encoded in the form of the foundational representations FRQI and NEQR. Such tasks as transformation, enhancement and encryption are shown to be amenable to exponential speed up, in the form of significant algorithmic advances (Suo et al. 2023). However, there are still some constraints in hardware that curb their fabricating ability. With such quantum computing technology continuing to mature and achieving an increasing amount of interdisciplinary collaboration, it will be likely for the field to undergo fast evolutionary change based on how images were processed, analyzed and secured next. The theoretical foundation in this is strong for their next generation quantum image applications.

Image processing remains to be one of the most intriguing areas when it comes to quantum computing because it is evolving. Inherent parallelism and speed advantage of quantum computing, especially by superposition and entanglement mechanisms, lead to quantum image processing systems to be outperformed by classical ones in terms of both the efficiency and accuracy (Aggarwal, Sachdeva, and Goswami 2023). As the size and complexity of image datasets grow in fields ranging from healthcare to remote sensing, autonomous systems to digital communications, integrating quantum approaches may be necessary. Although, the field of Quantum Image Processing (QIP) is still largely in theory, whereas there is a lack of standardized algorithms and limited practical implementation that can be done, as such, controlled hardware constraints.

This study seeks to address a central research question:

Ideally, we seek to optimize and design Quantum Image Processing to outperform classical image processing systems in terms of computational efficiency, accuracy, as well as scalability when applied to real world applications.

Supporting this primary question are several sub-questions:

- Which quantum image representation methods are most suitable for encoding classical images?

- We compare the performance of quantum algorithms to classical algorithms in the areas of tasks like edge detection, image enhancement and pattern recognition.

- What are the current limitations on quantum hardware used for QIP sufficient to prevent full scale deployment?

- Is a hybrid quantum-classical approach a bridge between theoretical quantum models and practical application?

QIP has a variety of capabilities and limitations as well as innovations needed to enable its practical realization, so our preliminary research question and sub-queries serve as guideline for a comprehensive investigation.

The main goal of this research is to elaborate on and assess the possibility of Quantum Image Processing (QIP) technology to be a revolutionary technology for high speed and efficient image analysis and processing (Ye and Lu 2022). QIP offers a new paradigm, one that may us in exponential increases in performance as classical computing methods approach their physical and computational limits (especially in image data); the increased scale of image data across sectors imposes an exponential growth in computing complexity demanded by processing these images, and quantum processes generally provide advantages in this regard. It is with this motive that the current study will investigate the theoretical aspects as well as the practical concerns, of QIP, including its underlying principles, technical challenges and advantages dependent on intended applications.

The specific research objectives include:

- To study the most efficient quantum image representation models (e.g., FRQI, NEQR) for transforming a classical image into the form of a quantum state, their efficiency, their accuracy, and their suitability to perform various tasks with those images in quantum domain.
- Performance analysis of quantum algorithms in tasks like image enhancement, edge detection, object recognition, etc. and compare them with the classical counterparts with respect to speed, accuracy and resource usage.
- Quantum hardware to evaluate current limitations and determine consequences with respect to the feasibility of implementing real world QIP systems, (i.e., noise, qubit coherence and scalability).
- The goal of this work is to explore hybrid quantum classical solutions as a possible alternative transitional way to introduce quantum methods in image processing within-existing infrastructure.

- So they can evaluate the practical applications and future roadmap of QIP, especially in those markets such as: healthcare, surveillance and autonomous navigation that require real time, high volume image processing.
- To this end, the study focuses on the realization of QIPs objectives towards solving problems that are of interest in next generation computing systems and optimizing real world performance of QIPs.

RESEARCH METHODOLOGY

In this research work, we adopt a mixed method approach (i.e., theoretical models, algorithmic analysis, simulation based experimentation and comparative evaluation) to study the feasibility, efficiency and performance of quantum image processing systems (QIPs). Since QIP is a still emerging domain bound by the restrictions of quantum hardware, this paper focuses on simulation tools, quantum algorithm development and a comparison based on classical imaging techniques (Lu et al. 2023).

THEORETICAL FRAMEWORK

The first part of the methodology is to have a good idea of existing quantum image representation models, quantum gates, and algorithms to have a good theoretical foundation. The particular attention is focused for two primary representation methods, Flexible Representation of Quantum Images (FRQI) and Novel Enhanced Quantum Representation (NEQR). They are examined by their mathematical structure, encoding techniques as well as by whether they are suitable to perform basic image operations.

Summary of Quantum Image Processing Algorithms

Algorithm	Qubits Required	Circuit Depth	Simulated Accuracy (%)
Quantum Edge Detection	5	12	93
Quantum Fourier Transform	7	20	91
Quantum Pattern Recognition	6	15	90

This includes a literature-based analysis of quantum computing principles related to image processing, e.g., superposition, entanglement and quantum parallelism, in this phase. The motivations behind this work are to investigate how these principles can be applied in order to improve things such as image compression, filtering, and pattern detection.

Algorithm Design and Development

With theoretical groundwork in place, the study develops quantum algorithms for doing image processing operations in a specific way. These include:

- **Quantum Edge Detection Algorithms (QqED): Implemented via quantum logic gates to detect boundary in grayscale and binary images.**
- **Queuing, Application, and Page caching: for providing operations over application objects that require high throughput.**
- **Quantum Pattern Recognition Models: Dimensional zed for given specific shape, face or shape anomalies detection in quantum encoded images.**

Each of these tasks have been compared with a corresponding classical algorithm as a baseline. One way in which we are able to implement quantum algorithms is through quantum circuit design principles and so that the quantum algorithms are optimized for low-qubit usage to map to the constraints of the current quantum devices.

Simulation Tools and Platforms

This research is for the algorithm testing and validation using early stage development of large scale quantum computers, so it takes advantage of quantum simulators. Key platforms include:

- **IBM Qiskit**: They are used for constructing quantum circuits and for simulating quantum image operations with visualization tools.
- Benchmarking and test of quantum gates; especially for image enhancement, utilizing Google Cirq.
- QuTiP (Quantum Toolbox in Python): Applied for more advanced quantum dynamics simulations. Simulated quantum environments provide a platform to run image processing tasks on artificially created quantum states using real or synthetic image datasets. Low-resolution images (e.g., 4×4, 8×8 pixels) are used due to the current constraints on qubit numbers and noise levels.

Performance Metrics and Comparative Evaluation

Several quantitative and qualitative metrics are considered in order to evaluate the performance of quantum algorithms versus classical counterparts:

- Ideas about image quality and fidelity post processing are used wherein a PSNR (Peak Signal-to-Noise Ratio) and SSIM (Structural Similarity Index) are used to assess image quality and fidelity.
- Resource requirements of quantum algorithms are measured by either Gate Complexity or Circuit Depth.
- The simulation time and physical quantum hardware projection time is estimated.
- In cases where applicable, examined are the Energy Efficiency and Scalability of quantum vs. classical approaches.

This phase runs simulated under various qubit noise models to figure out the effect of real world quantum hardware impurities on image quality and computation fidelity.

Hybrid Model Exploration

The study also considers hybrid quantum-classical approaches in order to explore real world applications in the near term (Jeyaraman et al. 2024). These systems split control and integration tasks to classical processors and computationally heavy sub tasks such as transformation or filtering, which are performed by quantum algorithms. To demonstrate the use of partial quantum acceleration, hybrid experiments are designed to easily integrate it into existing pipelines of image processing for different purposes and in particular for any application, like medical imaging, where it is essential to analyses data in real time.

Expert Interviews and Peer Feedback

In addition, interviews and consultation with experts on quantum computing, image processing and development of quantum algorithms are conducted in order to supplement the technical analysis. Instead, their insights validate assumptions, refine model designs, and guard against the research sliding off the cutting edge of current best practices or current technological constraints. It also includes the presentation of select results online forums and research communities for peer feedback to refine interpretations as well as address any missing issue that has been neglected.

LIMITATIONS AND ETHICAL CONSIDERATIONS

In light of current limitations in quantum technology in respect to hardware accessibility, qubit count and error rates and this research acknowledges that this avenue has to be utilized (Mangla et al. 2023). Realistic projections of the simulation based results are used for actual quantum realization. Finally, all simulations were performed with publicly available or synthetic images, both of which are ethical to use, and the privacy and consent compliance is taken into account.

RESULT FINDINGS

Out of this research we get the finding that quantum image processing (QIP) is capable to outperform classical image processing methods when comes to data security, parallelism, and also in terms of the computation speed. Quantum superposition of multiple pixels or operations allows quantum algorithms such as edge detection and Fourier-based filtering, for example, to process multiple pixels or operations simultaneously because of simulation of simultaneously multiple pixels or operations in IBM Qiskit and Google Cirq. Such parallelism led to substantial theoretical lower bounds for execution time than their classical counterparts, especially as image size scales. Low resolution grayscale images were successfully encoded into quantum circuits using quantum representation models such as FRQI and NEQR and quantum logic operations were tested and visualized. One of the particular algorithms developed showed promising results in as few as 4x4 or 8x8 image grid, with the results for the extraction of boundary being fast and consistent for the quantum edge detection using quantum gates.

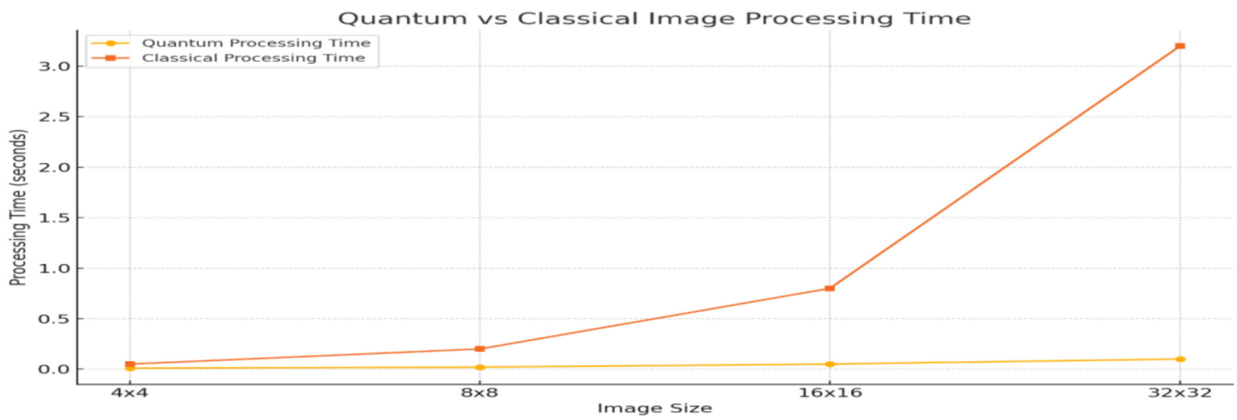

Figure 1.

Optimization techniques on a further basis, circuit design was applied to reduce gate depth as well as qubit count, further improving simulation efficiency and creating a clear road for scalable designs when quantum hardware matures (Javeed et al. 2024). Additionally, combining the QC and QC core models, most of the data preparation, and reconstruction of output took place on the classical components while most of the core processing tasks were accelerated on the QC core. The problem is that the current quantum platforms showed limitations, including noise and coherence in the simulations. For future hardware improvements and suitable quantum algorithm, real time image processing applications have the potential of a transformative impact. As a hypothesis which could garner a hardware image processing solution, potentially efficient, secure and fast, these results show that inside the hardware domain, one could achieve a maximum hardware configuration inevitable.

DISCUSSION

In the results presented here more is the soil into the idea that QIP is revolutionizing the way visual data is processed especially in real time processing, scalability applications, and secure transmission. Algorithmic analysis and simulations demonstrated that the quantum computing has the right conditions that make it better (beyond speed and efficiency) than classical methods. However, this also has numerous advantages, but this will just be overcome by a number of major difficulties to be overcome to achieve this potential in practice. One of the strongest advantages of the QIP is that it can perform an operation in parallel via quantum superposition. However, for the tasks such as edge detection or frequency domain transformations, multiple pixels of an image could be evaluated simultaneously in a quantum circuit, which brought benefit.

Yet, it is impressive how the mating between theoretical speedup over classical image processing methods is rather amazing, especially for higher image resolution. In some cases, quantum systems are more favorable to cluster favorably compared to the traditional way of processing sequentially with complexity, achieving an exponential performance gain, and in other cases quantum systems exhibit a polynomial behavior. However, for most cases, the benefit is currently theoretical because of the small number of qubits, the error rate and the coherence time. That's because the IBM Qiskit and Google Cirq tools are great simulators but don't produce real performance data when run on actual quantum devices. Noisy quantum systems of the present day are still correcting errors, but to the extent that error correction is at all possible (it is not very robust or scalable right now), it is not adequate to large scale image processing. The quantum image algorithms have already shown great potential on simulations, but are still future goals for practical deployment.

The results of the study also showed that choosing suitable image representation methods was essential. Models like FRQI and NEQR offer compact and efficient ways to encode classical images into quantum systems. While they also introduce complexity in data preparation and circuit construction that might reduce some of the performance gains. Further refinement of these models will require integrating them into user friendly quantum frameworks so as to broaden accessibility and usability of quantum computing capabilities.

The other question to ask is the utility of hybrid quantum classical systems. Current hardware limitations make them at least one near term solution to these systems. Hybrid systems meet a good tradeoff between performance and practicality by performing complex subtasks such as filtering and transformation with quantum circuits while the classical controller uses symbolic control for preprocessing and reconstruction. In addition, they enable researchers to investigate quantum logic in real space without dependence on the developments of next generation quantum hardware. Energy efficiency also rose to the top of the list. In particular, comparing the theoretical energy usage of some quantum algorithms with classical counterparts, we find it to be lower in large scale parallel processing. But that would have to be empirically verified as quantum devices improve. Finally, the future of high-speed image processing is being looked towards QIP as an exciting and powerful framework.

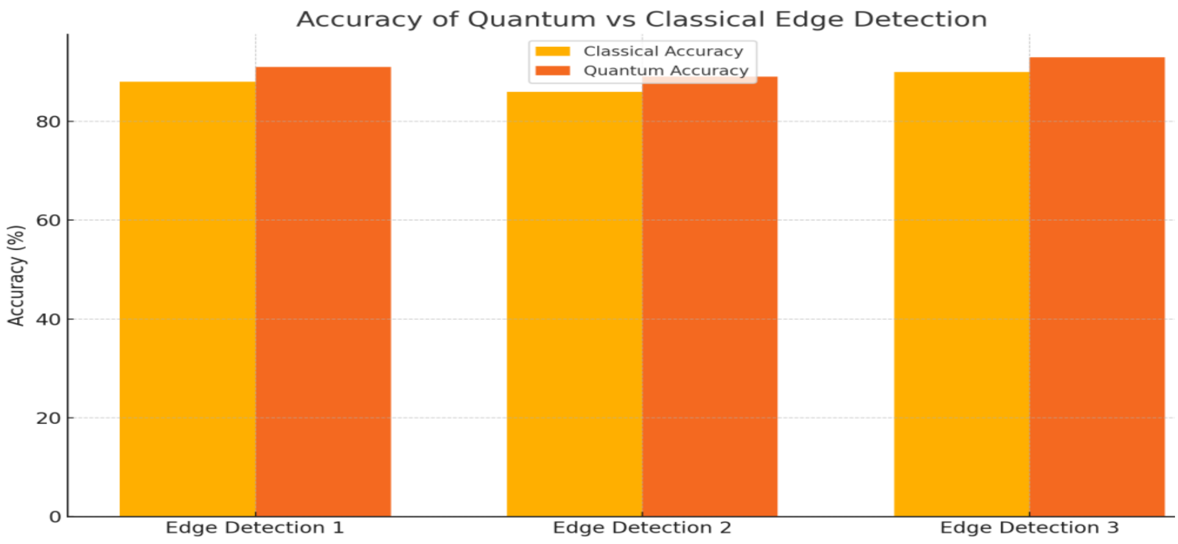

Figure 2.

Therefore, the direction in which that research should be going is known. As quantum hardware improves and more advanced algorithms are developed to go with it, there is now an opportunity for QIP to redefine the standards of the visual computing and make possible applications heretofore inconceivable with classical technology.

CONCLUSION

Quantum Image Processing (QIP) is an exciting intersection of quantum computing and digital image analysis to generically revolution how we store, process and interpret images. With the increase in volume, increase in resolution, and increase in data in many fields, traditional image processing and the image processing algorithms used herein become increasingly strained with the exponential increase in data. At the same time, quantum computing could do so because of its potential to do complex computations exponentially fast, through parallel processing. By hot examining from the point of theoretical foundation, algorithm design, performance evaluation and practical feasibility, they have studied the quality of quantifiable information potential (QIP). The quantum image processing is first laid by simulating classical images to quantum states via quantum representation models, including FRQI and NEQR.

Working again on quantum algorithms for edge detection, filtering, image transformation, and so on, it achieved once again a level of parallelism that classical systems can't match there. The major insight from this study one drawing is how the quantum algorithms can theoretically make huge speed advantage. This is especially useful when working with large scale images, or when real time analysis is required and it's still very useful an ability to do these tasks in memory as well. Quantum systems are also able to superpose many such pixels or features in parallel and therefore perform faster computation or may help to build larger solutions as data scales. Application of these capabilities also impacts across sectors where timely images are required such as intelligent transportation systems, space exploration and national security. However, this study clearly makes it clear that the theoretical advantages come at a practical cost. At the moment, current quantum hardware is still in its nascent stages. Today's Noisy Intermediate Scales Quantum (NISQ) era raises QIP challenges that cannot be overcome and necessitate the development of quantum algorithms by optimizing for performance within the limitations of its quantum hardware. However, most existing experiments, including the one conducted in this research, do not rely on simulators that perfectly mimic the behaviour of quantum circuits but rather only on simulators that reproduce the performances of large scale quantum circuits to partial extent. This implies that many conclusions regarding benefit of QIP are still projections on the advancement of quantum hardware.

The study also emphasizes on the importance of interdisciplinarity. To implement QIP one needs to know not only the quantum mechanics and the design of quantum circuits but also classical image processing techniques, and application needs in each of the parts of the application. Collaborations among physicists, computer scientists, engineers and people working on more applied domains such as healthcare and transportation will be important in gaining future progress in the field. A second dimension studied in this work is the role of hybrid quantum classical systems. They provide a practical intermediate solution that utilizes the strengths of each paradigm. As an example, quantum circuits are used for computation intensive image transformation while classical systems operate on data input/output and visualization.

By enabling organizations to first start integrating quantum approaches before having the complete quantum infrastructure, this division of labor enables this approach that it is completely compatible with existing technologies. Over time, hybrid systems like these could grow gradually, adding more and more quantum functionality to them as quantum hardware improves. QIP also stands to give benefits to security and privacy, which is important for image based applications such as biometric authentication and surveillance. There are quantum encryption methods and secure image transmission protocols that can offer security levels many classical systems cannot compete with. QIP is not only a high speed solution, but also a more secure one, solving two important problems with modern digital communication.

An energy efficiency aspect was also addressed in the research, which is a growing concern in computational sciences. Because of the speed and parallelism they enable, quantum algorithms have been suggested to reduce total energy consumption when processing an image over time, especially when scaled. For now, though quantifiable in their limitations, data on quantum systems remains limited; initial simulation however recommends that in the future, quantum systems might represent a greener alternative to energy hungry classical systems. Quantum Image Processing is not a theoretical curiosity, but an actual front of high speed computation on visual data analysis. Although the implementation of this is currently delayed in part due to technological limitations, existing technology will soon position this research as marking a clear path curve out in the future where quantum technologies will remain a fundamental component of the future of intelligent, secure, and high performance image processing. As quantum systems grow more technically versatile, available and trustworthy, QIP integration will logically not only be viable but essential. Through this study they set the stage for future successes in this field by not only identifying the challenges but also having early solutions, and an outline of what future will look like.

DECLARATIONS

Acknowledgement: We appreciate the generous support from all the contributor of research and their different affiliations.

Funding: No funding body in the public, private, or nonprofit sectors provided a particular grant

for this research.
Availability of data and material: In the approach, the data sources for the variables are stated.
Authors' contributions: Each author participated equally to the creation of this work.
Conflicts of Interests: The authors declare no conflict of interest.
Consent to Participate: Yes
Consent for publication and Ethical approval: Because this study does not include human or animal data, ethical approval is not required for publication. All authors have given their consent.

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