Recent Developments in Electronics and Communication Systems
KVS Ramachandra Murthy et al. (Eds.)

doi:10.3233/ATDE221232

Quantum Computing in Image Processing

Kumud Sachdeva*, Rajan Sachdeva, Himanshu Gupta
Department of Computer Science and Engineering, Chandigarh University, Gharuan, Punjab, 140413, India
*Corresponding author: kumud.cse@cumail.in

Abstract. If you read that quantum machine learning applications solve some traditional machine learning problems at an amazing speed, be sure to check if they return quantum results. Quantum outputs, such as magnitude-encoded vectors, limit the use of applications and require additional specifications on how to extract practical and useful results. In satellite images, degradation of image contrast and color quality is a common problem, which brings great difficulties for information extraction and visibility of image objects. This is due to atmospheric conditions, which can cause a loss of color and contrast in the image. Regardless of the band, image enhancement plays a vital role in presenting details more clearly. The research includes new computational algorithms that accelerate multispectral satellite imagery to improve land cover mapping and study feature extraction. The first method is a quantum Fourier transform algorithm based on quantum computing, and the second method is a parallel modified data algorithm based on parallel computing. These calculation algorithms are applied to multispectral images for improvement. The quantum-processed image is compared with the original image, and better results are obtained in terms of visual interpretation of the extracted information. Quantitatively evaluate the performance of the improved method and evaluate the applicability of the improved technology to different land types.

Keywords: Classical Computer, Image Processing, Quantum Computing, Parallel Computation.

1. Introduction

The basic steps of image processing include image acquisition, restoration, enhancement, compression and segmentation. Image acquisition is the first process, followed by preprocessing. The goal of image restoration is to remove the noise in the image. Next is image enhancement, which will sharpen the image details of the human eye. Image compression is used to reduce the size of the image. Processing specific parts of the image is called segmentation. Image enhancement is used to improve the color quality and contrast in the image for visual interpretation. Image enhancement is second only to image restoration, because even after restoration, the image will still be treated as the original image. Unless enhanced, the image can no longer be used in any application. Enhancement technology is very important in image processing, because compared with the original image, the image perception and visual interpretation need to be increased. Due to insufficient light produced globally and locally, the original image cannot be clearly understood. Depending on the application and characteristics of the problem, this defect should be resolved by improved technology.

2. Computational Image Processing

Computational image processing is a process of extracting, analyzing, and using the knowledge of images acquired from various detection platforms as shown in figure 1.

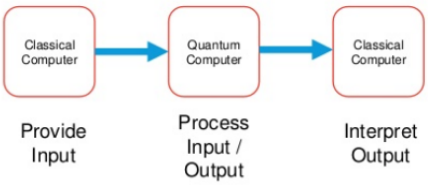

Figure 1. Quantum Computing

Computational image processing solves problems by using interdisciplinary technologies in advanced computing environments, including instrument design, phenomenon modeling, simulation, and experimentation. Computational image processing supports algorithm design and instrument experimentation.
Two novel computation enhancement methods are
(i) Quantum computation-based quantum Fourier transform
(ii) Parallel computation-based modified data parallel algorithm
These computation enhancement algorithms are also suitable for multispectral satellite images. Both computational enhancement algorithms have achieved high fidelity and Earth Sciences have improved the display of real satellite images. The enhanced image is displayed along with the image histogram and statistical values to briefly present the enhancement process.

3. Need for the Study

Research needs in order to facilitate image analysis and understanding of visual interpretation, the image must be enhanced from the original image to the enhanced image. In the enhancement technique, the method is trial and error, and you must highlight the appropriate features. The enhancement technology makes the original image interpretable and facilitates the perception of the image. There are several ways to enhance the technology, which can be done logically, requiring a lot of careful inspection and patience. It can also be said that enhancement technology is an art that allows images to increase survivability and highlights application-based features. Through histogram analysis of enhanced images, statistical features can highlight the features of digital images. In the past few years, researchers have been developing many proven techniques to enhance the image simply by stretching the digital image. Eliminate aliasing effects by using interpolation on the image. Therefore, it is necessary to develop an effective methodology from the traditional improvement methods [1]. Computing is generally defined as the activity of using and improving information technology and computer hardware and software. Here, quantum computing and parallel computing methods are used to enhance and extract features from multispectral satellite images.

4. Literature Review

Image Enhancementin *Remote Sensing Data*

In atmospheric science, image enhancement technology can reduce the impact of haze, fog, fog, and turbulent weather on meteorological observations [3]. Improved technology helps to detect the shape and structure of remote objects in environmental detection [4]. Satellite images must be restored and enhanced to eliminate noise. The analysis of the research and the use of the results aim to improve the visualization of images to provide different contextual information and to help achieve the end goal of designing effective training programs for clients [5].

In synthetic aperture radar (SAR), image enhancement reveals subtle image details that might otherwise be overlooked [6]. Image enhancements can provide insight into the shape and contour of objects and provide important information for the human visual system. Image enhancement helps distinguish features by improving the perception of visual quality, and is used in many fields. Contrary to enhancement, land cover categories in satellite images are difficult to classify because overall enhancement increases the overall brightness of the image. Information about the earth is lost in the dark and bright areas of the satellite image. Therefore, for land cover areas, different technologies should be used for improvement. The technology is an artificial neural network, which interprets the output as the presence gradient and edge pixels.

Chen et al. (2008) used fuzzy set theory and a three-stage algorithm to solve the improvement problem. They are fuzzy using C Means' fuzzy algorithm. Then use the stretch model to stretch the model to build and defuzzify. By enhancing satellite images and better contrast images for visual interpretation and display, the image output performs better [7].

Use a probabilistic neural network (PNN) classifier to classify remote sensing images so that multispectral pixels represent specific categories [8]. The complete PNN is implemented in multiple languages and platforms to measure the performance of computing technology. Generally, conversion from RGB to any color space will not change the hue. In the process of converting from one color space to another, a problem called Gramut is observed. The problem is that the values of the variables may not be in their respective ranges.

Naik and Murthy (2003) proposed a method in which hue-preserving color image enhancement is performed without color gamut issues. This is achieved by linear stretching, which is applied before the nonlinear transformation [9]. The simulation showed that the concept of quantum computing algorithm is much faster than the classical algorithm. Monte Carlo technology is used for quantum simulation and analysis [10].

Pang et al. (2006) designed an iterative quantum discrete cosine transformation algorithm for image compression. They found that the time complexity of the one-dimensional and two-dimensional Discrete Cosine Transform (DCT) is O ((N) 1/2) and O (N), respectively. They generated the famous Grover algorithm to solve complex unstructured search problems. Based on the two properties of DCT, the DCT quantum algorithm is designed. The first property is the DCT energy conservation transformation. The second characteristic is that the DCT coefficients are very close to zero; these coefficients are then discarded without severely affecting the quality of the reconstructed image. Image compression is based on 1DDCT quantum implementation. Quantum algorithms can do two different things. The first is the calculation of the DCT coefficients, which are performed at the same time. The second is the marking of the desired DCT coefficients,

which is also done at the same time. They also compared the DCT quantum iteration and the Grover iteration [11].

These algorithms are applied and studied, especially to enhance satellite images to improve visual interpretation. The first is quantum computing and the second is parallel computing. The enhancement is done by using a parallel computing algorithm on the same input image, which is used in quantum computing. Once these calculation algorithms have been applied, the improved images obtained from these two methods can be analyzed quantitatively.

5. Methodology

A new method of information processing is quantum computing. Existing traditional information processing methods are called classical information. As shown in figure 2, all aspects of computer science, information theory, and quantum mechanics combine to form quantum computing. The suppression architecture of the Von Neumann computer has the computational complexity of the classical algorithm, which usually slows down the speed and causes the loss of information, so it is necessary to find a new method to obtain this information. In classic computers, storage is done little by little. These bits are independent of each other. The connection of these independent bits is completed with software components. The bits in memory are not connected to each other, causing a loss of information. Each individual bit will represent certain attributes of the related image, namely spatial or light intensity. Image recovery is accomplished by extracting the binary data from hardware memory and using bit independent characteristics. Interconnection occurs in quantum computing. The computer in use today is called a classical computer. The calculation method used in classical calculations is the general Turing machine. In classical calculations, the `n` bit system forms a vector space of dimension` n`. However, the "n" qubits of a quantum system result in a dimensional state space. The exponential growth of space will make quantum computing run faster, more powerful, and more efficient. Quantum computing algorithms are implemented in satellite images for feature extraction and enhancement. The transform used for the enhancement is the Quantum Fourier Transform (QFT). QFT can perform quantum mechanical calculations more efficiently to reduce computational complexity below O (| I | log | I |).

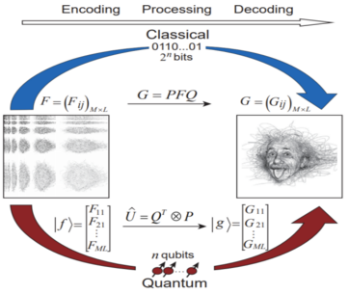

Figure 2. Comparison of image processing by classical and quantum computers

6. Conclusion and Future Scope

This paper gave a brief overview of quantum computation, how it has been used in image processing research, and how it can outperform classical computers. The superposition property of quantum states, which also leads to quantum parallel computing, is responsible for the advantage in quantum over classical storage technologies. Quantum algorithms can help with computational efficiency, but they may not be appropriate for all scenarios. The conclusion is simple and often a conclusive answer; the intermediate computation technique is difficult, suited for generating quantum state entanglement and superposition for parallel acceleration. The task of image classification and recognition fits this characteristic in quantum image processing. Feature extraction, classifier training, and other distance computations are among the intermediate algorithm execution operations. To decide whether an image belongs to a given category, the result merely needs to answer "yes" or "no." Quantum computing is used as like edge extraction, security and image denoising. Quantum technology can be used in various fields such as: Telecom, Aerospace, Transportation, healthcare, Government as shown in figure 3.

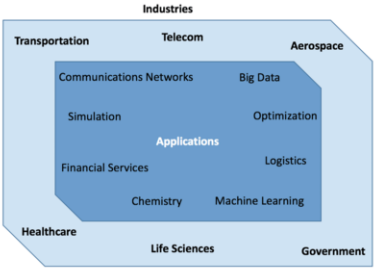

Figure 3. Application of quantum computing

The Quantum Computing based Quantum Fourier Transform image enhancement works well for Low Resolution as well as the High Resolution images.The Quantum Fourier Transform can also be extended to other areas of Satellite image processing.

References

[1] Buiten, H. J. and Clevers, J. G. P. W. “Land Observation by Remote Sensing Theory and Applications”, Gordon and Breach Science Publishers, Reading, pp. 642, 1993.

[2] Cleve, R., Ekert, A., Machiavello, C. and Mosca, M., “Quantum algorithms revisited”, Proc.R.Soc.London A. Vol. 454, pp. 339354, 1998.

[3] Woodell, G., Jobson, D., Rahman, Z. U. and Hienes May, G. “Advance Image processing of Arieal Imagery” in proc. SPIE Visual inform. Process. XIV Kissimmee, pp. 62460E, 2006.

[4] Vorobel, R. “Contrast Enhancement of Remotely sensed images”, in 6 thInl. Conf. Math. Methods in Electromagnetic theory, LVIV, Ukraine, Sep., pp.472-475, 1996.

[5] Karadakar, U., Nordt, M., Furuta, R. Lee, C. and Quick, C. “An Exploration of space – time constraints on contextual information in Image – Based testing interfaces”, Proc. ECDL 2006, Springer Berlin / Heidelberg, pp. 391-402, 2006.

[6] Dimov, A., Jager, G. and Frangos, P. “Adaptive Edge Enhancement in SAR Images Training on the Data VS Training on simulated data”, Inter conf. image process, Thessaloniki, Creece, pp. 493-496, 2001.

[7] Chen Chi Farn, Hung Yuchang and Li-Yu Chang, “A fuzzy based method for remote sensing image contrast enhancement”, The International Archives of the photogrammetry, Remote Sensing and spatial information science, Vol. XXXVII. Part B2, Beijing, 2008.

[8] Chettri, S. R., Cromp, R. F. and Birhmingham, M. “Design of neutral networks for classification of remotely sensed imager” Telematics and informatics, Vol. 9. No. 3, pp. 145-156, 1992.
[9] NaikSarif Kumar and Murthy, C. A. “Hue preserving color image enhancement without Gamut Problem”, IEEE Transactions on Image processing, Vol. 12(12), pp.1591-1598, 2003.
[10] WangYazhen, “Statistical Analysis of Quantum Simulation”, Annals of Applied Statistics, Vol. 5, pp. 1-20, 2011.
[11] Pang Chao Yang, Zheng-WeiZhou and Guang-can Guo, “Quantum Discrete Cosine Transform for image compression”, Available at: http://arxiv.org /PS_cache/ quant ph/pdf/0601/0601043v2. pdf .2006.
[12] RamitaManandhar, Inakwu, O. A., Odeh and TihoAncev, “Improving the Accuracy of Land Use and Land Cover Classification of Landsat Data Using Post-Classification Enhancement”, Remote Sensing. pp. 330-344, 2009.
[13] SauKartik, AmitabhaChanda and Milan Pal, “Color Image Enhancement Based on Wavelet Transform and Human Visual System”, IEMCON 2011 organised in collaboration with IEEE, pp. 77-81, 2011.
[14] Zhou Wang, Alan Conrad Bovik, Hamid Rahim Sheikh and Eero P. Simoncelli, “Image quality assessment: From error visibility to structural similarity”. IEEE Transaction on Image Processing, Vol. 13(4), pp. 600-612, 2004.
[15] VenegasAndraca, S. E. and Bose, S. “Quantum computation and Image processing : New trends in Artificial Intelligence”, proc. of the International conference on A.I. 2003.
[16] Nour Abura’ed, Faisal Shah Khan, and Harish Bhaskar. 2017. “Advances in the Quantum Theoretical Approach to Image Processing Applications”, ACM Comput. Surv., vol. 49, 4, Feb. 2017.
[17] H.-S. Li, P. Fan, H. Y. Xia, and R. G. Zhou, “A comment on “quantum image processing?” Quantum Information Processing, vol. 19, no. 5, p. 155, 2020.
[18] M. Mastriani, “Quantum image processing: the pros and cons of the techniques for the internal representation of the image. A reply to: a comment on “quantum image processing?” Quantum Information Processing, vol. 19, no. 5, p. 156, 2020.
[19] V. Havl´ıcek, A. D. C ˇ orcoles, K. Temme et al., “Supervised ´ learning with quantum-enhanced feature spaces,” Nature, vol. 567, no. 7747, pp. 209–212, 2019.
[20] A. B. Grilo, I. Kerenidis, and T. Zijlstra, “Learning-with-errors problem is easy with quantum samples,” Physical Review A, vol. 99, no. 3, Article ID 032314, 2019