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Quantum Neural Networks for Enhanced Crater and Boulder Detection Using Hyper Spectral Imaging

Priyanshu Halder

[1]School of Materials Science and Nanotechnology, Jadavpur University, Kolkata, India
priyanshuhalder03[at]gmail.com

Abstract: ***This study presents an advanced approach to detecting and analyzing craters and boulders using quantum neural networks and hyper spectral imaging (HSI). By leveraging pixel-by-pixel classification through semantic segmentation, our method accurately determines the edges and depths of geological features. The use of a custom quantum-based neural network with an n×n architecture enhances edge detection and reduces processing time, achieving an accuracy rate of 80%. The proposed algorithm efficiently converts RGB images into HSI data for in-depth spectral analysis, surpassing traditional Geographic Information Systems (GIS) techniques. Additionally, our approach integrates cognitive neural networks and advanced data servers to optimize location detection within a defined azimuth range. This research highlights the effectiveness of quantum-driven methodologies in improving spatial resolution and analytical precision, paving the way for enhanced geological feature classification in remote sensing applications.***

Keywords: QGIS Software, IBM Qiskit, Quantum Circuit, Nanosatellite

1. Introduction

Initially, we will take OHRC images which will be in RGB format. This data is transferred to the server where we convert the RGB image into Hyper spectral image (HSI) which will get stored to be processed and compared by the Cognitive Neural Network (CNN).

We then utilize the information of the dark bands, which will get detected in the image by using pixel-by-pixel classification (Semantic Segmentation) to determine edges and depths of identified craters and boulders.

To scrutinize the complete task, we use quantum based neural network, which reduces time constraint and enhances results, achieving an accuracy rate of 80%.

The neural core is based on n X n architecture and gives us better edge detection compared to other software available currently.

The algorithm being self-made demonstrates dominant and efficient in handling the HSI data.

2. Tools and technology used

QGIS SOFTWARE - For the comparison of outputs.
IBM’S QISKIT - For the neural code.
QUANTUM CODE - For the base ideology of the circuit.
QUNATUM NEURAL NETWORK - For relaying data from the sever to the circuit.
COGNITIVE NEURAL NETWORK - The logical circuit of the AI.
DATA SERVERS - For the conversion of RGB data to HSI.

3. Processes Involved

We have used neural networks to transform RGB data into Hyper spectral imagery (HSI). By using neural networks, We aim to enhance the spectral resolution and accuracy of the imagery, resulting in more precise analysis as well as interpretation of the image for various applications.

We have successfully achieved 80% accuracy rate in the identification of craters and boulders. This defines the efficacy of our methods and the precise use of our analytical techniques for accurately detecting and classifying the Geo-morphological features.

We have used an edge-detection algorithm which determines the precise coordinates and height of the craters and boulders. This algorithm effectively detects the boundaries of these Geo-morphological features, enabling accurate analysis and classification.

The traditional methods for crater detection, which relied on Geographic Information Systems (GIS) and other data processing technologies has been less efficient compared to the possibilities offered by Quantum Cognitive Neural Networks (Quantum CNN).

1. Initial Data Handling (MSI to HSI):

To solve the problem, we initiate the process by acquiring an OHRC image and converting it into RGB format. This RGB data is then transferred to a server, where it undergoes further processing to converted into a Hyper spectral Image (HSI). The HSI data is stored for subsequent analysis and comparison via Cognitive Neural Network (CNN).

3.1 Processes Involved

2. Analysis Approach and Advanced Technology Integration:

Semantic Segmentation utilizes pixel-by-pixel classification for analyzing dark bands. This helps in identifying edges and determining the depth of craters and boulders within the image.

3. Quantum-Based Neural Network:

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Implemented to expedite processing time and enhance the accuracy.

This neural network architecture is specifically designed to achieve a probability of 80% accuracy.

Its n x n Architecture refers to the specific structure of the neural core, optimizing edge detection capabilities beyond standard devices.

4. Algorithm Efficiency:

Custom Algorithm: Developed internally, also highly efficient in managing and processing HSI data. It ensures optimal utilization of the spectral information provided by the OHRC image.

5. Traditional Features and System Integration:

Edge Detection: Enhanced using the specialized n x n neural architecture, which surpasses the capabilities of conventional methods.

System Performance: Optimized for handling HSI data, balancing computational efficiency with the complexity of spectral analysis.

To summarize, the workflow begins with the OHRC image in RGB format, undergoes conversion to HSI for detailed spectral analysis. Using a quantum-based neural network with a custom algorithm allows the precise edge detection and depth assessment of craters and boulders. This setup not only ensures efficient processing but also leverages advanced neural network architectures to achieve high accuracy in results.

If we look at the graphical data given, it shows us the depth information. Hence, the technology we have used, will provide us with better resolution as well as better identification of the coordinates, depth and the height of the craters and boulders.

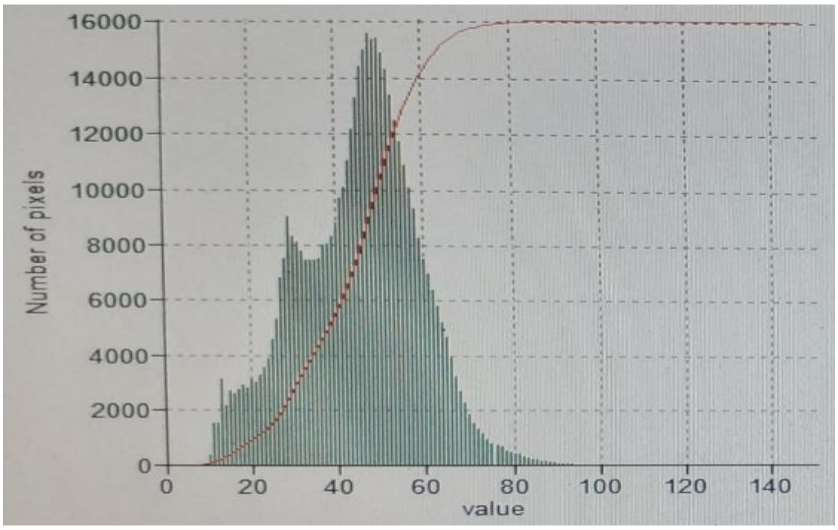

Figure 1: Depth Information

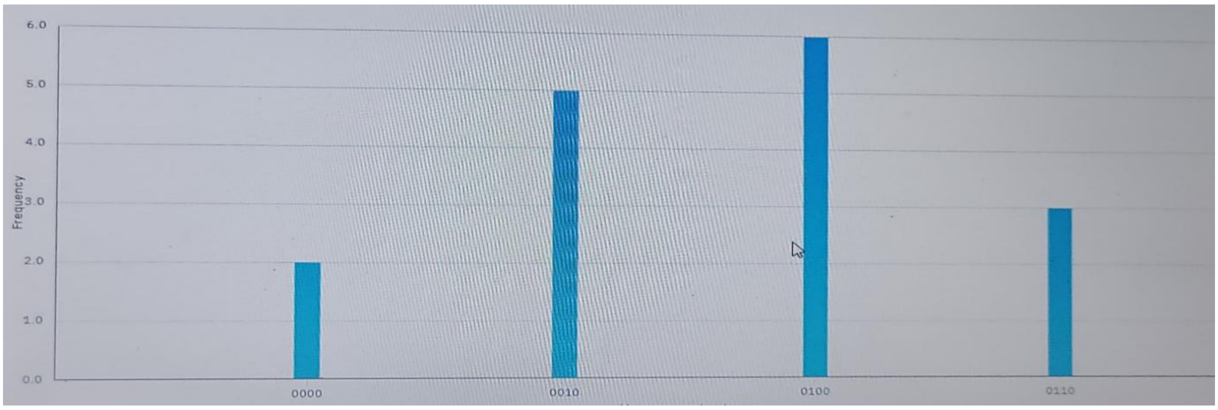

Figure 2: Height Information

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4. Proposed Architecture

This circuital diagram is a part of the quantum circuit. The entire circuit is not shown in the image

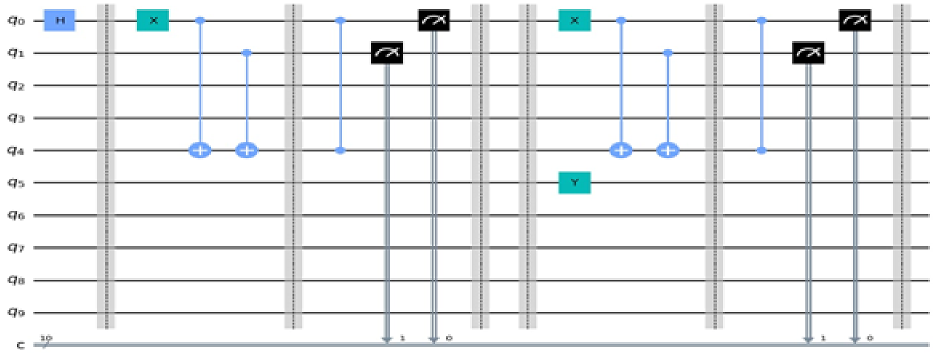

Figure 3: Quantum Circuit

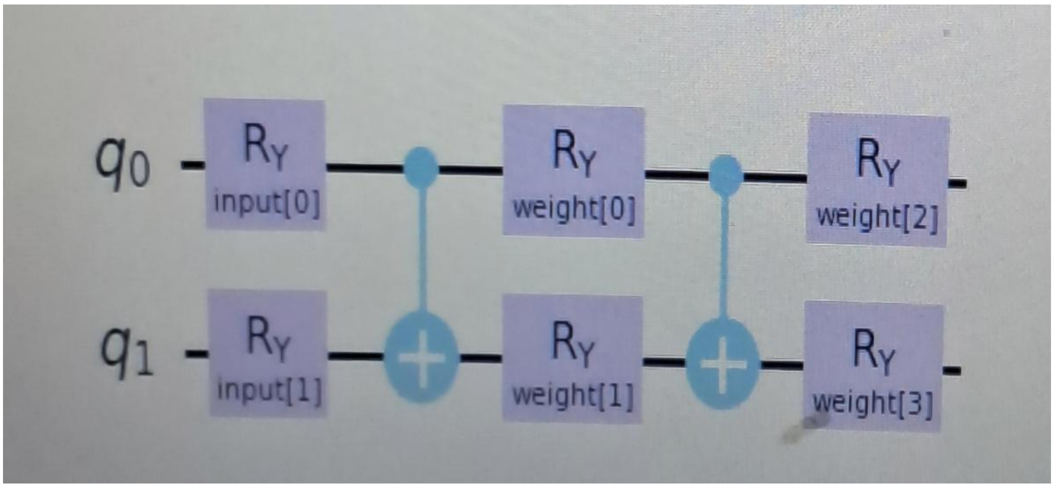

Figure 4: Quantum Gates

5. List of Features

The solution offers the conversion of RGB data into Hyper spectral imagery (HSI) which offers pixel to pixel classification and detailed observation of the image.

This is a processed image from the QGIS software which is pixel-by-pixel classified.

To optimize the entire task, we employ a quantum based neural network, which reduces the time constraint, and enhances results, achieving an accuracy of 80%.

The solution exhibits a location detection (-5 to +5 degrees from the azimuth) of the observed boulder and crater from the given data-set.

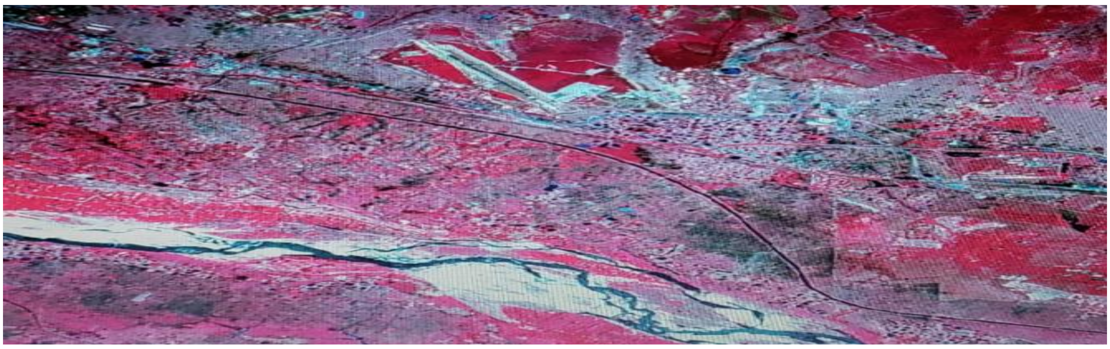

Figure 5: Hyper Spectral Image

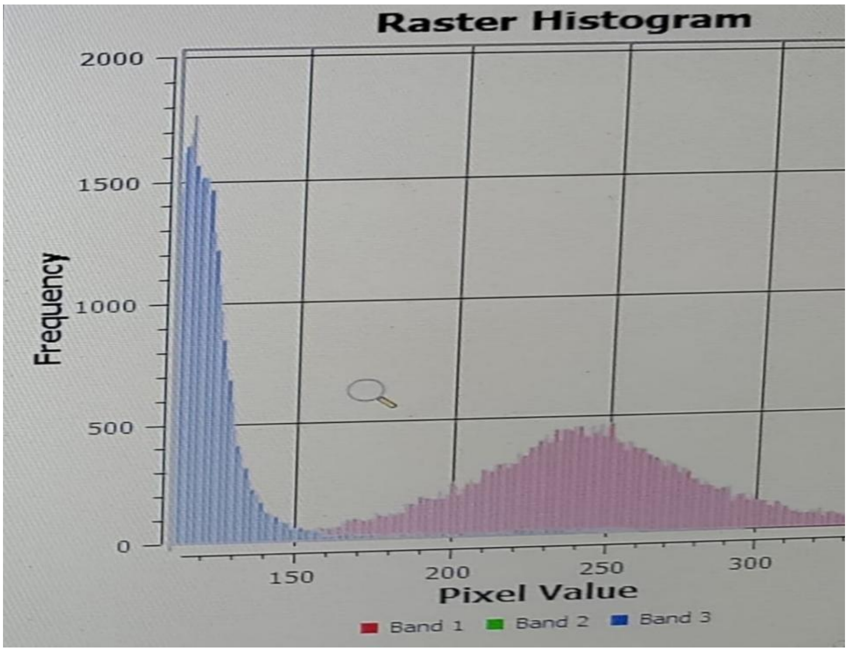

Figure 6: Histogram

6. Process Flow Diagram

The solution presented focuses on the analysis of RGB image data, which we are converting into hyper spectral imaging (HSI) and storing onto a server.

By using cognitive neural network, the system identifies and analyzes the Geo-morphological features, such as boulders and craters, determining their dimensions including height and depth.

To enhance the processing speed and efficiency, we implement quantum code, offering a significant improvement over other traditional system. The research findings which include detailed graphs and analysis, are documented, demonstrating the effectiveness and advancements of our approach.

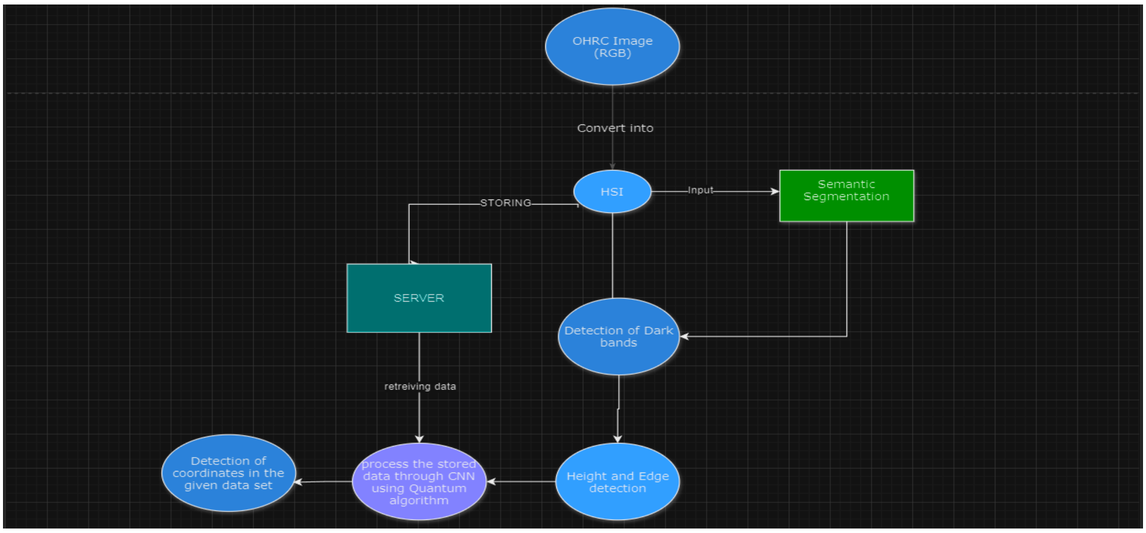

Figure 7: Process Flow Diagram

7. Conclusions

The rapid development and deployment of nanosatellites and associated miniaturized sensors are having a profound effect on our ability to understand complex environments that are rapidly changing. The low-cost, modular design, and off-the-shelf components provided by Cube-Sats makes them an accessible technology capable of disrupting the spacecraft industry and revolutionize Earth and deep-space missions. Their standardized units (“Us”) also simplify the conception, launch, and deployment of those nanosatellites. As with any disruptive technology, opportunities and limitations to the use of Cube-Sats have been identified by the scientific community. On one hand, major opportunities reside in the delivery of high temporal and spatial resolution observations, with global coverage, that is made possible by Cube-Sat constellations. New insights into biogeochemical, hydrological, cryospheric, and atmospheric processes have already been gained. Recent advances are expected to provide radar and LiDAR capabilities to Cube-Sats, among others, in addition to better navigation and position control for improved accuracy and reduced orbital debris. On the other hand, key challenges include data access and distribution, particularly as it applies to commercially-driven missions. Other issues relate to data quality, reliability, and long-term availability. It has been argued that, the more the Earth Science community takes part and engages in the use and development of Cube-Sat capabilities, the better it will be able to guide its development and evolution.

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Acknowledgements

I would like to thank everyone who helped me complete the paper.

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Author Profile

Priyanshu Halder is a student of PG1, Materials Science and Nanotechnology at JU.