Remote Sensing Data Analysis in Machine Learning and Proposed Quantum Computational Intelligence: A Meta-Analysis

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Abstract: Deep learning and machine learning are the top ranking techniques applied in objects classification in remote sensing data. We have conducted a meta-analysis and find out that feature selection is an important achievement in Machine Learning algorithms however, the following challenges were identified; Machine learning need large datasets for training and satellite images contain a lot of noise which may be classify as an object so it is not suitable for object detection in satellite images, Detection accuracy in machine learning depend on the quality of training datasets and finally Biased feature selection may led to the incorrect classification of objects in satellite images. While Most of the deep learning techniques suffer from data preprocessing problems especially when applying in satellite images because satellite images contain a lot of noise. Therefore the requirement of quality and quantity of training datasets is very high. The designed, development, improvement and adjustment of deep learning techniques to suit a specific research is still rely on the experience of the developer which is also a challenging issue. Application of deep learning techniques in remote sense data are still in an infant state because based on our review only few numbers of articles are published from Africa countries. We have suggested that quantum computational intelligence to be applied in remote sensing data analysis.

Keywords: Deep Learning, Machine Learning, Satellite Image, Quantum Computational Intelligence, Remote Sensing

1. Introduction

Remote sensing technology is recently used to capture accurate information for different variety of application such as weather and climate changes, urban and rural area detection, water body and snow detection, scene classification etc. American society for photogrammetry and remote sensing defined remote sensing as the” measurement or acquisition of information of some property of an object or phenomenon by a recording device that is not in physical contact with the object or phenomenon under study” [1].

The standard sensors used in remote sensing includes; Spectral and Hyper spectral Sensor, Radio Detection and Ranging (RADAR) sensor, Light Detection and Ranging (LIDAR) and Thermal Infrared Detectors. These are all used in satellites or suborbital aircraft such as airplane, helicopters and unmanned aerial vehicle (UAV). Most of these sensors recorded electromagnetic radiation (EME) that travel at a velocity of 3X10^8 ms^-1 from the source either directly through a vacuum space or indirectly through reflection or re-radiation to the sensor. The interesting features of this instrument is that there is no actual distance between the device and the object to be captured it could be 100m, 200m or even millions of meters.

Many countries are deeply involved in launching of remote sensing satellites since early 1960s, recently some developed countries has the capability of sending more than one satellite in one mission for instance in 2013 USA lunched 29 satellites, in 2015 Russia lunched 37 satellite, in the same year China lunched 20 satellites and in 2016 India lunched 20 satellites at a time [2]. Remote sensing satellite are classified based on orbital geometry and timing this includes; Geostationary, equatorial and Sun-synchronous orbits. Geostationary satellite has a period of 24 hours to make a complete rotation equal to the earth, it is mostly used for communication and weather forecasting. Equatorial orbit it make a cycle in a low
inclusion while sun-synchronous with a very high inclination angle [3]. There are many remote sensing satellites for environmental monitoring this includes; LandSat, IKONS, QuickBird, WorldView, CryoSat, SIRAL, Sentinel, SPOT, CHAMP, TerraSAR-X, CBERS, ZY-102C, ZY-3, HJ-1A/B, HJ-1C, GF-1, Jilin-1, JERS-1 and Resurs-F etc.

2. Quantum Computational Intelligence

Quantum computational intelligence algorithms such as quantum artificial neural networks, quantum artificial immune system, quantum fuzzy logic, and quantum swarm intelligence, quantum neuro fuzzy quantum probabilistic algorithm and so on by combining the complex quantum properties which includes, entanglement and superposition and the sensitivity of computational intelligence algorithm to formulate a heterogeneous system.

In the concept of information theory and quantum information the smallest unit are bit while in quantum is known as Qubit which were represented as Boolean in computing and represented as a neuron in neuro-computing, in fuzzy logic is either 0 or 1, and in digital electronics is either on and off. Which are also represented as Boolean state 0 and 1 and orthogonal quantum states labeled as $|0\rangle$ and $|1\rangle$ respectively in the quantum state are represented as a superposition $\alpha|0\rangle + \beta|1\rangle$, where $\alpha$, $\beta \in \mathbb{C}$ satisfy normalization.

Let consider a computer quantum system, that consist of the qubits and the state of each of this qubit is called superposition which is also represented as;

$$\psi = C_0|0\rangle + C_1|1\rangle$$

(1)

Where $|0\rangle$ and $|1\rangle$ are the called vectors and $C_0$, $C_1 \in C$, by combining the two qubits and analyze the system as one would have a possible state of the two qubits as;

$$\psi = \frac{|00\rangle + |11\rangle}{\sqrt{2}}$$

(2)

Then notation $|U\rangle$ and $|V\rangle$ are the breakdown of $|U\rangle$ and $|U\rangle$ in the quantum state and are called bell which represent the major property that shows there is no single qubit state $|a\rangle$ and $|b\rangle$ such that $|\psi\rangle = |a\rangle|b\rangle$ hence the following are possible.

3. Machine Learning

Machine learning (ML) is a branch of artificial intelligence that enable computer algorithm to learn from training datasets. This learning are categorized into three forms supervised, semi-supervised and unsupervised, supervised learning means the training inputs are given and the mapping between the input and the desired outputs are known and also the mapping between the input and outputs are learned by the algorithm. In unsupervised learning the inputs are given but the algorithm learn and identify pattern and produce the output, however, in semi-supervised learning the inputs and the outputs are partially given and the algorithms will find the missing pattern based on the inputs features [4].

Machine learning techniques are commonly applied to object detection in satellite images such as support vector machine is commonly applied techniques for to object classification in satellite images these are earlier proposed in [5] applied in change detection, more over another traditional object classification techniques is called K-Nearest-Neighbor (KNN) are applied to object classification in remote sensing images In addition to Artificial Neural Network (ANN) that are also applied in remote sensing data such as object detection, classification and change detection as presented in [6].

| S/N | Authors/Date | Research Title | Problem Addressed | Method Used | Weakness of the Method |
|-----|--------------|----------------|------------------|-------------|------------------------|
| 1. | Alshehhi et al., (2017) [7] | Simultaneous extraction of roads and buildings in remote sensing imagery with convolutional neural networks | Road extraction | Convolutional neural network | Computational complexity is high in this method and very difficult to adjust the network |
| 2. | Ajeet et al., (2018) [8] | Application of deep learning for object detection | Object detection | Deep learning | Data preprocessing problem and require large data for training |
| 3. | Absalberg, (2015) [9] | Detection of seals in remote sensing images using features extracted from deep convolutional neural networks | Seal detection | Convolutional neural network | Inadequate datasets for training |
| 4. | Abhishek et al., (2021) [10] Arshitha & Biju, (2020) [11] | Deep learning for object detection and Scene perception in self-driving cars | Scene perception in self driving cars | Deep learning | Data preprocessing problems |
| 5. | Ahmad et al., (2019) [12] | Accurate detection of building from satellite images using CNN | Building detection | Convolutional neural network | Un able to differentiate between shadow and building |
| 6. | Alexander et al, (2020) [13] | Small Objects Detection in Satellite Images Using Deep Learning | Object detection | Deep learning | In adequate datasets and training objects are too much |
| 7. | | Semantic segmentation of Aerial imagery for road Extraction with deep learning | Road extraction | Deep learning | Segmentation accuracy depend on the design and adjustment of the network |
4. Conclusion

Deep learning, machine learning are the major techniques applied in object classification in remote sensing image. We have conducted a meta-analysis and find out that feature selection is an important achievement in Machine Learning algorithms applied in computer vision however, the following challenges are identified:

Machine learning require large data for training and satellite images contain a lot of noise which may be classify as an object so it is not suitable for object detection in satellite images.

Detection accuracy in machine learning depend on the quality of training datasets.

Biased feature selection may led to the incorrect
classification of objects in satellite images.

Deep Learning techniques has an automatic ability to learn from the feature sets for several task and has been the major breakthrough in recent time with a successful applications in computer vision and image processing. Despite the tremendous advancement achieved in deep learning techniques the following challenges need serious attention;

Deep learning techniques are much dependent on large amount of data for training and testing to avoid over fitting. The time taken for feature extraction in remote sense data with deep neural networks for object detection is also a challenging task in computer vision. Many efforts are required to further improve the computational efficiency of the model.

Computational complexity of deep learning techniques which require large amount of system memory to process is also a challenging issue.

Most of the deep learning techniques suffer from data preprocessing problems especially when applying in satellite images because satellite images contain a lot of noise. Therefore the requirement of quality and quantity of training datasets is very high.

The designed, development, improvement and adjustment of deep learning techniques to suit a specific research is still rely on the experience of the developer which is also a challenging issue.

Application of deep learning techniques in remote sense data are still in an infant state because based on our review only few number of articles are published from Africa countries.

5. Recommendations

Based on this research work it is recommended that quantum computing should be applied heavenly in remote sensing data analysis which is a road map for further research directions.

References

[1] Dey, N., H., A. E., Bhatt, C., Ashour, A. S. & Satapathy, S. C. (2018). Internet of Things and Big Data Analytics Toward Next-Generation Intelligence. Springer International Publishing AG.

[2] Wenxue, F., Jianwen, M., Pei, C., & Fang C. (2020). Remote sensing satellites for digital earth. 4th edition, Manual of digital earth Ltd. Beijin China.

[3] Lingli, Z., Juha, S., Jingbin, L., Juha, H., Harri, K. & Henrik, H., (2018). Multi-purposeful application of geospatial data. IntechOpen Ltd Beijing, China.

[4] Jude, D. H. & Vania, V. E., (2017). Deep learning for image processing applications IOS Press Amsterdam, Berlin and Washington DC.

[5] Bai, X., Zhang, H. & Zhou, J., (2014). VHRR object detection based on structural feature extraction and query expansion. IEEE Transaction of Geosciences Remote sensing 52, 6508-6520.

[6] Malek, S., Benz, Y., Alajlan, N., Alhichri, H. & Melgani, F. (2014). Efficient framework for palm tree detection in UAV images. IEEE Journal Selection Topics of Application in Earth Observation Using Remote Sensing. 7, 4692-4703.

[7] Alshehhi, R., Marpu, P. R., Woon, W. L., & Dalla, M. (2017). Simultaneous extraction of roads and buildings in remote sensing imagery with convolutional neural networks. ISPRS Journal of Photogrammetry and Remote Sensing. 130, 139-149.

[8] Ajeet, R. P., Manjushe, P., & Siddharth, R. (2018). Application of deep learning for object Detection. International Conference on Computational Intelligence and Data Science (ICICIDS 2018).

[9] Absalberg, A. (2015). Detection of seals in remote sensing images using features extracted from deep convolutional neural networks. In Proc. IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 1893-1986.

[10] Abhishek, G., Alagan A., Ling, G. & Ahmed, S. K. (2021). Deep learning for object detection and Scene perception in self-driving cars: Survey, challenges, and open issues. Science Direct Array 10 (2) 157-171.

[11] Arshitha, F. & Biju, K. S. (2020). Accurate detection of building from satellite images using CNN. In Proceeding of the 2nd International Conference on Electrical, Communication and Computer Engineering (ICECCE) 12-13 June 2020, Istanbul, Turkey.

[12] Ahmad, M. Wessam, M. H. & Elah, S. (2019). Small Objects Detection in Satellite Images Using Deep Learning. 2019 IEEE 9th International Conference on Intelligent Computing and Information Systems (ICICS). 194-207 Cairo Egypt.

[13] Alexander, A. S. G., Ilma, A. & Edy, I. (2020). Semantic segmentation of Aerial imagery for road Extraction with deep learning, ICIC Express letter, 14 (1), 43-51.

[14] Chen, Y., Lin, Z., Zhao, X., Wang, G. & Gu, Y. (2017). Deep learning-based classification of hyper spectral data. IEEE J. sel. Top. Appl. Earth Obs. Remote Sensing, 7 (6), 2094-2107.

[15] Boualleg, Y. & Farah, M. (2018). Enhanced interactive remote sensing image retrieval with scene Classification convolutional neural networks model. In Proceedings of the IGARSS 2018–2018 IEEE International Geoscience and Remote Sensing Symposium, Valencia, Spain, 22–27 July 2018. 4748–4751.

[16] Chen, Y., Zhao, X. & Jia, X. (2015). Spectral-spatial classification of hyper spectral data based on deep belief network. IEEE J. sel. Top. Appl. Earth Obs. Remote sens. 8 (6), 2381-2392.

[17] Cheng, G., & Han, J. (2016). A survey on object detection in optical remote sensing images. ISPRS Journal of Photogrammetry and Remote Sensing. 117, 11-28.

[18] Claudia, P. D. & Shashikala, K. P. (2020). Satellite image processing to detect building using deep learning. International Journal of Innovative Research in Electrical Electronics, Instrumentation and control engineering, 8 (9), 17-25.

[19] Castelluccio, M., Poggi, G., Sansone, & Verdoliva, C. (2015). Land use Classification in Remote Sensing Images by Convolutional Neural Networks. arXiv 2015; 1-11, rXiv: 1508.00092.
[20] Duan, F., Liu, L., Jiao, P., Zhao, L. & Zhang, L. (2017). SAR image segmentation based on convolutional-wavelet neural network and Markov random field, *Pattern Recognition*, 64, 255-267.

[21] Deepthi, S., Sandeep, K. & Suresh, L. (2021). Detection and Classification of Objects in Satellite Images using Custom CNN. *International Journal of Engineering Research & Technology*. 10 (6), 629-635.

[22] Deng, Z., Sun, H., Zhao, S., Lei, L. & Zou, H. (2011). Multi-scale object detection in remote sensing imagery with convolution neural networks. *ISPRS Journal Photogrammetry and Remote Sensing*. 145, 3-22.

[23] Duarte, D. (2018). Satellite image classification of building damages using air bone and satellite image sampling in deep learning approach. ISPR Annals of Photogrammetry Remote Sensing and Spatial information science. 4 (2), 1-17.

[24] Erhan, D., Christian, S., Alexander, T. & Dragomir, A. (2014). Scalable object detection using deep neural networks. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition*. 2147-54.

[25] Eisnak, C., Dragut, L., & Blascke, T., (2011). A generic procedure for semantics Oriented landform classification using object-based image analysis. *Geo-morphometry*. 125-128.

[26] Gao, L., Song, W., Dai, J., & Chen, Y. (2019). Road extraction from high resolution remote sensing imagery using refined deep residual convolutional neural network, *Remote Sensing*. 11 (5), 552.

[27] Gao, F., Huang, T., Wang, J., Sun, J., Hussain, A. & Yang, E. (2017). Dual-branch deep convolution neural network for Polari metric SAR image classification. *Applied Science*. 7, 447.

[28] Ghamisi, P., Chen, Y., & Zhu, X. (2016). A Self-improving convolution Neural network for the classification of hyper spectral data, *IEEE Journal selection Geoscience and Remote Sensing Letter*, 13 (10) 1537-1541.

[29] Geng, J., Fan, H., Wang, X., Ma, B., Li, B. & Chen, F. (2015). High-resolution SAR image classification via deep convolutional auto-encoders *IEEE Geoscience and remote sensing letter* 12, (11), 2351-2355.

[30] Geng, J., Wang, H., Fan, J. & Ma, X. (2017). Deep supervised and contractive neural network for SAR image classification. *IEEE Transaction Geoscience Remote Sensing* 55 (4), 2442-2459, 2017.

[31] Guoji W., Wu, M., Wei, X. & Song, H. (2020). Water identification from high resolution remote sensing image based on multidimensional densely connected convolutional neural networks, *Remote Sensing*. 12 (5), 795.

[32] Gao, L., Song, W., Dai, J., & Chen, Y., (2019). Road extraction from high-resolution remote sensing imagery using refined Deep Residual Convolutional neural network *Remote sensing*. 11, 553.

[33] Zhang, C., Sargent, Pan, X., Li, H., Gardiner, A., Hare, J. & Attinson, P. M. (2018). An object-based convolutional neural networks (OCNN) for urban land use classification. *Remote Sensing Environment*. 216, 57-70.

[34] Zou, Q., Ni, L., Zhang, T. & Wang, Q., (2015). Deep Learning based feature selection for remote Sensing scene classification. *IEEE Geoscience Remote Sensing Letter* 12 (11), 2321-2325.