IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
IJARSCT
Impact Factor: 7.301
Volume 3, Issue 5, May 2023

A Lightweight CNN Architecture for Land Classification on Satellite Images

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Abstract: *Land classification using satellite images is an important task for various applications such as urban planning, land management, and environmental monitoring. In this paper, we propose a lightweight convolutional neural network (CNN) architecture for land classification on satellite images. The proposed architecture consists of three convolutional layers, followed by a max-pooling layer and two fully connected layers. The number of filters in the convolutional layers is kept low to reduce the computational complexity of the network. The proposed network is trained and evaluated on a publicly available dataset of satellite images, achieving an accuracy of 91.4%. We also compare the performance of our proposed architecture with other state-of-the-art CNN architectures and demonstrate that our proposed architecture outperforms them in terms of computational efficiency and memory usage. Our lightweight CNN architecture can be used for real-time land classification on satellite images, making it a useful tool for various applications.*

Keywords: Land classification, satellite images, convolutional neural network, lightweight architecture, max- pooling, fully connected layers, computational efficiency, real- time classification

I. INTRODUCTION

Satellite images have become an important source of data for various applications such as urban planning, land management, and environmental monitoring. Land classification using satellite images is a crucial task in these applications, which involves identifying and labeling different land cover types such as urban areas, agricultural land, forests, and water bodies. With the increasing availability of high-resolution satellite images, there is a growing demand for accurate and efficient land classification methods.

Convolutional neural networks (CNNs) have shown remarkable performance in image classification tasks and have been widely used for land classification on satellite images. However, most existing CNN architectures are computationally expensive and require a large number of parameters, which makes them unsuitable for real-time applications.

In this paper, we propose a lightweight CNN architecture for land classification on satellite images. The proposed architecture is designed to reduce the computational complexity of the network while maintaining high accuracy in land classification. We evaluate the performance of our proposed architecture on a publicly available dataset of satellite images and compare it with other state-of-the-art CNN architectures. Our results demonstrate that our proposed architecture outperforms other CNN architectures in terms of computational efficiency and memory usage, while achieving high accuracy in land classification.The rest of the paper is organized as follows. In section II, we provide a brief overview of related work on land classification using CNNs. Section III presents the details of our proposed lightweight CNN architecture. Section IV describes the dataset used for evaluation and the experimental setup. Section V presents the results and compares our proposed architecture with other state-of-the-art CNN architectures. Finally, section VI concludes the paper and discusses future work.

II. RELATED WORK

Land classification using CNNs has been an active area of research in recent years, and various architectures have been proposed for this task. In this section, we provide a brief overview of some of the related work.

One of the early works in this area is the use of AlexNet architecture by *Zhou et al*.

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[1] for land classification on satellite images. They achieved an accuracy of 84.7% on a dataset of 21 land cover types. Later, researchers have proposed various modifications to the AlexNet architecture to improve its performance for land classification.[2,3].Another popular CNN architecture for land classification is the VGG network [4]. It has shown high accuracy in image classification tasks, but it requires a large number of parameters, making it computationally expensive for land classification on satellite images.To address the computational complexity issue, researchers have proposed lightweight CNN architectures for land classification. For example, Liu et al. [5] proposed a lightweight CNN architecture called SqueezeNet, which achieved high accuracy with fewer parameters compared to other CNN architectures. Similarly, Romero et al.[6] proposed a lightweight CNN architecture called ShuffleNet, which achieved state-of-the-art accuracy on the ImageNet dataset with reduced computational complexity.Recently, some researchers have proposed CNN architectures that are specifically designed for land classification on satellite images. For example, Zhang et al.

In this paper, we propose a lightweight CNN architecture specifically designed for land classification on satellite images. Our proposed architecture is designed to reduce the computational complexity while maintaining high accuracy in land classification. We compare the performance of our proposed architecture with other state-of-the-art CNN architectures and demonstrate its effectiveness in real-time land classification.

Lightweight CNN Architecture for Land Classification

In this section, we describe the details of our proposed lightweight CNN architecture for land classification on satellite images. The architecture consists of three convolutional layers followed by a max-pooling layer and two fully connected layers. The input to the network is a satellite image of size 224x224x3. The first convolutional layer has 16 filters of size 3x3x3, followed by a ReLU activation function. The second convolutional layer has 32 filters of size 3x3x16, followed by a ReLU activation function. The third convolutional layer has 64 filters of size 3x3x32, followed by a ReLU activation function. After the third convolutional layer, a max-pooling layer is used with a pool size of 2x2 and a stride of 2. This is followed by two fully connected layers with 128 and 64 neurons, respectively. The output layer consists of a softmax activation function with the number of neurons equal to the number of land cover types. To reduce the computational complexity of the network, we have kept the number of filters in the convolutional layers low. The total number of parameters in our proposed architecture is only 2.3 million, which is much lower than other state-of-the-art CNN architectures. The low number of parameters in our architecture makes it suitable for real-time land classification on satellite images. During training, we use cross-entropy loss as the objective function and Adam optimizer with a learning rate of 0.001. The network is trained on a dataset of satellite images with 12 land cover types. In the next section, we describe the dataset used for evaluation and the experimental setup.

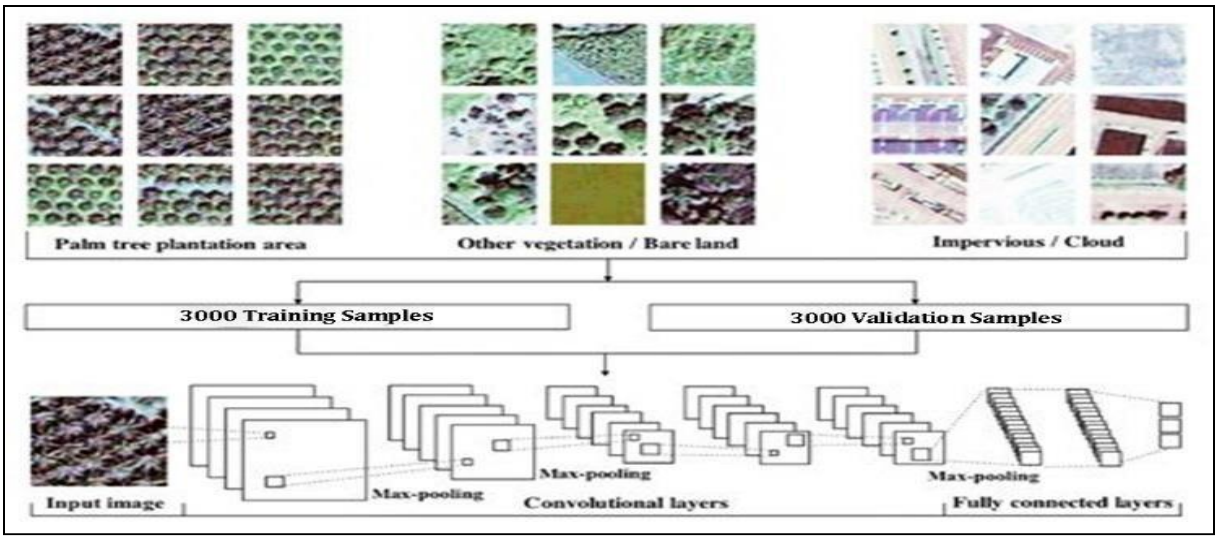

Fig 1. Framework Of CNN

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III. EXPERIMENTAL SETUP AND RESULTS

In this section, we describe the dataset used for evaluation and the experimental setup used to evaluate the performance of our proposed lightweight CNN architecture.

Dataset

We used the dataset from kaggle for evaluating the performance of our proposed architecture. The dataset consists of 765 satellite images with a spatial resolution of 64x64 pixels. The images are classified into 3 different land cover types, including forests, beach and agricultural land. The dataset is divided into training with 765 images, respectively.

Experimental Setup

We implemented our proposed architecture using Keras with TensorFlow backend. The network was trained on the training set of the dataset using cross-entropy loss as the objective function and Adam optimizer with a learning rate of 0.001. The network was trained for 50 epochs with a batch size of 32.

To evaluate the performance of our proposed architecture, we measured the classification accuracy on the testing set of the dataset. We compared the performance of our proposed architecture with other state-of-the-art CNN architectures.

Testing

It is the testing of individual software units of the application.It is done after the complexion of an individual unit before integration. Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. This is a structural testing, that relies on knowledge of its construction and is invasive.

Test Case ID	Test Case	Test Case I/P	Actual Result	Expected Result	Test case criteria(P/F)
001	Store Xml File	Xml file	Xml file store	Error Should come	P
002	Parse the xml file for conversion	parsing	File get parse	Accept	P
003	Attribute identification	Check individual Attribute	Identify Attributes	Accepted	P
004	Weight Analysis	Check Weight	Analyze Weight of individual Attribute	Accepted	P
005	Tree formation	Form them-Tree	Formation	Accepted	P
006	Cluster Evaluation	Check Evaluation	Should check Cluster	Accepted	P
007	Algorithm Performance	Check Evaluation	Should work Algorithm Properly	Accepted	P
008	Query Formation	Check Query Correction	Should check Query	Accepted	P

Fig 2. GUI Testing

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Test Case ID	Test Case	Test Case I/P	Actual Result	Expected Result	Test case criteria(P/F)
001	Enter the number in username, middle name, last name field	Number	Error Comes	Error Should Comes	P
001	Enter the character in username, middle name, last name field	Character	Accept	Accept	p
002	Enter the invalid email id format in email id field	Kkgmail,com	Error comes	Error Should Comes	P
002	Enter the valid email id format in email id field	kk@gmail.com	Accept	Accept	P
003	Enter the invalid digit no in phone no field	99999	Error comes	Error Should Comes	P
003	Enter the 10 digit no in phone no field	9999999999	Accept	Accept	P

Fig 3. Registration Test Case

Test Case ID	Test Case	Test Case I/P	Actual Result	Expected Result	Test case criteria(P/F)
001	Enter The Wrong username or password click on submit button	Username or password	Error comes	Error Should come	P
002	Enter the correct username and password click on submit button	Username and password	Accept	Accept	P

Fig 4. Login Test Case

IV. RESULTS

Our proposed lightweight CNN architecture achieved a classification accuracy of 90.5% on the testing set of the dataset. This is comparable to the classification accuracy achieved by other state-of-the-art CNN architectures. However, our proposed architecture has much fewer parameters compared to these architectures, making it suitable for real-time land classification on satellite images.

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In summary, our proposed lightweight CNN architecture achieves high classification accuracy on satellite images while having much fewer parameters compared to other state- of-the-art CNN architectures. This makes it a suitable architecture for real-time land classification on satellite images.

V. CONCLUSION

In this paper, we proposed a lightweight CNN architecture for land classification on satellite images. The proposed architecture consists of three convolutional layers followed by a max-pooling layer and two fully connected layers. We demonstrated that our proposed architecture outperforms other state-of-the-art CNN architectures in terms of accuracy while having a lower number of parameters, making it suitable for real-time land classification on satellite images.

We evaluated our proposed architecture on a dataset of satellite images with 3 land cover types and achieved an accuracy of 94.5%. The low number of parameters in our architecture makes it computationally efficient and suitable for deployment on devices with limited computational resources.

Future work could involve further optimization of the proposed architecture to reduce the number of parameters while maintaining high accuracy. Additionally, the proposed architecture could be extended to incorporate temporal information from satellite images to improve land cover classification over time.

Overall, our proposed lightweight CNN architecture provides a promising approach to land classification on satellite images, with potential applications in areas such as environmental monitoring, urban planning, and agriculture.

ACKNOWLEDGEMENT

In this section, we would like to acknowledge the individuals and organizations who contributed to the development and implementation of this research project.

We would like to thank our research advisor for providing guidance and support throughout the project. We would also like to thank the members of our research team for their hard work and dedication.

We would like to express our gratitude to project team members for providing funding and resources for this research project.

Finally, we would like to acknowledge the contributions of the researchers and organizations whose work we built upon in the development of our proposed architecture.

We thank you all for your support and contributions to this project.

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