Ship Detection from Göktürk-2 Satellite Images using Convolutional neural network

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Abstract. Ship detection from satellite images involves multiple steps of processing. Ship detection from satellite images is useful for controlling of ship traffic and determining the ship when necessary. Ship detection also used in solving several problems such as marine field violations and illegal hunting. Nowadays, optical satellite images and remote sensing methods are being used for ship detection. This project constitutes a prototype model to provide data to the government, coast guard units, general maritime, ship traffic services centers, and national defense. The aim of this study is to utilize the existing Turkish satellite data to perform ship detection. Göktürk-2 satellite images used in turkey for observation and were selected for the analysis. It is possible to distinguish between ships and all other objects in satellite images. Deep Convolution Neural Network (DCNN) model was proposed to obtain results. Some feature-based corrections have been made for satellite images. The shapes of the ships were detected in squares and their numbers were specified. This model has obtained a sufficient accuracy value by handling a pre-processed satellite image. Graphical results show that the proposed model provides an efficient detection process with an accuracy of 89.60%. The designed CNN model was preferred in a simple and easy to apply form, especially based on the Göktürk-2 satellite images.

Keywords: Deep convolutional neural networks, ship detection, remote sensing, satellite imagery.

1. Introduction

Several methods including Computer vision and artificial intelligence for solving varied problems in our life for long time without the need for human power [1]. Lately, numerous approaches in many areas have been replaced by deep learning methods due to the required high computing power in hardware, amount of data, and the rapid development of algorithms [2]. As in any case, these methods are of interest in the analysis of satellite images and their use is becoming widespread.

Analysis of satellite images plays a crucial role in many areas such as the determination of forest areas and fires, the monitoring of cultivated areas in agricultural land, city and road planning, security and military surveillance, disaster and crisis management [3]. Considering the available satellite images that can cover square kilometers,

former methods are very costly and time consuming [3], [4]. In addition, in order to obtain correct results, the people who will be performing the analysis tasks need to have experience in their fields. In the analysis of satellite images, computer vision solutions are categorized under three headings: classification, segmentation, and object detection. Convolutional neural networks (CNN) with deep learning architecture are used in all these analyzes, making use of the positional features on the image [1].

Currently, there are six Turkish satellites existing, three of them are used for communication and three are utilized for observations. Türksat 3A, Türksat 4A, and Türksat 4B satellites are used for communication. RASAT, Göktürk-1, and Göktürk-2 satellites meet the needs of observation purposes. Since the images of the ships in the seas were used in the project, images were taken from Göktürk-2, the observation satellite. Those images with high resolution are suitable for model training.

In this paper, ship detection using Convolutional neural networks was made from the satellite images. The aim is to propose a prototype model using the available Turkish satellite data to help in sea traffic management. The project can help institutions such as coast guard, defense industry, statistical studies, national defense, TAF, TURKSTAT, and SSB to obtain the relevant data.

2. Methods

In this section, tools development and satellite image processing methods implemented using ArcMap and MATLAB platforms. The general purpose of using MATLAB program is the CNN model development and training, ArcMap platform utilized to process the satellite images.

Figure 1. Manual selecting of ships from Göktürk-2 satellite images for training dataset.

2.1. Satellite images collection

A petition sent to "Ankara Keşif Uydu Komutanlığı" obtain "Göktürk-2" satellite images. As a result, 300 GB of satellite images were collected which are very useful for model training. According to the data exploring several images selected for the image extraction stage. The selected optical Göktürk-2 images were having 5-meter spatial resolution. All images were selected from Turkey in the data set. There are some images along the Mediterranean and Marmara Regions. (e.g., Kumluova-Armutveren, Fethiye-Zvezdets, İbiller-Bandırma, Manisa-Demirci Keslik, Bayraklı-Topcukoy, Boğazcık-Ayvacık, Dalaman-Karaevli). All the images that mostly cloudy, containing strips of no data were excluded.

2.2. Dataset Preprocessing

In this stage, the satellite images were processes, and ships were extracted. The satellite images were processed to generate the colored RGB images. Then, the ships were manually defined by sets of squares. Figure 1. Illustrate the manual selecting of ships from Göktürk-2 satellite images for the training dataset. Then, a model builder in Arcmap generated to extract the images for each ship from the images as illustrated in Figure 2. As a result of these processes, 94 RGB images of ships and non-ship with 63x62 24 bit depth were extracted. Examples of these images were presented in Figure 3.

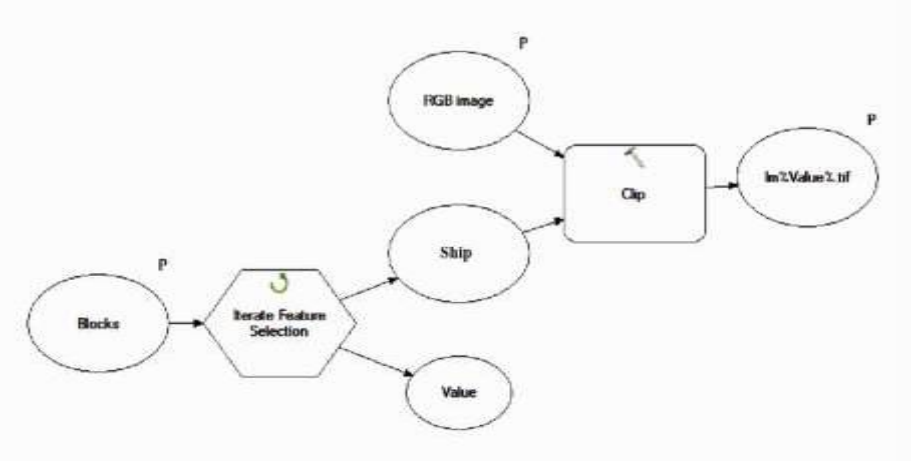
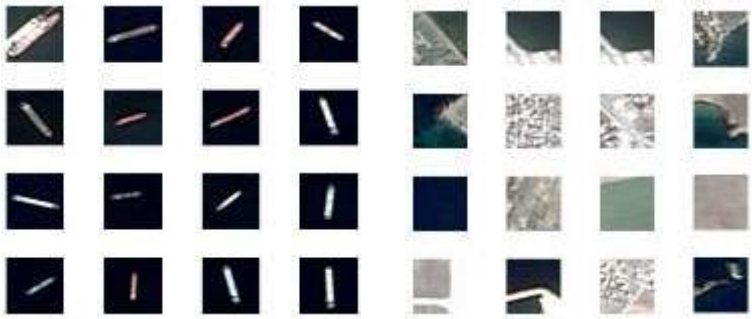


Figure 2. Model builder in Arcmap for extracting ships images from Göktürk-2 satellite images for CNN training.



(A) (B)

Figure 3. Examples of ships (A) and non-ships (B) extracted RGB images.

2.3. Convolutional neural network CNN

The main functionality of convolutional neural network is to perform images recognition, object detections and images classifications. CNN takes an input picture, processes and categorizes it. The input image as an array of pixels and depends on the image resolution. It refers to pixel values h x w x d (h = Height, w = Width, d = Dimension). CNN looks like a mixture of sciences such as biology and computers, but it is a very effective system used for image recognition. CNN detects low-level features such as curves and edges in an image and create concepts that are more abstract [5].

CNN uses the standard Neural Network to solve the classification problem, but uses other layers to identify information and identify some features. CNN consisting several layers of processing such as Convolutional Layer, Non-Linearity Layer, Pooling (Downsampling) Layer, Flattening Layer, Fully-Connected Layer. The CNN layers presented in Figure 4.

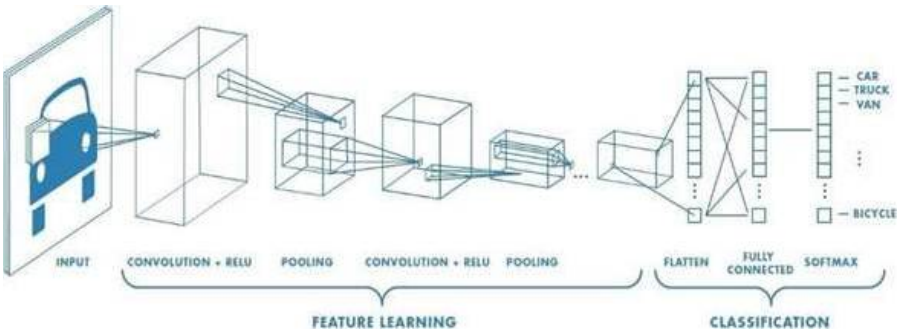


Figure 4. The layers of image processing in convolutional neural network

At this stage, deep learning was implemented based on convolutional neural networks to generate the model for ship detection. Firstly, the images of the ships were imported in Matlab. Then the CNN architecture defined (62 x 63 x 3 pixels). The train-ing options specified. The structure of this architecture was created from 8 layers that are related to

each other. These layers are Image Input Layer, Convolutional Layer, Batch Normalization Layer, ReLU Layer, Max Pooling Layer, Fully Connected Layer, Softmax Layer, Classification Layer. Specifying Training Options: After defining the network structure, training options were specified. SGDM (stochastic gradient descent with momentum) optimization process was applied in the network education with an initial learning rate of 0.01. The maximum Epoch value is set to 40. The epoch value is a complete training cycle across the entire training data set. Data was mixed in each cycle. Verification data and frequency were specified as 8. A CNN architecture created by adding a ReLU layer after each. Then, the CNN model generated and trained. The performance accuracy was calculated.

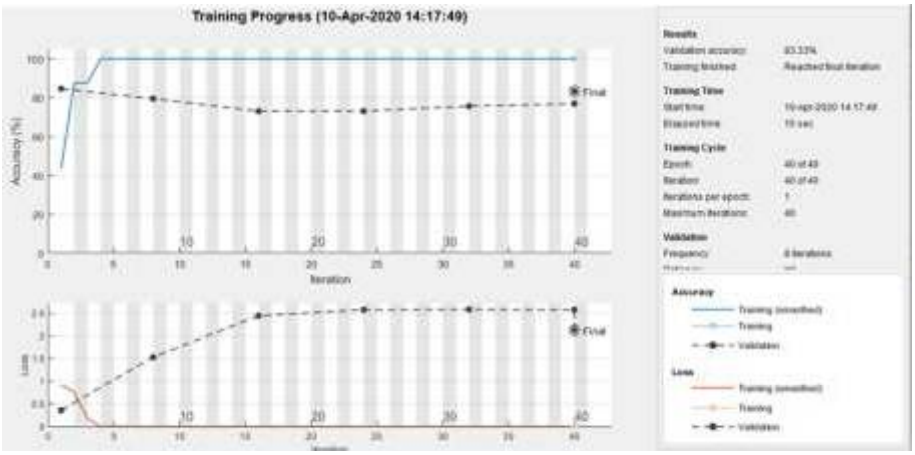


Figure 5. Performance accuracy of CNN based on the Göktürk-2 satellite images for ship detection

3. Results and conclusion

In this article, ship detection was made using the CNN model in Göktürk-2 satellite images. Detection was made using layers that are fully linked with the convolutional neural networks. Satellite images used effectively for ship detection. The progress of the model education was graphically monitored. The proposed model provides both accuracy and other performance evaluation parameters. The labels of verification data were estimated using the trained network and the final verification accuracy was calculated. Accuracy is the proportion of images that correctly classified by the network. At the end of the study, the accuracy value was calculated as 83.33%. Im-ages with the feature of ship classification and detection from the satellite can be used in future studies, with a larger dataset, to improve the model learning process. The obtained accuracy value as a result of this study is shown in Figure 5.

References

[1] Y. A. Kara, Ö. K. Uçarer, and B. Gündoğdu, "Automatic Warship Recognition System : Dataset, Feature Representation and Classification Analysis," in *2019 27th Signal Processing and Communications Applications Conference (SIU)*, 2019, pp. 1–4, doi: 10.1109/SIU.2019.8806462.

[2] F. UCAR and D. KORKMAZ, "Ship Target Classification in Satellite Images using Deep Convolutional Neural Networks," *Sak. Univ. J. Sci.*, vol. 24, no. 1, pp. 197–202, Feb. 2020, doi: 10.16984/saufenbilder.587731.

[3] Y. Liu, H.-Y. Cui, Z. Kuang, and G.-Q. Li, "Ship Detection and Classification on Optical Remote Sensing Images Using Deep Learning," *ITM Web Conf.*, vol. 12, 2017.

[4] B. Jiang, X. Ma, Y. Lu, Y. Li, L. Feng, and Z. Shi, "Ship detection in spaceborne infrared images based on Convolutional Neural Networks and synthetic targets," *Infrared Phys. Technol.*, vol. 97, pp. 229–234, Mar. 2019, doi: 10.1016/j.infrared.2018.12.040.

[5] Ö. Kutlu, Ö. Demir, and B. Doğan, "Analysis Of Images Obtained By Unmanned Aerial Vehicle By Deep Learning Methods," in *2019 1st International Informatics and Software Engineering Conference (UBMYK)*, 2019, pp. 1–4, doi: 10.1109/UBMYK48245.2019.8965587.