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EMPLOYING NEURAL NETWORKS MACHINE LEARNING ALGORITHM FOR LULC MAPPING

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ABSTRACT: Land use/land cover (LULC) maps represent a primary requirement for several geospatial applications around the world such as change detection, time series analysis, environment and urban researches. Mapping LULC from remote sensed data based on satellite image classification handle the rapid changes in extensive geographical areas. Several effective and efficient mechanisms suggested for supervised satellite image classification. Neural networks machine learning algorithm became a major method in supervised satellite image classification. The objective of this article is to employing neural networks as machine learning algorithm for LULC mapping. The study applied in Ankara area, which is the capital city of Turkey. This work utilized free Landsat 8 satellite images with Operational Land Imager OLI sensor to implement the analysis. The images were obtained and processed in ArcGIS software. Then, the machine learning data set developed by using Python scripting language. Every band out of the Landsat 8 image bands consider as input explanatory variable, while the target output defined based on visional interpretation. The training dataset built based on signature file and random sample points. The training dataset divided to three sections, one for training, second for validation and the last section for testing. The training and testing processes were implemented based on Google Tensor Flow Keres library from Anaconda distribution. Feed forward neural network structure implemented with 500 neurons in the hidden layer. Confusion matrix used as accuracy assessment metrics to measure the performance of the developed model. The overall accuracy of the developed model was 92%. In terms of overall accuracy and robustness machine learning neural networks algorithm was effectively implemented and the LULC map produces. The model gained high accuracy that it is satisfied the geospatial accuracy target. The consequence shown the competence of Machine learning neural networks algorithm to generating LULC maps from landsat 8 satellite images.

Keywords: *Machine Learning, Neural Networks, Land Use/Land Cover (LULC), Satellite Image Classification*

1. INTRODUCTION

Land use land cover LULC mapping is an indispensable process for varied geospatial-relevant applications. LULC is the backbone data compulsory to perform the analysis in geospatial human activities and natural landscape (Abdullahi and Pradhan 2018). LULC term separately defined as first, land use represent in what way land is utilize by humans. Second, land cover represent the physical material casing the earth surface comprising artificial surfaces built by human activities, soil, water and vegetation (Aydinoglu et al. 2010). In addition, LULC maps are a critical element affecting the spatial distributions of species (Saputra and Lee 2019). Recently, satellite images have been extensively utilized to generate LULC data. Base on LULC data, several analyses performed for instance urban growth, intensity of agricultural activities, deforestation, degradation level of wetlands, other human activities and predict their impacts on the landscape (Ikiel et al. 2012). Landsat satellite images represent a valuable data source to perform LULC mapping. The first satellite of Landsat series launched in 1972, while the last version is working until these days. Landsat satellite images are freely provided by United State Geological Survey USGS with medium spectral and spatial resolution (Hakkenberg et al. 2019).

Machine learning ML algorithms consider as the most modern and major method for mapping LULC. Neural networks NN is one of the main ML algorithms that gained robust performance in supervised satellite image classification area (Pelletier et al. 2019). NN inspired and developed based on the process of biological cell (Jacobson 2013; Power 2017). During the past years, significant number of researches have been in the literature for mapping LULC using NN. Previous studies employed several NN structure and sub-algorithms to gain high classification performance. Furthermore, the traditional NN algorithms gained good performance accuracy in generating LULC maps from satellite images (Wang et al. 2019). However, NN algorithms still need further improvement to gain high accuracy by adapting most modern NN algorithms instead of conventional algorithms.

Therefore, this paper aim is to employing neural networks as machine learning algorithm for LULC mapping. This paper adopting free TensorFlow ML library for LULC mapping. TensorFlow is one of most feasible and accessible solutions for artificial intelligence and machine learning. TensorFlow help researchers by providing high level programing library thought Python. TensorFlow-Keras to provide fast NN experimentation and high performance (Liao et al. 2019).

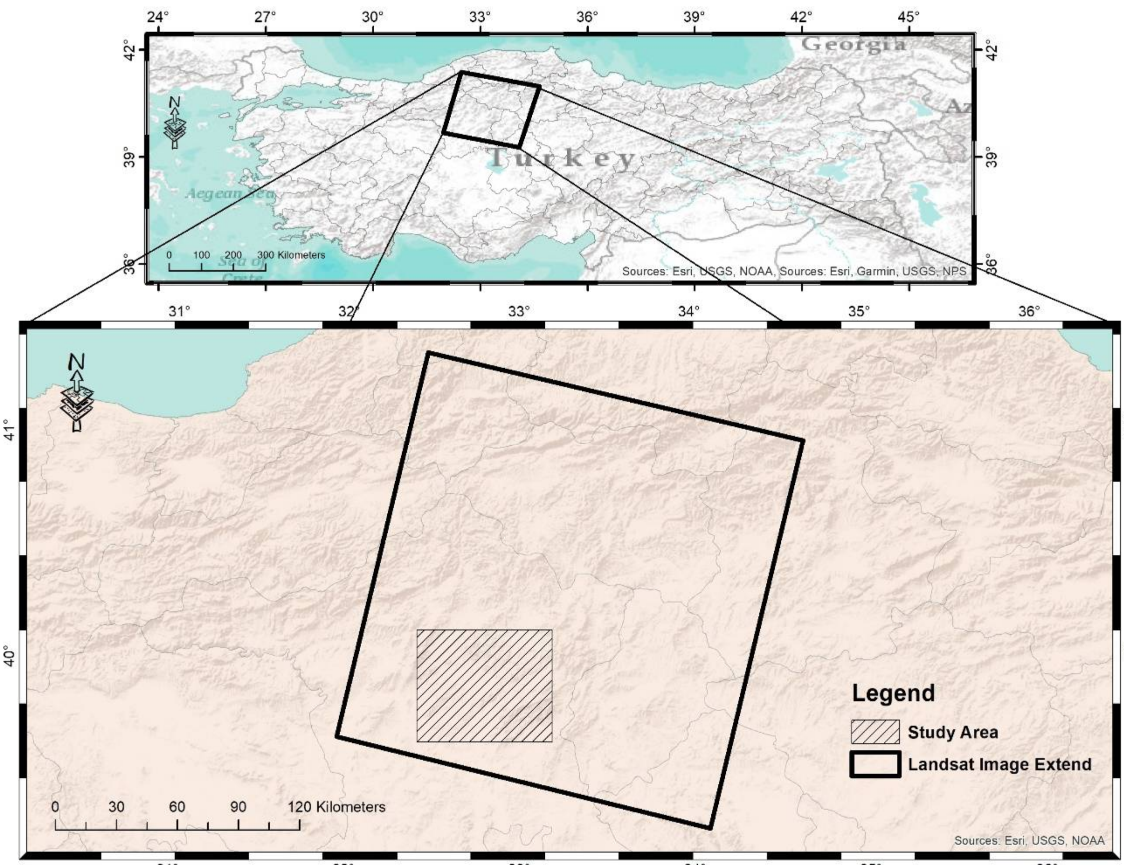

Figure 1 Study area Ankara-Turkey (Extend of Landsat satellite image in Ankara)

2. METHODS

This section discusses the methods content through the following sections: first, Study area, data collection, second, satellite image Pre-processing, third, neural networks training and testing, finally, LULC post processing.

2.1 Study area and data collection

The study area of this paper applied in Ankara urban area in Turkey. The area is 122 km^2 and has a *population* of over 5.4 million. The geographical location of the study area illustrated in Figure 1. Additionally, the figure presenting the extend of the satellite image.

The satellite image obtained from USGS webs. The image gained from the Landsat 8 archive for 2019 year. The image is 11 band produced by Operational Land Imager OLI sensor. Since the image is reach in the spectral content, thus it helps the training stage to produce high performance NN model. workflow for LULC mapping presented in Figure 2.

2.2 Satellite image Pre-processing

The Landsat satellite image undermine to several pre-processing operations before developing the NN model such as unifying the cell size, masking the bands to the study area, unifying number of rows and columns, and exclude the thermal band.

In addition, the sampling strategy relays on the Image classification toolbar in ArcMap software. Strategy is to draw some polygon for each LULC class then convert these set of polygons to grid of points based on the pixel spatial resolution. The number of sample in this study for training stage is 18050 points.

Moreover, the 10 bands of study area were reconstructed to produce the testing datasets for full area. 20 sub-datasets were generated. Mainly, python scripting language utilized to applied the image pre-processing.

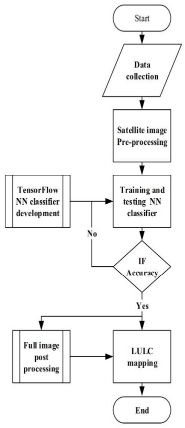

Figure 2 workflow for LULC mapping

Algorithm 1. Pseudocode of developing NN classifier and mapping LULC

```
Importing the required basic Python libraries
Importing TensorFlow library

## Training stage
Read the dataset from sample points
Divide the dataset to training and testing sets
Normalizing the datasets
Building the NN classifier structure and algorithms
Define NN classifier (inputs, hidden layers, outputs and connections)

for j=1: number of neurons do
   Training the NN classifier using (j) neuron in the hidden layer
   Evaluating the performance accuracy of the classifier
   If the performance accuracy is satisfying the training parameters:
       Stope and save the final classifier
   Else:
       Continue the training process

## Testing stage
for h=1: number of chunks do
     read the chunk dataset
     using the trained NN classifier to classify (h) chunk dataset
     save the output classified values in txt format
```

2.3 Neural networks training and testing

This stage is the main stage in this article. Training dataset used to develop the NN classifier. The classifier generated using Keras library in TensorFlow. The classifier developed using feed forward neural network structure. Classifier consisting one input layer, two hidden layers (including 500 and 100 neurons respectively) and one output layer (consisting 5 classes).

The established model stored and used to classify the full satellite image. Confusion matrix metric employed to evaluate the performance accuracy of the classifier. Python pseudocode of the developed NN classifier presented in algorithm 1.

2.3 Datasets post processing and LULC mapping

In this section, the developed classifier used to classify testing datasets. The datasets sent to the developed classifier and the classified values were stored in vector shape. Then, the output through python processed in Arcmap software to generate the final LULC map.

3. RESULTS

This section consisting the outcomes of employment of neural networks algorithm for LULC mapping. the analysis applied in three stages, mainly pre-processing, NN training and LULC mapping. Landsat 8 image were the utilized data during the applications. The study area is Ankara area in Turkey. TensorFlow library to develop the NN classifier.

The NN classifier trained until accomplished minimum error. The performance accuracy is 92% for training dataset based on confusion matrix metric, while accuracy is 89% for testing dataset. The optimal performance accuracy achieved after several experiments using different training functions or different number of neurons in the hidden layers. The ideal number was 500 neurons in the first hidden layer and 100 neurons in the second hidden layer. Based on 10 bands, NN easily gained high performance accuracy in limited training time.

In the next step, and after developing the NN classifier with high performance accuracy, the classifier used to classify the full satellite image for Ankara area. The complete image consisting 2216 columns and 1837 rows. This size of image considers as big size to be process for ML in regular computer processor. This study employed chunks method to divide and process the image. Blok by block, all the image transferred to the classifier and classified.

Then, the classified values processed in ArcGIS software and LULC map produced. The generated LULC map demonstrated in Figure 3. The LULC map consisting 5 classes. The open areas occupy the highest percentage from the total area (86%). The urban areas represent 9.15% and green lands 3.69%. The roads represent 0.37%. While water bodies represent the minimum areas 0.31%.

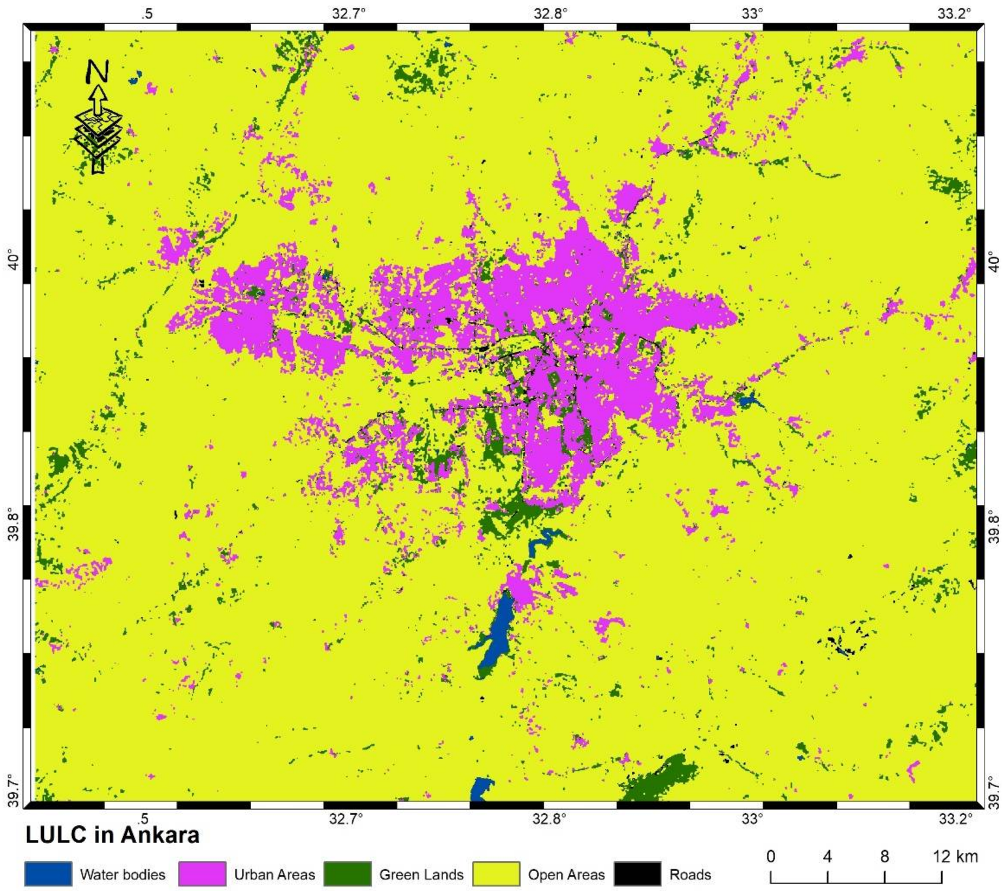

Figure 3 LULC map (map used classifier to classify Landsat 8 image based on NN and TensorFlow)

4. CONCLUSION

The objective of this article is employing neural networks as machine learning algorithm for LULC mapping. Landsat 8 image collected and processed in ArcGIS, then, TensorFlow ML library in Python programing language used to develop the classifier. Feed forward neural network structure utilized in classifier development stage. The developed classifier gained 92% accuracy.

To conclude, TensorFlow is powerful platform used as ML library to applying NN and classifying multispectral satellite images. TensorFlow platform consisting complete set of function to handle the geospatial data. This study successful employed and applied NN for mapping LULC from satellite images in reasonable time. NN based on TensorFlow libarary is capable to provide superior result passed on medium spatial resolution data. For future works, authors recommend TensorFlow library to examine other ML algorithms.

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