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Commun.Fac.Sci.Univ.Ank.Series A2-A3
Volume 62, Number 2, Pages 153-163 (2020)
DOI: 10.33769/aupse.627897
ISSN 1303-6009 E-ISSN 2618-6462

Received by the Editors: October 01, 2019; Accepted: August 26, 2020

MODERN LEARNING TECHNIQUES AND PLANT IMAGE CLASSIFICATION

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ABSTRACT. The intelligent machines concept is born in sci-fi scenarios. Today it seems to be we are much closer to realizing this idea than ever before. By imitating the human nervous system, machines can learn many things. This paper explains modern learning techniques like artificial neural networks, transfer learning. Later purposes an experiment to classify plant seedling images to test the transfer learning with two different CNN architectures. Although the architects were not actually created for this task, result were quite accurate for a different classification task.

1. INTRODUCTION

The idea of "machines that can think" has emerged in the late 19th century in books as science-fiction scenario. After that, because of the world wars technology began to advance more rapidly than ever before. This progress has removed the obstacles to the realization of the concept of intelligent machines, which was previously only a sci-fi scenario.

In 1950, famous mathematician, computer scientist and crypto-analyst Alan Turing asked the question of "Can machines think?" [1]. This article can be considered as the beginning of the concept of Artificial Intelligence. In the same article, Turing introduced The Imitation Game, also known as the Turing Test. In this test, the machine, together with a person, is hiding outside the field of view of a person asking the questions. The interrogator tries to determine which is human and which is computer by asking questions. If the interrogator fails to correctly identify the person after a series of questions, the machine will pass the Turing test.

Keyword and phrases. Plan classification, convolutional neural network, AlexNet, VGGNet

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Artificial Intelligence can be defined as the ability of a computer or a computer-controlled robot to perform various activities in the same way as intelligent living things [2]. In the years when the concept of Artificial Intelligence first emerged, researchers developed step-by-step methods that mimic the humans for solutions to the problems. Later, these methods were found to be insufficient on large data and more sophisticated methods were developed over the years. One of the most important of these modern methods is Machine Learning.

Machine learning is a field of study that aims to make software applications more accurate in predicting results without explicit programming. Machine learning is based on building algorithms that can predict outputs by statistical analysis, based on input data, and update outputs as new inputs arrive. Machine Learning algorithms generally examined into two categories as supervised and unsupervised algorithms.

Supervised algorithms required output data to test the results and generally applied on classification and regression problems. On the other hand, unsupervised algorithms do not require any output data and generally utilized to solve clustering problems.

In the last 10 years Deep Learning has emerged as a branch of Machine Learning. Deep Learning is a subset of Artificial Intelligence and Machine Learning, which predicts solutions to problems through experience using multi-layered artificial neural networks. Deep Learning differs from traditional methods in that it can automatically learn how data is represented without requiring expert or explicit coding.

Traditional machine learning techniques are limited by their ability to process natural data in raw forms. For many years, pattern recognition and machine learning systems required careful engineering and expertise to design feature extractors. Deep learning has enabled systems that do not require feature extraction.

Plants are very clearly one of the most important factors for the maintenance of natural life. Therefore, analysis, classification and protection of plants is a very important issue. Systems for classification and monitoring of plants have been developed in many parts of the world. Classification of plants by modern learning techniques, not by hand, will allow the systems to operate autonomously.

In this paper, first Artificial Neural Networks and Convolutional Neural Networks (CNN) were explained. Also two well-known CNN architectures were examined and Transfer Learning was explicated. After that, these two architectures were used to classify a plan seedlings data set. In the last section, classification results were evaluated.

2. Modern Learning Techniques

In this section, the details of Deep Learning techniques will be examined with the subtitles of Artificial Neural Networks, Convolutional Neural Networks and Architectures and Transfer Learning.

2.1. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks are abstract structures that imitate the nervous system of people in order to develop robots that can learn like humans. The term neural is derived from the neuron, the basic functional unit found in the brain of the human nervous system.

Here, the concept of learning consists of adjusting the weights to decide the strength of the incoming signals.

In fact, the history of Artificial Neural Networks dates back to 1943. McCulloh and Pitts [3] developed a simple electrical circuit to model the neuron in their study. In the 1960s, perceptron which is the simplest neural network with a single cell, was developed for classification purposes. Perceptron failed to learn the XOR operation, while yielding pretty good results for AND and OR operations. This failure caused a loss of excitement and confidence over the field.

Until the beginning of the 21st century, interest in artificial neural networks increased and decreased periodically. In recent years, with the rapid development of graphic processing units of computers which enables huge amount of parallel processing power, the interest in artificial neural networks has reached the highest level.

2.2. CONVOLUTIONAL NEURAL NETWORKS

Convolutional Neural Networks is a type of multilayer perceptron. The structure of CNNs differs from that of other artificial neural networks (Fig. 1). Normal neural networks transform the input by inserting it into a series of hidden layers and each layer fully connected to the previous layer. In CNNs, the layers are primarily 3-dimensional, including depth, width and height. Not all neurons are fully connected to each other, but only those in a certain region are interconnected. Furthermore, the output layer is a vector which includes probabilities.

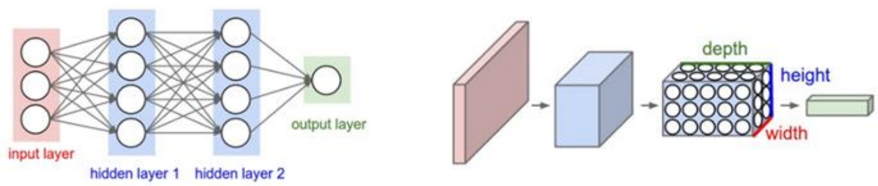

FIGURE 1. Normal Neural Network and Convolutional Neural Network [4].

CNN layers are divided into two parts which are feature extraction and classification. In the feature extraction part which is also named Hidden Layers, a series of convolution and pooling operations are performed. In the classification part which consist of fully-connected layers, classification is performed using extracted features.

2.3. CNN ARCHITECTURES

In this section the famous CNN architectures will be explained in detail. The architects to be mentioned here are those who succeed in the annual ImageNet face recognition competition [5]. In this competition, there is a data set of 1.2 million pictures and 1000 classes. This competition is held every year to find the architectures that classify this data set as the most successful.

The architecture that succeeded in this competition in 2012 is AlexNet [6]. AlexNet consists of a total of 8 layers with 5 convolutions and 3 fully-connected layers (Fig. 2). ReLU activation function and max pooling are used after each convolution layer. The ReLU activation function provides nonlinearity to the system.

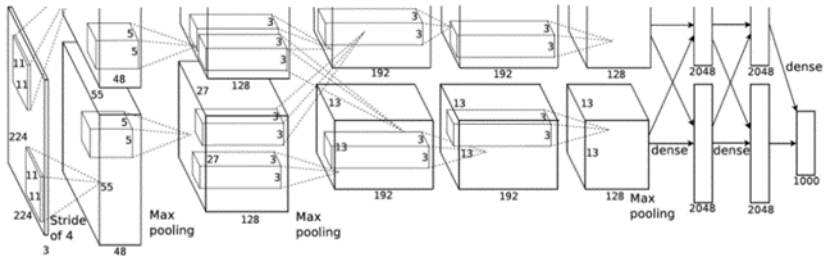

FIGURE 2. Architecture of AlexNet [6].

Another architecture is VGGNet [7], which produced successful results in the same competition in 2014. The number of layers of the VGGNet is 16 (Fig. 3), but there are versions with 19 layers. As it is understood, it has a much deeper structure than AlexNet. It has produced far more successful results than AlexNet by reducing the error rate from 16% to 8%.

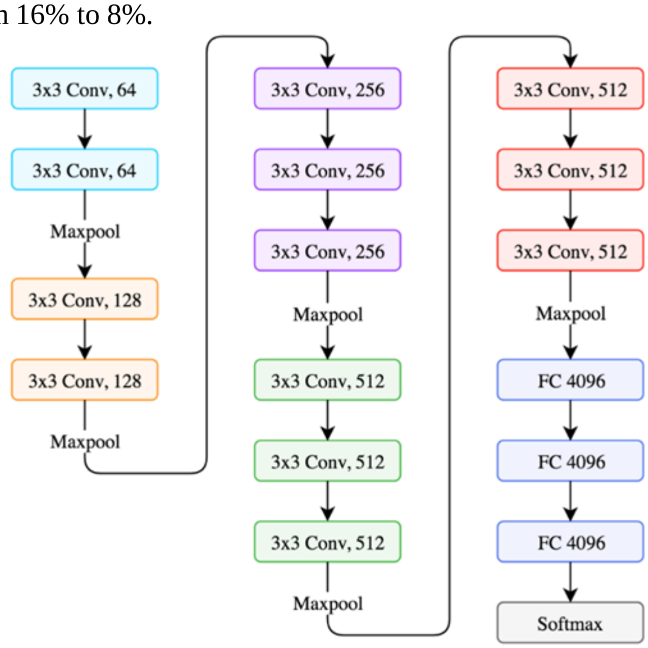

FIGURE 3. Architecture of VGGNet [7].

2.4. TRANSFER LEARNING

In practice, very few people try to create an artificial neural network from scratch, train it and calculate their weight. A network that has previously been trained for a task can be used in other similar tasks. For this purpose, it is compulsory to remove the fully connected layers at the end of the artificial network. After removing the fully connected layers, a classifier based on the new problem which is working on, must be added. The remainder of the network is used as a feature extractor for the new dataset.

3. Plant Classification

Plants have a very important place in natural life. Many countries around the world are forming plant monitoring networks in their regions. Therefore, plant identification and classification has become an important problem in recent years [9].

In plant classification problem, feature extraction method is used in the literature in general. For this purpose, classification procedures are made by looking at leaf shape [10-12], shape and surface [13], color [14] and vascular structure [15].

Larese et al. [16] classified vascular structures of bean leaves with Random Forest and SVM in their study and achieved successful results in the range of 87% to 95%. Grinblat et al. [17] improved previous work using a 5-layer CNN (Fig. 4) and increased the success range from 93% to 97%.

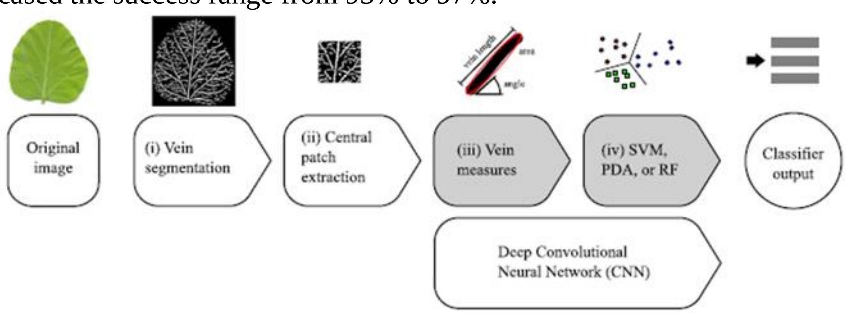

Figure 4. The system of the study of Grinblat et al. [17].

Lee et al. [18] used AlexNet architecture, a pre-trained model for object recognition. The artificial neural network architectures which was orginally constructed for object recognition, can be used for other generic tasks and they produce very successful results [19]. As a result, they have achieved 99% success in the classification of the data set with 44 species of plant leaves.

3.1. EXPERIMENT

In this study we designed an experiment for plant classification using transfer learning method. The aforementioned AlexNet and VGGNet architectures were used for classification purposes. As stated before these two architecture were originally designed to classify faces but can be used for similar task like classification of plant pictures.

The experiment was conducted using Plant Seedlings [20] dataset of Aarhus University. This data set contains 4750. Sample images from data set can be seen in Fig. 5.

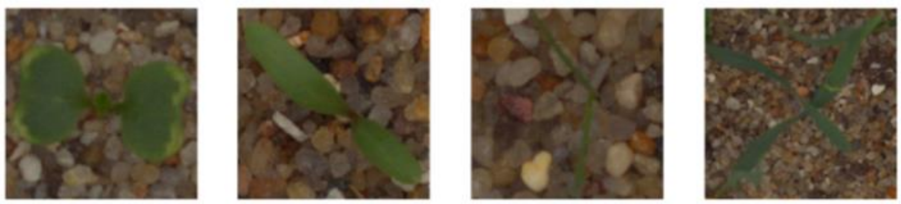

FIGURE 5. Sample images from dataset.

The specifications of the computer used in these experiments have Intel i7 7700K 4.20 Ghz CPU, Nvdia GeForce 1080 GPU, 16 GB RAM.

3.2. RESULTS

Dataset was used to test both architectures with 10-fold cross validation. Result of the training process of the AlexNet architecture can be seen in Fig. 6. Also training and validation loos of the architecture is in the Fig. 7.

Result of the 10 run of the 10-fold cross validation can be seen in Table 1. AS can be seen, AlexNet architecture produced better results regarding VGGNet. While VGGNet correctly classified the 75% of the plant images, success rate of the AlexNet was nearly 90%. Also result of the t-Test can be seen in Table 2. Looking at the table, one can see that the results are statistically significant (t Stat >> t Critical, P=1.29622E-11<<0.05).

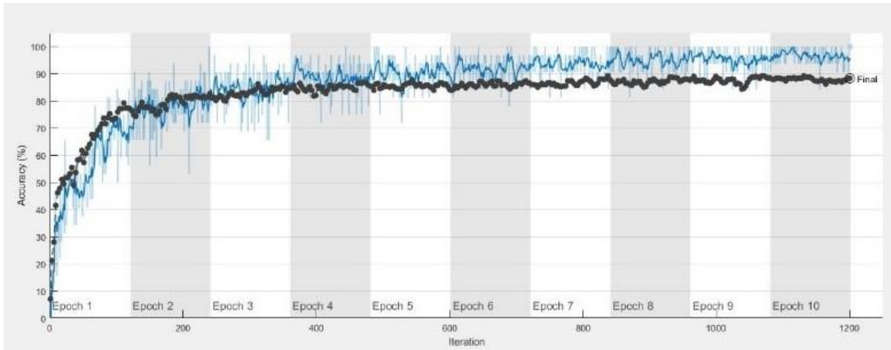

FIGURE 6. Result of the training process of the AlexNet architecture.

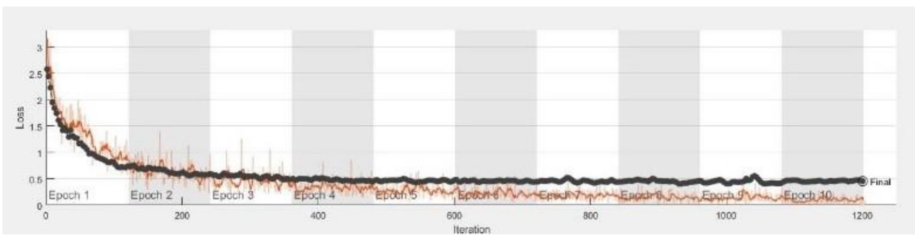

FIGURE 7. Sample training and validation loss.

TABLE 1. The results of 10 run of two different architectures.

	AlexNet	VGG16
1	0.8998	0.7589
2	0.8765	0.7554
3	0.8834	0.7640
4	0.8904	0.7585
5	0.8928	0.7491
6	0.8671	0.7434
7	0.8998	0.7569
8	0.8741	0.7446
9	0.8601	0.7475
10	0.8834	0.7510

TABLE 2. t-Test result.

	AlexNet	VGG16
Mean	0.88274	0.75293
Variance	1.79289E-03	4.65734E-05
Observations	10	10
Pearson Correlation	0.618046202	
Hypothesized Mean Difference	0	
df	9	
t Stat	38.63155235	
P(T<=t) one-tail	1.29622E-11	
t Critical one-tail	1.833112933	
P(T<=t) two tail	2.59244E-11	
t Critical two tail	2.262157163	

4. CONCLUSIONS

With the developing technology, machines became more and more intelligent day by day. The meaning of the intelligence in this context is the improvement of the ability to learn and to solve different problems. Since the very beginning of the artificial intelligence technology, scientists try to mimic human to enhance the learning ability. For this purpose, first perceptron was invented which followed by basic neural networks. After success of neural networks, deeper and more complex networks were generated to solve specific problems.

In this study, we designed a transfer learning method for plant image classification. First, artificial neural network and CNN was explained. Than different architectures of CNNs for modern face classification was mentioned. After that, transfer learning was explained. An experiment was evaluated for plant classification using this technique and a plant dataset.

The AlexNet architecture achieved better results than VGGNet on the dataset. The results show that a CNN architecture for a specific task can achieve good results in different tasks.

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