Chapter 77
Convolutional Neural Network

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ABSTRACT

Machine learning is the study of algorithms and models for computing systems to do tasks based on pattern identification and inference. When it is difficult or infeasible to develop an algorithm to do a particular task, machine learning algorithms can provide an output based on previous training data. A well-known machine learning model is deep learning. The most recent deep learning models are based on artificial neural networks (ANN). There exist several types of artificial neural networks including the feedforward neural network, the Kohonen self-organizing neural network, the recurrent neural network, the convolutional neural network, the modular neural network, among others. This article focuses on convolutional neural networks with a description of the model, the training and inference processes and its applicability. It will also give an overview of the most used CNN models and what to expect from the next generation of CNN models.

INTRODUCTION

In a broad sense, a convolutional neural network is one of many methods to achieve artificial intelligence.

Artificial intelligence (AI) is a field of computer science dedicated to the research of methods and algorithms that permit to perceive information from the environment, learn from it and taking actions and decisions based on the learning outcomes without any explicit orientation from external agents. AI consists of many sub-fields, including evolutionary computation (e.g., genetic algorithms), vision (e.g. object recognition), expert systems (e.g. decision support systems), speech processing (e.g. speech recognition), natural language processing (e.g., machine translation), and machine learning (e.g. decision trees).

Machine learning (ML) is a type of algorithms and models for computing systems to do tasks based on pattern identification and inference (Mitchell, T., 2017). When it is difficult or infeasible to develop an algorithm to do a particular task, machine learning algorithms can provide an output based on previous data. Machine learning algorithms identify features from data and build models from these features so that new decisions can be produced based on these models and rules. Examples of machine learning

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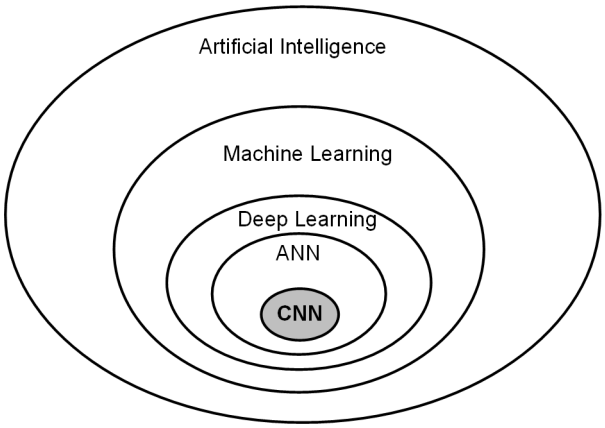
models include deep learning, support vector machines (SVM), genetic algorithms, clustering, dimensionality reduction, artificial neural network, decision tree and others.

In this chapter we are particularly interested in deep learning (DL) (Aggarwal, C., 2018). Deep learning teach computers to learn by example. Deep learning first appeared in 1980, but only recently has been applied in practice because it requires large amounts of labeled data and high-performance computing. Its application is vast including areas like computer vision, speech recognition, language processing, among others.

The most recent deep learning models are based on artificial neural networks (ANN) with a large number of layers. Deep learning networks are first trained using a large set of labeled data in order to learn features from the training data without being explicitly programmed to learn them.

There are several types of artificial neural networks including the feedforward neural network, the Kohonen self organizing neural network, the recurrent neural network, the convolutional neural network, the modular neural network, among others. The convolutional neural network (CNN) is one of the most used deep learning architecture for artificial intelligence (see figure 1).

Figure 1. Convolutional Neural Networks in the context of artificial intelligence



Convolutional neural networks are one of the most used deep learning models in the industry and business. Therefore, for those interested in understanding how deep learning is applied in this markets it is fundamental to understand the architecture of CNNs and understand the evolution and trends of CNNs during the last decade.

This article focus on convolutional neural networks with a description of the model, the training and inference processes and its applicability. It will also give an overview of the most used CNN models and what to expect from the next generation of CNN models.

BACKGROUND

Artificial neural network (ANN) is a machine learning model that mimics the structure of the human brain consisting of interconnected neurons. Theoretically, an ANN is a universal model capable to learn