A Review of the Impact of Deep Learning in Practical Contemporary and Near-Future Applications in the 21st Century

# Abstract

# Introduction

## Overview

Deep learning is a type of neural network-based machine learning that involves using a set of multiple hidden layers, typically at least 6-10, of nonlinear processing units for feature extraction and data transformation. Each layer composed of *n* number of nodes feeds the next with connections made between each layer’s nodes to the next. The great number of connections made between nodes means exponential increases in complexity when expanding the number of layers and/or nodes. This makes deep learning, as a highly complex model of neural network, very computationally expensive when compared to traditional algorithms. A large proportion of the computational power used will not necessarily be used within the calculations performed on a prepared network but the training of a network, the length of which is directly tied to the number of connections within a network.

## Machine Learning Methods

Learning can be supervised, semi-supervised or unsupervised. Supervised learning consists of teaching a network to recognise patterns based on learning the values of pairs of input and output values fed to the system. The network will adjust to these values, called a training set, to prepare it for receiving novel data. In theory a trained network will be able to adjust itself to recognise novel data presented to it and accurately calculate the correct result intended by the training process. Semi-supervised learning is a technique in which unlabelled data is mixed with the training data, which can improve the learning accuracy of a network. A problem with supervised learning is that often a network may be trained too specifically towards training data. In contrast, unsupervised learning does not have predicted accuracy due to the lack of concrete examples from which the network can learn. However a network will still be able to detect and learn patterns and similarities between data sets available to it.

# Methods

An initial search performed on the University of South Wales Library portal, looking for articles associated with deep learning. For this purpose, I used multiple searches using the additional key words of “medical”, “scientific”, “commercial”, “industrial” and “applications”. An initial selection process involved picking articles and conference proceedings based on their relevance to deep learning. From here I went into each article and downloaded a PDF copy where available and any associated articles I could find that were presented on the website. I found a large quantity of articles available, particularly on the website “ScienceDirect” and downloaded a few dozen linked articles. Going further, I searched directly on the ScienceDirect website for articles on deep learning and found many. I then followed this up with a set of searches on google scholar, JSTOR, arXiv and Jurn. JSTOR unfortunately has a paywall preventing me from using that source but I obtained many useful articles from google and Jurn. Of note several of these journal search engines linked to each other and my searching involved going back and forth between different websites. This initial data gathering was to find a great deal of material on the subject I am covering, followed by a later culling of inappropriate or poor sources.

My initial gathering of articles en masse without appreciable quality control yielded 93 articles of interest about deep learning. All articles gathered mention deep learning within the title or the abstract. I will cull this greatly through a skim read of the article to determine the suitability of each article to this review paper. Approximately 30 articles were carefully picked out one by one in a manual fashion. The remainder were collected through links to associated papers.

A sift through the articles resulted in 19 articles dropped from my selection due to one of the following reasons:

* The article not once mentions deep learning in the main body of the text, nor neural networks
* The article does not go into sufficient detail to be useful or coverage of the subject is very low

The remaining 74 articles have had a basic skim read to confirm their utility. An exceptional article, involving a study of spindle power data from mining tools, does not refer to deep learning but only neural networks. I decided to include this based on its future applications. All other articles explicitly refer to deep learning at a good level of detail.

# Scientific Applications of Deep Learning

Reconstruction of cosmic ray induced air showers has been performed using deep learning (Erdmann, Glombitza and Walz, 2018). Using simulation of ground-based particle detectors on a regular grid of neural network nodes, it was found that resolution of higher cosmic ray energy was improved.

# Medical Applications of Deep Learning

Medical applications include the use of predicting patient conditions based on medical history and diagnosing tumours from scan results. Medical image analysis has had more than 300 papers alone surveyed in one review paper (Litjens et al., 2017).

Cancer prediction has been implemented using gene expression data (Xiao et al., 2018), specifically involving Lung Adenocarcinoma, Stomach Adenocarcinoma and Breast Invasive Carcinoma. Results concluded with an increase in prediction accuracy with all tested RNA-sequence data sets.

Segmentation of brain tumours in scans have been automated with deep learning (Zhao et al., 2018).

Lesion detection in the context of diabetic retinopathy, a preventable side effect of diabetes has been shown to be automated using deep learning (Orlando et al., 2018).

# Commercial Applications of Deep Learning

Commercial applications include the use of self-driving cars, using deep learning algorithms that can accurately detect the presence of vehicles and road lanes. Detecting pedestrians via their head pose and body orientation, a subset of automated human activity recognition, is tackled by deep learning (Raza et al., 2018). Because the orientation of a head and torso is greatly predictive of human movement, correct estimates are of great use for automobiles avoiding collision. Raza et al. in experiments achieved a mean accuracy of 0.91 and 0.92 for head pose and full body estimation.

Deep learning also plays a significant role in data mining using big data (Zhang et al., 2018). Zhang et al. note that deep learning is used to learn features on extremely large datasets but that in the future with increases in computational power slowing down and a simultaneous increase in the size of data sets, it will be more difficult computationally.

# Public Safety Applications of Deep Learning

An approach for detecting traffic accidents from social media data has been demonstrated (Zhang et al., 2018). Deep belief networks (DBN) and long short-term memory were used, with an overall result of 85% accuracy when using a DBN.

Self-driving also benefits from identification of pedestrian activity, which is difficult with low resolution images (Raza et al., 2018).

# Conclusions

Medical technology seems to be a less advertised landscape for deep learning than is commonly known. The future potential in medical tech is in two broad scopes; an increase in accuracy of diagnosis and treatment and a reduction in labour required by medical doctors. The first is accomplished through deep learning techniques that act as greatly superior computational algorithms to current medical technology, the second through deep learning acting as a highly technical automation of current technology.

Self-driving cars are an area that has much documentation and work performed. It seems inevitable that self-driving cars will be on the roads en masse within a matter of years, depending on the results of current testing being performed.

# Recommendations and Predictions

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