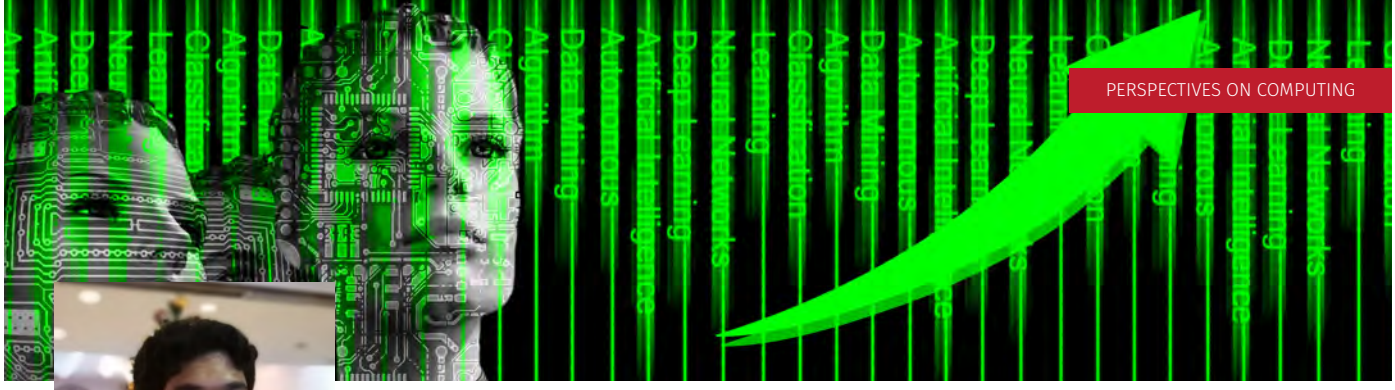

The Boost of Deep Learning: Why Now and Not Earlier?

Dr. Siyamalan Manivannan *explains the reasons behind the increased popularity of deep learning at the dawn of the AI age.*

Deep Learning (DL) is a sub field of Machine learning (ML), and they both come under Artificial Intelligence (AI). DL is a hot research topic today, and it has shown tremendous progress in a wide variety of applications in various fields including Computer Vision, Medical Imaging, and Natural Language Processing. Many tech giants such as Google, Facebook and Amazon are already using some form of DL in their projects. For example, face detection and recognition in Facebook, language translation in Google. So what is DL? How does DL differ from traditional ML and AI? Why it became so popular recently and not earlier? What are the important applications of DL? Are there any challenges with DL? This article aims to expound and answer these questions.

What is DL? - DL is nothing more than a deep version of Artificial Neural Networks (ANN). ANNs are inspired by the way the human brain works. They consist of artificial neurons, which are interconnected in a structured way. Each connection consists of a weight. Each neuron is the basic non-linear unit of information processing; it receives input from other neurons which are connected to it, processes the inputs by applying a weighted summation, applies a non-linear transformation on the weighted summation, and then sends the output to other nerons. The aim of learning an ANN is to learn the interconnection weights between the neurons by the use of an objective function. An example objective function could be Mean Squared Error (MSE), which tries to reduce the error between the desired outputs (targets or labels) and the outputs provided by the ANN for a given set of inputs.

How DL differs from AI and ML? - AI can be thought of as any technique which enables computers to mimic the human behaviour. For example, let's assume that you are building an expert system for disease diagnosis. Here, you acquire knowledge from clinicians and convert it into a knowledge base. On top of this knowledge base you build an inference engine, which is to answer the queries from the users. In AI, this inference engine is merely built based on a set of human derived rules, in the form of if-then-else.

ML, on the other hand, aims to gain some useful knowledge from the data. For example, in ML you give a set of images of apples, and another set of images of oranges and ask the ML algorithm to create a model to distinguish apples from oranges. When the model is trained, it can be used to predict any new image into either apple or orange. Here, unlike AI, the ML algorithm tries to automatically learn the differences between apples and oranges. However, ML is often called "Shallow Learning", because only a part of the overall process is learned by the machine, and the other part is "hand-crafted", i.e., provided by a human. Based on your expert knowledge, you can specify what kind of features are better suited for telling apples and oranges apart. An example feature could be the colour or the shape. After this hand-crafted feature extraction phase, which is done with your aid, the machine will learn to distinguish between apples and oranges.

It is quite easy to specify what are the discriminative features to differentiate between apples and oranges. However, for many other problems, for example, classifying cats from dogs, it is often difficult to

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specify what kind of features are better suited. DL has the ability to learn almost everything (features as well as classifier) from data. As the entire model (features and the classifier) is learned in an end-to-end setting from data, the learned model is usually very robust in differentiating among object categories.

Why DL became popular now, and not earlier? - DL is a deep version of ANN. As they are deep (contain more layers and parameters), they require lots of data and clever algorithms for training, and in addition, they require high computational power such as GPUs. The unavailability of big data, high computational power and better algorithms to train deep models limited the use of DL in the past decade. However, recently DL received a significant boost due to such reasons as the availbility of large, publicly available labeled datasets (e.g., ImageNet), availability of high speed GPU computing power for the acceleration of model training, and the invention of better DL models and algorithms. In addition, the appearance of public DL libraries such as PyTorch, TensorFlow, etc., also contributed to the success of DL as they help with faster prototyping.

Scalability was an issue with earlier days of ANN due to problems such as vanishing gradients, overfitting, etc., which limited the use of number of layers in an ANN. However, introduction of new activation functions such as Rectified Linear Units, introduction of Skip Connections (e.g., in ResNet) and the introduction of Batch Normalization alleviated the problems associated with vanishing gradients and therefore, provided an efficient way of training deep models which can contain hundreds of layers. In addition, regularization techniques such as dropout, transfer learning techniques, etc., also helped to reduce the problems associated with training deep models.

Some applications of DL - Nowadays DL is widely used in various fields from agriculture to medicine. The following is a list some important applications of DL.

1. Image analysis: Image classification, object detection and segmentation approaches are used in computer vision for several purposes including scene understanding for autonomous vehicles. Disease detection, classification and segmentation approaches were also explored in agriculture to diagnose diseases in plants; similarly medical image analysis is used to diagnose diseases in humans. Face recognition, activity recognition, pose estimation are also some of the DL applications.

2. Image Processing: Generative Adversarial Networks (GANs) are a special type of DL models which can be used for automatic image editing, image super resolution, style transfer (e.g., day-time image to night-time image, and vice versa), image inpainting (fixing damaged photographs), etc.

3. Natural Language Processing (NLP): DL is used in NLP for various purposes including language translation, text summarization, and sentiment analysis.

4. Digital Signal Processing: DL is used for analyzing signals, e.g., for voice recognition and speaker identification.

5. Gaming: DL plays a significant role in gaming, e.g., Chess.

Challenges with DL - Although DL provides the state-of-the-art results on almost all domains, still there are several challenges to be addressed.

1. The need for a large amount of annotated data: one of the main challenges with DL is the availability of a large amount of annotated/labeled data. DL models are usually data hungry, i.e., they require a large amount of labeled data for training. Obtaining such a large amount of labeled data is a tedious and expensive process.

2. Overfitting: It is a problem with the generalization ability of the DL models, where the trained model works well for the training data, but performs much poorly on the test data. Overfitting can easily occur particularly when a large model is trained with a small amount of data.

3. Class imbalance: This problem occurs when training a discriminative DL model where different classes contain different numbers of samples, which may make the training biased towards the class, which contains a large number of samples.

4. Model interpretability: It is one of the major problems associated with DL. Usually DL provides black box solutions, i.e., it is hard to interpret what the model has learned. The model interpretability is of particular interest to the clinicians; for instance, when an image is classified as cancerous, clinicians need to know which features make it cancerous.

5. Incremental learning: Most of the DL algorithms require all the trainin-

g data before they can start training. In incremental learning we won't have all the data initially, but the data will accumulate over time.

Various solutions also have been investigated for the above problems. For example, transfer learning, semi-supervised learning, data aug-mentation, and data generation approaches are widely being used to overcome the need for large amounts of labeled data for training. Techniques such as regularisation and dropout are explored to reduce overfitting.

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IEEE WIE Student Branch Affinity Group - SUSL

IEEE Women in Engineering (WIE), being one of the largest international professional organizations, is dedicated to promote and inspire women engineers and scientists around the world with the mission of facilitating the recruitment and retention of women in technical disciplines globally. IEEE WIE Affinity Groups are established worldwide in order to maintain the local level network and organize a variety of activities locally and internationally.

In June 2021, the Sabaragamuwa University of Sri Lanka succeeded in establishing the IEEE Women in Engineering Chapter in the university as one of the IEEE WIE Student Branch Affinity Groups in the Sri Lanka Section, with the aim of encouraging and facilitating the young female undergraduates in the university to achieve technical and professional eminence and enhancing women leadership and empowerment globally. This is an excellent opportunity for female undergraduates to grow and demonstrate their diverse abilities.

The first Annual General Meeting was held on the 23th of June, 2021 with the participation of Prof. Udaya Rathnayake, theVice Chancellor of Sabaragamuwa University of Sri Lanka and Dr. Rasara Samarasinghe, the Chair of IEEE WIE Sri Lanka Section as the Guest speaker, Dr. Rasangi Sabragamuwa, the Dean of the Faculty of Applied Sciences, Prof. S. Vasanthapriyan, the Head of the Department of Computing and Information Systems, academic staff members of the Department, and the IEEE and IEEE WIE student members of SUSL.

IEEE SUSL WIE Student Branch Affinity Group in its Action Plan has identified diverse activities including organizing technical workshops, webinars, charity work, promotional activities, mentorship programmes, and hackathons aligning with the mission of IEEE WIE focusing not only the university, but also other universities, institutes, schools etc. Affinity Group also encourages the members to collaborate with the IEEE WIE community, R10 and the worldwide WIE networks and to participate and contribute in a variety of activities and programs organized. There are plans to conduct weekly/monthly Techno Meet-ups, establishing Girls' Techno Groups and Innovation Hubs with the intention of developing a platform for the female undergraduates through which they can improve technical knowledge and present their innovative ideas.

IEEE WIE Student Branch Affinity Group of SUSL will always be a potential platform for female undergraduates to enhance themselves and pursue engineering careers while advancing in leadership roles and career advancement.