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A Compendium of Deep Learning Frameworks

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Abstract

This paper presents an in-depth analysis and review of various Deep Learning frameworks that currently exist, along with weighing the pros and cons of each. Deep Learning has recently become widely accessible to the masses, with companies such as Google, open-sourcing their Deep Learning frameworks. With other companies following similar protocols, the question as to which framework to choose remains. This paper contrasts, elaborates and discusses reasons why various frameworks are better suited for Deep Learning.

Keywords: Deep Learning, Framework, TensorFlow

I. INTRODUCTION

Conventionally, programming has always comprised of describing the steps necessary in order to solve a given problem. With the advent of machine Learning, this approach is reversed, which is to say, the desired output is clearly defined, and the program learns the steps needed to reach that outcome. This procedure can be implemented with the increasing number of frameworks that have recently been made available to the public. This study begins with major fields of Deep Learning, the different frameworks available, and concludes with a summary of the most optimal approach to Deep Learning.

II. MAJOR AREAS OF APPLICATION

Deep Learning needs data to prosper, and at the rate data is being consumed today, it's applications are more plentiful than ever. Listed below are some of the major milestones Deep Learning has accomplished in recent years.

2.1 Image Processing

Within the field of image processing itself, a multitude of opportunities exist for machine Learning to expand and improve. A prime example of recent innovation in this regard comes from the autonomous driver systems, whose major objectives include, but are not limited to, distinguishing road signs and adapting accordingly. The elements of a particular road sign would be traditionally taught to the program with parameters such as unique geometry being provided as manual input. With machine Learning, this can be simplified greatly by providing a plethora of images, labelling the set under a class, and allowing the program to extract the features and learn for itself what the sign looks like.

2.2 Speech Recognition

Virtual assistants are on the rise, and continue to improve on a daily basis. These include services like Alexa, Siri, Cortana and Google Assistant. Not only are new functions added regularly, but the accuracy of speech detection and recognition has seen a dramatic increase, as more people begin to adopt the services offered. These services collect speech information from the users and through machine Learning, improve upon their already existing foundation. The sheer quantity of audio information that is used to improve on the already existing speech recognition system is how Deep Learning enables new features to be added on almost a weekly basis. This was how the minimum syllables required for detection has been reduced to 3 from 4, as seen in the case of Google Assistant – Previously O-kay-Goo-gle, can now be customized to activate when it hears: Hey-Goo- gle.

2.3 Fraud Detection

Machine Learning can also be used in situations where the steps to reach a certain goal are unknown. In the case of banks, suspicion of fraudulent activity does not necessary being able to narrow down the search to a particular individual. These situations can be addressed promptly by machine Learning. A log file containing all user information is given to the program and the objective is to detect which user is different from all the other users, this way without having to go through regular channels, fraud detection becomes both swift and simple.

2.4 Game Playing

Deep learning has come a long way since its inception. As the capacity and capability of the concept is larger now than ever before, the benefits of deep learning have found their way into games as well. This can be seen in both single player games, whose outcomes are primarily used for research purposes to determine how well a system can adapt to a situation when a set of constraints is present, as well as in multiplayer games, where a player is able to play against the computer without the need for another human to be present.

III. ADVANCEMENT OF DEEP LEARNING

Deep Learning is unique in that it's performance does not degrade with addition of vast data. On the contrary, the more data available, the better Deep Learning takes place.

In comparison, legacy algorithms fail to increase performance once a certain stage has been reached.

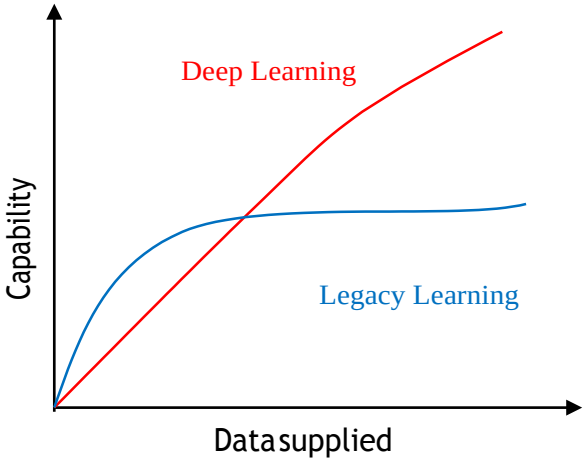

Fig. 1. Deep Learning compared with legacy learning

Many machine Learning models currently exist, the most common of which is Neural Networks. When a Neural Network that consists of several layers to make a prediction, it is termed as Deep Learning. It is by far, the most accurate subdivision of machine Learning due to the vast amount of data that is processed. Deep Learning is advancing at a rapid rate for two major reasons, the increasing amount of data and datasets available for consumption, the open source community backing Deep Learning frameworks. Major companies including Google and Microsoft have made their frameworks open to the public which have only led to heightened activity in the domain of Deep Learning which is seen in GitHub Repositories for the same.

The most capable and feature-rich frameworks which will be detailed below are: Caffe, Keras, Theano, TensorFlow, MXNet, CNTK and Neon.

IV. FRAMEWORKS

With a technique as prospective as Deep Learning comes a choice of which path to follow in order to obtain the desired solutions. Developers and researchers alike have the freedom of choosing from these choices which present themselves in the form of Deep Learning Frameworks. Many of these frameworks have been released to the public recently which makes starting up with any decision, considerably faster owing to the wide range of community support. Below several frameworks are contrasted highlighting factors that could influence a project's development

A. Caffe

Caffe was the first reliable Deep Learning framework that was made available to the public. It was developed by Berkeley AI research along with collaborators in late 2013. In caffe each node is considered as a layer with its individual forward and backward passes. The result of this is each node is unnecessarily large making it inefficient. This legacy approach was well received at the time of introduction, however with an appreciable array of applications demanding greater computing necessities, Caffe failed to provide streamlined GPU integration. In order to enable simultaneous GPU and CPU support, additional functions have to be defined. Caffe provides support for Convolutional Neural Networks but lacks the same for Recurrent Neural Networks. It has a direct successor dubbed 'Caffe2' which was released by Facebook and is cross-platform, but with many other frameworks which favor efficiently rising, developers and enthusiasts alike have migrated elsewhere.

B. SciKit

SciKit-Learn is not technically considered a Deep Learning framework, however its ease of use and general-purpose approach have paved the way for other frameworks to improve upon its principles. SciKit is an open source machine Learning library that makes use of python. It makes use of a simple fit-predict workflow model that allows for supervised or unsupervised Learning. The major drawbacks with SciKit are that it provides no support for either Neural Networks or GPU integration. SciKit Flow solves the above issues by acting as an interface with TensorFlow as it's backend. In addition to maintaining its simplicity scikit flow provides a set of high level model classes that include Deep Neural Networks, Recurrent Neural Networks and Convolutional Neural Networks.

C. Keras

Keras is open source library that is also written in python. It is primarily used for building Neural Networks, and follows an object-oriented design throughout its interface that results in a consistently cleaner framework. Keras is capable of working with multiple backend sources such as TensorFlow, Theano, MXNet and CNTK. It was introduced in early 2015 and as such contains lots of documentation. It works in correlation with other frameworks and provides several high-level APIs and a range of tools that simplify image and text processing.

D. TensorFlow

TensorFlow is an open source software library for Machine Learning. It was developed by Google and released to the public in late 2015. It is extremely efficient for numerical computation using data flow graphs. It finds its primary purpose in Deep Learning Research. This framework is sufficiently general to allow TensorFlow to have a wide range of applications. TensorFlow supports both Recurrent and Convolutional Neural Networks. The models in TensorFlow are represented as data flow graphs, each graph consists of a set of nodes. Each node is considered a matrix operation which uses Tensors as it's input and output. A Tensor is a multidimensional array that communicates between operations and is how data is represented in TensorFlow. This architecture is not only

efficient and easy to use but also allows for ample flexibility. This is seen with the GPU support. The TensorFlow architecture supports computation over multiple CPUs and GPUs across desktops, servers and mobile devices by invoking a single API. An important advantage that TensorFlow possesses is that it was made by Google, who also happen to be in possession of the world's largest data collection. This colossal collection of data at their disposal only benefits TensorFlow's growth, which is backed by staggering levels of engagement on GitHub.

TensorFlow does however also face one major drawback that is equal in magnitude to its prime advantage. It currently has no native support for Windows, which is something other Deep Learning Frameworks offer.

E. Theano

Theano is a python library that was developed at the University of Montreal. Theano provides the strongest competition to TensorFlow given the numerous similarities between the two. This includes the capability to support multiple CPUs and GPUs. Theano even outperforms the latter when it comes to computation on a single GPU, but pales in comparison during parallel GPU computing. It also allows for evaluation of mathematical expressions involving multidimensional arrays. When compared to TensorFlow is not as user-friendly, but has still been used in a multitude of AI ventures. One thing is having that TensorFlow does not, is native support for Windows.

F. MXNet

MXNet is Deep Learning Framework that was collaboratively developed by universities and companies including NVidia, Intel, Carnegie Mellon University and the University of Washington. MXNet supports an abundance of languages including C++, R, Python, Matlab, Javascript, Julia and Scala. MXNet also supports distributed computing which makes it the go to decision if computing involves multiple GPUs and CPUs. In addition to relatively fast performance, MXNet supports both Recurrent and Convolutional Neural Networks. The most widely known application of MXNet is in Amazon Web Services.

G. CNTK

The Microsoft Cognitive Toolkit (CNTK) is an open source toolkit that is used for training Deep Learning algorithms. It has been available under the open source license since 2014. It too supports Recurrent Neural and Convolutional Neural Networks, provides swift GPU computing options that can be automated in a distributed computed environment. CNTK is also capable of combining model types such as Deep Neural Networks and Convolutional Nets. It can work with either C++ or Python. Its applications can be found in well-known Microsoft services including Skype, Cortana and Xbox.

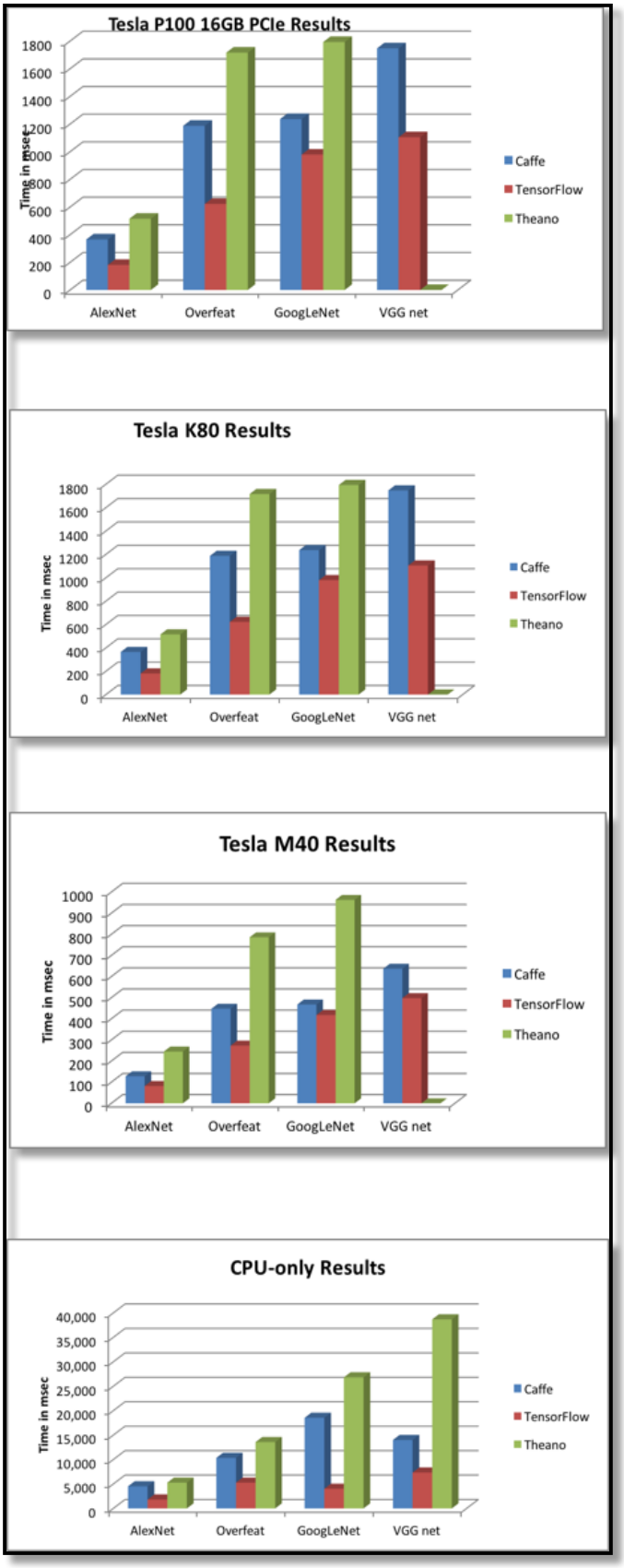

Fig. 2. Benchmarks of Deep Learning Frameworks run across different GPUs

V. CONCLUSION

Deep Learning, research regarding it, the developers dedicated to it and as a dominant field in its own right, is progressing at a rapid rate. While many frameworks currently exist that are capable in their own areas, to select which one is best suited for Deep Learning all factors must be taken into consideration this includes documentation available, ease-of-use, modularity, flexibility, GPU acceleration and support for Neural Networks. Given the above parameters, TensorFlow presents the most viable blend of all desirable attributes of a Deep Learning Framework. With impressive GPU computation speeds, an ever-expanding library and developer pool, TensorFlow will continue to grow and soon become the standard for Deep Learning.

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