Open Source Frameworks for Deep Learning and Machine Learning

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Abstract—This study aims an analysis of different existing open source technologies used recently to implement Deep Learning and Machine Learning models. Knowledge of existing open source frameworks can utilize in implementing difficult and complex models of Deep Learning more efficiently and fast by reducing time and effort on duplicate development. It is great beneficial for researchers and software engineers of Artificial Intelligence field to use these open source technologies in right way.

Keywords—Open Source Technology, Frameworks, Packages, Deep Learning, Machine Learning, Artificial Intelligence.

1 Introduction

The growth of deep learning in the field of artificial intelligence and data science has been astounding in recent time. Keeping up with the growing methodologies and improved algorithms has been a real struggle for researchers and engineers. However, a majority of these literature is not accompanied by their corresponding implementations. Implement these great ideas from scratch is very effort and time demanding process, for researchers and software engineers. Because of these reasons, new derived methodologies may not be implemented and applied in real world.

2 Contribution of Open Source Technologies

To avoid duplication of development, it is highly recommended to use open source technologies and frameworks. There are many reasons behind this. Open Source Development enables all community to read the code, modify based on their own requirements and redistribute them again, based on terms of licence. Using source code for any deep learning methodology, if already available will impact the progress of development at very large scale by reducing efforts and time in implementing the same work.

3 Impact of Open Source Technologies in AI Field

In the open source movement in Artificial Intelligence field, software frameworks for neural networks play key roles in the development and application of deep learning methods. However, as new types of deep learning models are developed, existing frameworks designed for convolutional neural networks are becoming less useful.[3]

Implementing neural networks requires a set of specialized building blocks, including multidimensional arrays, activation functions, and autonomous gradient computation.

4 Existing Open Source Technologies

To avoid duplicating frequently used models of deep learning, many developers efficiently use open source deep learning frameworks such as Caffe, DeepLearning4J, deepmat, Eblearn, Neon, PyLearn, TensorFlow, Theano, Torch etc. [3] This study aims to analyse different open source frameworks for deep learning.

5 TensorFlow: Most Used Framework By Google

TensorFlow is a machine learning system that operates at large scale and in heterogeneous environments. TensorFlow uses dataflow graphs to represent computation, shared state, and the operations that mutate that state. It maps the nodes of a dataflow graph across many machines in a cluster, and within a machine across multiple computational devices, including multicore CPUs, general purpose GPUs, and custom-designed ASICs known as Tensor Processing Units (TPUs). This architecture gives flexibility to the application developer: whereas in previous "parameter server" designs the management of shared state is built into the system, TensorFlow enables developers to experiment with novel optimizations and training algorithms. TensorFlow supports a variety of applications, with a focus on training and inference on deep neural networks. Several Google services use TensorFlow in production, we have released it as an open-source project, and it has become widely used for machine learning research. In this paper, we describe the TensorFlow dataflow model and demonstrate the compelling performance that TensorFlow achieves for several real-world applications. [2]

6 PyLearn2

Pylearn2 is a machine learning research library. This does not just mean that it is a collection of machine learning algorithms that share a common API; it means that it has been designed for flexibility and extensibility in order to facilitate research projects that involve new or unusual use cases. Pylearn2 is developed by LISA at Universit´e de Montr´eal. The goal of the library is to facilitate machine learning research. This means that the library has a focus on flexibility and extensibility, in order to make sure that nearly any research idea is feasible to implement in the library. The target user base is machine learning researchers. Being "user friendly" for a research user means that it should be easy to understand exactly what the code is doing and configure it very precisely for any desired experiment. Sometimes this may come at the cost of requiring the user to be an expert practitioner, who must understand how the algorithm works in order to accomplish basic data analysis tasks. This is different from other notable machine learning libraries, such as scikit-learn [4] or the learning algorithms provided as part of OpenCV, the STAIR Vision Library, etc. Such machine

learning libraries aim to provide good performance to users who do not necessarily understand how the underlying algorithm works. Pylearn2 has a different user base, and thus different design goals. [5]

5 Comparitive Study

Among available frameworks including Caffe, DeepLearning4J, deepmat, Eblearn, Neon, PyLearn, TensorFlow, Theano, Torch, etc. Different frameworks try to optimize different aspects of training or deployment of a deep learning.

TABLE 1: COMPARISION AMONG MOST POPULAR OPEN-SOURCE TOOLKIT

Framework	Core Programming Language	Interfaces from Other Languages	Programming Paradigm	Wrappers
Caffe[a]	C++/CUDA	Python, Matlab	Imperative	
TensorFlow[b]	C++/CUDA	Python	Declarative	Pretty Tensor, Keras
Theano[c]	Python (compiled to C++/CUDA)	–	Declarative	Keras, Lasagne, or Blocks
Torch7[d]	LuaJIT (with C/CUDA backend)	C	Imperative	

[a](Jia et al., 2014). Developed by the Vision and Learning Center at UC Berkeley.
[b](Abadi et al., 2015). Developed by Google.
[c](Bastien et al., 2012). Developed by Université de Montréal.
[d](Collobert et al., 2011). Developed by Facebook, Google, Twitter, New York University, and others.

Comparative study of different frameworks is done based on three major perspectives: extensibility, hardware utilization and speed. For instance, Caffe emphasises ease of use where standard layers can be easily configured without hard-coding while Theano provides automatic differentiation capabilities which facilitates flexibility to modify architecture for research and development. Several of these frameworks have received wide attention from the research community and are well developed allowing efficient training of deep networks with billions of parameters, thanks to their strong GPU backends.

TABLE 2: EFFIEIENCY OF FRAMEWORKS

Property	Caffe	Neon	TensorFlow	Theano	Torch
Core	C++	Python	C++	Python	Lua
CPU	✓	✓	✓	✓	✓
Multi-threaded CPU	✓Blas	x Only data loader	✓Eigen	✓Blas, conv2D, limited OpenMP	**✓Widely used**
GPU	✓	✓customized Nvidia backend	✓	✓	✓
Multi-GPU	✓(only data parallel)	✓	**✓Most flexible**	x Experimental version available	✓
Nvidia cuDNN	✓	x	✓	✓	✓
Quick deploy. on standard models	**✓Easiest**	✓	✓	x Via secondary libraries	✓
Auto. gradient computation	✓	✓Supports Op-Tree	✓	**✓Most flexible** (also over loops)	✓

TABLE 3: RANKING OF THE OPEN SOFTWARE LIBRARIES BASED ON THE STARS AND FORKS RECEIVED BY THE COMMUNITY ON GITHUB

Framework	Stars	Forks	Contributors	Language
Caffe	15,057	9338	222	C++
Keras	10,875	10,875	327	Python
MXNet	7471	2764	250	C++
Torch	6163	1793	113	Lua
Convnetjs	6128	1198	15	JavaScript
Deeplearning4j	5090	1970	103	Java
Tensorflow	4505	667	573	Python
Paddle	4069	1024	53	C++
DSSTNE	3531	559	22	C++
Chainer	1983	512	96	Python
DIGITS	1800	1052	34	Python
H2O	1628	714	70	Java

7 ADVANTAGES OF OPEN SOURCE MOVEMENT IN AI

Writing a machine learning or deep learning algorithm from scratch is probably beyond the skillset of most researchers, from non-computer science discipline. It is much more efficient to utilize the tremendous resources available in a toolkit.[10] There are many deep learning and machine learning toolkits and frameworks available for different domains like natural language processing, data analytics, health care, agriculture and business analytics, and we have described many in this study. Selecting the best toolkit will depend on the skills and background of the researcher or developer, and may also be impacted by the project and available resources.

8 ETHICS FOR OPEN SOURCE COMMUNITY

It is highly recommended to use existing codes and frameworks to implement new project or methodology for improvement of performance. At the same time, one should give back to open source community. One's contribution toward open source community will help the practice of researchers and engineers in very positive way. So, do not forget to give back to society.

9 CONCLUSION

This study analyse system and their programming models of different open source frameworks and libraries. Initial experience with most of these technologies is really

encouraging! A large number of industries and researchers have deployed these open source tools for deployment of machine learning and deep learning applications. It is really good for developers, researchers and artificial intelligence industry to get benefited from such open source technologies for fast implementation with better performance. At the same time, one should also contribute and give back to open source community.

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