



Artificial Intelligence - a Perspective on Applicability of Deep Learning, Computer Vision and Semantic Web technologies in Medical Informatics

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Abstract

The main purpose of this paper is to Introduce Basic concepts related to Machine Learning, explore relationship between Machine learning, Deep learning and Computer Vision, understand few Deep learning models and evaluate few frequently used Deep models for computer vision. Recently Deep learning has penetrated its presence in all fields and Medical Informatics has promising applications in future. In this paper we touch base few areas of applications of Deep learning algorithms and their usage in Computer Vision.

Keywords: Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks, Ontology, computer Vision

1. Introduction

Mathematics is mother of all science is olden proverb. Today's scenario we need to redefine 'Mathematics and Machine learning' is mother of future science. The reason being the future boon is towards Artificial Intelligence for which Machine learning technology is the back bone. Today we have huge amount of BIG data piled up across all domains due to digital revolution in past 20 years and penetrated use of internet enabled electronic devices. This has resulted in Big data available in heterogeneous format such as text, image, audio, video etc. Also it is observed that this data is embedded with lot of patterns from which humans can derive intelligence.

But it is impossible for humans to derive same manually or through Big data tools, as they are programmed to solve problems mathematically. So in nutshell we can use Machine learning technology to derive meaningful Intelligence by defining a Learning problem from any domain data which has patterns and mathematically not solvable. In this Paper we are going to introduce and review few Machine Learning techniques and their usage on medical domain applications.

Computer Vision is parallel subdomain of Artificial Intelligence which can be integrated with Machine learning. Also we are planning to analyze how Machine learning integrated with Computer vision technology can provide viable solutions in Medical domain.

2. Machine Learning Process

There are lot of literatures [1] that talk about basic machine learning and its versatile algorithms. The core objective of Machine learning (ML) is classification of huge datasets and automatic prediction meaningful Inferences from them. This is achieved by developing a machine learning model based on one of the ML algorithms. The ML algorithms are categorized broadly into 4 categories such as Supervised, Unsupervised, Semi supervised and Reinforcement Learning Algorithms. Each of this broad category caters specific sets of Models/algorithms targeting variety of application domains.

The end to end Machine Learning Process consists of key 5 steps.

1. Preprocessing the given input data,
2. Splitting the input data into training and testing data,
3. Feature selection and Parameter detection \learning predictors from training data,
4. Learning attributes and building a model using preprocessed input training data,
5. Applying the above model on the Testing data and performing the Classification\Prediction.

In the above process the first 2 steps are common for all ML models. Depending on application the 3rd step aims at identifying the function mapping that helps to map the given input data to a suitable class. Based on the output of 3rd step in the 4th Step we need to build the ML model. The performance of the ML model is having strong correlation on attributes selected and number of informative features selected as part of the model. So at 4th step we need to ensure an optimal model is built with right tradeoff between complexity and generalizing capability.

Based on the type of network selected for the function mapping the ML model could be designed. Some of examples are Neural network, SVM, KNN etc, once model is selected we need to determine and fit the value of attributes(parameters/function using mathematical computational methods.

3. Deep Learning

One of main limitation of traditional ML process is that lot of time is spent in step 3, i.e. Feature detection, feature parameter identification by manually selecting right and robust features that could be a viable predictor of the given classification problem. This is overcome and lead to a new technological boon called Deep learning.

Deep learning as name indicates is a deep multilayer representation of objects and learning will happen at multiple levels which results in accurate classification. In a Deep learning process the step 3 is replaced by deep stacks or Layers and the Feature identification and function mapping is taken care by these stacks. So Automatic Feature learning and extraction is done by deep stacks. In most of the deep learning scenarios the feature extraction and building models are done in a single step. [3]

The end to end Deep Learning Process is redefined as below in step 3 in contrast to Machine Learning step3 as below

1. Preprocessing the given input data,
2. Splitting the input data into training and testing data,
3. Automatic Feature Learning and extraction by Deep Stacks
4. Building Deep Learning model using preprocessed input training data,
5. Applying the above model on the Testing data and performing the Classification\Prediction.

[2] The Deep learning technology aims at increased classification Performance by taking advantage of improvements and happening in other technology tracks like GPU hardware, Parallel computing algorithms, adaptive Neural networks, data representation, image processing, computer vision and of course the nonlinear mathematics.

4. Deep Learning Frameworks

There are variety of Deep learning architectures available. Neural networks are designed based on the idea of human brain function. Convolution Neural Networks (CNN) is one of frequently used Neural network model (NN). [2] Other forms of NN like Recurrent Neural network (RNN), Auto encoders, Generative Adversarial Networks (GAN), Deep Belief Networks (DBN), and Deep Boltzmann's Machine (DBM) etc. The high computational efficiency in using Deep nets is achieved at cost of need of extensive count of labelled data, extensive computational resources, long time training and overfitting issues due to convergence issues

Architecture wise Deep learning supports both supervised and unsupervised learning. Software packages such as Cafe, DeepLearning4j, and Tensor flow, Theano, Torch and Keras are customized as libraries in popular languages C++, Java and Python. Neon and Wolfram Math are software packages with Cloud computing support as well.

5. Medical Applications of Deep Learning

Deep learning usage is observed in Genomics [3], medical Imaging and Informatics [3]. This covers Detection, classification and Prediction of various diseases. The input data for these learning tasks

are derived from various medical images, scans, Electronic Health Records (EHR\EMR) and Lab test results. Some of readymade test datasets are available in downloadable forms also.

In medical imaging the Convolution Neural Networks model is widely adopted in disease detection and pathology analysis of tumors. The quality of CNN feature extraction, classification and interpretation is proven accurate on MRI, X-ray and CT images. Recently the CNN is combined with other type of Deep learning models and used as Hybrid CNN models and this concept is called Extreme Machine Learning. (EML) and this is similar to Boosting & Bagging in traditional Machine learning. By using hybrid CNN the classification is cascaded and it is seen up to 22 layers can be cascaded to make a strong classifier. Bootstrapped CNN is a viable research area, with crowdsourcing as one option proposed to collect medical image dataset. [6]

Transfer learning is another approach where pre-trained database of natural images is available for researcher. Pre-training the lower layers of CNN with natural images, Parallel classification by multitasking more CNN, stacked de-noising Auto encoder for bio-marker extraction from brain images. DBM the Deep Boltzmann machines are powerfully used in object detection and segmentation. Recent advancement called Marginal space deep learning helps to detect objects in low contrast regions like optic track.

In addition, Mobile cloud computing when combined with deep learning provide many health tracking mechanisms. This is used in human activity recognition using wearables integration. eg RBM used to learn activities from smart watches is latest trend. Sensor issues in such scenarios are overcome by appropriate pre-processing techniques. DBN the Deep Belief Network is widely used along with ECG for cardiac Anomaly detection and when combined with wearables used to monitor heart rhythm.

EHR the Electronic Health records carry huge amount of Patient Specific Information in form of heterogeneous data such as Diagnostic, Procedural and laboratory information. The nature of this EHR is complex, time series, multimodal and unstructured. DNN models have proven to be more suitable for this type of Big data training. The main advantage of DNN is it uses online Machine learning and stacked Auto encoder, so this facilitates its usage in online real-time recommenders. RBM and CNN also used for prediction.

6. Computer Vision Using Deep Learning

Computer Vision is the latest technological revolution and fortunately it is one of the prominent applications of Deep learning. The major goal of computer vision is to interpret images and extract information from the Images. This can be otherwise called as video understanding or image understanding. This is achieved by simulating the human Visual processing mechanism. As we know in humans the neurons process visual information from eye to brain i.e., to the visual cortex, which recognize and reconstruct it. In nutshell the Computer vision aims for soft vision which simulates human vision.

In a human vision process, the given input image is sensed, the edge of the image is detected and the brain reconstructs it first as 2D image and then 3D image. This means the human eye sense the geometric shape of any object before it perceives an object completely.

Following are some of the tasks and use cases probed in computer vision field by various researchers in recent years [5]

- Object detection
- Object recognition
- Image classification
- Image captioning

- Face - detection, processing, recognition, expression training
- Emotion recognition
- Human computer interface,
- Activity recognition

Deep learning training of above tasks need a huge image training data set. ImageNet is one of the largest benchmark dataset available with 14million images in 22 categories. Deep Learning Algorithms used in Computer vision improve the VISION\Image \VIDEO Processing capability. The CNN, RNN, RBN, DBN are some of deep learning algorithms well performing for Computer vision use cases mentioned in above section [5]. In addition to ImageNet the populate image datasets available for training are Alex net, Googlenet, MSRA etc which are made up of huge layers

7. Ontology and Semantic Web in Deep Learning

The Ontology and Semantic web is part of Web3.0 which is based on meaningful graphical representation on Web using RDF, RDFS and OWL the ontology web language. The Ontology is defined as a formal and explicit specification of conceptualization. [7]

It is normally a collection of knowledge about a domain. Domain ontologies are one type representation about end to end concepts in a domain. Medical domain is growing with Ontology based representation for meaningful representation and interchange of medical concepts. This will increase the interoperability of Medical data exchange. This will help for improvised, speedy and interoperable medical treatment. [8, 9]

RDF, the resource description frame work based on a RDFS Resource Description Framework Schema is used to build an ontology. Also there is on- going research on implementing Ontology based Electronic health record EHR usage and learning EHR through Ontology based Restricted Boltzmann Machine (ORBM) the deep learning algorithm. In case of Deep learning, the Image as ontology improves understanding of the image and hence if ontology based deep learning model is one of emerging trend in computer vision.

8. Conclusion

This paper summarizes what is Artificial Intelligence (AI), Machine learning (ML), Deep Learning, Computer vision (CV) and Ontology based Semantic web. There is strong Interrelation between AI, ML, CV and Semantic web and there is stronger applicability in VISION based problems.

This paper also touches the usage of Deep learning algorithms across computer vision and Semantic Web Medical domain usages. Also it is understood that Convolution Neural networks (CNN) and Boltzmann Family of Neural Network Algorithms such as DBN and RBM are more powerful and high performing in Computer Vision Domain.

Based on this study following research directions are identified

1. Deep learned Electronic Health Record Ontology
2. Exploring the CNN, RNN, RBM algorithm's capability in setting up soft vision- i.e. artificial vision in human
3. Analyze the Transfer Learning approach in Deep learning and improve the Face emotion \Vision Processing capability in children with Autism and [4], the attention deficit hyperactive syndrome ADHD.
4. Deep Learning and Prediction from Medical Images
5. Applicability of Computer vision to Autism and vision parameters improvement of autism children.

6. Deep learning and its applicability in children with LD Learning Disability.

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