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Classification of Pattern Recognition Techniques Used Deep Learning and Machine Learning

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ABSTRACT
A comparative study of deep learning and machine learning techniques which is used in pattern recognition domain is introduced. This study includes an analysis and specification of the most researches that had been published in this scope with an accurate analysis of their advantages and disadvantages. The research proposes a new classification of the pattern recognition systems according to many concepts which are: dataset type and size, learning type, fusion techniques and the type of application which is useful to use in recognition approaches. As a result, it can be noted that some research did not give important to the effect of the size of the dataset and its impact on the accuracy and some researches did not give important to the type of database and application which we wanted to obtained in the selection of appropriate technology.

Keywords :— Machine Learning, Deep Learning, Pattern Recognition, Supervised Learning, Unsupervised Learning, Classification, Regression, Dimensionality Reduction, Clustering.

I. INTRODUCTION

Pattern recognition is closely related to Artificial Intelligence and it can be considered as a type of problem while Machine Learning is a type of solution. It deals with the construction and study of systems that can learn from data, rather than follow only explicitly programmed instructions whereas Pattern recognition is the recognition of patterns and regularities in data. The goal of Machine Learning is never to make "perfect" guesses because Machine Learning deals in domains where there is no such thing. The goal is to make guesses that are good enough to be useful. It is a field that uses algorithms to learn from data and make predictions. A Machine Learning algorithm then takes these examples and produces a program that does the job [7].

The learning method depends on the kind of application that we want to have at our disposal so when we have both the inputs and outputs (i, o) of the data that is called supervised learning, when we only have the inputs (i) this is called unsupervised learning and Sometimes we have no direct access to the correct output, but we can get some measure of the quality of an output o following input I this is called reinforcement learning [23].

In traditional Machine learning techniques, most of the applied features need to be identified by a domain expert in order to reduce the complexity of the data and make patterns more visible to learning algorithms to work. As shown in Fig.1, the biggest advantage of Deep Learning algorithms is that they try to learn high-level features from data in an incremental manner [23,7].

Although deep learning has historical roots going back decades, it attracted relatively little notice until just over five years ago. Virtually everything changed in 2012, with the publication of a series of highly influential papers such as Krizhevsky, Sutskever and Hinton's 2012 ImageNet Classification with Deep Convolutional Neural Networks (Krizhevsky, Sutskever, & Hinton, 2012), which achieved state-of-the-art results on the object recognition challenge known as ImageNet (Deng et al.,). Other labs were already working on similar work (Cireşan, Meier, Masci, & Schmidhuber, 2012). Before the year was out, deep learning made the front page of The New York Times, and it rapidly became the best known technique in artificial intelligence, by a wide margin. If the general idea of training neural networks with multiple layers was not new, it was, in part because of increases in computational power and data, the first time that deep learning truly became practical. It is important for organizations to clearly understand the difference between machine learning and deep learning. in the case of machine learning, the algorithm needs to be told how to make an accurate prediction by providing it with more information, whereas, in the case of deep learning, the algorithm is able to learn that through its own data processing. It is similar to how a human being would identify something, think about it, and then draw any kind of conclusion [11].

II. RESEARCH PURPOSE

Nowadays, Machine Learning and deep learning are in trend because of Advances in computing power & distributed programming. Deep Learning is discovered and proves to have the best techniques with state-of-the-art performances. Thus, Deep Learning is surprising us and will continue to do

so in the near future. The study aims to classify research published in the field of deep learning and machine learning according to several aspects in order to compare these researches and identify the advantages and disadvantages of them. This study will serve as a reference study for models that use deep learning and machine learning techniques.

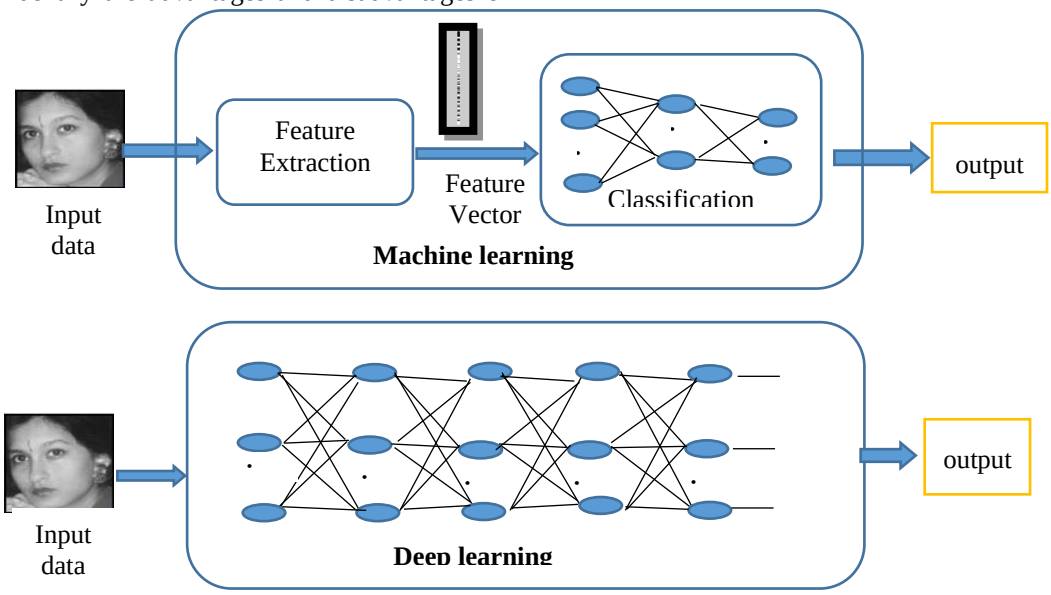

Fig.1: comparison between deep learning and machine learning

III. METHODOLOGY

A. Performance Measure

In this study, research and methods published in the field of deep learning and machine learning from 2010 to 2019 are classified. This researches will be the main subject for the study and we will evaluate the performance using following measurements>

A.I Accuracy(ACC)

ACC is the measurement used to determine which model is best at identifying relationships and patterns between variables in a dataset based on the input, or training data set. Mathematically, this can be stated as:

$$ACC = \frac{TP+TN}{TP+TN+FP+FN} \quad (1)$$

Where:

True positive (TP) = the number of cases correctly identified in first class.

False positive (FP) = the number of cases incorrectly identified in first class.

True negative (TN) = the number of cases correctly identified in second class.

False negative (FN) = the number of cases incorrectly identified in second class.

A.II Sensitivity(SEN)

SEN measures the proportion of actual positives that are correctly identified as such (e.g., the percentage of sick people who are correctly identified as having the condition).

$$SEN = \frac{TP}{TP+FN} \quad (2)$$

A.III Specificity (Spec)

Spec measures the proportion of actual negatives that are correctly identified as such (e.g., the percentage of healthy people who are correctly identified as not having the condition).

$$SPEC = \frac{TN}{TN+FP} \quad (3)$$

A.IV Root Mean Square Error (RMSE)

RMSE is a frequently used measure of the differences between values (sample or population values) predicted by a model or an estimator and the values observed.

$$RMSE = \sqrt{\sum_{i=1}^{T} \frac{X1-X2}{T}} \quad (4)$$

Where: X1, X2: Variables observed over T times,

A.V Mean Square Error (MSE)

MSE measures the average of the squares of the errors that is, the average squared difference between the estimated values and what is estimated.

$$MSE = \frac{1}{N}\sum_{I=1}^{N}(Y1 - Y2)^2 \quad (5)$$

Where:

N: number of samples for all variables.
Y: the vector of observed values of the variable being predicted.

B. Type of data and its effect on recognition model performance

In machine learning and deep learning world, data is nearly always split into six groups: numerical, categorical, text, image, video and audio. Numerical data is used to mean anything represented by numbers (floating point or integer). Categorical data generally means everything else and in particular discrete labelled groups are often called out. These two primary groupings—numerical and categorical—are used inconsistently and don't provide much direction as to how the data should be manipulated.in machine learning it is useful to use numerical and categorical type of data because it needs less computational time while in deep learning it is more useful to used (image, video, audio) data because it features extraction done automatically contain more features so we will get better performance.

C. Recognition System Constrains

System constraints play an important role in determining system performance. The accuracy of the system may increase and its reliability is reduced by many limitations, while the other systems are less accurate in their compliance with more determinants, but the efficiency and reliability of these systems is higher. For example, the performance of a system is higher when tested with a small set of data while its performance decreases when tested using a large dataset. The speed of the learning process is related to the type of dataset used for training and testing and the choice of the application.

The biggest challenge is to reduce system design requirements to a minimum while maintaining good performance. This is the most important equation.

D. Fusion of Deep Learning and Machine Learning Techniques in Recognition System

A number of researchers combine a set of deep learning and machine learning techniques together to increase the performance of recognition systems. These techniques combine according to several methods which we classify it into three basic types:

- combine more than one machine learning algorithms together.
- combine more than deep learning algorithms together.
- combine deep learning techniques with machine learning techniques together.

The first type of fusion is designed to increase the speed of classification by integrating regression or classification techniques with dimension reduction techniques. This type is the simplest to use because it reduces the dimensions of the data to be processed [2].

The second is commonly used in natural language processing systems where the dataset is media (text) due to the high effectiveness of deep learning networks in this field. This type is the most complex and accurate [38].

The third is the most widely used type, where deep learning networks are used in the stage of features extraction and then the extracted features used as input into one of the machine learning algorithms. This type gives good accuracy and minimizing the complexity of the model to be built [9].

IV. RESULTS AND DISCUSSION

In order to facilitate the study of the methods and studies presented in the field of pattern recognition using machine learning and deep learning techniques. A classification of these methods was suggested as shown in Fig. 2, which was depend on it during this study.

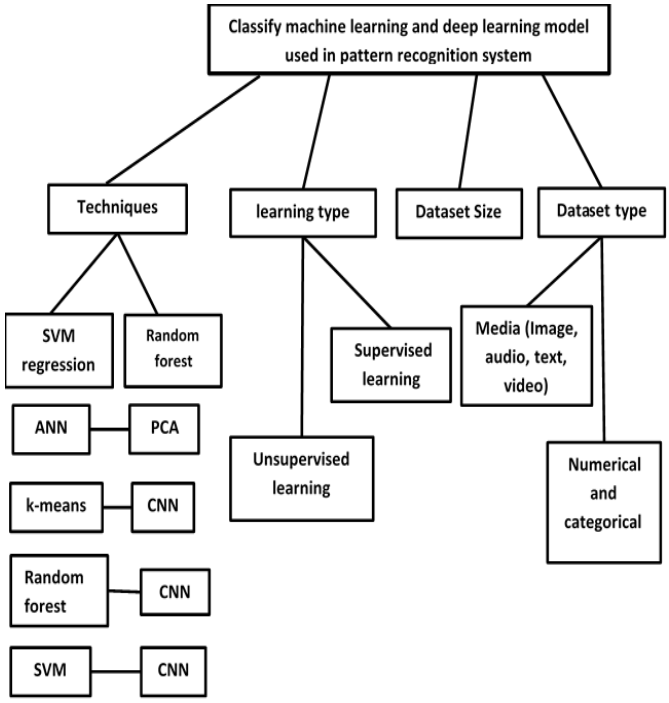

Fig. 2: The general classification diagram

E. Classification According to the Type and Size of Dataset

The type of dataset which is used in training and testing the recognition model varies according to the researches presented in the field of deep learning and machine learning. Some of algorithm used numerical database while other use a dataset that contains image, video or audio data.

Table (1) provides a summary about Performance of recognition systems using deep learning and machine learning algorithms published researches between 2010 and 2019 depending on the type and size of the data and system accuracy rate.

TABLE (1)

PERFORMANCE OF RECOGNITION SYSTEMS USING DEEP LEARNING AND MACHINE LEARNING ALGORITHMS DEPENDING ON THE TYPE AND SIZE OF THE DATA AND SYSTEM ACCURACY RATE.

researcher	Data type	Data size	accuracy
Nithin Vr [21], 2014	numerical	IMDB (1050 records)	80%
Konstanin [17], 2015	numerical	SEER(162500 records)	71%
Sharad p. [31], 2016	image	54306 images	99%
Aharon satt [1], 2017	Audio and video data	12 hours of audio-visual data	66-68%
Suhant ramesh [33], 2017	numerical	Pima (6912 records)	81%
Elie al jabout [14], 2018	image	MNIST (7000 images)	87.6%
Titus josef [34], 2018	image	399 images	93%
Prabhpeet kaur [24], 2019	image	miniMIAS (322 images)	91%

Accuracy is not entirely depending on the type of data used but the data type and size play an important role in determining its value. The type of algorithm used is one of the most important and most important factors affecting on accuracy and This is what we will discuss later.

F. Classification According to Learning Type

The learning type in machine learning and deep learning algorithms are divided into two basic types: supervised learning and unsupervised learning. The suitable type is selected according to the type of application to be obtained.

The supervised learning usually used in the recognition, prediction, detection and diagnosis of diseases. Nithin VR [21] used supervised learning(regression) in prediction movie success, Konstanin [17] used supervised learning (classification) to detect cancer and later Sharada [31] used supervised learning in plant diseases detection. supervised learning also used in recognition application, Brandon [9] use supervised learning(regression)in face recognition and Aharon [1] used it in emotion recognition.

The other type of learning is unsupervised learning which is used to draw inferences from datasets consisting of input data without labeled responses. The most common unsupervised learning method is cluster analysis, which is used for exploratory data analysis to find hidden patterns or grouping in data. researchers used clustering in predictive aspects. Nell [20] used clustering algorithms to predict poverty Using survey and satellite data from five African countries (Nigeria, Tanzania, Uganda and Malawi).

Researcher used unsupervised learning in dimensionality reduction to reduce the size of data that we used to train and test model so that's led to less computation time and it's more effective. Allesandar [2] used dimensionality reduction algorithm to reduce sensorial features from the acquired sensor signals because multiple sensorial features are extracted to feed artificial neural network-based machine learning paradigms so an advanced feature extraction methodology based on Principal Component Analysis (PCA) is implemented to decrease the dimensionality of sensorial features via linear projection of the original features into a new space. Juan [15] used dimensionality reduction algorithms on climate data consisting of 36500 96×96 surface temperature fields.

Table (2) present the classification of deep learning and machine learning algorithms published researches between 2010 and 2019 according to the type learning.

TABLE (2)
CLASSIFICATION DEEP LEARNING AND MACHINE LEARNING ALGORITHMS ACCORDING TO TYPE OF LEARNING

researcher	Learning type		application
Nithin [21], 2014	Supervised learning	regression	Prediction movie success
Konstanin [17], 2015		classification	Diseases Diagnosis
Brandon [9], 2016		regression	Face recognition
Sharada [31], 2016		classification	Plants diseases detection
Aharon [1], 2017		Regression	Emotion recognition
Neal [20], 2016	Unsupervised learning	clustering	Predict poverty
Alessandra [2], 2018		dimensionality reduction	decrease the dimensionality of sensorial features
Juan [15], 2018			Reduction climate data features

G. Classification According to Techniques

The methods used in the recognition systems vary according to the application to be obtained. In the classification applications, algorithms such as (PCA) and deep neural networks were used in the extraction features and then the use of these features as input for one type of classifier such as SVM, Random forest, k-nearest neighbors and ANN. some of research tend to integrate more than one type of deep learning network together or used gene selection algorithms to have more powerful classifier. Table (3) present the classification of deep learning and machine learning algorithms published researches between 2010 and 2019 according to Technique.

TABLE (3)
CLASSIFICATION MACHINE LEARNING AND DEEP LEARNING ALGORITHMS ACCORDING TO TECHNIQUES

Researcher	Technique	accuracy
NITHIN [21], 2014	SVM regression	-
Konstanain [17], 2015	SVM	71%
DEVI [13], 2015	SVM and gene selection	67%
Zhihua [39], 2015	Random forest	86.54%
Brandon [9], 2016	CNN and SVM	98%
Yunjie [37]2016	CNN	89%
Suhant [33], 2017	CNN and random forest	81%
Elie [14], 2018	CNN and k_means	87.6%
Sivara [32], 2018	CNN (ALEXNET, VGG 16)	ALEXNET (93.7%) VGG16 (94.5%)
Sarmad [30], 2018	Pre_trained CNN(AlexNet)	99.5%
Alessandra [2], 2018	(PCA) and ANN	-

Researcher start to used regression algorithms in many aspects like prediction and optimize business processes. In 2014, Nithin Vr [21] used IMDB dataset to build a regression model that predict the movie success using SVM regression with error tolerance 12.5%.

In 2015, Konstanain kourou [17] do research in detecting cancer using SEER dataset which contains 162500 records and compare between SVM and ANN. The accuracy of the classifier is not good enough because it was difficult to determine the significant features.

Later, Devi Arockia [16] used SVM with gene selection to do gene expression data classification but the accuracy of classifier is low (67%) because of small dataset that he used to train the model.

In 2016, brandon Amos [9] try to combine deep learning with machine learning algorithms to design face recognition model. he used CNN in feature extraction then used SVM as classifier and got high accuracy (98%).

In 2018, some researcher tries to use pre_trained deep network (Alexnet and VGG16). AlexNet consists of 8 weight layers including 5 convolutional layers and three fully connected layers, and three max-pooling layers are used following the first, second and fifth convolutional layers while VGG16 Is much deeper which consists of 16weight layers including thirteen convolutional layers with filter size of 3×3, and 3 fully-connected layers which it improves the prediction performance. Sivara makrishnam [32] used Alexnet and VGG-16 to improved malaria parasite detection and the accuracy was 93.7% for alexnet and 94.5% for VGG-16.

Then in 2018, research tries to use dimensionality reduction algorithms to reduce the size of data that will be processed so that will speed up learning stage. Alessandra Caggiano [2] used principle component analysis on CFRP dataset to reduce Sensorial Features and then used ANN in classification and the Root mean square error is 1.78E-04.

H. fusion of deep learning and machine learning techniques in pattern recognition

At the beginning of deep learning and machine learning researchers start to use simple algorithms to build their model but due to vary the dataset and the application they start to combine more than one techniques in their model. Table (4) present the performance of system recognition model according to fusion techniques.

TABLE (4)
PERFORMANCE OF MODEL ACCORDING TO FUSION TECHNIQUES

researcher	Data set	Fusion techniques	Performance measurement
Brandon [9], 2016	12hours(audio and video)	Deep learning with machine learning	Acc = 98%
Suhant [33], 2017	Numerical (6912 records)		Acc = 81%
Elie [14], 2018	Image (7000)		Acc =87.6%
Alessandra [2], 2018	numerical	Two machine learning techniques	RMSE = 1.78E-04
Juan [15],2018	numerical		MSE = 4.9
Zathanasios [38], 2019	DBpedia (text)	Two deep learning techniques	Acc =72.2%

In 2015, Brandon amos [9] combine deep learning and machine learning techniques to build face recognition system using media data set. he used deep neural network in features extraction then used machine learning algorithm in recognition and the accuracy is 98%.

In 2018, Alessandra [2] combine two machine learning algorithms on CRFP dataset. she used PCA to reduce the number of sensorial features and the mean square error is 1.78E-04. JUAN [18] combine PCA with SVM to reduce the dimension of Climate Data set and the MSE IS 4.9.

Later and because of natural language processing spreading, researchers go to combine more than deep neural network which is prove its efficient in this domain.

In 2019, Athanasios Giannakopoulos [38] combine recurrent neural network with CNN to build text classification model. she used DBpedia dataset and the accuracy is 72.2%.

V. GENERAL DETAILED COMPARISON

The previous detailed study included comparison of recognition systems using deep learning or machine learning algorithms.

Following this study, the findings of Table (5), which includes a comprehensive and detailed comparison of research from all previous aspects mentioned, can be summarized. In addition, we mentioned the most important weaknesses and gaps in these previous studies.

It should be noted that this comparison includes the most important research that was prepared in the field of deep recognition and machine learning from the beginning of it until 2019.

TABLE (5)
AN OVERALL COMPARISON OF THE MOST IMPORTANT RESEARCH IN THE PATTERN RECOGNITION SYSTEM USING DEEP LEARNING AND MACHINE LEARNING TECHNIQUES.

Researcher, date	application	Dataset	Techniques	Performance Measurements	weakness
Nithin [21], 2014	Predicting Movie Success	IMDB Dataset (1050 records)	Logistic Regression, SVM Regression and Linear Regression	SVM, Linear regression MSE=20% logistic regression MSE= 12.5%.	The need to consider additional features to improve performance
KONSTANIN[17] , 2015	Cancer prognosis and classification	Seer(162500 records)	SVM and ANN (machine learning)	ACC=71%	difficult to define significant features
Devi [13], 2015	Gene Expression Data Classification	two cancer microarray datasets	SVM and gene selection	ACC=67%	Consume lots of computation time and less accuracy
Zhihua [39], 2015.	Lung cancer classification	(NSCLC) dataset	Random forest	ACC=86.54 % SEN=84.37%	Small dataset and separate it to test and train set
Zhanyi [38], 2015	Traffic identification	Collected from internal network	ANN	MSE=10%	17% flow data can't be identified even the precise rules are made
Saahil [27], 2015	Predicting Stock Price Direction	CRSP stock database	SVM	ACC=60%	don't know ahead of time which stocks the model will be able to predict accurately and which it will not.
Brandon [9], 2016	Face recognition	LFW dataset	CNN and SVM	ACC=98%	Lot of time to train new classification model
Yunjie [37] 2016,	Detecting extreme weather	Weather broadcast dataset	CNN	ACC=89%	Small data set lead to less accuracy
Alexis [4], 2016	Deep CNN for Natural Language Processing	large-scale data sets introduced by Zhang et al	Deep CNN	MSE=37%	increase the network depth lead to less error test but more complexity
Neal [20], 2016	Predict poverty (regression)	satellite imagery dataset	CNN and mean clustering	R^2=0.81	A lack of temporal labels(i.e., the exact date of each image is unknown)
Sharada [31], 2016	Plant diseases detection and classification	54306 images of diseased and healthy plant	CNN	ACC=99%	There is no standard data set to train and test the model
Benjamin [8], 2017	cardiovascular risk prediction	institution's electronic health record	CART (classification and regression tree)	MSE = 0.12	The large amount of predictor variables so it is often challenging to know which and how many should be used in model.
Suhant [33] 2017,	Optimal Predictive analytics of Diabetic	Pima dataset (6912 records)	Deep neural network and RF classifier	MSE= 0.211 ACC=81%	Limited and small dataset
Aharon [1] 2017,	Emotion Recognition from Speech	IEMOCAP dataset	LSTM,CNN	LSTM ACC=68% CNN ACC= 66%	The Complexity of the building model

TABLE (5)
CONTINUED

Researcher, date	application	Dataset	Techniques	Performance Measurements	weakness
Ravikumar [25], 2017	Brain tumor classification	MRI filtering dataset	SVM	ACC=96%	Linear SVM separate the data only for two classes
Sahar [28], 2018	financial sentiment	StockTwits data	Deep neural network (LSTM, CNN)	ACC=75%	only 10% of messages in Stock Twits are labelled so that's

	analysis using deep learning				reduce the accuracy
Titus josef briuker,2018[34]	Skin cancer detection	Pomponiu et (399 images)	CNN	ACC=93%	publicly available datasets are limited
Kedija [16], 2018	PEDIATRIC FRACTURE HEALING TIME	data obtained from the pediatric orthopedic unit in University Malaya Medical Centre	SVM, ANN, RF(random forest)	SVM AND RF ACC=81% SVM ANN ACC=79%	dataset that was available for this project were limited in numbers
Yousra [36], 2018	Alzheimer detection	ADNI database(800 images)	(AAL + LPBA40)	ACC=94% SEN= 95%	Need a lot of pre-processing (like dimensional reduction) consume a lot of time and efforts
Sivara [32] , 2018	improved malaria parasite detection	Gopakumar et al dataset	CNN (ALEXNET and VGG 16)	ALEXNET ACC=93.7% AlexNet SEN=94% VGG ACC= 94.5% VGG SEN=93.3%	the accuracy depends on smear quality and expertise in classifying and counting parasitized and uninfected cells
Sarmad shafique, 2018[30]	Leukemia Detection and Classification	ALL-Image DataBase (IDB) data set	Pre_trained CNN (AlexNet)	ACC=99.5% SEN=98.11%	This model detected only white blood cell
Alessandra [2], 2018	Dimensional Reduction of Sensorial Features	CFRP dataset	(PCA) and ANN	RMSE=1.78E-04	Dimension reduction improve the efficiency but reducing the number of useful data to be stored .
Juan [15] , 2018	DIMENSION REDUCTION OF CLIMATE DATA	CMIP5 dataset	(PCA) and DNN	MSE=4.9	Small and noisy data set otherwise using DNN with small number of hidden layer
Ruth[26] , 2018	Using human brain activity to guide machine learning	fMRI dataset	CNN features, RBF-kernel SVM classifiers	ACC=98.44%	deriving a scalar activity weight led to much more meaningful information captured by the human brain is inevitably being ignored.
Phan [22] , 2018	Land cover classification	Sentinel-2 Imagery	KNN, SVM, Random forest	ACC=90 to 95%	Small training sample size
Yapping [35], 2018	in-season classification system of field-level crop types	Landsat image data	Deep neural network	ACC=96%	Small dataset and difficult to obtain it.
Prabhpeet [24], 2019	breast cancer detection	Mini mias (322 images)	Multi class SVM and CNN	ACC=91%	Lot of layer in deep neural network cause long train time and high computation needs.
Sanjay [29], 2019	Microarray Data Analysis Techniques of Machine Learning	EcoCyc and Regulon database	SVM, Random forest	SVM ACC= 85% RF ACC= 95%	The model require training data to contain both positive and negative examples, which are difficult to obtain
Zathanasios Giannakopoulos, 2019 [38]	Text classification	DBpedia	RNN AND CNN	ACC=72.2%	not reach to a one-size-fits-all go-to model for any novel text classification task

VI. CONCLUSION

The previous study presented a detailed and analytical presentation of most of the systems studied in the field of pattern recognition using machine learning and deep learning techniques from 2010 to 2019. The researches were classified according to the type and size of dataset used, the learning type and the techniques proposed in built model. Each classification was divided into smaller taxonomic parts so that all aspects of research were covered by weaknesses, strengths, limitations, conditions and determinants. it can be noted that some research did not give important to the effect of the size of the dataset and its impact on the accuracy and some researches did not give important to the type of database and application

which we wanted to obtained in the selection of appropriate technology.

Through the study of this research and as a result, we can say that machine learning techniques will be suitable with numerical type of data set and give us good accuracy in small time so it is the simplest way to use in small application but when we have data set contains huge amounts of images and video, it's better to combine machine learning with deep learning to build the model because deep neural networks have great performance in this case.

In natural language processing domain and when we have text dataset, we suggest to combine different kind of deep neural network (RNN, CNN,) to build our model despite of that will need more computational time but it give us great performance.

Finally, we can say that depending on the dataset and the kind of application we can choose the best way to build our model and this paper can guide us and give help to build good systems which are reliable and effective.

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