Arabic Sentiment Analysis based on Neural Network Models: Overview and Comparison

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Abstract: Sentiment Analysis (SA) or opinion mining tries to select the sentiment orientation (positive, neutral, or negative) of a text. Arabic Sentiment analysis (ASA) is complicated, it is considered a challenging task compared to other foreign languages by dint of the complications of Arabic at the level of morphology, orthography, its ambiguity, the lack of resources, and various dialects. Deep learning (DL) is a kind of machine learning (ML) and contains several Neural Network (NN) models. The purpose of our work is to debate the issue of DL models that is very important in the ASA domain also provide a comparative analysis of the most valuable and famous NN models that gain salient results in this field, namely: ANN, CNN, RNN, and LSTM. We found through this deep evaluation that the NN models: CNN and LSTM that is a type of RNN have numerous benefits in the ASA field.

1 INTRODUCTION

A wide range of social media platforms users expresses their opinions and feelings about various topics. A vast number of the comments is not unstructured in a pre-defined and significant manner. That is why there is a high need to classify the data. SA Systems is an excellent way to solve this task, where the objective is to predict the sentiment conveyed in some text.

As part of our ASA issue, we try to show our comparative evaluation of many existing NN Models to conclude a general decision on the most important ones in the ASA domain.

The various kinds of neural networks in DL are transforming the method we interact with several modern tasks. These various NN models' kinds are very important in the DL revolution, powering applications such as Sentiment Analysis, especially in the Arabic language. Due to the several Arabic dialects together with its complex structure and the very high lack of its resources, the Arabic language is complicated compared to the English language, for example. All these challenges, make the ASA research domain very difficult. Selecting the most suitable collection of NN Models that satisfies our requirements best is arduous work. For this reason, we base this deep evaluation on multiple good aspects.

This deep evaluation of the NN models is very important. It would enable ASA researchers to select the most appropriate group of NN Models in their projects to make good and correct decisions.

The following parts of this work are organized as follows: Section 2 gives the difference between ML and DL. Section 3 outlines NN Models for ASA with a comparative analysis of these NN Models. In Section 4, the comparison between NN Models is discussed in detail, and this work is concluded with definitive ideas in Section 5.

2 DIFFERENCE BETWEEN MACHINE LEARNING AND DEEP LEARNING

DL is a technique of ML that relies on a NN with various deep layers to process the data. therefore, it learns complicated features from features that are very simple as it proceeds to start by lower to higher layers utilizing weights for each link and real-number activations for each neuron.

ML tries to extract new knowledge from various and several data that are preprocessed and loaded in

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the system.The rules are formulated by the users and destined for the machine, and it relies on them. Occasionally, users might interfere to treat and correct the errors. On the other hand, DL is a little different:

Table 1: Comparison between ML and DL.

ML	DL
Huge data amounts	Short datasets, as long as they are of good quality
Computation-heavy	Not always
A draw precise conclusion from raw data	Accurately pre-processed data
Take a very long time to train	Can take a reduced time to train
Incapability to know what are the specific features that the neurons exemplify.	The clarity of the logic behind the decision of machine
It can be utilized in unforeseen manners	For resolving a particular problem, the algorithm is created.

3 NEURAL NETWORK MODELS FOR ARABIC SENTIMENT ANALYSIS

A large variety of Neural Network algorithms have been utilized to resolve the sentiment analysis task. In this work, we concentrate on three NN models that are considered the most valuable and achieved numerous benefits and outstanding results in the ASA field.

3.1 Artificial Neural Network

ANN is a set of several neurons or perceptrons at each layer. Besides, it is named a Feed-Forward NN because inputs are treated only in the forward direction. This model is considered the most straightforward variant of NN, it passes information in one direction only, through several input nodes, until it makes it to the node of output. The network may have hidden node layers or may not, making their functioning more interpretable.

3.2 Convolutional Neural Network

CNN is considered the most valuable and famous model used in various fields, especially in ASA. This computational model has one or multiple convolutional layers that can be either entirely pooled or connected and employs a variation of multilayer perceptrons.

3.3 Recurrent Neural Network

RNN is more complex compared to other NN models. This type of neural network model didn't transmit the information in only one direction. This is how the RNN model is said to learn predicting the layer outcome. Each model's node acts as a memory cell, continuing the operations computation and implementation. If the prediction of the network is incorrect, then during backpropagation, the system self-learns and keeps running towards the correct prediction. RNN contains numerous kinds. But there is a specific type of RNN, capable of learning lengthy-time period dependencies that gained significant results.

- LSTM: is a unique type of RNN network that is very effective in dealing with learning long-term dependencies and long sequence data. LSTM is widely used today for various tasks, especially in ASA.

The following tables: Table 3 and Table 4, highlights the numerous criteria to evaluate these NN Models. We can deduce through these tables that each Neural Network Model has its characteristics.

Table 2: Multiple Criteria of Long Short-Term Memory Model.

	Characteristics	Advantages	Disadvantages	Works in ASA
LSTM Model	LSTM relies on the concept of gates and has three: • Input gate: controls the amount of incoming information. • Forget gate: controls the information flow from the previous memory state. • Output gate: controls the amount of outgoing information	• They are more robust to the challenge of short memory than 'Vanilla' RNNs. • They can model long-term sequence dependencies.	• The memory needed is higher than the one of 'Vanilla' RNNs due to multiple memory cells. • They raise the computing perplexity compared to the RNN model with the introduction of more parameters to learn.	(Ombabi et al.)(Heikal et al.)(Elfaik and Nfaoui) (Abu Kwaik et al.)(Alayba et al.)(Abdullah et al.) (Albayati et al.)(Al Omari et al.)(Wahdan et al.)

Table 3: comparison of the most useful NN Models based on various characteristics.

	ANN	RNN	CNN
Parameter Sharing	No	Yes	Yes
Data Type	Tabular Data, Text Data	Sequence data	Image Data
Fixed Length input	Yes	No	Yes
Spatial Relationship	No	No	No
Exploding and Vanishing Gradient	Yes	Yes	Yes
Recurrent Connections	No	Yes	No

Table 4: comparison of the most useful NN Models based on multiple criteria.

	ANN	RNN	CNN
Advantages	• Containing a distributed memory. • Working with incomplete knowledge. • The capability to save information on the entire network. • It is having fault tolerance.	• Is even applied to expand the efficient neighbourhood of pixels. • Remembers each information through time. • Because of the feature to remember preceding inputs, this model is influential in time series prediction only. This is called: LSTM.	• Automatically discovers the significant features in the absence of any human direction. • Weight sharing.
Disadvantages	• Unexplained the network behaviour. • Hardware dependence. • Determination of proper network structure.	• Training an RNN is a tough matter. • Gradient exploding and vanishing challenges. • It cannot treat sequences that are too long if utilizing hyperbolic tangent or rectified linear unit activation functions.	• Is incapable of being spatially never changing for the input data. • Doesn't encode the object orientation and position. • Lots of training data are needed.
ASA works	(Moraes et al.)(Zahidi et al.)	(Wahdan et al.)(Jerbi et al.)	(Ombabi et al.) (Heikal et al.) (Abu Kwaik et al.) (Alayba et al.) (Abdullah et al.) (Al Omari et al.) (Wahdan et al.) (Al-Azani and El-Alfy) (Omara et al.) (Dahou et al.)

4 RESULTS AND DISCUSSION

In our literature review, we relied on the most famous and valuable NN models: ANN, CNN, RNN, and LSTM. We can utilize each of them in different ways. We attempted to present a global view of them to help you create a great choice for your issue:

- ANNs are less potent than RNNs and CNNs.
- RNNs contain less feature compatibility in comparison to CNNs.
- CNNs are more valuable than RNNs and ANNs.
- Temporal data relies on RNNs (also named sequential data).
- CNNs are destined to use lower pre-processing amounts.
- Unlike feed-forward NNs, RNNs can utilize their internal memory for treating arbitrary inputs sequences.
- RNNs can deal with input/output lengths arbitrarily.
- CNNs pick up fixed sizes inputs and produce outputs of fixed size.

In conclusion of this part, these NN models are all advantageous in the ASA domain. However, according to our deep evaluation, the literature, and various significant works in the ASA field, we deduce that: CNN and LSTM that is a type of RNN Neural Network models have gained popularity by showing impressive results in the field of ASA, compared to other existing Neural Network models.

5 CONCLUSIONS

In this work, we have defined and explored the most useful NN models in ASA. Moreover, we have discussed in detail the characteristics of each model

in the domain of ASA. Hence, the ASA research's future opportunities contain applying these NN Models in the ASA research field. This ASA future work will be focusing on creating a technique to perform ASA and will be relying on the techniques of word embedding.

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