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Deep Learning for Opinion Mining: A Systematic Survey

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Abstract*—The hype of sharing the thoughts, plans, opinions, sentiments, reviews what-so-ever comes in our mind on Social networking sites are increasing day by day and is at an all-time high. The data collected and made from this is enormous, and using them for analyzing, reviewing and as a guiding light by the calculative minds shows the advent of this era and the tremendous growth of technology. It also helps the industries, organizations in various forms. One of them is to gather the thoughts of the people globally, which is termed as opinion mining or sentimental analysis. This helps them to understand the market demand and help make the things consumers want and to separate the goods that are undesired or to fix a specific issue. It enables growth at a much higher pace. This study focuses on the literature done in the years 2015-2019 and will help the researchers and scholars to analyze the recent works in the field of Opinion mining.

Keywords— Opinion Mining, Deep Learning, Sentiment Analysis, Neural Networks.

I. INTRODUCTION

The role of social networking has slowly but steadily made a base in our lives. In one way or another we are slowly drawn towards it no matter how much we keep ourselves at bay but at the end of the day we always find our way back to it whether we want to check the reviews or are bored and want to look at other people plans or want to buy a particular thing. It's a new trend to post everything you feel or does to share with others, and opportunists use this habit of people for their profits. The textual content, emoticons, photos and videos all help in coming up at a better conclusion of the opinions regarding a specific subject. Sentiment analysis or opinion mining classifies the data into three categories: positive, negative and neutral. Since it is not physically possible for anyone to read all the reviews and posts posted on a site thus, researchers and scholars are adamant on finding a way that does it with lesser computational power and time frame and therefore the vast area of machine learning and text mining is Sentimental analysis. The three basic approaches of Opinion mining are: Lexicon drove in which we use word dictionary of textual guide or corpus-based method, Machine Learning approach and Hybrid, i.e. integration of both Lexicon and Machine Learning approach. In recent years, various powerful techniques are implemented in machine learning for a higher possibility of correct prediction such as SVM ("Support Vector Machines"), DT ("Decision Tree"), NB ("Naive - Bayes"), and its ensemble approaches such as GBT ("Gradient Boosted Trees"). Other than this Deep Neural Networks (DNN) is also in use for text classifications. In this survey,

The concept of fuzzy networks is introduced in [1] as in a simple sentence there may be positive and negative or both words and thus discriminative algorithms such as SVM, DT, NB and GBT do not provide a correct representation. This paper focuses on a "fuzzy method that involves combining or the fusion of relationship degrees for each class of multiple fuzzy classifiers produced with discrete arguments setting (e.g., T-norms and T-conorms)". It focuses on the detection of cyberhate, i.e. hate speeches that are posted on online platforms that can result in antisocial activities. It deals with race, sexual orientation, religion and disability by developing the fuzzy approach to deal with the text ambiguity that can arise in other methods. Secondly, it deals with the semi-fixed rule of defuzzification. This proposed fuzzy method with both qualities can achieve effective recapitulate of text.

A Knowledge-based recommendation system which helps in monitoring human emotions and detecting psychological disturbances such as stress and depression is addressed in [2]. Based on this monitoring, messages will be sent to the users according to their state like motivational, happy and calming posts and the intensity of them can also be monitored by it as well as warnings can also be sent to higher and designated authorities. Character level representation is done using Convolutional Neural Network and disorder entity recognition by BiLSTM-RNN ("Bi-directional Long Short term memory-Recurrent Neural Network"). It provides an enhanced recommendation system that provides a personalized and improved sentiment metric and a mobile application that requires low computational power, memory and energy. The projected model gives the precision of 0.90 and 0.89 to identify stressed and depressed users, respectively.

A deep learning-based model is introduced in [3] to categorize reviews expressed by different users called RNSA. In this, a "consolidated feature set which is representative of sentiment knowledge, word embedding, sentiment shifter rules, statistical and linguistic knowledge is thoroughly studied for sentiment analysis". This model differentiates between the senses of the word and applies a strategy to create a single demonstration per word procedure. Contextual polarity is also taken into account as it changes concerning contexts. Therefore, yielding advanced performance enhancements in contrast with other existing renowned methods.

Guang Yang addresses the issues in [4] that in micro-blog sentimental analytics, emoticons also help to get precise emotional meanings. According to previous studies, they considered emoticons as noisy sentiment labels and overlooked their potential for emotional feelings. In this paper, a new "Emoticon Semantic Enhanced Convolutional Neural Network, i.e. ECNN model" is proposed. Thus, we

can identify subjectivity, emotion and polarity in micro-blog environments. In this, an emotional space is constructed using many common emoticons based on the principle of semantic composition calculation of vector representation, the emotional vectors and the word vectors is more explicit. People commonly use these emoticons to express their emotions since they are easy to understand and correlate, which can play an essential role in opinion mining.

A novel approach to distinguish and extracting the opinion terms and aspect terms from the data is proposed in [5] as they are profoundly misguided by each other. Firstly, we articulate the chore of two sequence labelling problems and then followed by a multi-task learning framework via joint optimization. Next, the ILP (Integer Linear Programming) framework is applied to "perform global inference over the results of the neural network and designing several intra-task and inter-task constraints for global consistency." Therefore, automatically extracting opinion terms and aspect terms from online reviews.

Detection of irony in texts as sometimes while posting some issues or comments is listed in [6] as we seldom use ironical lines that combines a positive polarity term and a negative term in the same sentence and the meaning of the sentence is opposite of the sentiments are behind it. A model is proposed for "attention-based models" for integrating "sentiment features as an alternative of feature vector concatenation". In this, we learn in-depth features on sentiments and transferring them into "the attention-based model" of neural networks to detect both implicit and explicit context incompatibility. It is also discovered that hash-tag labelled dataset is more comfortable to identify than human labelled dataset for irony detection.

The scope of sentimental analytics in new product development in [7] as it relates the sentiments of users afore and after the introduction of goods in the market. It gives a real-time opinion about the expectations of the users about the product and what can be done to accomplish it. It also helps in the advertising as we have a view of the emotions possessed by the customers regarding the particular product. Total three products experimented, and 302,632 tweets were collected in which before and after reviews of the products were listed. Thus, if any changes have to be done in the product in its next version according to the public reviews, it could be done. It can also tell the market value, the future growth rate of the particular product.

"Weakly supervised multimodal deep learning system" is developed to predict a microblog sentiment that composes of images, texts and emoticons in [8]. The main challenge that we encounter, i.e. difficulty in collecting training labels for a better modal prediction is overruled. This scheme learns from the "weak" emoticon labels that are iteratively and selectively learnt by Convolutional Neural Network, which often contain noise but are otherwise cheaply available. Also, a feasible graphical model is instigated to capture the modality dependency and to filter out label noise and therefore, the modal "infer the confidence of label noise as well as learn discriminative label noise".

The techniques of analyzing movie reviews with deep learning is discussed in [9] and [10]. The movies before and after their release have an excellent level of excitement. This analysis will help in learning constructive criticism or help them to generate statistics of the sentiments showcased by the people. The procedure is as mentioned below:

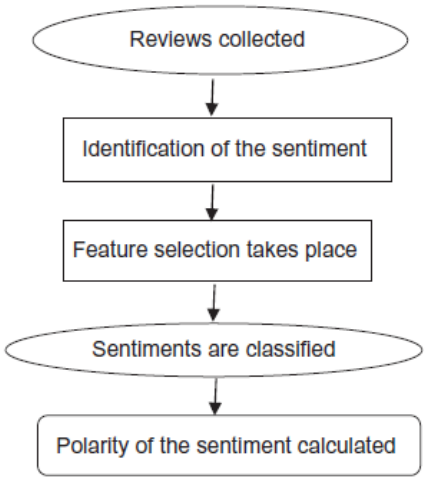

Fig. 1. Procedure of analyzing movie reviews with deep learning

They use various methods to gather the sentiments and analyze them for their benefits. Since reviews of movies are of high demand.

A different approach to mine opinions from big data in [11] as it uses a deep learning model called "SS-BED (Sentiment and Semantic-Based Emotion Detector)." They also develop a chatbot that can chat with humans and can train as well as converse with them in a textual manner. It provides a response that is emotionally linked and thus makes the user more compatible and helps the user to feel emotionally connected.

Further paper is divided into various sections, i.e. Section II consists of Literature review, Section III consists of Datasets used in multiple other papers, Section IV comprises of Parametric Comparison, Section V of Issues and Challenges in Deep Learning for Opinion Mining Field, Section VI consists of Conclusion and Future Work and Section VII consists of References.

II. LITERATURE REVIEW

The texts represented by researchers were commonly traditional texts. They could be a single word opinion, a line or a blog which expresses a person's sentiments about a particular thing. These texts require various algorithms to extract the right emotion from them. We can get the essential information, knowledge of recent trends, summarize the long blogs, characterize emotions or classify them etc. Often human sentiments are difficult to understand because they seldom use ironical or sarcastic comments to tell their views. Thus, we have to classify them thoroughly.

The primary concern of opinion mining is to distinguish between the negative and the positive polarity. We first distinguish the sentiments via their domain since it highly depends on it. Then, we either break it to sentence-level or we apply various algorithms that are concerned with document level to extract opinions from documents. In [12] words are clustered in different groups so that it can be easy to determine the context of the word once used as well as in [13] we determines the words which change their meaning with context and can seldom be confused. A hybrid approach is then proposed in [14] for a model to obtain "opinionated

content". Now, below is the architecture of Sentimental Analysis:

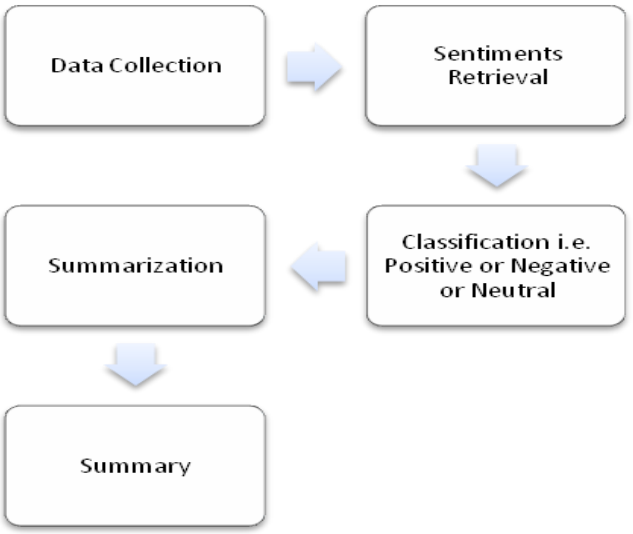

Fig. 2. Architecture of Sentimental Analysis

Many times researchers and scholars use Twitter datasets or its API to collect information and reviews but there are various other platforms that are widely used for this. In [15] a novel approach is proposed to collect data from other social networking sites such as Instagram, Facebook etc. and algorithms are proposed to gain the best conclusive review.

Earlier, supervised algorithms were used to identify the sentiments, but since everyone has their opinion and things change with time, we cannot prepare a supervised algorithm to give us the desired result. "Support Vector Machines, Naïve Bayes, maximum entropy" algorithms can give the result only till a particular level. Thus, we started using unsupervised or reinforcement learning to train our models, and deep learning and neural networks come into the picture. Let's discuss below how Deep Learning and neural network algorithms work in opinion mining [21] as they help in word embedding's that are used in the skip-gram model, solve "sentiment classification tasks" [22] [23] [24] and other tasks that can help in progressing the research of developing and understanding natural language processing [25]. Given below is the explanation of Deep Learning and Neural Networks that are the core domain in NLP for sentimental analysis. Opinion mining has reached several heights and is continue in doing so due to these:

A. Deep Learning

In Deep learning [26], we use algorithms to transform the data; each level learns to convert its input data into a composite representation. Deep learning architectures are used in sentiment analysis, computer vision, voice recognition, natural language processing, drug design etc.

Deep learning defines how deeply data should transform to get the information. In this data is modified in the layer-wise process. By layers, we can get the information about any figure if we take the example of an image, the input image is reconstructed in different layers to get the constituents of an image. Firstly the pixels of input are extracted to get the edges of the figure. Secondly, these edges will be composed or encoded, the third layer encodes the features of the image like if there is an image of a human, then it will recognize the nose, eye etc. in the fourth layer, it will finally recognize the image. Similarly, it happens with the textual content. It is first retrieved and then passed on to different layers which check the sentiment, information etc. out of that data.

To manipulate the input into output is done by the deep neural network, DNN found the correct mathematical way to transform the input into the output. These networks are trained to found the right sentiments in a way that has a high probability of an accurate outcome since they have various different approaches. As in [27] the effectiveness of Deep Learning is checked by "Mining of Sustainable aspects of the hotel client opinions", [28] shows an approach to mine opinions in the field of Agriculture and a hybrid semantic knowledge-base approach is shown in [29].

B. Neural Networks

Neural Networks is also known as "Artificial Neural Networks". It is an information processing pattern which is developed by getting idea from an animal brain or especially the human brain.

It's been thousands of years we are studying the human brain. In 1943, the first stride was taken towards Artificial Neural Network when "Warren McCulloch and Walter Pitts", a neurophysiologist and a young mathematician respectively, wrote a paper about how neural network works. They modelled neural network uses electronic circuits. It modifies itself with the changing relationships of inputs and develops a framework that helps process different algorithms of ML. The neural network can be further divided into two, i.e. "Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN)." In CNN, the input generated is considered, but in RNN, the previous inputs generated as well as the current one all are considered. Usually, we use RNN's much more than CNN's for natural language processing since the results are much more accurate with RNN's.

Sentimental analysis can be considered as an example of neural networks implementation. For example, in sentimental analysis or opinion mining, the machine might learn to identify basic emotions by observing and analyzing the sample set of reviews on which it is already manually labelled as the type of emotion and device will use the result of these set of texts for identifying sentiments in other real-world applications such as identifying the abusive or the hate speeches [30] [31]. Even the machine does not have any prior knowledge about the feelings that they have different polarities, they have information, they have aspect and opinion terms, but gradually it will generate the results based on the learning.

There were various algorithms used by the researchers and scholars [32] to get highly optimized results. Some of them with there merits and demerits are:

TABLE I. SOME OF ALGORITHMS USED BY THE RESEARCHERS AND SCHOLARS WITH THERE MERITS AND DEMERITS

SR No.	Algorithms	Merits	Demerits
1	KNN	It is simple and used for multi class categorization of data	Takes lot of time and memory.
2	Decision Trees	It automatically classifies the data according to it's features and require less data preparation.	Diagnol partitioning can't be done.
3	Naïve Bayes	It is easier to implement and requires less training data to obtain good results. It require less memory access.	In some cases, there is a chance of low accuracy whenever dependencies occur. It cannot modify dependencies.
4	SVM	It works well with problems that are high dimensional, not linearly separable.	It has multiple vital parameters that may work with a particular data but may not with another.
5	Convolutional Neural Network	It is efficient as it saves time and memory when used with an efficient GPU. It reduces the number of parameters by weight sharing.	Requires high computational cost; otherwise, it will be slow.
6	Long Short Term Memory	LSTM is used when the output is again used. It forms a loop-like structure.	This will only give future outputs the experience of past outcomes since it works unidirectionally
7	Bi-directional Long Short Term Memory	It uses both ancient and upcoming data to generate a result; thus, accuracy is very high.	The higher number of layers may cause gradient explosion.

III. DATASETS

There were different datasets used scholars and researchers in their work. [33] Reviews different datasets and techniques that are used in recent years. These datasets can be collected from various sources such as Blog Writing Pages, Review sites, micro-blogging websites or social media etc. in the papers discussed the datasets collected were of different types explicitly collected for their task. Some of the datasets are explicitly designed for these experimentations. Some of them contain emotional labels like "happy", "sad", "disgust", "like", "hatred" etc. They are mentioned below:

TABLE II. DATASETS

#	Reference	Paper Name	Datasets Used
1	R1	A Fuzzy Approach to Text Classification With Two-Stage Training for Ambiguous Instances	Twitter data collected between 300 000 and 1.2 million, from which randomly sampled 2000 were collected to be human coded.
2	R2	A Knowledge-Based Recommendation System that includes Sentiment Analysis and Deep Learning	Named Entity Recognition (NER) datasets are used, and 27,308 labelled Facebook messages were used.
3	R3	Deep learning-based sentiment classification of evaluative text based on Multi-feature fusion	1) The Movie Review (MR) Dataset. 2) The Document Understanding Conferences (DUC) datasets.
4	R4	Emotion-Semantic Enhanced Neural Network	1) Chinese Sina Weibo. They use the API of Sina Weibo to obtain the data to establish the first dataset. 2) NLPCC 2013 Chinese microblog sentiment classification competition. 3) SEMEVAL 2013 to 2015, which is the well-known Twitter sentiment classification datasets.
5	R5	Global Inference for Aspect and Opinion Terms Co-extraction based on Multi-Task Neural Networks	1) SemEval-14 Laptop (Laptop14) 2) SemEval-14 Restaurant (Rest14) 3) SemEval-15 Restaurant (Rest15)
6	R6	Irony detection via sentiment-based transfer learning	1) Reyes13 2) Barbieri14 3) Ptacek2014 4) SemEval2018 5) Riloff2013 6) SemEval2018
7	R7	Pre- and post-launch emotions in new product development: Insights from Twitter analytics of three products	302,632 tweets that contain or mention data of 3 products.
8	R8	Predicting Microblog Sentiments via Weakly Supervised Multi-Modal Deep Learning	80K microblog sentiment dataset crawled from Sina Weibo that contains 435,458 tweets.
9	R9	Sentiment Analysis on a Set of Movie Reviews Using Deep Learning Techniques	"300-dimensional space, 40 minimum words and 10 words in context have been used as features to train the Word2vec model."
10	R11	Understanding emotions in the text using deep learning and big data	17.62 million tweets and their responses from 2012 through 2015.

IV. PARAMETRIC COMPARISON

TABLE III. PARAMETRIC COMPARISON

SR No.	Reference	Author	Architecture	Compared Algorithms	Methodology	Application
1	R1	Han Liu, Pete Burnap, Wafa Alorainy, and Matthew L. Williams	Generative Learning: Fuzzy method	SVM, NB, DT, GBT	In this method an algorithm is designed so that it is trained for ambiguous instances and immediately detects it.	Text classification
2	R2	Renata L. Rosa, Gisele M. Schwartz, Wilson V. Ruggiero, and Dem´ostenes Z. Rodr´iguez	CNN and Bi-LSTM	CNN BLSTM-RNN using softmax, CNN BLSTM-RNN using SVM, SMO, Random Forest, Naïve bayes	In this a recommendation system is created using ontology and sentiment metric.	Monitoring emotional health
3	R3	Asad Abdi, Siti Mariyam Shamsuddin, Shafaatunnur Hasan, Jalil Piran	RNSA	CNN, DBN, LSTM, BiLSTM, Tree BiLSTM, CNN-LSTM	A unified feature set which is constructed using the sentiment-based, word embedding-based, statistical and linguistic knowledge-based feature vectors	Review categorization
4	R4	Guang Yang, Haibo He, and Qian Chen	Enhanced CNN	SVM, MNB, EMB, ESM, MCNN, DCNN, BiLSTM, CharSCNN	It uses emoticon embedding as an emotional space projection operator.	Emotion detection
5	R5	Jianfei Yu, Jing Jiang and Rui Xia	RNCRF: Bi-LSTM, CMLA	DLIREC, HIS_RD, EliXa, WDEmb, MIN, DP, DA-Crf, DA-Aux	It uses two different sequence labeling problem for aspect and opinion terms extraction.	Determine aspect and opinion terms
6	R6	Shiwei Zhang, Xiuzhen Zhang, Jeffrey Chan, Paolo Rossob	Sentiment transferred Bi-LSTM	Bi-LSTM, CN-LSTM, LSTM, CNN	It consists of 2 Bi-LSTM's: One for extracting sentiment feature and another as irony detector.	Irony detection
7	R8	Fuhai Chen, Rongrong Ji, Jinsong Su, Donglin Cao, and Yue Gao	WS-MDL	CBM-LR, CBM-SVM, HGL	It firstly computes the sentiment probability distributions and multi-modal sentiment consistency from the pretrained CNN and DCNN models. Then, it trains a probabilistic graphical model to distinguish the contribution weights of the noisy label which are further sent back to update the parameters of CNN and DCNN models, resp.	Microblog sentiments prediction
8	R10	Nehal Mohamed Ali, Marwa Mostafa Abd El Hamid, Aliaa Youssif	Hybrid CNN-LSTM	SVM, NB, RNTN, MLP, CNN, LSTM	It uses a hybrid CNN and LSTM model for best analysis of movie reviews.	Movie review analysis
9	R11	Ankush Chatterjee, Umang Gupta, Manoj Kumar Chinnakotla, Radhakrishnan, Srikanth, Michel Galley, Puneet Agrawal	SS-BED	NB,SVM, GBDT,CNN, LSTM	It uses two LSTM's. One layer uses a semantic word embedding and other sentiment word embedding.	Textual Emotion detection

TABLE IV. PARAMETRIC COMPARISON

SR No.	Paper Name	Year	Algorithm	Advantages	Advancements Proposed
1	A Fuzzy Approach to Text Classification With Two-Stage Training for Ambiguous Instances	2019	Generative Learning: Fuzzy method	In comparison with traditional fuzzy method it uses two step method for training the model	A larger real time dataset can be used and the hate speeches could be diversified for a better result and exploration of this method.
2	A Knowledge-Based Recommendation System that includes Sentiment Analysis and Deep Learning	2019	CNN and Bi-LSTM	This system will actively help the people who are depressed or sad and will also help reduce the suicide rate.	It can be applied in other services and can help in people in various ways across the globe.
3	Deep learning-based sentiment classification of evaluative text based on Multi-feature fusion	2019	RNSA	It encompasses various features to make a hybrid vector representation of each sentence and it also help cope up with various other problems such as contextual polarity, sentiment shifter, word sense variations etc.	It can inspect in depth about the sarcastic or comparative sentences.
4	Emotion-Semantic Enhanced Neural Network	2019	Enhanced CNN	It uses emoticons in a sentence to identify the emotional and semantic structure of sentence.	It can be modified to identify many other emotions felt by people and can also used with textual analysis. So that the result will take both emoticons as well as text to identify the sentiments.
5	Global Inference for Aspect and Opinion Terms Co-extraction based on Multi-Task Neural Networks	2019	RNCRF: Bi-LSTM, CMLA	It differentiates the aspect and opinion terms so that it can help in easily grasping the concept of a sentence.	It can extend the global inference method so that it it can work on a large unlabelled dataset which is majorly seen in real time scenarios.
6	Irony detection via sentiment-based transfer learning	2019	Sentiment transferred Bi-LSTM	This method helps in identify the textual congruity and detects the irony if present in a sentence.	It can be applied on more complex sentences and should read the hashtags in order to identify it better.
7	Predicting Microblog Sentiments via Weakly Supervised Multi-Modal Deep Learning	2018	WS-MDL	A multi-modal dataset is released that is largest till date in literatures as well as a weakly supervised modal is used to identify the sentiments of a microblog.	Further investigation can be done on the order of emoticons labels.
8	Understanding emotions in the text using deep learning and big data	2019	SS-BED	It harnesses both sentiment and semantic based features for more accurate prediction.	It can be extended for various other emotional classes as well as to understand the context of any sentence.

V. ISSUES AND CHALLENGES IN DEEP LEARNING FOR OPINION MINING FIELD

There have been issues and challenges in Deep Learning for Opinion Mining field. There has been a tremendous amount of growth and development in the field of Opinion mining [16], but still, there are many challenges in this field:

1. It is not always crucial that the use of negative terms gave the result as negative or vice versa. Sarcasm and ironical sentences are used by many people to describe their views. Thus, a sentence can be either positive or negative, depending on the situation [17].
2. When given a complicated blog of review [18], which is mixed of several things in spite of one line sentence reviews, the result may not be precise.
3. These models work well with the training and testing datasets but can have low accuracy in real-world datasets [19].
4. People tend to provide their sentiment in many different ways in which the object and subject terms vary with different sentences [20].
5. Many times spammers upload fake or spam reviews to affect the review of a product for their personal benefit.
6. In comparative sentences, it's tough to identify and extract the correct opinion.

VI. CONCLUSION AND FUTURE WORK

The opinion mining is rapidly transforming the industry. In this paper, we tried to provide the current evaluation and update of the sentimental analysis usually done through social networking. In the past we have seen that various literature and research carried in this area and while working upon them it is much clearer to me now that, Sentiment analysis is a much deeper topic to be dug upon, and it is also beneficial for market growth.

We have discussed various uses and approaches that can provide us with an accurate result. It can be analyzed by hash-tags, emoticons, text etc. However, there are many

challenges in this field yet to be resolved like how the emotions of the customer on a product affect it, as well as making a system that is able to understand multiple languages and detect them instead of a particular one since various users from across the world use a single platform to present their reviews or ideas. All these issues can also involve the fact that we identify fundamental or essential emotions, but several emotions can be used so we can train a model in a way that it identifies many more emotion classes. It can also be trained to detect abrupt emotional changes in customer behavior.

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