Sentiment Analysis and Summarization of Product Reviews using Deep Learning Techniques

End Term Evaluation

Guided and Approved By:-
Prof. Rashmi Rane

Presented By:-
Group B25
Swaroop Nayak 1032180202
Kartik Bhutada 1032180229
Amey Bhide 1032180301
Divyang Bagla 1032180739

MIT-WPU
॥ विश्वशान्तिर्ध्रुवं ध्रुवा ॥

Agenda

1. Introduction
2. Problem Statement
3. Literature Survey
4. Applications
5. Implementation Details
6. Algorithms/Methodology
7. Results and Analysis
8. Conclusion
9. Publication Details
10. References

Introduction

- As potential customers, people usually seek help from the online portals to gain knowledge on a particular product, and finally, decide if the purchase should be made or not.
- It takes several hours to read all the reviews, sometimes even leading to missing out the important ones, thus ending up making the wrong decision on purchasing the product.
- A more well defined and concise product review is proposed such that the user need not skim through all the reviews, thus saving their time and effort.
- As a solution to the ongoing problem that the customer experiences daily, automatic review summarization will be used to analyze the product reviews and convert them into a user-readable and in a more concise and precise format.

Problem Statement

Sentiment Analysis and Summarization of Product Reviews using Deep Learning Techniques

Objectives:

- To provide a brief summary of a product with a large number of reviews available in order to take a quick glance at both the positives and negatives of any product.
- We will tackle the above problem using deep learning techniques like LSTM-attention mechanism and/or BERT.
- We have implemented the project in 2 phases: classification and summarization

MIT-WPU
॥ विश्वशान्तिर्ध्रुवं ध्रुवा ॥

Literature Survey

- As mentioned, our project is implemented in two phases: Classification and then Summarization of the reviews.
- Recent works in Product Reviews Classification has been done in [1][2][6] where they have used various machine learning models such as **decision tree, logistic regression, multinomial NB, SVM and LSTM and compared then and analyzed that the LSTM model has achieved accuracy of around 97.35%.**
- The use of a **Convolutional Neural Network, BOW, to execute Word Vector with 97 percent accuracy** and higher performance in all areas was discussed by Li Rong et al [3]. **The only obstacle being here is the dataset used here is a Chinese Character Dataset** in which case the model performance may give different results for reviews in English.

- Aishwarya et al., [4] has talked about Summarization and Prioritization of Amazon Reviews based on **multi-level credibility attributes using LSTM, NLTK, TF-IDF**. This paper also discusses how we can find the credibility of reviews and summarizes the next reviews based on the positive and negative keywords. **The average accuracy achieved via LSTM was around 90.28%.**
- P. Porntrakoon et al., [5] used **Simplified Sentiment Analysis, multidimensional lexicon** to get the summarized Thai food reviews. The average accuracy in analyzing the negative, positive and all sentiments is **31.96, 90.26 and 85.05 respectively.**

- For **text summarization**, various resources have been cited for proposed implementation. The paper regarding extractive text summarization for multi-document summarization has been discussed by Tohalino et al [12]. using **multi-layer networks and pagerank algorithm.**

- Another work for text summarization, we have referred to Shapira et al., [8] which uses **clustering and weak reference extraction** and **Fast Abstractive Summarization (FAS)** for massive-multi document summarization (MMDS). **We have taken this as our base paper to implement review clustering and weak reference extraction as part of our implementation.** Similarly, J. Shah et al., [7] has discussed NLP based Text Summarization of reviews using NLP based Seq2seq encoders with attention layers but the **dataset to which model is applied is of one category only** and model to implement for various categories of products has not been discussed.
- There are also works which explore end to end models for simultaneous execution of classification as well as review summarization [9,11] but for **proposed implementation becomes computation heavy** and a more well refined encoder-decoder transformer like BERT is more suitable for our purpose.

ACCURACY VALUES FOR PRODUCT SENTIMENT ANALYSIS

Model	Precision	Recall	F1 Score
LSTM [1]	0.97	0.97	0.97
Fully Connected Neural Network (FCNN) [3]	0.81	0.97	0.92
TF-IDF + Chi2 [6]	0.82	0.88	0.86
Decision Tree [1]	0.951	0.95	0.95

APPLICATIONS

- There is a potential for this project to be implemented and deployed in a web extension which scrapes the reviews from popular e-commerce sites such as Amazon and then finds the summary of the reviews of the product. Text summarization is currently computationally heavy, so the work remains to increase its efficiency and make sure it takes less time to fetch reviews and give the summarized results.
- E-commerce Sites can add this extra feature to help their customers have an overall review of the product. They can also use this tool to analyze products and to find an overall sentiment about the product.

MIT-WPU
॥ विश्वशान्तिर्ध्रुवं ध्रुवा ॥

Implementation Details

Dataset - Amazon Review Dataset - 2018

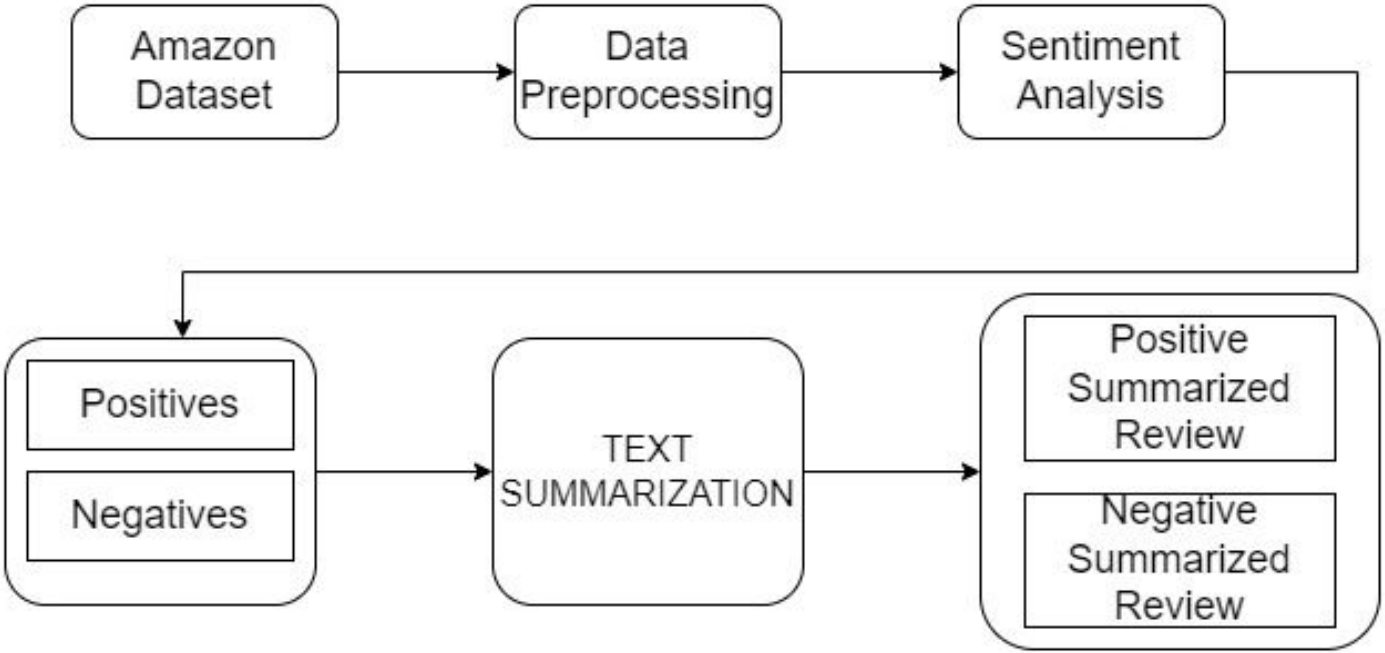
- This dataset includes reviews metadata like ratings, text, helpfulness, votes. Product metadata like descriptions,category information, price, brand, etc.
- The format of this dataset one review per line in JSON
- This dataset contains reviews of each categories of products like books, electronics, movies, sports etc.
- This dataset contains 42 gb of data and contains 233.1 million reviews.

Dataset - Sample Review

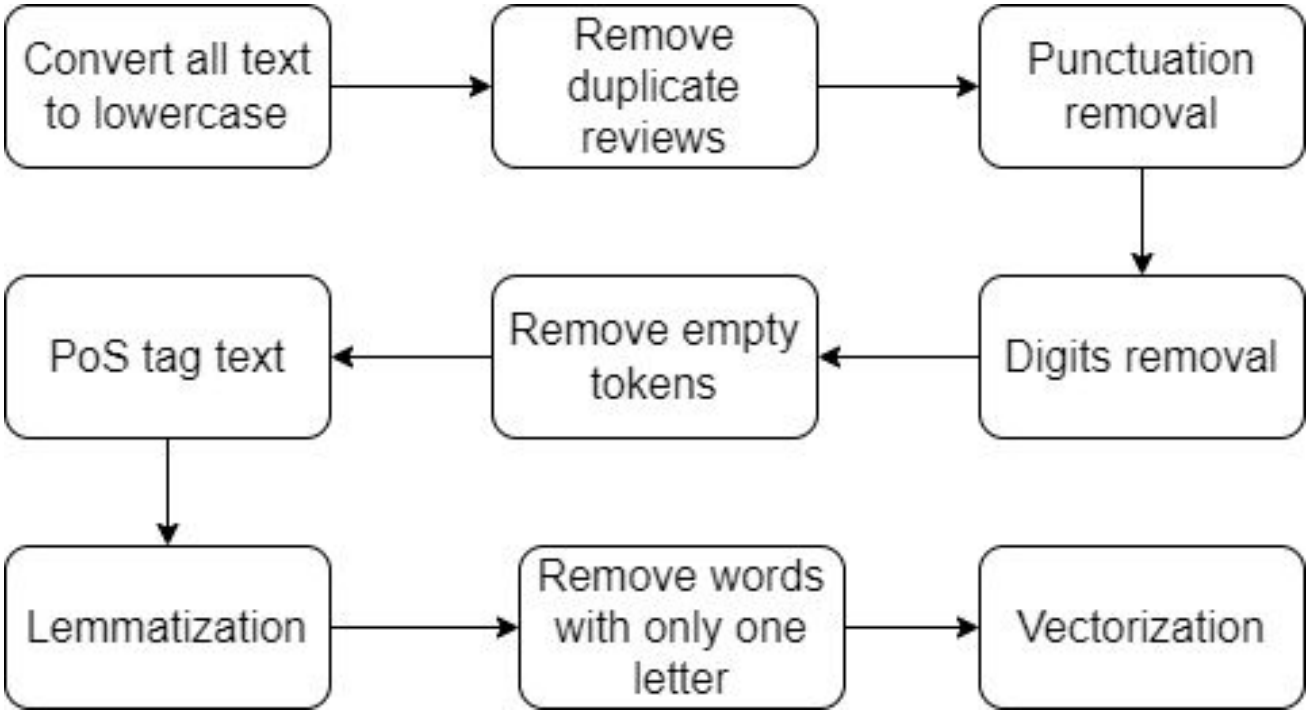
Sample Review:


```
{
  "reviewerID": "A2SUAM1J3GNN3B",
  "asin": "0000013714",
  "reviewerName": "J. McDonald",
  "vote": 5,
  "style": {
    "Format:": "Hardcover"
  },
  "reviewText": "I bought this for my husband who plays the piano.
He is having a wonderful time playing these old hymns.  The music  is
at times hard to read because we think the book was published for
singing from more than playing from.  Great purchase though!",
  "overall": 5.0,
  "summary": "Heavenly Highway Hymns",
  "unixReviewTime": 1252800000,
  "reviewTime": "09 13, 2009"
}
```

High Level Architecture Diagram



Low Level - Data Preprocessing



Preprocessing

1. The data is initially extracted from an independent source of Amazon review dataset manually.
2. Preprocessing steps have applied and explained earlier
3. Exploratory Data Analysis is performed
    a. Creating a new column sentiment based on overall ratings
    b. Dropped columns with unnecessary data
    c. Created a word cloud
4. Feature Extraction is performed:
    a. Label encoding of the ratings columns

Phase - 1: Sentiment Analysis

- For the first phase, we have performed sentiment analysis on the incoming data which would later be subjected to text summarization.
- Due to data imbalance, we have performed data upsampling for the minority category and added initial weights and bias.
- For the sentiment analysis, we have split the data in a 70:30 ratio of training and test set respectively. For the model itself, we have used a LSTM neural network.
- The final layer is dense with 2 outputs and the optimizer used is the ‘adam’ optimizer. The metrics used is accuracy and the loss function used is the categorical cross entropy. The accuracy obtained was 0.9485.

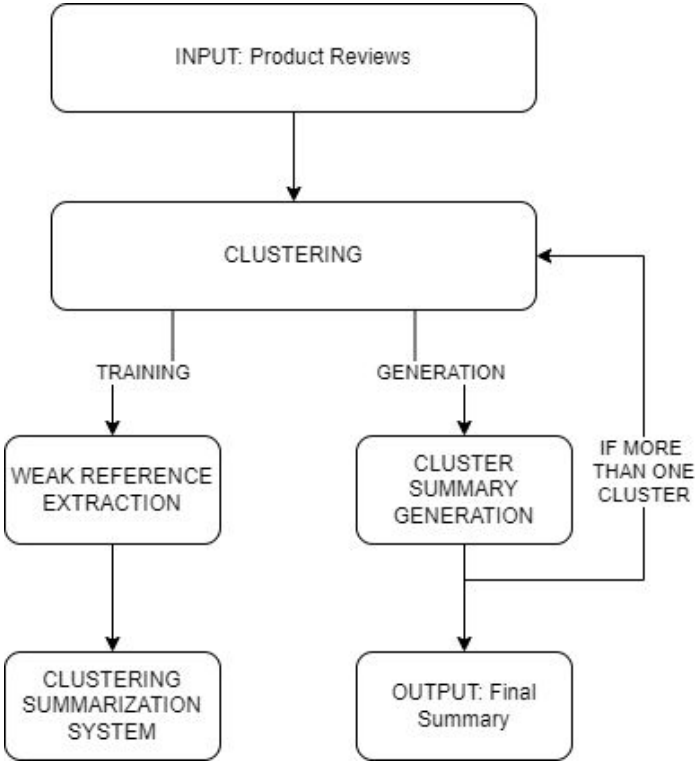
Phase - 1: Sentiment Analysis

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding_1 (Embedding)     (None, 488, 128)          320000

 spatial_dropout1d_1 (Spatia  (None, 488, 128)         0
 lDropout1D)

 lstm_1 (LSTM)               (None, 196)               254800

 dense_1 (Dense)             (None, 2)                 394

=================================================================
Total params: 575,194
Trainable params: 575,194
Non-trainable params: 0
_________________________________________________________________
```

Phase - 2: Review Summarization

- We can collect the data required to train/test the summarizer. For this phase, we have chosen the BERT extractive summarizer.
- As this is a pre-trained model, there is minimal need to train the model. We just needed to tune in the hyperparameters.
- After testing with several hyperparameters, we came to a conclusion that the default parameters gave the best results as per the metrics used.

Low Level - Text Summarization

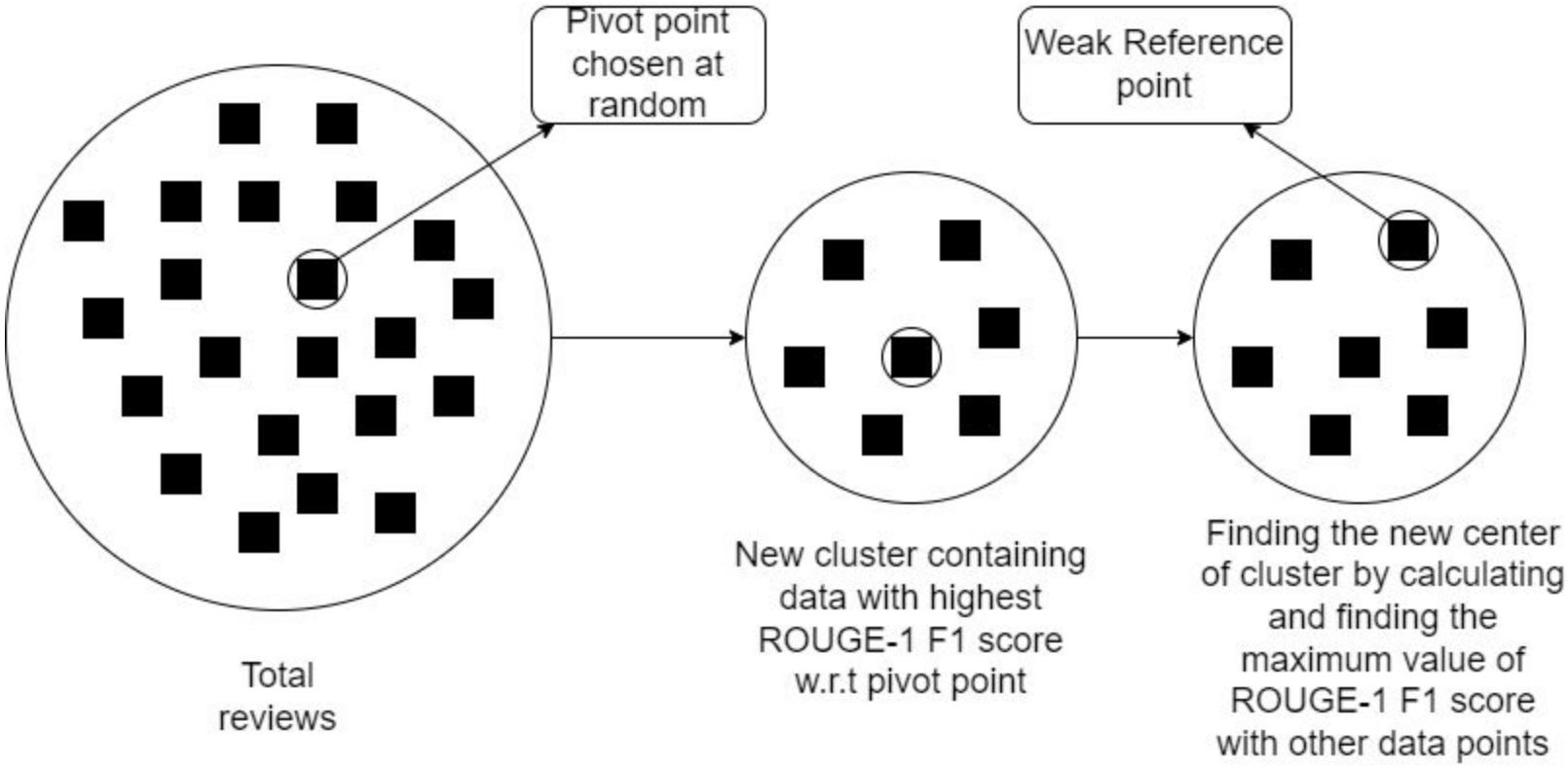


Clustering Of Reviews:-

- It is a collection of data which are resembling each other the closest. A form of pivot clustering has been used. It means to select a randomly assigned pivot point in the dataset.
- We then find the ROUGE-1 F1 score of all the data in the dataset and the data points having the highest score are added in the cluster along with the pivot data.

Weak Reference Extraction:-

- In a given cluster, we find the similarity function of every data point in the cluster with each other.
- The similarity function uses ROUGE-1 F1 score.
- The weak reference extraction will be chosen from the data point with the greatest average ROUGE-1 F1 score.


Pivot point chosen at random
Weak Reference point
Total reviews
New cluster containing data with highest ROUGE-1 F1 score w.r.t pivot point
Finding the new center of cluster by calculating and finding the maximum value of ROUGE-1 F1 score with other data points

Summary Generation

- The process of summary generation starts with the clustering step. In this step, we do not take any min-rev parameters.
- We create the clusters based on the above parameters and then proceed to find the summary of the said cluster.
- Next the summaries are clustered together within the constraints of the parameters provided.
- Then, to construct second-level summaries, we locate the summaries of the aforementioned clusters. This technique is repeated until a final summary is obtained.

MIT-WPU
॥ विश्वशान्तिर्ध्रुवं ध्रुवा ॥

Algorithms/Methodology

Preprocessing Techniques:-

1. **Lemmatization** : This is performed to bring the words in their root form so that if familiar words are used in different forms, they can be considered as same words.E.g -> doing, done, do
2. **Vectorization** : Method in which textual data in converted into a numerical form(binary, int, float) since machine learning algorithms cannot work with text form data
3. **Tokenization** : Tokenization is essentially splitting a phrase, sentence, paragraph, or an entire text document into smaller units, such as individual words or terms. Each of these smaller units are called tokens. E.g -> ‘Natural language Processing’ => [‘Natural’, ‘language’, ‘processing’].

Model to be used for training the dataset for Classification and Summarization

- LSTM, BERT.

BERT Architecture

- Built a sentiment classifier using the base model, which is a 12-layer, 768-hidden, 12-heads, 110 million parameter neural network architecture.
- The pre-processed reviews were fed to the model using ‘Adam’ as the optimizer, ‘SparseCategoricalAccuracy’ as the accuracy metric, and ‘CategoricalCrossentropy’ as the loss function.
- For our dataset, we have fine-tuned the model up to 2 epochs, which gives us a validation accuracy of 98.51%.

LSTM Architecture

- Built our model on top of the Sequential class of keras, where we have used the LSTM layer as a bidirectional layer, which is added along with the Embedding and Dense layers on top of the Sequential class.
- The pre-processed reviews were fed to the model using ‘Adam’ as the optimizer, and ‘binary_crossentropy’ as the loss function.
- For our dataset, we have fine-tuned the model up to 20 epochs, which gives us a validation accuracy of 97.35%.

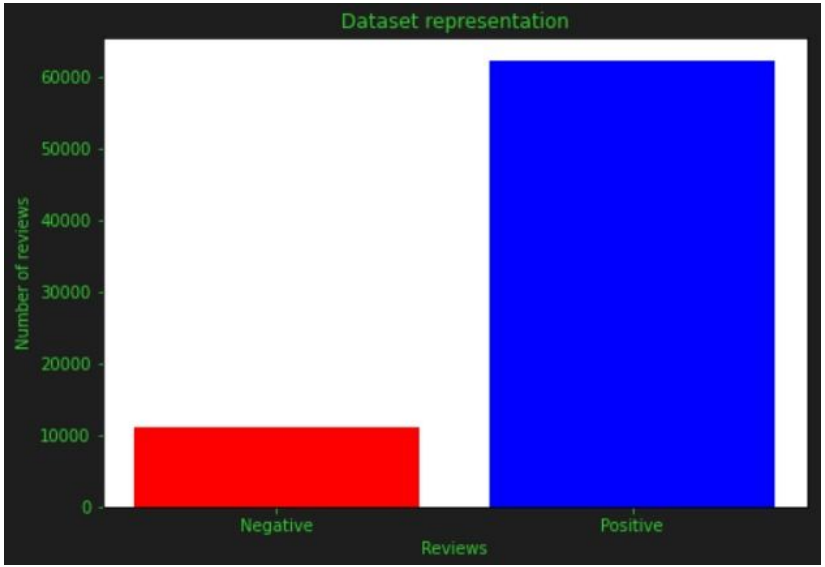
Implementation Details - Application

1. We are planning to develop a chrome extension. Whenever you’re on an Amazon Product page or Flipkart product page, just clicking on that extension will give you a summarized review of that product
2. A web scraper will extract all the reviews of that particular product.
3. These reviews will be pre-processed as per our model requirements.
4. After, these reviews will be feeded to our model which will generate a summarized review.
5. This summarized review will be show on the extension UI.

MIT-WPU
॥ विश्वशान्तिर्ध्रुवं ध्रुवा ॥

Results and Analysis

ANALYSIS



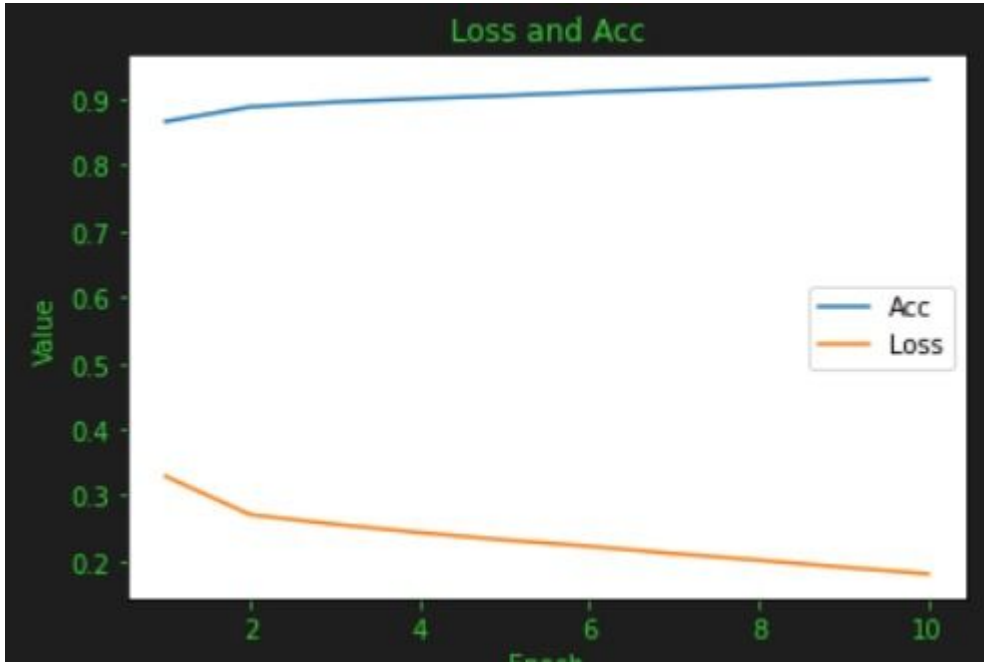
Number of positive reviews with negative reviews

Word Cloud of the dataset

Results and Discussion

- For sentiment analysis and text summarization, we developed an end-to-end procedure.
- We used the LSTM model, which has a 4-layer, 575,194 trainable parameters neural network architecture, to create a sentiment classifier for sentiment analysis. With 'Adam' as the optimizer, 'Accuracy' as the accuracy metric, and 'Categorical Cross Entropy' as the loss function, the pre-processed reviews were input into the model.
- We fine-tuned the model up to 10 epochs for our dataset, resulting in an accuracy of 94.85%. We utilized the BERT extractive model with default hyperparameters for text summarization. The results can be found in Table II.

Results for Sentiment Analysis




```
confusion matrix [[ 1341   861]
 [  460 11867]]
              precision    recall  f1-score   support

           0       0.74      0.61      0.67      2202
           1       0.93      0.96      0.95     12327

    accuracy                           0.91     14529
   macro avg       0.84      0.79      0.81     14529
weighted avg       0.90      0.91      0.91     14529
```

Results for Review Summarization

	Recall	Precision	F1 score
ROUGE-1	0.50146	0.19342	0.27379
ROUGE-2	0.24515	0.08510	0.12297
ROUGE-L	0.47792	0.18467	0.26125

ROUGE SCORES OF THE BERT EXTRACTIVE SUMMARIZER

	Unnamed: 0	Reviews
0	0	It is very nice. I liked it very much because ...
1	1	This is highly disappointing. Took all the mea...
2	2	I really like this product because it's quali...
3	3	The media could not be loaded. I like the prod...
4	4	I use this during my last Himaalayan expeditio...
5	5	Amazing glasses. Very much comfortable. The gr...
6	6	Very bad defective product
7	7	Mastt sunglasses Amazon product so good look T...
8	8	Although i have other brand sunglasses, I boug...
9	9	The media could not be loaded. They have not p...
10	10	Instead of Green Color Fast track Goggle , Bla...
11	11	Great
12	12	Has some power in the glass. Feels very much f...
13	13	Got it in a sale for a really great price... A...
14	14	Sabse pehle jo mere yaha delivery boy ata hain...
15	15	This is the best budget wayfarer in budget. I ...

Positive Summary -

I really like this product because it's quality is very good according to the price the frame and the lense is very durable and it really protect from UV rays and we get very clear image. Got it in a sale for a really great price... At that point I wasn't expecting it would look so good in real... I was just having a wish to get a nice quality Sunglasses to block sunlight didn't cared how it looked on me... I have a little sensitive eyes to sunlight & I have been a bad Kite flyer for that sole reason... I wasn't expecting anything about looks... As till now I was an aviator lover... Never went on about wayfarers... But it came out to be entirely awesome... Quality: The name says it all Fastrack.

Negative Summary -

Its not perfect black but honestly you really don't need to wear all black it feels uncomfortable while driving and this one UV protected as well as some short of polarized too so while driving at daytime everything's is clear and punchy in colour. Do not expect much from the product...its very light almost like any other product on roadside..the mark of fastract makes it stand out a bit..its beautiful in design.

	Unnamed: 0	Reviews
0	0	Good product according to price .
1	1	Just one issue. The advertisement tells you th...
2	2	I loved it.. Just go for it.. Been a customer ...
3	3	This is the second time I have bought Ben Mart...
4	4	The Size, length, and waist of pant are just a...
5	5	The product quality is good For the product fi...
6	6	Looks verry good quality,fits perfectly, let's...
7	7	Nice jeans . I like it. Best jeans at low Price.
8	8	Since lockdown I reduced by 15kgs and existing...
9	9	Quality ia good but this pant number is 32.. b...
10	10	Cheap quality material. But I had to see it co...
11	11	I am writing this review 4 month after buying....
12	12	I ordered this item for the 2nd time same size...
13	13	It's Narrow Fit. Not the product you see in th...
14	14	Good jeans, only material not much soft, it ro...

Positive Summary -
Not the product you see in the picture Not comfortable in wearing if your Thigh got Muscle. Good product according to price .Just one issue.

Negative Summary -
This size very too slim and small fitting I'm return this product not sure full money return refunds

	Unnamed: 0	Reviews
0	0	First off, these shoes look way way better han...
1	1	very bad, there is a metal piece at the back, ...
2	2	It's not at all breathable after wearing for s...
3	3	Excellent
4	4	Grate product original Nike
5	5	Poor product and not real
6	6	1) Colour Combination is as expected 2) Bit lo...
7	7	Awesome
8	8	Yes I like it
9	9	Good Comfort and looking Rich....
10	10	quite well fit and comfortable
11	11	I like the cushioning in it but i prefer air v...
12	12	Product is good . Comfortable. But looks littl...

Positive Summary -
Poor product and not realFirst off, these shoes look way way better hands-on, than what they look in the images. AwesomeYes I like itGood Comfort and looking Rich....quite well fit and comfortableI like the cushioning in it but i prefer air vents like the zoom pegasus33 or 35Just amazing.

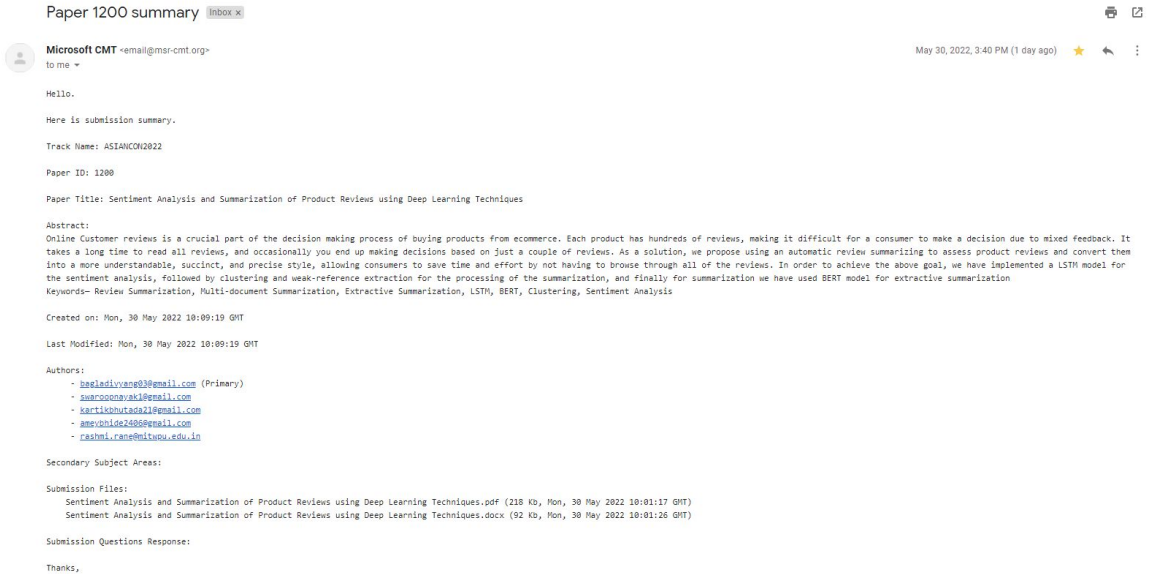
Negative Summary -
Product is good . Comfortable. But looks little bit fake by its logo nike

CONCLUSION

- We presented an effective technique to summarize positive and negative evaluations in this paper.
- We look into deep learning techniques rather than machine learning models to perform sentiment analysis of product reviews and perform summarization on them, particularly LSTM and BERT models.
- We use LSTM to classify reviews as positive and negative and then we implement review summarization using the BERT model on these classified reviews to have both positive as well as negative reviews summary.
- We have performed extractive text summarization which fetches the reviews and extracts the words from it to form the summary.

Publication Details

- **CPF-IEEE 2ND ASIANCON 2022-SCOPUS INDEXED CONFERENCE**
- **Hosted by** - PCCOER, Pune, India,
- **Conference URL**: http://asiancon.org
- **Date of Conference:** 26th Aug – 28th Aug. 2022



Paper 1200 summary Inbox ×

Microsoft CMT <email@msr-cmt.org> May 30, 2022, 3:40 PM (1 day ago)
to me

Hello.

Here is submission summary.

Track Name: ASIANCON2022

Paper ID: 1200

Paper Title: Sentiment Analysis and Summarization of Product Reviews using Deep Learning Techniques

Abstract:
Online Customer reviews is a crucial part of the decision making process of buying products from ecommerce. Each product has hundreds of reviews, making it difficult for a consumer to make a decision due to mixed feedback. It takes a long time to read all reviews, and occasionally you end up making decisions based on just a couple of reviews. As a solution, we propose using an automatic review summarizing to assess product reviews and convert them into a more understandable, succinct, and precise style, allowing consumers to save time and effort by not having to browse through all of the reviews. In order to achieve the above goal, we have implemented a LSTM model for the sentiment analysis, followed by clustering and weak-reference extraction for the processing of the summarization, and finally for summarization we have used BERT model for extractive summarization
Keywords– Review Summarization, Multi-document Summarization, Extractive Summarization, LSTM, BERT, Clustering, Sentiment Analysis

Created on: Mon, 30 May 2022 10:09:19 GMT

Last Modified: Mon, 30 May 2022 10:09:19 GMT

Authors:
- pagledivyang03@gmail.com (Primary)
- swaroopnayak1@gmail.com
- kartikbhutada21@gmail.com
- ameyphilip2406@gmail.com
- rashmi.rane@mitwpu.edu.in

Secondary Subject Areas:

Submission Files:
Sentiment Analysis and Summarization of Product Reviews using Deep Learning Techniques.pdf (218 Kb, Mon, 30 May 2022 10:01:17 GMT)
Sentiment Analysis and Summarization of Product Reviews using Deep Learning Techniques.docx (92 Kb, Mon, 30 May 2022 10:01:26 GMT)

Submission Questions Response:

Thanks,

References

[1] Desai, Z., Anklesaria, K., & Balasubramaniam, H. (2021, July). Business Intelligence Visualization Using Deep Learning Based Sentiment Analysis on Amazon Review Data. In *2021 12th International Conference on Computing Communication and Networking Technologies (ICCCNT)* (pp. 1-7). IEEE.

[2] AlQahtani, A. S. (2021). Product Sentiment Analysis for Amazon Reviews. *International Journal of Computer Science & Information Technology (IJCSIT) Vol*, *13*.

[3] L. Rong, Z. Weibai and H. Debo, "Sentiment Analysis of Ecommerce Product Review Data Based on Deep Learning," 2021 IEEE 4th Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC), 2021, pp. 65-68, doi: 10.1109/IMCEC51613.2021.9482223.

[4] Aishwarya, N., Bhuvana, L. S., & Kayarvizhy, N. (2021, August). Summarization and Prioritization of Amazon Reviews based on multi-level credibility attributes. In *2021 International Conference on Recent Trends on Electronics, Information, Communication & Technology (RTEICT)* (pp. 5-9). IEEE

[5] P. Porntrakoon, C. Moemeng and P. Santiprabhob, "Text Summarization for Thai Food Reviews using Simplified Sentiment Analysis," 2021 18th International Joint Conference on Computer Science and Software Engineering (JCSSE), 2021, pp. 1-5, doi: 10.1109/JCSSE53117.2021.9493839.

[6] F. Rustam, A. Mehmood, M. Ahmad, S. Ullah, D. M. Khan and G. S. Choi, "Classification of Shopify App User Reviews Using Novel Multi Text Features," in IEEE Access, vol. 8, pp. 30234-30244, 2020, doi: 10.1109/ACCESS.2020.2972632.

[7] J. Shah, M. Sagathiya, K. Redij and V. Hole, "Natural Language Processing based Abstractive Text Summarization of Reviews," 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC), 2020, pp. 461-466, doi: 10.1109/ICESC48915.2020.9155759.

[8] Shapira, O., & Levy, R. (2020). Massive multi-document summarization of product reviews with weak supervision. *arXiv preprint arXiv:2007.11348*.

[9] Chan, H. P., Chen, W., & King, I. (2020, July). A unified dual-view model for review summarization and sentiment classification with inconsistency loss. In *Proceedings of the 43rd International ACM SIGIR Conference on Research and Development in Information Retrieval* (pp. 1191-1200).

[10] Ravali Boorugu, Dr. Gajula Ramesh, Dr. Karanam Madhavi (2019). Summarizing Product Reviews Using NLP Based Text Summarization. International Journal of Scientific & Technology Research

[11] Ma, S., Sun, X., Lin, J., & Ren, X. (2018). A hierarchical end-to-end model for jointly improving text summarization and sentiment classification. *arXiv preprint arXiv:1805.01089*.

[12] Tohalino, J. V., & Amancio, D. R. (2018). Extractive multi-document summarization using multilayer networks. *Physica A: Statistical Mechanics and its Applications*, *503*, 526-539.

MIT-WPU
॥ विश्वशान्तिर्ध्रुवं ध्रुवा ॥

THANK YOU !!