

# Detecting Interests in Social Media

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## **Abstract**

Thanks to recommender systems it is common that a users social media feed will be filled with posts relating to other posts they have previously interacted with. This can lead to a user being shown posts that are similar to the posts they have already seen. In this project it is viewed that this can lead to a user being shown posts that are biased towards their own opinions. This project aims to identify topics that users are interested in based off of their social media feed.

First, a comparison of different Natural Language Processing models is completed to identify what model is best suited for the task of classifying social media posts into topics (sports, politics, etc.). It was found that RoBERTa outperformed RNNs, LSTMs, and BERT. RoBERTa was then fine-tuned on Reddit and Wikipedia data for this classification problem. This resulted in a model with a 69% accuracy.

Next, the project attempts to improve this accuracy by including context to aid with the classification process. The context that was included was the media attached to the post as well as the comments/threads that the post was a part of. This resulted in around a 20% improvement in accuracy.

Finally, the project works on creating a User Interface that allows a user to view the difference in topics they see on social media compared to what is commonly available across the whole of the social media site. This allows users to gauge what topics they are interested in. On top of this users are able to search for posts relating to any topics of their choice.

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# Chapter 1

## Introduction

### 1.1 Motivation

The content seen on social media varies greatly from user to user. This is because social media use recommender systems to show users content they are likely to be “interested” in. These recommender systems are based on a users past interactions. Typically, if a user views a certain type of post, they are likely to view similar posts in the future. This project aims to find the interests of a user by analysing their social media posts.

Take a look at the following example:

This set of social media posts are taken from a user’s social media feed. As a human, we can easily identify what the user is interested in; they are interested in Formula 1 and Food (specifically, steak). We make this assumption based on the content of the posts.

Looking at the posts, there rises a couple questions:

- What are the posts about?
- Are the posts seen representative of all posts across the social media platform?

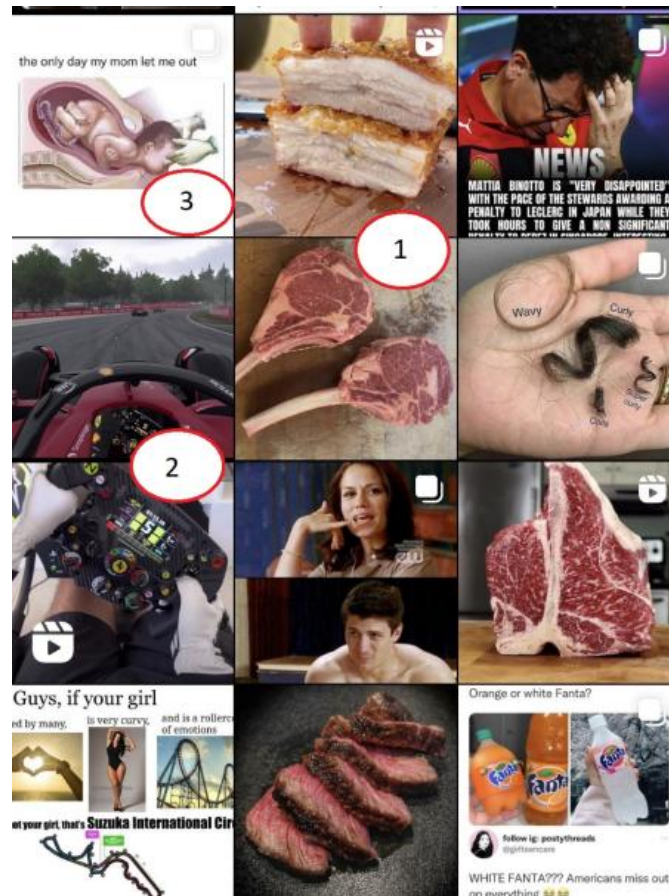


Figure 1.1: Example tweet

- How can users find other posts that are dissimilar to the posts they are shown?

### 1.1.1 Topics

This project will use the notion of topics to identify what the posts are about.

a subject that is discussed, written about, or studied

Figure 1.2: Topic Definition - ?

This definition of a topic is a good starting point for this project. This definition is a bit too specific. If this definition were to be used there would be no meaningful output from this project - due to the fact you could classify each post into its own unique topic. To overcome this, we will use a more general definition of a topic. Essentially, a topic comprises of a set of words that are related to each other.

### 1.1.2 Problem Statement

The goal of this project is to be able to classify social media posts. This will allow us to identify interests through comparing similarities between posts shown to the user. This will be followed by quantifying a set of posts to compare the similarity between a users posts and posts from the entire social media site. Finally, this project aims to create a user interface that allows users to discover what their social media feed says about their interests and how they compare to the rest of the social media site. The user interface will also allow users to discover posts that are dissimilar to the posts they are shown.

## 1.2 Related work

TODO: Add LDA



### 1.2.1 Pythia - Litou and Kalogeraki (2017)

Pythia is an automated system for short text classification. It makes use of Wikipedia structure and articles to identify topics of posts. Essentially, "Wikipedia contains articles organized in various taxonomies, called categories". Pythia then goes on to use this information as their training data as well as handling sparseness in posts on social media.

Pythia also demonstrates a method to overcome the lack of context in short texts - This is a large problem in identifying smaller social media posts like tweets, and will be further worked on in this project. They use a method called "Post Enrichment", which performs i) Named Entity Recognition then ii) Lemmatization and stop word removal. We then use the named entities to query wikipedia for similar articles that are then appended to the post.

Although this method works well in cases where keywords are used, there are cases where no keywords are used, and more context is needed. Take for example the following tweet:



Dear @MrBeast @hasanthehun @xQc and @ishowspeedsui

Figure 1.3: Example tweet

The text gives us very little context; What is this tweet about? the best guess I could give is it is a message to other users. If these users had wikipedia articles, we could use them. But in reality this post is about something else. Lets add some other form of context; add the media the tweet contains. This gives us a lot more context; the tweet is discussing the earthquake that hit Turkey and Syria, if we use this for our query we get more relevant articles:

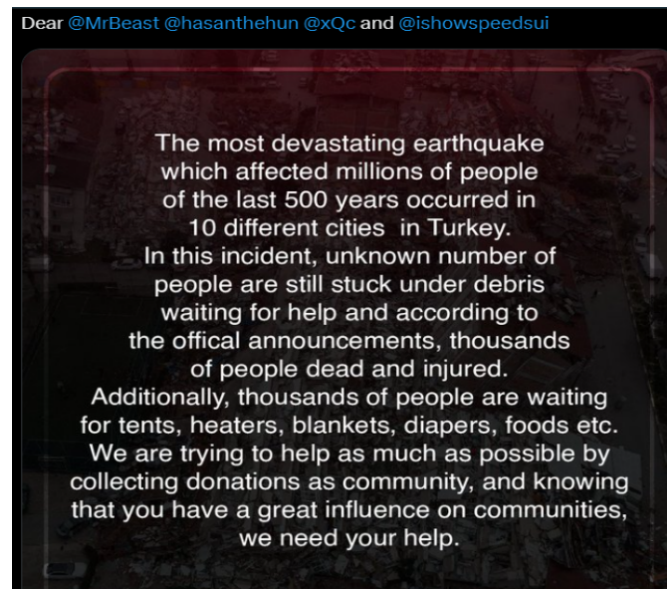


Figure 1.4: Example tweet - media



Figure 1.5: Wikipedia articles related to the hashtag "BLASTPremier"

We now have a lot of relevant information to append to the post. We could use other information for context as well: Tweet author, images/media in tweets, retweet information, like information, etc.

### **1.2.2 Topic tracking of student-generated posts - Peng et al. (2020)**

This paper proposes a solution for determining valuable information/topics discussed in student forums on online courses. It uses a model called "Time Information-Emotion Behaviour Model" or otherwise called "TI-EBTM" to detect key topics discussions, keeping in mind the progress of time throughout the forum.

Although this paper specializes in academic online forums, the approaches made could be relevant and useful for this project.

### **1.2.3 Topic classification of blogs - Husby and Barbosa (2012)**

This paper uses Distant Supervision - 'an extension of the paradigm used by (Snow et al. (2004)) for exploiting WordNet to extract hypernym (is-a) relations between entities' - to get training data via Wikipedia articles. Then trains their own designed model on this data to be able to classify topics via a multi-class recognition model (69% accuracy) and via a binary classification model (90% accuracy).

## **1.3 Objectives**

To achieve the problem statement, the following objectives must be met:

- Generate a list of topics for classification
- Implement methods for identifying the topics in social media posts
- Compare and contrast the results of the different methods
- Create a user interface
  - Allow users to compare their interests to the rest of the social media site

- Allow users to discover posts that are dissimilar to the posts they are shown

The largest problem with this project is the second objective of finding and creating methods for identifying topics.

## Chapter 2

# Background

### 2.1 Topic Modelling

As discussed in Chapter 1, this project uses topics to identify what the posts are about. This section will discuss how topics are created and how they are used in this project.

There are 2 methods of topic modelling that were considered for this project. The first method is Unsupervised Learning, and the second method is Supervised Learning.

#### 2.1.1 Unsupervised Learning

Unsupervised learning is a method of machine learning that does not require labelled data. This method is used to identify patterns in data. For this project, the patterns are topics.

Using LDATopic ? and BERTTOPIC ?, topics were identified from a set of unlabelled documents.

The benefits of using unsupervised learning are that it does not require labelled data, it is easy to implement, and the classification of posts with the generated topics should be accurate - as the topics are generated to be seperable. The downsides of using unsupervised learning are that the topics generated may

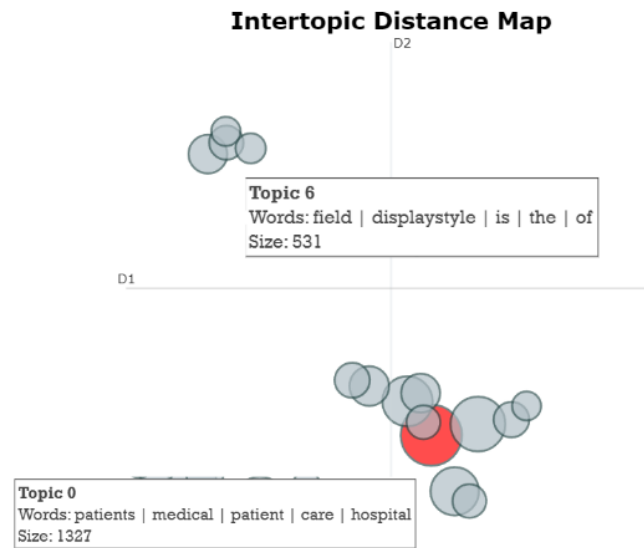


Figure 2.1: LDATopic creating topics from a set of unlabelled documents

not be meaningful; Take for example Topic 6 from Figure 2.1. This topic is made up of the words ‘displaystyle’, ‘is’, ‘the’, and ‘of’. It is quite hard for a human to understand what this topic is about.

## 2.1.2 Supervised Learning

Supervised learning is a method of machine learning that requires labelled data. This method is used to identify patterns in data. For this project, a set of topics can be manually created and then used to label the posts. This method is much easier to implement than unsupervised learning, as the topics are already created. The downside of this method is that it requires labelled data, which can be time consuming to create.

For this project, supervised learning was used to classify the posts into the topics that were created. The original set of topics were:

- **Culture**
- **Entertainment**
- **News**
- **Philosophy**
- **Religion**
- **Science**
- **Sports**
- **Technology**
- **Law**
- **History**
- **Geography**
- **Video Games**
- **Music**
- **Medicine**
- **Business**
- **Foods**
- **Disasters**
- **Nature**
- **Education**
- **Politics**
- **Economics**
- **Computer Science**
- **Mathematics**

Pythia Litou and Kalogeraki (2017) gave inspiration for most of the topics. Some extra topics were included to deal with uncovered topics, such as 'Video Games' and 'Foods'.

Once the topics were created, labelled data was created using a distant supervision method. Using Subreddits and Wikipedia categories as ground truth labels, and posts within those Subreddits and Wikipedia categories as the data. The labelled data was then used to train a supervised learning model. Although distant supervision allows us to quickly create labelled data, it is not perfect. The ground truth labels may not be accurate, and the posts may not be relevant to the topic. This is due to the fact that the posts can be made by anyone and it is possible that someone may post something that is not relevant to the subreddit or wikipedia category they are posting in.



## 2.2 Text Classification

As mentioned in Chapter 1 there exists research on topic identification in short texts such as social media posts. Topic analysis on short posts is harder than on longer texts because of the lack of context ; Twitter posts are limited to 280 characters, so users tend to attach images, or reference other tweets (via retweeting) to add context that would not be obvious from the text alone.

### 2.2.1 Recurrent Neural Networks (RNN)

Recurrent Neural Networks (RNNs) are Neural Networks that are used to model sequential data. They are good at modelling sequential data because they can take into account the previous inputs in the sequence when making a prediction. This makes them good for text as the text input can be seen as a sequence of words and we can leverage the previous words to make a prediction about the whole sentence.

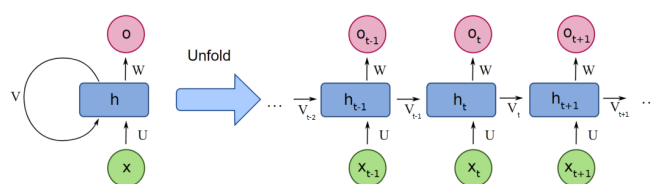


Figure 2.2: RNN Architecture

The RNN architecture in Figure 2.2 is a simple RNN. It takes in a sequence of words ( $X_i$ ), and outputs a prediction. The RNN takes input words one at a time, and passes a hidden state ( $V_i$ ) to the next word. The hidden state contains information about the previous words in the sequence. At the end of the sequence, the final hidden state of the RNN is fed through a softmax layer to get a probability distribution over the possible classes.

The main problem with RNNs is the affect of short-term memory. For every new word in the sequence, the RNN ‘forgets’ parts of the previous words in the sequence. This is because the hidden state is updated by each new word.

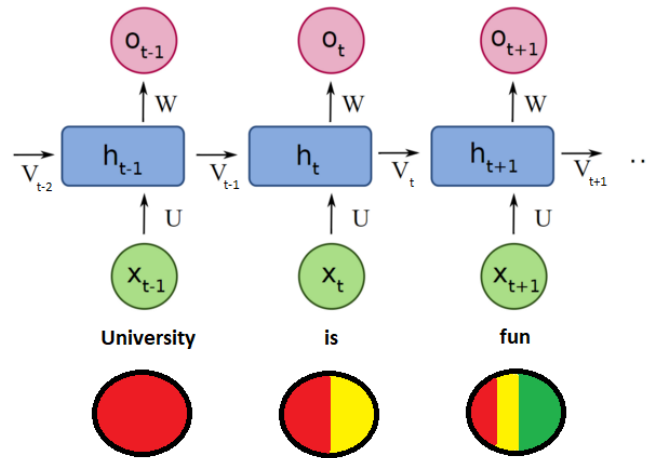


Figure 2.3: Problem with RNNs

In figure 2.3, we can see how much each ‘word’ in the sequence affects the hidden state over time. For long sequences, the hidden state is predominantly affected by the last words in the sequence. This means we lose information about the earlier words in the sequence. This could be a problem with our text classification problem as the key information in the text may be in the beginning of the sentence. For example: “Manchester United lost the match 2-1, it was a poor performance but the atmosphere in the theatre of dreams was astounding.” The key information in this sentence is that Manchester United lost the match (meaning the text is about sport). However, this information could be lost due to the short-term memory problem. In the case above it is likely we classify the text as entertainment due to the later references of ‘performance’ and ‘theatre’

### 2.2.2 Long Short-Term Memory (LSTM)

The Long Short-Term Memory (LSTM) model was developed in 1997 to solve the short-term memory problem in RNNs. It does this by using 3 memory gates: the input gate, the forget gate and the output gate. These gates perform different functions:

- **Input Gate:** The input gate decides which values from the current input should be added to the cell state.
- **Forget Gate:** The forget gate decides which values from the cell state should be kept.
- **Output Gate:** The output gate decides which values from the cell state should be used to make a prediction.

TODO: add lstm diagram and explain how the changes solve the short-term memory problem.

LSTM's (as well as RNNs) have another problem: they can only process information in one direction at a time. This means that they can only use previous words to understand the current word, or the next words to understand the current word. Bidirectional versions of these models aim to solve this problem by processing the sequence in both directions at the same time. However, this is not a perfect solution as it only 'learns' the context from both directions and not as a whole. In section 2.2.3 we will discuss a model that solves this problem.

### 2.2.3 Transformers

#### Architecture

In 2017 Google released a paper called *Attention is all you need* ?. This paper introduced the Transformer architecture.

Figure 2.5 shows the architecture of a Transformer model. Focussing on the encoder, the input is passed through a 'Multi-Head Attention' layer. This layer takes in the input and creates a matrix of attention weights. These attention weights essentially say how much of an impact each word has on each other.

#### Self-Attention

Before looking into Multi-Head Attention, let's discuss Self-Attention.

Self-Attention is a Sequence-to-Sequence model that calculates the attention

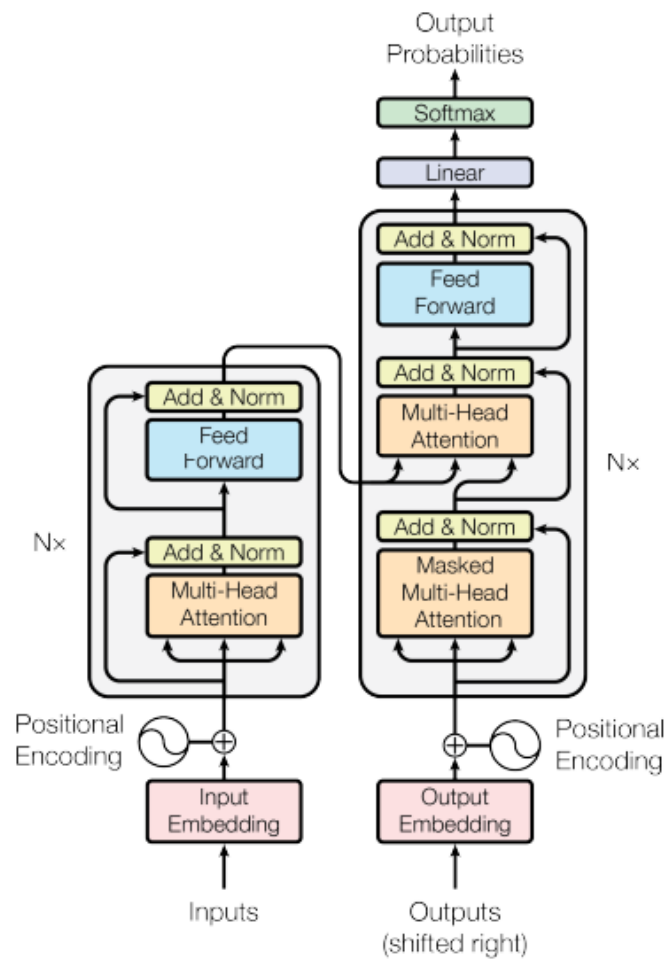


Figure 2.4: Transformer Architecture - ?

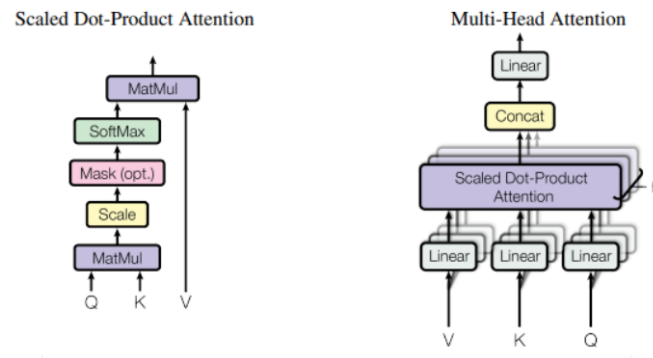


Figure 2.5: Self-Attention - ?

weights between each word in the sequence. The attention weights are how important each word is to the other words in the sequence. The attention weights are calculated using 3 vectors: Query, Key, and Value. All of these vectors are made from passing the input through a linear layer. Each vector is made using a different linear layer.

Figure 2.5 shows how the attention weights are calculated. First, the Query and Key vectors are multiplied together. This is then passed through a softmax layer to convert all weights into probabilities. These probabilities act as the attention weights. The attention weights are then multiplied by the Value vector to get the final output.

### Multi-Head Attention

The paper *Attention is all you need* ? also introduces the Multi-Head Attention layer. This layer uses self-attention but splits the Query, Key and Value vectors into multiple heads. Each head calculate the attention weights independently, and their outputs are concatenated together.

TODO: benefits

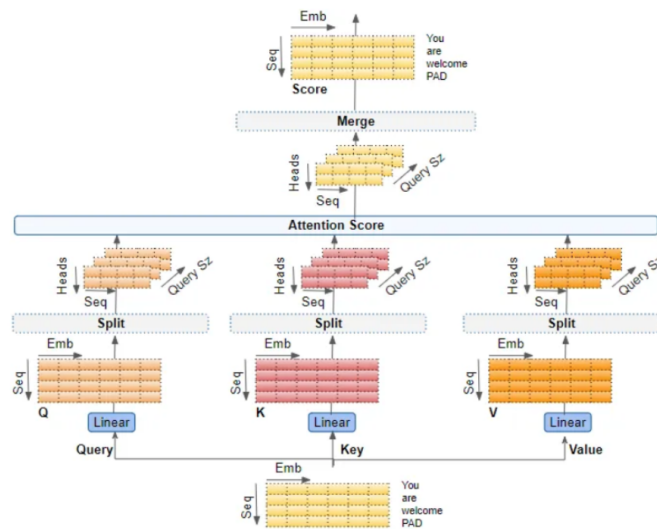


Figure 2.6: Multi-Head Attention

## 2.2.4 Bidirectional Encoder Representation of Transformers (BERT)

- ?

BERT is an acronym for Bidirectional Encoder Representations from Transformers. Its architecture uses several Transformer encoders put together. Transformers make use of self-attention to learn contextual representation of words. This solves the problem discussed in ?? where the RNNs only look at the previous words in the sentence, or both directions independently.

A BERT classification model is trained in 2 steps: pre-training and fine-tuning. The pre-training step is done on a large corpus by Google. The fine-tuning step is done on a smaller dataset specific to the task at hand.

### pre-training

The pre-training step of the BERT model consists of learning 2 objectives: masked language modelling (MLM) and next sentence prediction (NSP).

**Masked Language Modelling (MLM)** is a task where the model is given a sentence with some words masked out. The model is then expected to predict the masked words.



Figure 2.7: BERT Architecture

**Next Sentence Prediction (NSP)** is a task where the model is given 2 sentences, a and b. The model is then expected to predict whether sentence b is the next sentence following a.

The pre-training step is done on a large corpus of unlabelled data. This makes it easy to train the model, as it does not require collecting a large amount of labelled data. Using Transformers makes the model more efficient, as it can process the entire sentence at once instead of processing the sentence word by word.

### **fine-tuning**

To use BERT for our task of topic classification, we need to fine-tune the model using a labelled dataset - posts labelled with the corresponding topic they belong to (as figured out in ??).

	MNLI	QNLI	QQP	RTE	SST	MRPC	CoLA	STS	WNLI	Avg
<i>Single-task single models on dev</i>										
BERT <sub>LARGE</sub>	86.6/-	92.3	91.3	70.4	93.2	88.0	60.6	90.0	-	-
XLNet <sub>LARGE</sub>	89.8/-	93.9	91.8	83.8	95.6	89.2	63.6	91.8	-	-
RoBERTa	<b>90.2/90.2</b>	<b>94.7</b>	<b>92.2</b>	<b>86.6</b>	<b>96.4</b>	<b>90.9</b>	<b>68.0</b>	<b>92.4</b>	<b>91.3</b>	-

Figure 2.8: Comparing RoBERTa and BERT Liu et al. (2019)

Before fine-tuning, the model needs a final output layer to be added. This output layer will be a linear layer with  $x$  neurons, where  $x$  is the number of topics (so currently 23). The fine-tuning step is trained using categorical cross-entropy loss, and the Adam optimizer. The model is trained for 6 epochs, with a batch size of 32. The model is then evaluated on the test set, achieving an accuracy of  $\approx 42\%$ . Please refer to ?? for a more detailed analysis of the model's performance.

### 2.2.5 Robustly Optimised BERT Approach - RoBERTa

RoBERTa is a variant of BERT that is more efficient and robust. It uses the same architecture as BERT, but with some modifications to the pre-training step. RoBERTa only performs the masked language modelling task, and does not perform the next sentence prediction task. On top of this, RoBERTa uses dynamic masking, where during runtime the model randomly masks out words in the sentence, instead of masking out words statically (masking the same words for a given sentence).

TODO: add more details from papers about RoBERTa.

The pre-training of RoBERTa was done on a larger corpus of text than BERT. This improved the model's performance.

The figure above shows how RoBERTa performs better than BERT on most NLP benchmark tests. This led to RoBERTa being tested for this project. RoBERTa was fine-tuned using the same method as BERT, and achieved an accuracy of  $\approx 71\%$  on the test set. Evaluation of the model is discussed in ??.



## Chapter 3

# Design

In this chapter, we describe the overall design of our solution to the problem identified in Chapter 1, building on work described in Chapter 2.

### 3.1 Topic Classification

Chapter 2 discussed 4 different models for classifying text into topics: RNN, LSTM, BERT, and RoBERTa. The chapter also used intuition to determine which model would be expected to perform best - RoBERTa. The reason being, RNNs and LSTMs suffer from being unable to understand context of a whole sentence; they are limited to understanding context in a single direction (left to right or right to left). BERT and RoBERTa both use a technique called self-attention to overcome this limitation. From observing results in Liu et al. (2019) RoBERTa outperforms BERT in most cases.

Building off of the RoBERTa model described in Chapter 2, we use the model to classify posts into topics. The design of this model is relatively simple due to the fact we are performing transfer learning on a pre-trained model.

As seen in the diagram, the RoBERTa model has been altered with a new classification layer.

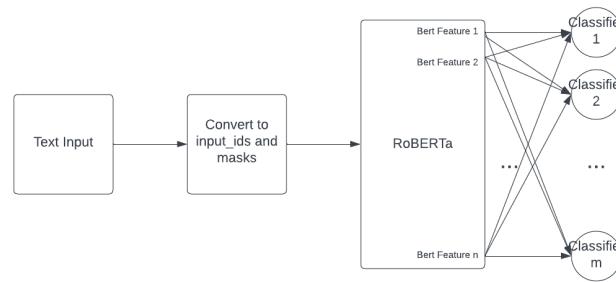


Figure 3.1: RoBERTa model

## 3.2 Adding Context

### 3.2.1 What is context? and why is it important?

As discussed in section sec:pythia, context is an important factor in classifying posts. In figure 1.3 there is a tweet that would be hard to classify with the text alone. The section then goes onto show how adding the image that the tweet was posted with (figure ??) adds more information to the post and makes it easier to classify.

### 3.2.2 Methods for adding context

There are many ways to add context to a post. Pythia uses Named Entity Recognition (NER) for adding context. In this project the use of Optical Character Recognition, Audio Transcription, and Threads/Retweets are explored.

#### Named Entity Recognition - NER

#### Optical Character Recognition - OCR

Images in posts may contain text. This text adds context to the post and can be helpful in classifying the post. Using OCR we can extract any text from an image and use it in addition to the text of the post. This should improve the accuracy of the model when infographics/text based images are used.

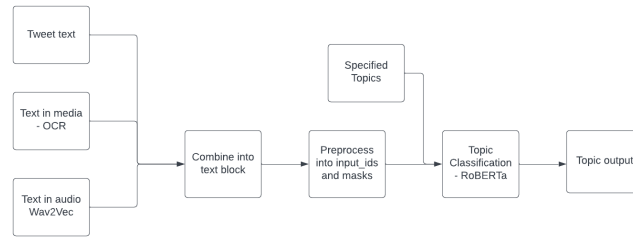


Figure 3.2: Context Aware Model

### Audio Transcription - Wav2Vec

Some posts may contain videos. The audio in the videos may contain useful context. Using Wav2Vec we can extract the audio from the video in the form of text. This text can be used in addition to the text of the post. This should improve the accuracy of the model when audio descriptions/explanations are used in a post.

### Retweets and Threads

Although a post alone may not contain enough context to classify it, there may be a conversation around the post. This conversation would be found in the retweets and threads of the post. If the retweets and threads are discussing the same topic as the post, then the extra context given by the retweets and threads can be used to help classify the post.

### 3.2.3 Context Aware Model

The context aware model created in this project will use OCR, Wav2Vec, and retweets/threads to add context to posts. The extra text extracted from these methods will be added to the text of the post. This will be done before the post is classified. The model will then classified with all the additional text.

The RoBERTa classification model will be the same as the one designed figure 3.1. The only difference is the input to the model.

### **3.3 Python Application**

The Python application is made to show users the topics they are interested in and allows them to compare their interests to the social media site. For this project, this application will be made as a prototype to show such a system is feasible.

The first step of design for the application was to decide what features the application should have. This led to the process of requirements analysis.

#### **3.3.1 Requirements Analysis**

##### **User Stories**

Before building the application, user stories were created to help guide what features are required. The user stories created were:

1. As a user, I want to be able to see what topics I see the most on social media/see what topics I am interested in.
2. As a user, I want to be able to compare what I see on social media to what other people see on social media.
3. As a user, I want to be able to reach out and find posts on topics I am not interested in.
4. As a user, I want to be able to see what topics are trending on social media.

These stories help set up the requirements for the application.

##### **Business Cases**

The next step is to outline the business cases (methods of solving the problem) for the application. For this project, All business cases will be made by the author of this dissertation. The business cases created were:

1. **Do Nothing** - This does not improve the problems users face. It is a baseline case.
2. **Chrome Extension** - Allow users to see what percentage of their social media feed is made up of each topic, as well as compare this to live data from the social media platform.
3. **Python Application** - Allow users to see what percentage of their social media feed is made up of each topic, as well as compare this to live data from the social media platform.

The difference between the chrome extension and the python application is the framework they are built in as well as how they are interacted with. The chrome extension would be built in JavaScript, whereas the python application would be built in Python. The chrome extension would be accessible from a chrome browser (via the extensions store), whereas the python application would be run from a python script.

Although, a chrome extension would be more accessible to users and easier to distribute, it would be more difficult to implement as I would have to learn JavaScript and the chrome extension API. I am already familiar with Python and the python libraries used in this project.

## Requirements

Using the user stories and chosen business case, the requirements for the application can be determined. **C** - User Requirement **D** - System Requirements

- Functional Requirements

1. C) The user should be able to see what topics they see the most on social media/see what topics they are interested in.
  - 1.1 D) The application should be able to get access to the users social media feed via the social media API.
  - 1.2 D) The application should be able to classify the posts in the users social media feed.

- 1.3 D) The application should be able to calculate the percentage representation of each topic in a users social media feed.
- 1.4 D) The application should display the top 5 topics the user is interested in as well as their percentage impact on the users social media feed.
- 2. C) The user should be able to compare what they see on social media to what other people see on social media.
  - 2.1 D) The application should be able to get access to live posts from the social media API.
  - 2.2 D) The application should be able to classify the live posts from the social media API.
  - 2.3 D) The application should be able to calculate the percentage representation of each topic from live social media data.
  - 2.4 D) The application should display the top 5 topics that are trending on social media as well as their percentage impact on the social media platform.
  - 2.5 D) The application should display a similarity metric between the users social media feed and the live posts.
- 3. C) The user should be able to reach out and find posts on topics they are not interested in.
  - 3.1 D) The application should store all posts that are classified as a topic to be able to search through them.
  - 3.2 D) The application should store alongside the post the top topic it was classified as.
  - 3.3 D) The application should allow the user to search for posts by topic.
  - 3.4 D) The application should display a random selection of posts that are classified as the topic the user searched for.

- Non-Functional Requirements

- 1. C) The User Interface should be easy to use within 5 minutes of use.

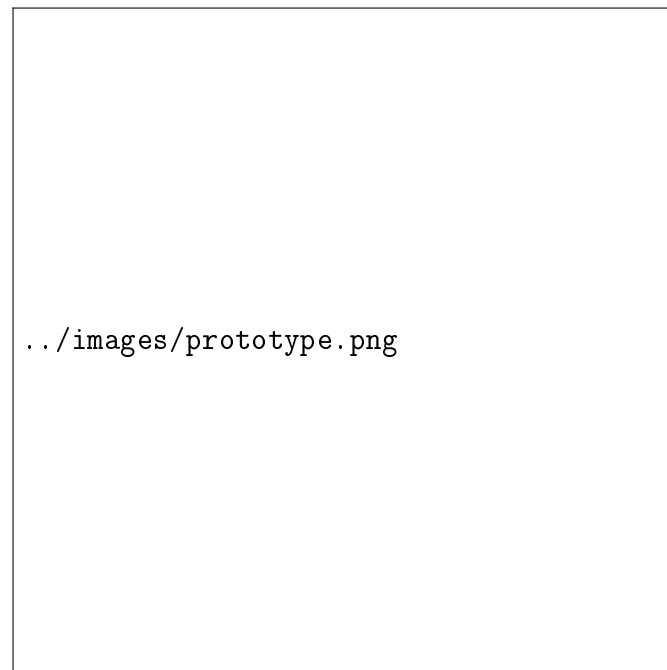


Figure 3.3: Prototype

2. C) The User Interface should not be unresponsive for more than 5 seconds.
3. C) The User Interface should be suitable for users with no technical experience.

### 3.3.2 Frontend

#### User Interface Design

Figure 3.3 shows the drawn out design of the user interface for the prototype. All 3 customer requirements are met with this design.

**The user should be able to see what topics they see the most on social media/see what topics they are interested in.**

In the middle display layout there are 10 percentage bars that show the percentage of the users top 5 topics, as well as the percentage of the top 5 topics

on social media. This identifies what topics the user is interested in.

**The user should be able to compare what they see on social media to what other people see on social media.**

As mentioned above, the user is also able to see the top 5 topics on social media. This allows the user to compare what they see compared to what is available. On top of this, the left hand side display is created to show word-clouds of both the users social media feed and the live posts. This adds a visual representation to the differences between the users social media feed and the live posts.

**The user should be able to reach out and find posts on topics they are not interested in.**

The right hand side display allows users to select a topic by clicking on the button labelled with the topic. This will then display the text of the 4 posts that are classified as the topic. On top of this, links to the post are provided to allow the user to view the post on the social media platform.

### **3.3.3 Backend**

The backend of the application is responsible for making calls to the social media API to get required posts. It is also responsible for classifying the posts and storing them in a database. When data is required by the frontend, the backend will retrieve the data from the database.

#### **API Design**

To hit requirement 1.1 and 2.1, the application needs to be able to access the social medias API. For this project, the social media platform that will be used is Twitter.

The module 'Tweepy' will be used to access the Twitter API. This module acts



as a wrapper for the twitter API and allows for easy access to twitter data. The module can be found at <https://www.tweepy.org/>. One downside to the twitter API is that the default access level does not allow for access to any media that is attached to a tweet. This means that the application will not be able to make use of images or videos to add context prior to classification. This was thought of as not being a major issue as the time taken to run OCR and Wav2Vec on the media would be too long to be practical.

For requirements 1.2 and 2.2, the application needs to be able to classify the posts. As described in section 3.1, the application will use a fine-tuned RoBERTa model for classification. For each individual post, we will store the 'tweetid' and the 'top topic', it was classified as, in the database. This information is also useful to fulfill requirement 3.1 and 3.2. The chosen database for this project is sqlite3. This is a lightweight database that is easy. Due to the nature of this project being a prototype, the database will be stored locally on the users machine.

Requirements 1.3 and 2.3 require the application to calculate the percentage of posts that are about each topic. To do this, the application will take the confidence score (probabilistic weight of output nodes in the classification layer) of each post in a set of posts. Using the confidence scores, the application will sum them together then together then convert them to a percentage. This will give the percentage representation of each topic. The application will store these values alongside an ID to identify the set of posts.

Requirement 3.2 will be achieved by taking the topic input given from the frontend request and searching the database for all posts that are primarily classified as that topic. Then, 4 posts will be randomly selected to be sent to the frontend for display. Figure 3.4 shows the backend architecture. The points raised above can be seen in this diagram along with how the frontend interacts with the backend.



Figure 3.4: Backend Architecture

## **Database Design**

The database needs to be able to store the following information:

- The tweetid of a post.
- The tweet text.
- The tweet link.
- any hashtags in the tweet.
- The top topic a post was classified as.
- The ID of a set of posts.
- The percentage representation of each topic in a set of posts.
- The conversation ID that links posts to its parent post.

The database will be a sqlite3 database. The schema will be as follows: The information required can be accessed using a set of queries. The implementation specifics of these queries will be discussed in Chapter 4.



Figure 3.5: Database Schema

## Chapter 4

# Implementation

In this chapter, we describe the implementation of the design we described in Chapter 3. You should **not** describe every line of code in your implementation. Instead, you should focus on the interesting aspects of the implementation: that is, the most challenging parts that would not be obvious to an average Computer Scientist. Include diagrams, short code snippets, etc. for illustration.

### 4.1 Data Collection

To facilitate with the fine-tuning of the BERT/RobERTa models and the training of the LSTM/RNN models, it was necessary to collect a large amount of labelled data. As discussed in 2, data was collected from Wikipedia and Reddit. Wikipedia was first chosen due to the fact it has a large amount of data and all are labelled into categories. The one downside to Wikipedia is the style of writing is very formal and factual which does not represent how social media posts are written. This is why Reddit was also used. Reddit is a social media platform, whose subreddits give us a large amount of labelled data.

The input data went through a preprocessing step before being used to train the models.

A post/article corresponds to the input data, and the subreddit/wikipedia category corresponds to that inputs label. The data was collected using the Reddit API and Wikipedia API.

After collecting all the data, there was roughly 1500 data points for each label (topic).

### 4.1.1 Preprocessing

Some preprocessing was necessary to clean the data. The preprocessing step would remove any punctuation and remove stopwords. This was done to reduce the size of the input while keeping the most important words.

In retrospect, it could be possible that the self-attention mechanism of BERT/Roberta would be able to learn the context of some stopwords and punctuation to improve the accuracy. This has been left as future work.

### 4.1.2 Wikipedia Data

Wikipedia data was collected using the Wikipedia API. There exists a python library called 'Wikipedia-API' that acts as a wrapper for the Wikipedia API. The library supplies useful functionalities such as:

- **WikiAPI.page** - Takes in a string that acts as a query for the API. In this project the query string is "Category:{topic}" which returns a list of articles/subcategories
- **categorymembers.values()** - given the results of the page query, this function is used to return the articles/subcategories.

The way WikiAPI.page works means that we may be returned another category. Because of this, a recursive function is used to take the subcategories found and get the articles from those subcategories. This could recurse on indefinitely, so a maximum depth of 1 was used to prevent this. A depth of 1 means that we get articles from the main category and the subcategories of the main category. The recursive function fetches the titles of articles so they can be queried afterwards.

Using this function the labelled data can be collected as follows:

---

**Algorithm 1** *get\_category\_members*

---

**INPUT:** category, level, max\_level  
*category\_members*  $\leftarrow$  list of articles in category  
     – **WikiAPI.page("Category:{category}").categorymembers.values()**  
*titles*  $\leftarrow$  empty list  
**for** each member in *category\_members* **do**  
     **if** member is a category AND level < max\_level **then**  
         *titles.append*(*get\_category\_members*(member, level + 1, max\_level))  
     **else**  
         *titles.append*(title of member)  
     **end if**  
**end for**  
**return** *titles*

---



---

**Algorithm 2** Algorithm to Retrieve Wikipedia Data

---

*topics*  $\leftarrow$  list of topics to collect data for  
*data*  $\leftarrow$  empty list  
**for** each topic in *topics* **do**  
     *titles*  $\leftarrow$  *get\_category\_members*(topic, 0, 1)  
     **for** each title in *titles* **do**  
         *page*  $\leftarrow$  WikiAPI.page(title)  
         *text*  $\leftarrow$  *page*.text  
         **if** *text* is empty **then**  
             *text*  $\leftarrow$  *page*.summary  
         **end if**  
         **if** *text* is empty **then**  
             CONTINUE  
         **end if**  
         *text*  $\leftarrow$  preprocess(*text*)  
         *data.append*((*page*.content, topic))  
     **end for**  
**end for**  
 Write data to csv file

---

The algorithm loops through each topic and gets the article titles from 'get\_category\_members'. It then loops through each title, attempts to find text in the page, and if it does, it appends the preprocessed text and the topic to the data list. The data list is then written to a csv file.

### 4.1.3 Reddit Data

Reddit data was collected using the Reddit API. There exists a python library called 'PRAW' [1] that acts as a wrapper for the Reddit API. The library provides useful functionalities. The ones used in this project are:

- **PRAW.reddit** - Takes in API key and secret to authenticate with Reddit API. Returns a Reddit object that can be used to query the API.
- **reddit.subreddit** - Takes in a string that acts as a query for the API. In this project the query string is "{topic}".
- **subreddit.hot()** - Returns a list of hot posts in the subreddit. Optionally a limit parameter can be set.

These functions are used to get the data as follows: Fetching Reddit data is

---

```

topics ← list of topics to collect data for
data ← empty list
for each topic in topics do
    subreddit ← reddit.subreddit(topic)
    hot ← subreddit.hot(limit=100)
    for each post in hot do
        text ← preprocess(post.title + text)
        data.append((text, topic))
    end for
end for
Write data to csv file

```

---

much simpler than fetching Wikipedia data due to the fact that when querying a subreddit, only posts are returned and no other subreddits.



## 4.2 RNN and LSTM

For creating the RNN and LSTM models, the ‘tensorflow’ and ‘keras’ libraries were used. This was to take advantage of the ‘tensorflow’ GPU support on the Department of Computer Science’s (DCSs) batch compute system. Also, previous experience with these libraries made it easier to use them.

For both RNN and LSTM models the data was preprocessed in the same way. The data was tokenized using the ‘Keras Tokenizer’ ?. TODO: what does a tokenizer do? The output values were one-hot encoded using pandas ‘get\_dummies’ ?. The data was split into training and testing sets using the ‘train\_test\_split’ function from ‘sklearn.model\_selection’ ?.

The RNN model was created using the ‘Sequentia’ model from ‘keras’. A sequential model allows us to build up our model by adding layers. The architecture of the model is as follows:

- **Embedding** - TODO
- **Bidirectional(SimpleRNN)** - TODO
- **Dense** - TODO
- **Dense** - TODO

The model was compiled using the ‘categorical\_crossentropy’ loss function and the ‘adam’ optimizer. The model was trained for 10 epochs with a batch size of 64.

A bidirectional RNN was used to attempt to overcome the problem of unidirectional context.

The LSTM model was created similarly to the RNN model. However, using a bidirectional LSTM instead of a bidirectional RNN. The architecture of the model is as follows:

- **Embedding** - TODO
- **Bidirectional(LSTM)** - TODO

- **Dense** - TODO
- **Dense** - TODO

The same loss function and optimizer were used. The model was trained for 10 epochs with a batch size of 64.

### 4.3 BERT

To get the BERT model, the 'tensorflow\_hub' library was used. This library gives developers access to pretrained models. The BERT model and preprocessing functions can be imported as follows:

---

```
preprocess = tensorflow_hub.KerasLayer("https://tfhub.dev/tensorflow/bert_en_uncased_preprocess/3")

bert = tensorflow_hub.KerasLayer("https://tfhub.dev/tensorflow/small_bert/bert_en_uncased_preprocess/3")
```

---

When creating the model, these layers can be included in the model architecture. The architecture of the model is as follows:

- **Input** - TODO
- **preprocess** - TODO
- **bert** - TODO
- **Dropout** - TODO
- **Dense** - TODO

The model was compiled using the 'categorical\_crossentropy' loss function and the 'adam' optimizer. The model was trained for 6 epochs with a batch size of 32. discuss use of tensorflow hub for getting BERT Discuss data preprocessing discuss dropout layer and dense classification layer Discuss Training Arguments

## 4.4 RoBERTa

While tensorflow and keras were used for all previous models, the ‘huggingface’ library was used for the RoBERTa model. Huggingface was only discovered during development of RoBERTa after struggling to get RoBERTa to work using tensorflow and keras. Huggingface is a company based in New York that aims to advance artificial intelligence through open source projects. They have a library called ‘transformers’ Huggingface that provides access to pretrained models. A major benefit to the transformers library is it supports interoperability between different frameworks (PyTorch, TensorFlow, and JAX) Huggingface. Currently, there are 190 supported models in the transformers library including RoBERTa Huggingface.

The transformers library provides a model and a tokenizer for RoBERTa. the Tokenizer is important as RoBERTa does not directly accept text as input. Instead, the text must be ‘tokenized’ and converted into a list of integers. The tokenizer and model can be imported as follows:

---

```
tokenizer = transformers.RobertaTokenizerFast.from_pretrained("roberta-
base")
model = transformers.RobertaForSequenceClassification.from_pretrained("roberta-
base", max_length=512)
```

---

Following this, the data must be tokenized using this tokenizer.

---

```
data = tokenizer(data, padding=True, truncation=True)
```

---

The data was then split into training and testing sets by randomly shuffling the data and splitting it into 90% training and 10% testing. Then the data was converted into a pandas dataframe and converted into a PyTorch dataset - This can be used with the transformers library.

The next step with Huggingface Transformers is to construct a ‘TrainingArguments’ object. This object specifies training parameters. The parameters used are as follows:

- **output\_dir** - roberta-finetuned-topic
- **evaluation\_strategy** - epoch
- **save\_strategy** - epoch
- **num\_train\_epochs** - 5
- **learning\_rate** - 2e-5
- **per\_gpu\_train\_batch\_size** - 4
- **per\_gpu\_eval\_batch\_size** - 4
- **weight\_decay** - 0.01
- **load\_best\_model\_at\_end** - True
- **metric\_for\_best\_model** - accuracy
- **push\_to\_hub** - True

TODO: explain some of these parameters

The next step is to create a 'Trainer' object. This object is used to train the model. This object takes the base RoBERTa model, the training arguments, the training dataset, the testing dataset, and a method for calculating metrics. The metrics used are accuracy. Discuss use of RoBERTa and how it was used. Discuss use of huggingface library. Discuss data preprocessing. Discuss how training was done using huggingface. Discuss Training Arguments.

## 4.5 Context Aware Model

The next step for this project was establishing a method of getting context for tweets. As discussed in chapter 3, the context model uses media sources and comments to get context for tweets. Focussing on twitter as the social media platform, the context model uses the 'tweepy' library as a wrapper for the twitter API. The 'Basic access' API was not a suitable option for adding context. This was due to the fact the API does not provide access to media

sources. Because of this the 'Elevated access' API was used. This allows us to get access to media sources Twitter.

### 4.5.1 Setup tweepy

To setup connection to the twitter API via tweepy, the use of the 'API' and 'Client' objects were used. The API object gives access to v1.1 of the twitter API. v1.1 is required to get access to media sources. This function call requires passing in authentication credentials. These are created via twitter developer portal and saved in a '.secret' file that is not included in the repository. This file is parsed and the credentials are passed into the 'API' function. The credentials required are:

- **consumer\_key**
- **consumer\_secret**
- **access\_token**
- **access\_token\_secret**

The Client object is initiated in a similar way with the same credentials. This object gives us access to the newer v2 of the twitter API. However, as stated previously, this does not give access to media sources. But does give access to 'conversation\_id' which allows us to find comments/threads/retweets.

### 4.5.2 Get Tweets

Given a tweet id, the 'get\_tweet' function can be used to get the tweet data from the API. This function also takes in optional parameters to specify any additional fields that should be returned. This is done via the 'tweet\_fields' and 'expansions' parameters. Because we want to get media sources, the tweet field 'entities' is required. Then the 'extended\_entities' expansion is used to get the media sources. The tweet data returned (in JSON format) can be queried for URLs to the media sources.

```
tweet_data = api.get_tweet(tweet_id, tweet_fields='entities', expansions='extended_entities')
```

```
media_sources = tweet_data.extended_entities["media"][0]
```

Following this, the URL can be used to get the media source using the “requests” library. This library is used to make HTTP requests. The media is saved locally and the path to the media is returned. This path can then be used by the model to get the media to add context.

The ‘get\_tweet’ function can also be used to get the ‘conversation\_id’ of a tweet. To do this, the ‘tweet\_fields’ parameter includes ‘conversation\_id’. Then the ‘conversation\_id’ can be used to get the comments/threads/retweets of a tweet via the ‘search\_recent\_tweets’ function. This function takes in a query and returns a list of tweets. In this case, the query would be “conversation\_id:{conversation\_id}”. The downside to using this function is that it can only return tweets if they have been posted in the last 7 days. There does exist a function to search all tweets but this requires a higher level of access to the API. All posts with the same ‘conversation\_id’ are returned and are then appended onto the original tweet text.

### 4.5.3 Feeding into RoBERTa

When all information is gathered (including media) then the tweet can be processed. First the media is processed. This is done either by using ‘Wav2Vec’, if the media is a video, or ‘Optical Character Recognition’ (OCR), if the media is an image. This turns the media into text that can be prepended to the tweet text. This text block is then passed through the RoBERTa model to get the topic. The next 2 sections will discuss how media is stored and processed in more detail.

#### Photos and Images

The JSON data returned from the twitter API contains a field that displays the type of the media source (if there is one). This field can be accessed via the

'tweet.extended\_entities["media"][0]["type"]' field. If the type is 'photo' then the media is an image. If the type is 'video' then the media is a video.

For photos, the media url is fetched from the JSON data and the image is downloaded using the 'requests' library and stored locally in the 'media store'. The media store is a collection of 3 folders: 'jpg', 'mp4', and 'wav'. jpg will store all images, mp4 will store all videos, and wav will store all converted audio.

Before processing a tweet that contains an image. OCR is used to convert the image into text. The library used for OCR was 'keras\_ocr'. This library allows for easy conversion of images into text; The library is pre-trained and can be used with only a few lines of code.

---

```
pipeline = keras_ocr.pipeline.Pipeline(detector=keras_ocr.detection.Detector(),
recognizer=keras_ocr.recognition.Recognizer())
image = keras_ocr.tools.read(image_path)
prediction = pipeline.recognize(image)
```

---

## Videos

Processing videos is a little more complicated. The goal is to convert any audible words in the video into text. To do this the 'Wav2Vec' model is used. For this the 'transformers' library from HuggingFace is used. This library contains a pre-trained Wav2Vec model. This requires the import of the 'Wav2Vec2ForCTC' model and the 'Wav2Vec2Tokenizer' tokenizer. The model is then loaded and the tokenizer is used to tokenize the audio. The audio is then passed through the model to get the text.

Using a similar method to the one used for images, the video is downloaded and stored locally. However, this will be stored in 'mp4' format. The audio needs to be extracted from the video. This is done using the 'moviepy' library. This is simply done by loading the video and then extracting and writing the audio to a 'wav' file.

Now that the audio is extracted, it can be used with the Wav2Vec tokenizer and model. This is implemented as such:

---

```
video = moviepy.editor.VideoFileClip(video_path)
audio = video.audio
audio.write_audiofile(audio_path)
```

---

```
tokenizer = Wav2Vec2Tokenizer.from_pretrained("facebook/wav2vec2-base-960h")
model = Wav2Vec2ForCTC.from_pretrained("facebook/wav2vec2-base-960h")
input_audio = librosa.load(audio_path, sr=16000)[0]
input_values = tokenizer(input_audio, return_tensor="pt").input_values
logits = model(input_values).logits
predicted_ids = torch.argmax(logits, dim=-1)
transcription = tokenizer.batch_decode(predicted_ids)
```

---

The librosa library is used to convert the audio into a format that can be used by the tokenizer (numpy array).

#### 4.5.4 Problems with Context Model

The context model increased the running time of the application by a significant amount. This was due to the extra computation required to process the media. Because of this, only the conversation context will be included for the Python Application. A further analysis of this will be performed in chapter 5. Discuss use of tweepy library for getting tweets Explain process in detail Discuss how data was preprocessed for RoBERTa model Discuss problems with long processing times

## 4.6 Python Application

### 4.6.1 Frontend

PyQT was the chosen library used to create the UI for the application. This was largely influenced by the 'PyQT Designer' tool. This tool gives developers



the ability to design a UI without writing the code for it; it gives a drag and drop tool to create the UI. This tool is very useful for creating a UI quickly and easily. The UI design can then be imported into the python application and the code to link the UI to the backend can be written.

The development of the UI was heavily influenced by the original design set out in chapter 3. The UI was designed to be simple and easy to use with the aim to be easy to use within 5 minutes of use (section 3.3.1). See below the final UI design:



Figure 4.1: Final UI design - Wordcloud

TODO: discuss pros and cons of design Discuss PyQT and how it was used  
Discuss benefits to PyQT designer Discuss development of UI

#### 4.6.2 Backend

The backend was also developed using Python. This allowed for easy integration with the frontend. In fact, the backend was developed as a standalone class that could be imported into the frontend and used directly. The design shown

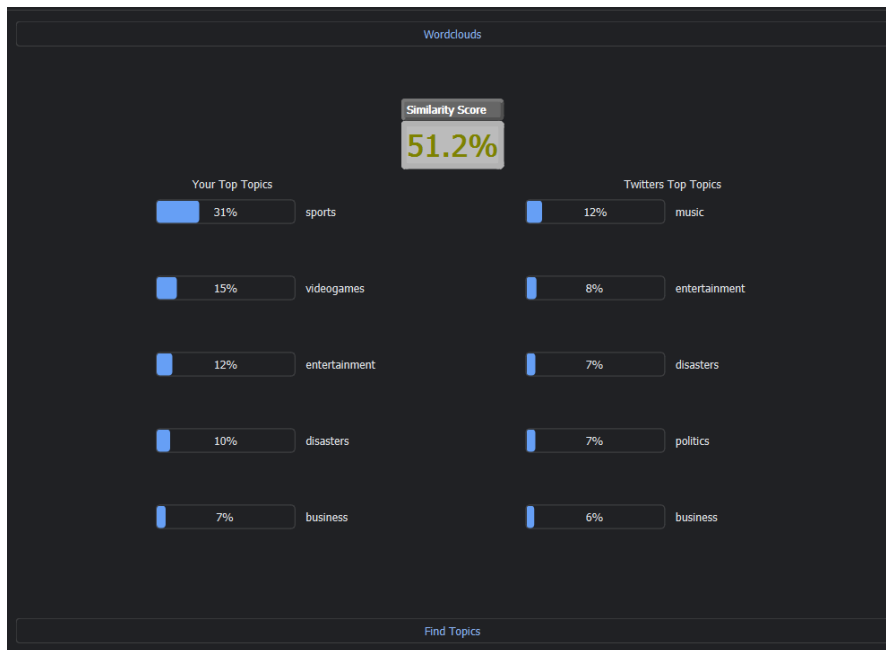


Figure 4.2: Final UI design - Wordcloud

in fig. 3.4 shows how the backend works. The design ignores any implementation specific details. For example, the design just shows that there is tweets and not how the tweets are retrieved. While working with the 'tweepy' library, multiple methods for retrieving tweets were used. The first method was to use the 'get\_home\_timeline' method. This returns the most recent tweets from the user's home timeline. The second method was using a 'StreamingClient' to listen for live tweets. Finally, the use of the 'get\_tweets' method was used to retrieve specific tweets via ID. On top of this, as discussed in section 4.5 the use of the 'conversation\_id' tweet\_field was used so that the retweets/replies to a tweet could be retrieved. For retrieving live tweets check Appendix ?? for the code used.

For retrieving users tweets check Appendix ?? for the code used.

The backend database schema laid out in chapter 3 required slight adjustments to include the ability to store tweets with the same 'conversation\_id'. It also required the addition of a 'hashtags' table to store the hashtags found in tweets sorted by topic. This was overlooked originally as the design was based on

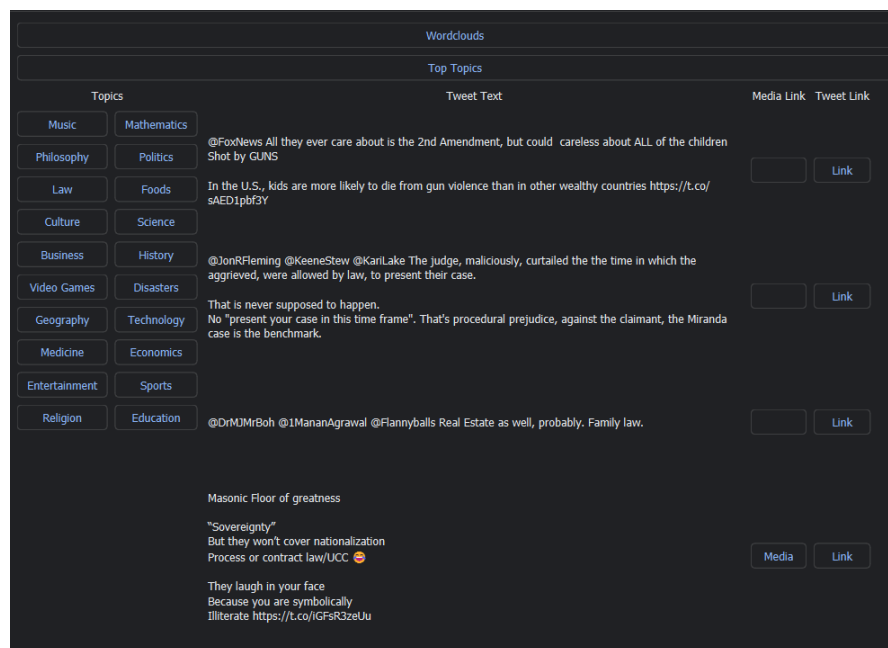


Figure 4.3: Final UI design - Wordcloud

the assumption of using the base RoBERTa model and not the context aware model. Below is the updated schema

The next step is to create the queries to create/update/retrieve data from the database in-line with the schema and backend design. Queries required:

#### 1. Create tweet

---

```
INSERT INTO tweets VALUES (NULL, conversation_id, text, tweet_url, media_url)
```

---

#### 2. Create conversation

---

```
INSERT INTO conversations VALUES (conversation_id, NULL, tweetset_id)
```

---

#### 3. Create tweetset

#### 4. Set conversation topic



Figure 4.4: Updated database schema

---

```
INSERT INTO tweetset VALUES (NULL, is_live, NULL ( $\times 20$ ))
```

---

5. Set tweetset topic scores
6. Get hashtags for topic
7. Get top topics for tweetset
8. Get tweets for a given tweetset
9. Get tweets for a given topic

---

```
UPDATE  conversations  SET  topic=topic  WHERE  conversa-
tion_id=conversation_id
```

---

---

```
UPDATE tweetset SET medicine_val=medicine_val, ... WHERE tweet-  
set_id=tweetset_id
```

---

---

```
SELECT hashtag FROM hashtags WHERE tweetset_id=tweetset_id AND  
tweet_id IN (SELECT tweet_id FROM tweets INNER JOIN conversations  
ON tweets.conversation_id=conversations.conversation_id WHERE conver-  
sation.topic=topic)
```

---

---

```
SELECT * FROM tweetset WHERE tweetset_id=tweetset_id
```

---

---

```
SELECT tweets.text, tweets.tweet_url, tweets.media_url, con-  
versations.topic FROM tweets INNER JOIN conversations ON  
tweets.conversation_id=conversations.conversation_id WHERE conver-  
sations.tweetset_id=tweetset_id
```

---

---

```
SELECT text, tweet_url, media_url FROM tweetset INNER JOIN conversa-  
tions ON tweets.tweetset_id=conversations.tweetset_id INNER JOIN tweets  
ON conversations.conversation_id=tweets.conversation_id WHERE conver-  
sations.topic=topic
```

---

Discuss how the backend was created Develop on database architecture to show how data is retrieved Show SQL queries used

## **4.7 Implementation Strategy**

### **4.7.1 Model Creation**

While creating the different models for the topic detection an iterative approach was used. This allowed for the design, implementation and testing of each model to be done in a short period of time and then move on to the next model. This waterfall-like approach works well for model creation, especially with the RoBERTa model; the first iteration of the model created the base topic classification model. This model was then used in the second iteration to create the context aware model. Discuss iterative development cycle and how a waterfall sub approach was used Explain why this approach worked well backup with evidence

### **4.7.2 Python Application**

For the Python application, an agile Kanban approach was used. This was partly due to the time constraints, but also because it allowed for any minor changes required during development to be easily implemented. The Kanban board created consisted of the following columns:

- Ideas
- Designs
- In-Progress
- Testing
- Completed

Due to the fact this project was a solo project, the need for a more complex Kanban board was not required. On top of this, the solo project means less focus on how items move through the board is required. Usually, items would move using a given protocol (e.g. pull system). For this project the Kanban board was treated as a simple to-do list and allowed a visual representation of the status of the project. Discuss how an agile Kanban approach was used explain why this approach worked well backup with evidence

# Chapter 5

## Evaluation

Describe the approaches you have used to evaluate that the solution you have designed in Chapter 3 and executed in Chapter 4 actually solves the problem identified in Chapter 1.

While you can discuss unit testing etc. you have carried here a little bit, that is the minimum. You should present data here and discuss that. This might include *e.g.* performance data you have obtained from benchmarks, survey results, or application telemetry / analytics. Tables and graphs displaying this data are good.

### 5.1 RNN and LSTM

To analyse the performance of BERT/RoBERTa, the performance of RNN and LSTM models were analysed for comparison. All models were trained on the same data discussed in section ???. There were 2 hypotheses made about RNNs and LSTMs.

1. RNNs and LSTMs will perform worse than BERT/RoBERTa
2. LSTMs will perform better than RNNs



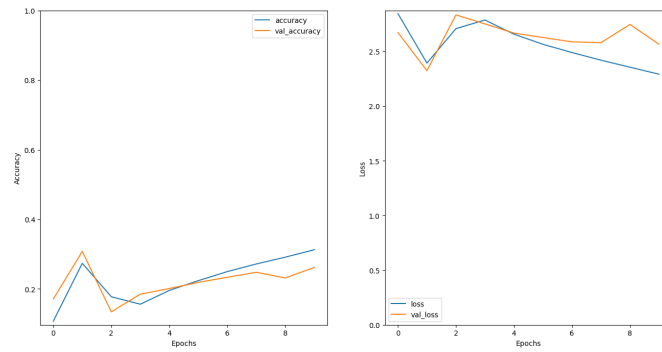


Figure 5.1: RNN results

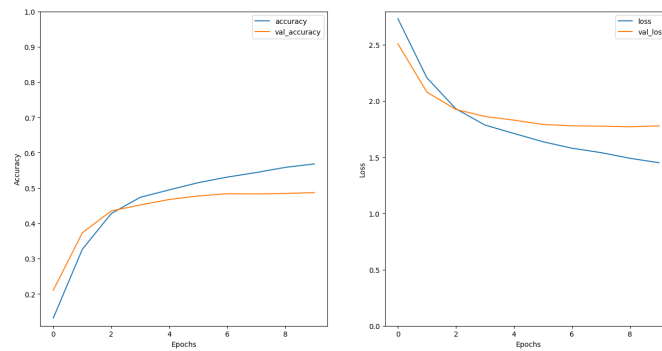


Figure 5.2: LSTM results

The reasoning behind these hypotheses was discussed in chapter 3. This test was performed to test this hypothesis. Below are the results of The RNN and LSTM models.

Figures 5.1 and 5.2 show the accuracy of the RNN and LSTM models respectively. The results show that the LSTM model outperforms the RNN model (26% accuracy compared to 48% accuracy). This helps validate the second hypothesis that LSTMs will outperform RNNs. The other hypothesis will be discussed in section 5.2.

## 5.2 BERT vs RoBERTa

During development, both BERT and RoBERTa were used to classify the posts into topics. BERT and RoBERTa have been compared before in Liu et al. (2019).

	MNLI	QNLI	QQP	RTE	SST	MRPC	CoLA	STS	WNLI	Avg
<i>Single-task single models on dev</i>										
BERT <sub>LARGE</sub>	86.6/-	92.3	91.3	70.4	93.2	88.0	60.6	90.0	-	-
XLNet <sub>LARGE</sub>	89.8/-	93.9	91.8	83.8	95.6	89.2	63.6	91.8	-	-
RoBERTa	<b>90.2/90.2</b>	<b>94.7</b>	<b>92.2</b>	<b>86.6</b>	<b>96.4</b>	<b>90.9</b>	<b>68.0</b>	<b>92.4</b>	<b>91.3</b>	-

Figure 5.3: RoBERTa vs BERT - Liu et al. (2019)

In this paper the results shown were:

The results of the paper show RoBERTa beats BERT in all given Natural Language Processing tasks. In this project similar tests were carried out on the specific topic classification task. The results of the classification were compared to see which model performed better.

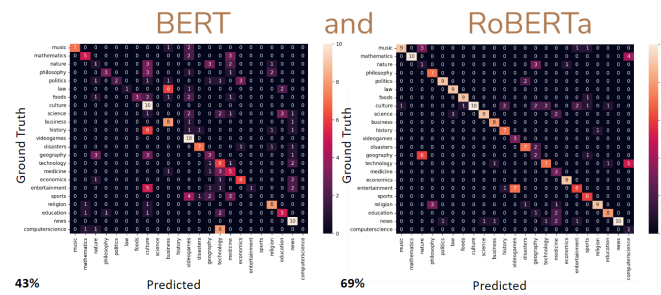


Figure 5.4: BERT vs RoBERTa on our problem

Figure 5.4 shows the confusion matrices of BERT and RoBERTa respectively for the test set - the test set was a random 10% sample of the training data. The columns of the confusion matrix represent the predicted labels and the rows represent the ground truth labels. It is obvious from the confusion matrices that BERT did not perform as well as RoBERTa; there are a lot of misclassifications. A misclassification can be identified as a cell in the confusion matrix that is not on the diagonal. Comparing this to the confusion matrix of RoBERTa, it is clear that RoBERTa performed much better. In fact, RoBERTa is 60% more accurate than BERT (43% compared to 69%).

With respect to the hypotheses made in section 5.1, the first hypothesis holds form RoBERTa but not BERT. Recall the LSTM model achieved 48% accuracy. BERT could not beat this accuracy but RoBERTa did. This was a surprising result as it was believed that BERT would outperform LSTM models. The reason

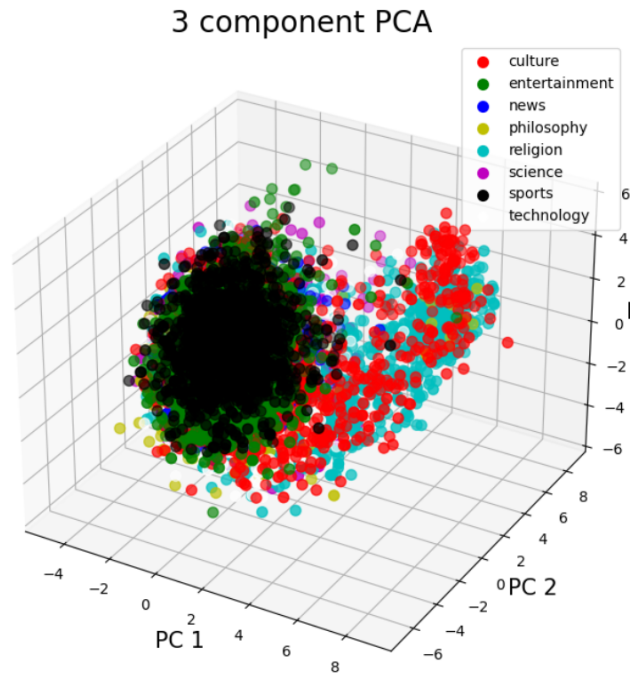


Figure 5.5: PCA of data

behind this could be that BERT was trained using only 6 epochs, whereas the LSTM model was trained using 10 epochs.

### 5.3 Principal Component Analysis (PCA) of data

One thing to note in the RoBERTa confusion matrix in Figure 5.4 is that the model has high concentration of misclassifications; the model makes the same misclassification often. After noticing this trend, it was believed that the topics that were commonly misclassified were similar to each other - could be grouped together.

Principal Component Analysis (PCA) was used to reduce the dimensionality of the data and to allow for visualisation of the data. PCA was performed on the output features of RoBERTa.

Figure 5.5 shows the PCA of the data. The data was reduced to 3 dimensions using PCA. The data was then plotted on a 3D graph. The colours of the points

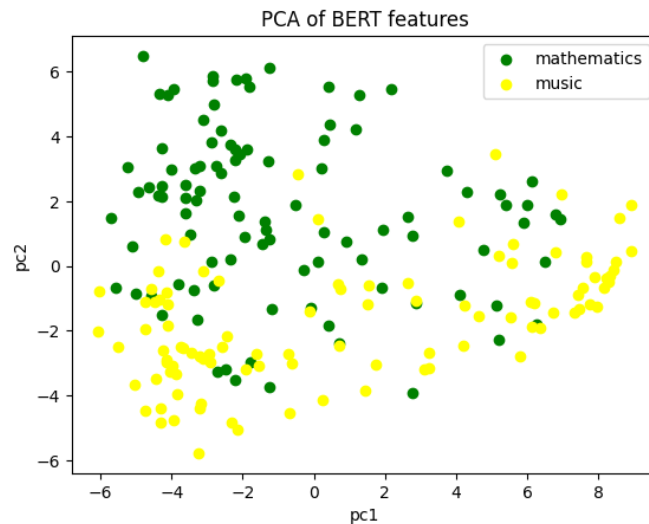


Figure 5.6: Mathematics vs Music

represent the topics (of which some are identified in the legend). The graph is not easy to interpret; the only visible trend is that 'Religion' and 'Culture' seem to be very dissimilar to the other topics.

To help interpret the data, the analysis was performed on 2 topics at a time. This time the data was reduced to 2 dimensions using PCA. The data was then plotted on a 2D graph.

### 5.3.1 Findings from PCA

In this section, the notable findings from the PCA are discussed.

#### Mathematics vs Music

This comparison was made to act as a baseline for the rest of the comparisons. The hypothesis was that these topics would be dissimilar to each other.

Figure 5.6 shows the PCA of the data for the 'Mathematics' and 'Music' topics. There is a clear separation between the two topics. Although the data is not linearly separable, there is a strong trend that the data points of the 'Mathematics' topic are on the bottom of the graph and the data points of the 'Music' topic are on the top of the graph.

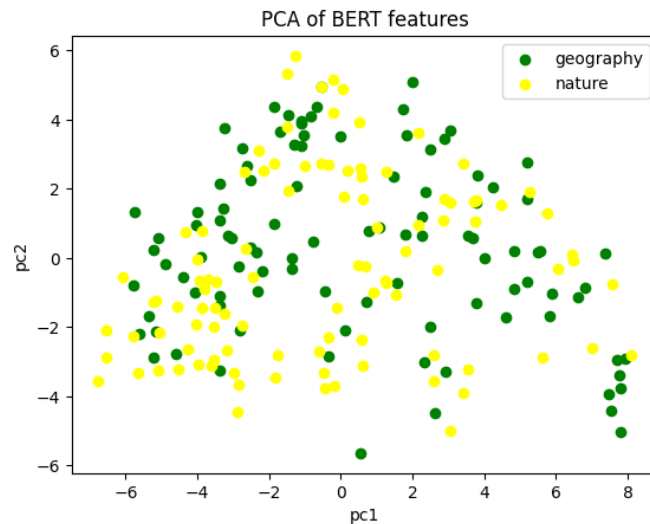


Figure 5.7: Geography vs Nature

topic are on the top of the graph. Using a perceptron classifier on the 2 principal components, led to an accuracy of 73%. This is a strong indicator that the 2 topics are dissimilar to each other.

### Geography vs Nature

Looking back at the confusion matrix of RoBERTa in Figure 5.4, the model predicts 'Geography' instead of 'Nature' 6 times out of 10. This is a very high concentration of misclassifications. The hypothesis was that the topics are very similar.

The figure shows the PCA of the data for the 'Geography' and 'Nature' topics. In comparison to Figure 5.6, there is no clear separation between the two topics. In fact, visually, the two topics seem to be almost identical. Using a perceptron classifier on the 2 principal components, led to an accuracy of 52%. This is a strong indicator that the 2 topics are similar; the fact the classifier is only a minor improvement on random guessing shows that the 2 topics are similar.

From this finding it was concluded that the model was not able to distinguish between the two topics. This led to the merging of the 'Geography' and

'Nature' topics into a single topic. It was decided this topic would be called 'Geography'.

### **Technology vs Computer Science**

Similarly to the previous comparison, the confusion matrix in Figure 5.4 shows that the model predicts 'Technology' instead of 'Computer Science' 5 times out of 10. The hypothesis was that the topics are very similar. However, the results from the perceptron classifier on the 2 principal components showed a very high accuracy of 82.5%. This is not the result expected and caused confusion as to why the model was unable to distinguish between the two topics.

To further investigate this, the data was manually inspected to attempt to reach a new hypothesis. This led to the discovery of the unbalanced nature of the data. The 'Technology' topic had 10 times more data points than the 'Computer Science' topic. This answers why the perceptron classifier performed so well but the model was unable to distinguish between the two topics.

The imbalance of the data was a surprise as the script used to scrape the data was designed to scrape an equal number of data points. It was found that the search query for the 'Computer Science' topic yielded no results on wikipedia leading to a small number of data points.

It was decided to remove the computer science topic from the dataset due to the limited dataset.

### **News**

In the confusion matrix for BERT in Figure 5.4, the model predicts 'News' often for 'economics', 'sports' and 'entertainment'. PCA analysis was performed on these topics to test their separability.

These figures show the PCA of the data for the 'Economics', 'Sports' and 'Entertainment' topics against the 'News' topic. The results for each of these tests gave a separability rate of 57.5%, 57.5% and 50% respectively. These results show that the data is not easy to separate. This is not surprising as the 'News' topic is a very broad topic and is likely to cover a lot of the other topics.

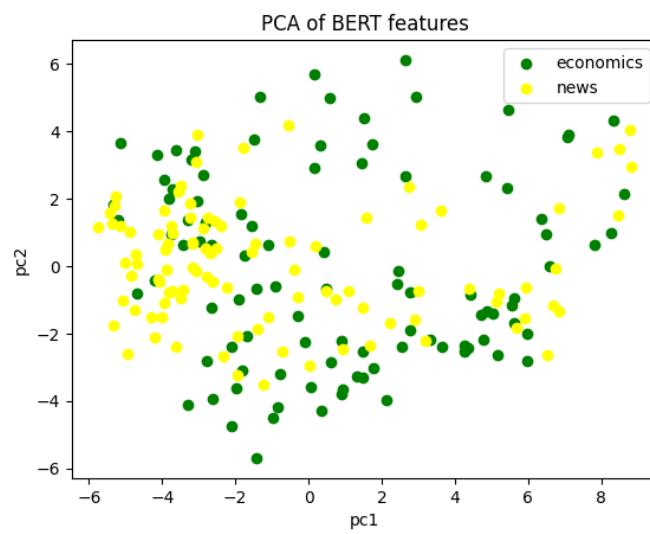


Figure 5.8: Economics vs News

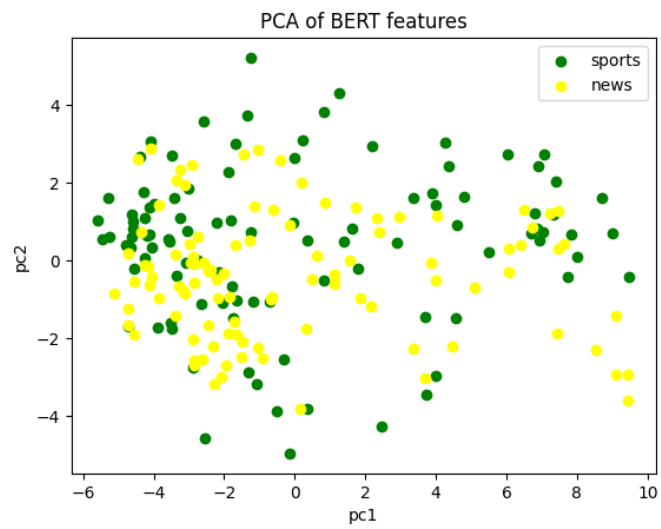


Figure 5.9: Sports vs News

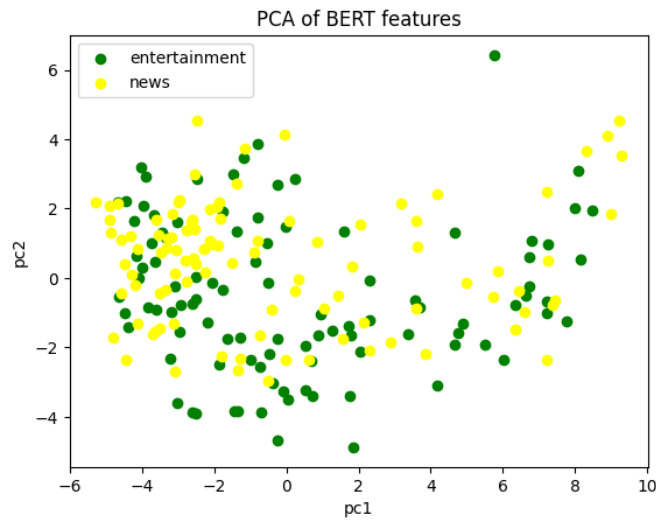


Figure 5.10: Entertainment vs News

Because of these findings, it was decided that the News topics should be removed.

## 5.4 Context

### 5.4.1 Media - Images and Videos

After implementing OCR and Wav2Vec, the model was tested on a set of 60 hand picked posts (3 for each topic). The updated context aware model was compared to the original model.

Figure 5.11 shows the confusion matrix of the original model. Figure 5.12 shows the confusion matrix of the updated context aware model. The addition of the media context improved the accuracy of the model by 10%. This is a notable increase in accuracy. However, due to the nature of gathering this test data, it must be noted some form of bias is present. The test data was hand picked, so some unconscious bias may have been introduced to provide posts that would be hard to classify without the media, but easy to classify with the media. Although, this could be the case this test does show that the context



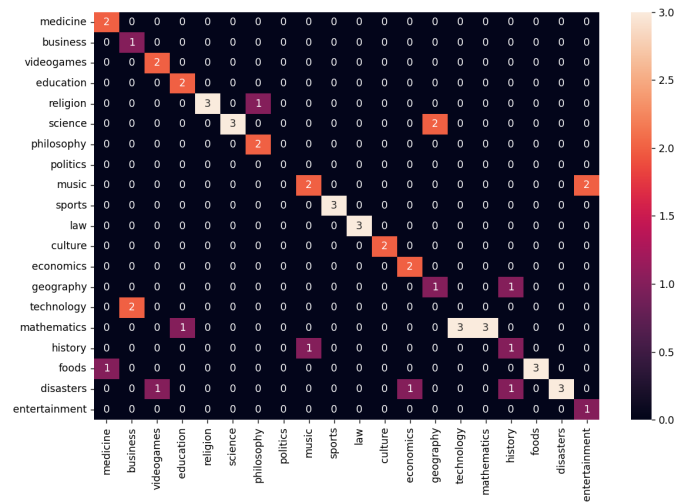


Figure 5.11: Confusion Matrix without Media Context

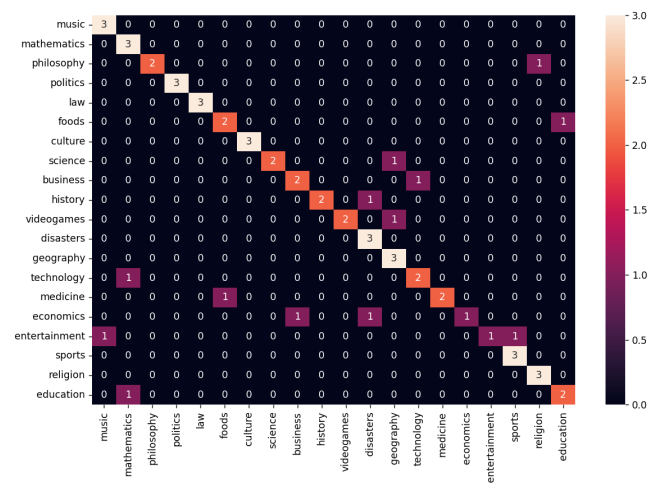


Figure 5.12: Confusion Matrix with Media Context

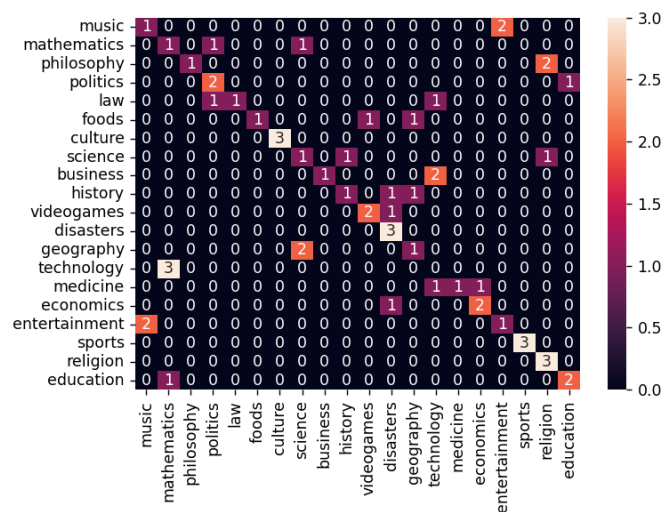


Figure 5.13: Confusion Matrix without Thread/Retweet Context

from media can still be useful in classifying posts.

## 5.4.2 Retweets and Threads

Separately to implementing OCR and Wave2Vec, another model was created that added the context of retweets and threads. This model was made separately to allow us to see the performance impact of the retweet and thread context. If we had tested them together, we would have seen an improvement but would not have been able to identify the impact of each feature.

The model was tested on a set of 60 hand picked posts, that were different to the posts used in the previous test. The reason behind this is simply the API used to access the tweets was unable to access retweets and threads from posts older than 7 days - The posts used in the previous test were all older than 7 days when this test was performed.

Figure 5.13 shows the confusion matrix of the original model. Figure 5.14 shows the confusion matrix of the thread/retweet context aware model. Similarly to the previous test, the addition of the thread/retweet context improved the accuracy of the model by 10%. Again, this is a notable increase in accuracy

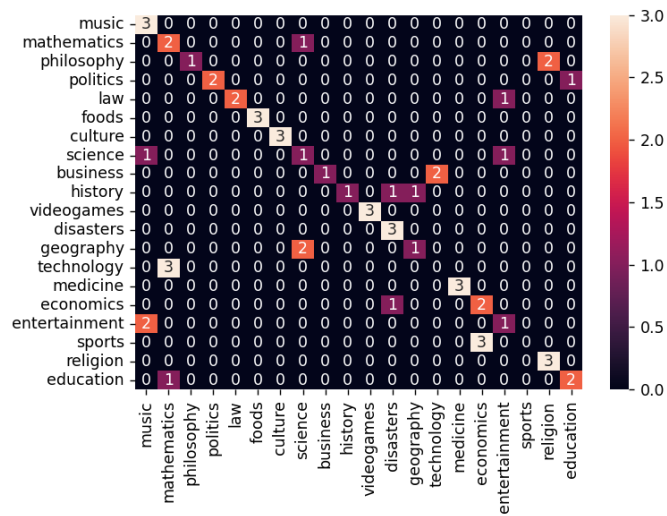


Figure 5.14: Confusion Matrix with Thread/Retweet Context

although the same bias as the previous test is present.

### 5.4.3 Context Aware Conclusion

The context aware models both improved the accuracy of the model by 10%. This shows how this extra context can be useful in classifying posts. However, there are cases where the extra context is not useful. For example, some videos are paired with songs for their audio. This audio is not related to the topic of the post. Which could cause the model to misclassify the post. In its current state the model is not able to identify whether the audio is related to the topic of the post or not.

This project shows that the context of the post can be useful in classifying posts. However, due to the naive approach taken in this project, the context is not always useful. In Chapter 6 we will discuss how this context can be used in a more sophisticated way to improve the accuracy of the model.

## Chapter 6

# Conclusions

The project aimed to:

- Classify social media posts
- Quantify and compare a users social media feed to the rest of the social media site to identify interests
- Build a user interface that allows users to discover what their social media feed says about their interests and how they compare to the rest of the social media site
- Build a user interface to allow users to find posts that are dissimilar to the posts they are shown

It is clear that all of these aims were met. RoBERTa was fine-tuned for the topic classification task. The fine-tuning was done using labelled data from Reddit and Wikipedia. Quantification of a set of tweets was done using the mean of the probabilistic outputs from our model. A user interface was built that is able to show a comparison of topics between a users social media feed and the rest of the social media site. The user interface also allows users to discover posts that are dissimilar to the posts they are shown.

From this, we can conclude that the project was a success.

## 6.1 Future work

### 6.1.1 Advanced Context Input

During this project the use of context was limited to media that was text based and comments/threads. However, there is a lot more information that can be used to improve accuracy of topic classification.

Key information such as author, location, and date can be used to add context to a post. For example, if a post is made by a politician, then the topic is likely to be about politics whereas if the post is made by a sports star, then the topic is likely to be about sports. This information in itself will not be 100% accurate, as politicians and sport stars can post about other topics as well. However, this information still serves as extra context to the post. Including this context, in a similar manner to how we included media and comments/threads, could improve the accuracy of the model.

Another method of improving the context aware part of the model is to create a more sophisticated method of incorporating the context data. Currently, the media text and comments/threads text is concatenated with the post text. This is a very naive method for adding context. For the media, a possible improvement could be to use transfer learning. This would allow us to extract more meaningful data from media and not just the text that is present in it. TODO: talk about video transformers. As seen in Figure 6.1, The post text is fed through RoBERTa and the media is fed through Video Transformers. The outputs of both models are fed through a linear layer separately, and then concatenated together. This is then fed through a linear layer and a softmax layer to get the final output.

### 6.1.2 Chrome Extension

Originally, the project was going to create a chrome extension. However, due to the time constraints of the project and the fact that I have never worked with JavaScript or Chrome extensions before, this was not possible. An extension to

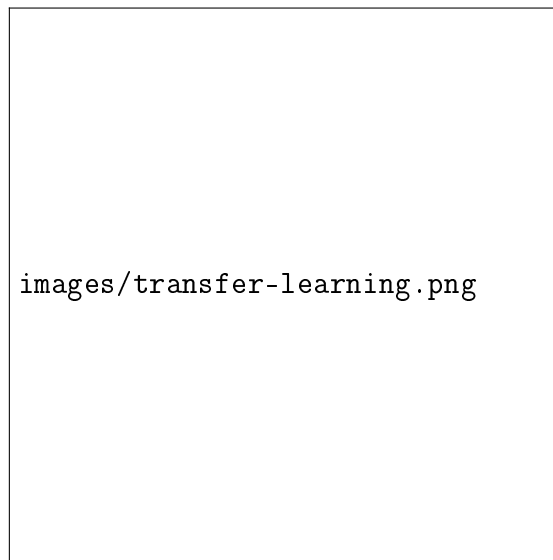


Figure 6.1: Transfer Learning with RoBERTa and Video Transformers

this project would be to learn these frameworks and transfer the user interface to a chrome extension. This would give the application a better platform to be used on - chrome extension store.

### 6.1.3 Bias Analysis

When first developing the idea for this project the main aim was to be able to find bias in someones social media feed. The idea came from some reading on echo chambers: “an epistemic environment in which participants encounter beliefs and opinions that coincide with their own” Ruiz and Nilsson (2023). An Echo chamber can cause individuals to be subject to posts that agree with their ideologies, whether or not they are ‘true’ or ‘representative’ of all viewpoints. The notion of ‘bias’ comes from the fact the posts that are shown are not truly representative of all viewpoints; the user is only shown posts that agree with their own.

This project is a good baseline for analysis on bias in a users social media feed. This project allows us to identify what topics a user is interested in. However, this in itself does not gauge whether the feed is bias or not. A user may be interested in a topic and see posts that show all viewpoints on that topic. This

is not bias. However, if a user is only shown posts about one side/part of the given topic, then this can be construed as bias. For example, take a user who is interested in sports. For this user to be non-bias they would need to see posts on a range of sports: Football, Rugby, Cricket, Athletics, and so on. However, if they only see posts on Football this can be seen as bias towards football.

This project can be extended to find the differences within topics to identify bias that is present in a users social media feed. Some early ideas for this include:

- Keyword analysis to find subtopics within a Topic.
- Building new models that given an overarching topic can identify sub-topics.

## Bibliography

- Boe, Bryce. PRAW: The Python Reddit API Wrapper â PRAW 7.7.0 documentation. URL <https://praw.readthedocs.io/en/stable/%7D>.
- Huggingface, Developers. Transformers. URL <https://huggingface.co/docs/transformers/index%7D>. V4.27.2.
- Husby, Stephanie & Barbosa, Denilson. Topic classification of blog posts using distant supervision. In *Proceedings of the Workshop on Semantic Analysis in Social Media*, pages 28–36, 2012.
- Litou, Iouliana & Kalogeraki, Vana. Pythia: A system for online topic discovery of social media posts. In *2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS)*, pages 2497–2500, 2017. doi: 10.1109/ICDCS.2017.289.
- Liu, Yinhan & Ott, Myle & Goyal, Naman & Du, Jingfei & Joshi, Mandar & Chen, Danqi & Levy, Omer & Lewis, Mike & Zettlemoyer, Luke & Stoyanov, Veselin. Roberta: A robustly optimized BERT pretraining approach. *CoRR*, abs/1907.11692, 2019. URL <http://arxiv.org/abs/1907.11692>.
- Peng, Xian & Han, Chengyang & Ouyang, Fan & Liu, Zhi. Topic tracking model for analyzing student-generated posts in spoc discussion forums. *International Journal of Educational Technology in Higher Education*, 17 (1):35, Sep 2020. ISSN 2365-9440. doi: 10.1186/s41239-020-00211-4. URL <https://doi.org/10.1186/s41239-020-00211-4>.
- Ruiz, Carlos Diaz & Nilsson, Tomas. Disinformation and echo chambers: How disinformation circulates on social media through identity-driven controver-



sies. *Journal of Public Policy & Marketing*, 42(1):18–35, 2023. doi: 10.1177/07439156221103852. URL <https://doi.org/10.1177/07439156221103852>.

Snow, Rion & Jurafsky, Daniel & Ng, Andrew. Learning syntactic patterns for automatic hypernym discovery. *Advances in neural information processing systems*, 17, 2004.

Twitter, Developers. Developer account support. URL <https://developer.twitter.com/en/support/twitter-api/developer-account%7D>.