Sentiment Analysis With Python, Pt. 1

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Sentiment analysis is a natural Language Processing (*NLP*) technique which consists of identifying the emotional tone behind a body of text. This analysis can be applied to multiple contexts such as product review, public opinion, social media polarity, and even support ticket satisfaction measurement.

Sentiment Analysis can be performed using Machine Learning algorithms, computational linguistics, or a combination of both. There are a number of libraries that can be used to achieve this task, the most popular being VADER, TextBlob, SpaCy and Flair, and transformer ML models such as GPT, Google's BERT, RoBERTa and XLNet.

In this Portfolio Project, we'll build an end-to-end Sentiment Analysis application which includes a GUI, two NLP models, a wide variety of options for analysis, and various customizations. It's important to mention that this project is more inclined towards the software engineering aspect of the application, and less towards the sentiment analysis models themselves; we will not be designing our models from scratch.

We will also not include all the project code in this article since it's extense, and will instead limit to examples and explanations for the key sections. Still, the complete project including the resources used can be found in the Portfolio Project Repo.

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Preface

Sentiment Analysis methods can provide insight regarding the tone, polarity, subjectivity and most prevalent parts of speech of a given text. We can create our own model from scratch, use a pretrained one out of the box, perform transfer learning on a pretrained model with our own datasets, or use a rule-based approach where no ML model is required.

Machine Learning approaches

As mentioned before, sentiment analysis can be achieved using **Machine Learning models**. If we think in simple terms, extracting sentiment out of text can be modeled as a classification problem.

Let us illustrate this with an example, where we have a set of movie reviews we would like to classify as positive, neutral or negative:

> A riotous film that finds depth, clarity and refreshment in even the shallowest of pools.

> It would be a disservice to consider this generous film a mere homage.

In general terms, we would preprocess our text data, extract relevant features, train our classification model with labeled data and use our trained model to predict the sentiment of future data sets:

Data preprocessing: The text data is preprocessed by removing stop words, special characters, and converting it to lowercase to reduce noise in the dataset:

- Original text: A riotous film that finds depth, clarity and refreshment in even the shallowest of pools.
- Preprocessed text: riotous film finds depth clarity refreshment even shallowest pools.

Tokenization: Before we pass our sentences to the model, we must also tokenize them, meaning breaking the sentence into tokens consisting of smaller sentences, phrases, symbols or words. Our tokenized sentences would look something like such:

```
rev_1 = ['riotous',
         'film',
         'finds',
         'depth',
         'clarity',
         'refreshment',
         'even',
         'shallowest',
         'pools']

rev_2 = ['would',
         'disservice',
         'consider',
         'generous',
         'film',
         'mere',
         'homage']
```

Feature extraction: The tokenized text is transformed into a numerical representation of features that the model can understand. We can use techniques such as bag-of-words (*BOW*), n-grams, and word embeddings.

The bag-of-words approach considers a vocabulary of all the unique words in the dataset and represent each review as a vector of word counts:

review	rev_1	rev_2
riotous	1	0
film	1	1
finds	1	0
depth	1	0
clarity	1	0
refreshment	1	0
even	1	0
shallowest	1	0
pools	1	0
would	0	1
disservice	0	1
consider	0	1
generous	0	1
mere	0	1
homage	0	1

Table 1: Bag-Of-Words For 2 Movie Reviews

Model training: We now train our sentiment analysis model with previously labeled data, where each text sample (*in this case, a word*) is associated with a sentiment label (*e.g. positive, neutral or negative*). An example of a simple set of labeled words could consist of the following:

Word	Label
riotous	Negative
film	Neutral
finds	Neutral
depth	Neutral
clarity	Positive
refreshment	Positive
even	Neutral
shallowest	Negative
pools	Neutral
would	Neutral
disservice	Negative
consider	Neutral
generous	Positive
mere	Neutral
homage	Positive

Table 2. Sentiment Labels For Words

Since we want to calculate a score for the entire sentence, labels are usually expressed numerically, instead of textually Positive, Neutral or Negative. We could, for example, define a vector $[-1, 0, 1]$, representing each label.

Model testing and validation: The trained model is tested and validated on a separate dataset to evaluate its performance. The model's performance is measured using metrics such as accuracy, precision, recall, and F1 score.

Prediction: Once the model is trained and validated, it can be used to make predictions on new text data. The model will analyze the text and classify it as positive, negative, or neutral sentiment based on the learned patterns and features.

This was a simplified example, but in reality, ML models such as transformer models make associations between words in order to understand the context of a sentence or paragraph by grouping words using Part of Speech (*POS*) tags or other attributes; this technique is called **lemmatization** and is extremely relevant in NLP; even though both of the reviews we used were very positive, there were some words tagged as Negative (*e.g. disservice, riotous*), so the final score would not be 100% Positive.

There are a wide variety of models we can use:

- **Supervised Learning**
  - Naïve Bayes Classifier (*NBC*)
  - Support Vector Machines (*SVM*)
  - Logistic Regression (*LR*)
  - Random Forest Classifier (*RFC*)
- **Deep Learning**
  - Convolutional Neural Networks (*CNN*)
  - Recurrent Neural Networks (*RNN*)
  - Deep Belief Networks (*DBN*)
  - Long-Short Term Memory (*LSTM*)

Most available pretrained large models already offer great performance in terms of social media and product review analysis out of the box. On top of that, there are thousands of variations for each existing large model; there are multiple forks containing tuned pretrained models specific for a given application, such as Twitter polarity analysis or IMDB movie rating analysis.

Rule-based approaches

As its name suggests, the rule-based approach follows a set of predefined, hardcoded rules in order to classify the text's sentiment. The result is a set of rules based on which the text is labeled as positive/neutral/negative. These rules are also known as lexicons, hence the Rule-based approach is also called **Lexicon-based approach**.

Upon performing the sentiment analysis on a sentence or paragraph, each of the words are scored, and a final score is calculated based on the frequency of each word.

In general, a rule-based approach follows similar initial steps to a ML approach, the biggest difference being there's no model to train, test and validate: We preprocess the text, tokenize it, enrich it with part of speech (*POS*) tagging, and classify it according to a set of predefined rules; it's essentially a simpler process.

The major disadvantage with this approach, is that most libraries are not capable of contextualizing sentences or paragraphs; the final score is given by the cumulative score of each word, without taking context into account.

Still, rule-based algorithms have proven extremely useful and fairly accurate, with a low amount of effort required in terms of their implementation.

There are two main libraries for performing sentiment analysis using rule-based approaches:

- VADER (*Valence Aware Dictionary for Sentiment Reasoning*)
- TextBlob

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Concept Design

We want to design an easy-to-use Guided User Interface which provides the user a way to perform sentiment analysis on one or more datasets. We also want to include deeper analysis capabilities and results exporting, so that the user can visualize textually and graphically the analysis results.

1. GUI

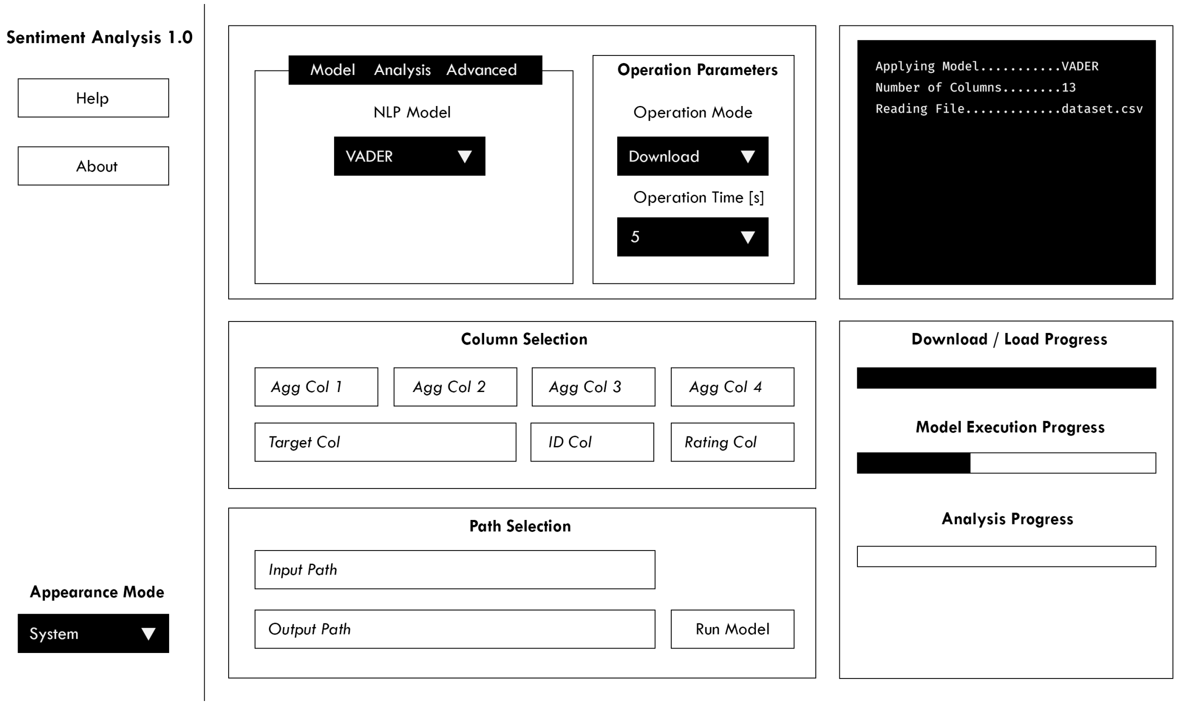
The Guided User Interface should include the following:

- Option to bulk-download datasets from a list of URLs provided by the user, or bulk-read existing datasets.
- Option to perform sentiment analysis for a user-selected column of a given dataset, using two different models.
- Option to include up to 4 additional columns in order to perform deeper analyses.
- Option to include a Rating column in order to compare sentiment analysis results with actual rating.
- Option to export results using 4 different formats:
    - **Technical:** In-depth analysis including plots and Excel files with results
    - **Business:** Business-like presentation including plots and Excel files.
    - **Visual:** All plots from Technical and Business, without the Excel files.
    - Complete: All plots and Excel files.
- Option to perform in-depth POS analysis correlating POS tags with sentiment scores.
- Option to customize color scheme and transparency for generated plots.

Apart from the main components, we should also include the following:

- A Help popup window containing operation instructions.
- An About popup window containing information related to the project.
- An Appearance Mode menu for selecting System, Light or Dark.
- A text prompt informing the user about the current progress.
- Progress bars for each step of the process.

In the end, we are looking for an interface like the sketch below:



```
Applying Model...........VADER
Number of Columns........13
Reading File.............dataset.csv
```

Figure 1: GUI Concept Sketch, Generated By Author

2. Models

For this project we will implement both VADER and TextBlob as options to the user.

VADER is a lexicon and rule-based sentiment analysis tool that is specifically attuned to sentiments expressed in social media.

VADER accepts a string (*word, sentence, paragraph or document*) as input and returns four scores:

- Positiveness probability $[0, 1]$
- Neutrality probability $[0, 1]$
- Negativity probability $[0, 1]$
- Compound score $[-1, 1]$

TextBlob is a library for processing textual data. It provides a simple API for diving into common natural language processing (NLP) tasks such as part-of-speech tagging, noun phrase extraction, sentiment analysis, classification, translation, and more.

The TextBlob sentiment method accepts a `textblob.blob.TextBlob` object containing a string (*word, sentence, paragraph or document*) as input, and returns a tuple of two scores:

- Polarity $[-1, 1]$
- Subjectivity $[-1, 1]$

The advantage of these 2 models, is that both output a polarity score in the same scale $[-1, 1]$, meaning we can use all analysis for both cases without having to rescale or normalize the results. Also, the range is continuous and can be used to perform correlational analysis with other continuous variables selected by the user.

General project structure

When starting a project, the first step is to design a structure which makes sense for what we're building. We can look at the structure as how our folders, files, classes and functions will be ordered, and how will they interact with each other. This is extremely important since we'll be writing a lot of modular code, and things can get lost easily, specially when we're escalating our application to bulk operation.

1. Structure chart

There are multiple ways of approaching a project structure design; it really depends on each personal taste, although there are good practices in place to guide us through. The best way to start designing our process flow, is to implement a **structure chart** (*SC*).

A structure chart is a chart which shows the breakdown of a system to its lowest manageable levels. It's used in structured programming to arrange program modules into a tree; each module is represented by a box, which contains the module's name. The tree structure visualizes the relationships between modules.

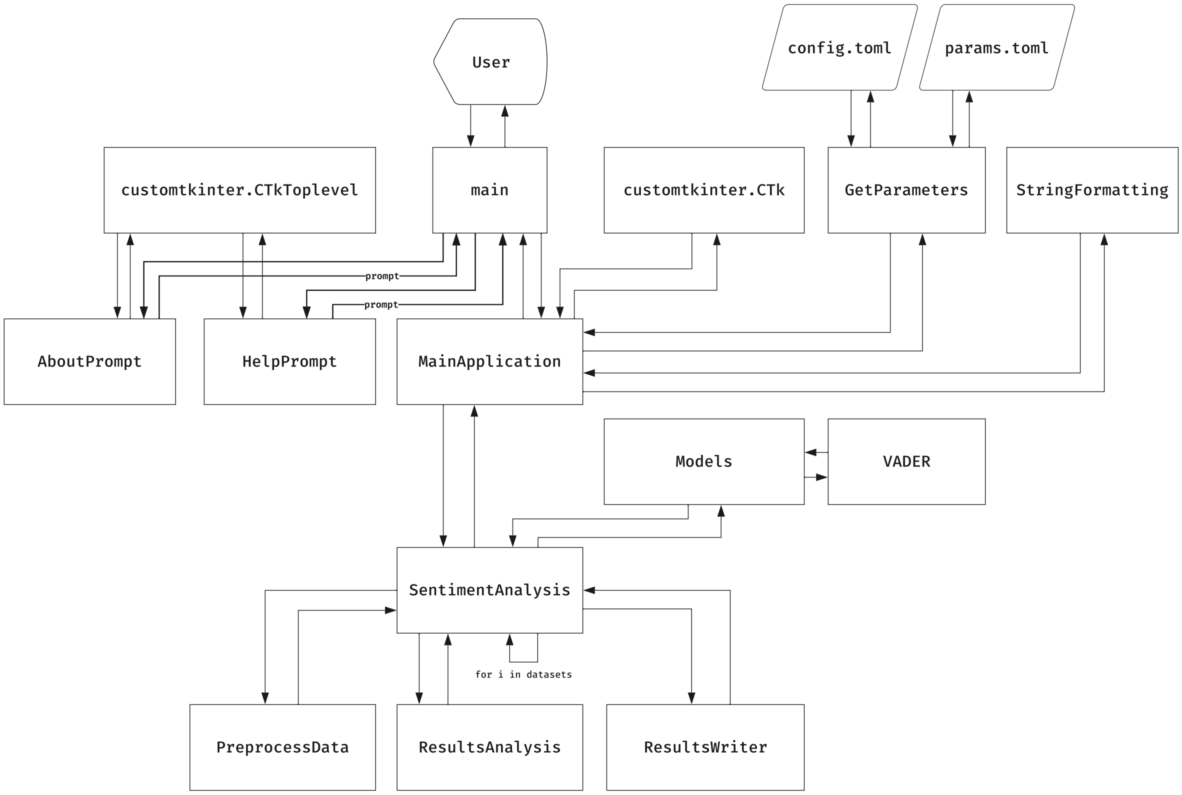


Figure 2: Structure Chart For Sentiment Analysis Application, Generated By Author

As we can see from the SC above, we'll be implementing a frontend, a backend, configuration files and utility functions, so a main folder with subfolders as packages makes sense for our case.

2. Project components

Below is what we'll need for this project:

- An input folder.
- An output folder.
- A virtual environment.
- A source code folder `src`:
  - A main function which will execute the application.
  - A frontend module containing all GUI components
  - Two configuration files:
    - A configuration file for variable options.
    - A parameters file for modifying our GUI's appearance.
  - A configuration & parameter getter module, which will read the parameters from our configuration files.
  - A string formatting module which will format the text outputs displayed in the GUI's text log.
  - A preprocessing module which will download/load and clean our data before feeding it into the model.
  - A sentiment analysis file which will apply the NLP models to our data.
  - A results analysis file which will perform analysis on our sentiment analysis results.
  - A results writer which will write the analyses to Excel files or plots, depending on the user's choice.

We will create a master folder (*project folder*) where the inputs, outputs and source code will reside. This folder will have the following structure:

- `sentiment-analysis-with-python`: The project folder.
  - `datasets`: Where our datasets will be downloaded and read from.
  - `outputs`: Where our analyses will be written in.
  - `se_env`: Our virtual environment.
  - `src`: Where the source code will be located.
  - `requirements.txt`: Where all the dependencies will be specified.

The application will be divided into multiple **packages** denoted by folders. Each package will contain **modules** belonging to a similar functionality, denoted by files. Each file will serve a specific purpose and will contain one main **class**. Each class will contain one or more **methods** denoted by functions.

The package structure inside `src` will be as follows:

- `src`: Where the source code will be located.
  - `main.py`: Our main function which the user will execute (*this will be the only point of contact for a typical user*).
  - `application`: Frontend packages
  - `config`: Where we will store configuration files and default parameters for our application.
  - `sentiment_analysis`: Where all the packages related to the analysis will be located.
    - `models:` Where the model definition for VADER will be located.
  - utils: Where helper scripts will be located.

3. Class definition approach

When working with a modular, multi-class structure, we have some approaches available we can use to create relations within classes:

- Mixin classes
- Single/Multiple inheritance classes
- Composite classes

- Data Transfer Object classes
- Composite classes

In Python, a **mixin** is a class that provides methods to other classes but is not considered a base class itself. In short, a mixin is a class that extends the functionality of other classes without requiring initialization using an `__init__` function, calls to `super()` to initialize parent classes, and other aspects that a conventional class would require.

Below are some other advantages of a mixin approach over conventional classes:

- The main class inherits all mixin class methods directly from `n` mixin classes.
- Parameters & data are defined on the main function, so there's no need to redefine attributes inside mixin classes.
- `self` from the main class is automatically accessible inside mixin class methods.

Singe/multiple inheritance is the traditional approach to OOP and works hierarchically (*vertically*), by defining a parent class and a child class, where the latter inherits methods and attributes from the first. We can think of inheritance in terms of a child class or subclass that is **derived** from another class, or as a parent class whose behavior is **extended** by a child class.

Composition works horizontally, by defining two classes that can interact with each other without the vertical structure (*child-parent association*) from the inheritance approach. We can think of composition in terms of a class that has a **relationship** with another class. A composition approach has a **composite** class which in turn can have a **component** class associated.

Data Transfer Objects (*DOT*) are data structures typically used to pass data between application layers or between services. They don't possess methods of their own; instead, they simply transfer data. This approach is useful when, for example, we have three child classes where:

- We don't want to create an inheritance structure between them.
- We would like to set attributes, but we don't have access to a parent class (*it can be part of a third-party framework we're using, and is simply not accessible without involving modifications to the class's source code, which is far from ideal*).

In this project, we'll use the following:

- Mixin classes to extend the behavior of other classes.
- Single/Multiple inheritance to interact with our GUI's package, `customtkinter`.
- Data Transfer Object classes to set common variables for three classes in our `_app.py` module.

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Preparing the environment

We will start by creating our main folder along with the required subfolders:

Code

```
mkdir sentiment-analysis-with-python/src
```

```
cd sentiment-analysis-with-python
```

```
mkdir datasets, outputs
```

```
cd src
```

```
mkdir application, config, sentiment_analysis, utils
```

Creating a virtual environment

We will create a virtual environment tailored for this project. We'll be using Python 3.9.0, which we will need to download if we haven't already.

We will then create our environment using the installed Python version. This environment will be located inside our project folder, `sentiment-analysis-with-python`:

Code

```
C:\Users\username\AppData\Local\Programs\Python\Python39\python.exe -m venv 'se_env'
```

Installing required libraries

Since we'll be using a fair ammount of libraries, its easier for us and for the final user to define a `requirements.txt` file, the reason being we can quickly install all dependencies with a single `pip` command.

The `requirements.txt` file will be located inside our project folder, `sentiment-analysis-with-python`, and will contain the following packages:

```
customtkinter
xlsxwriter
matplotlib
nltk
numpy
pandas
polars
pyarrow
pyinstaller
scikit-learn
seaborn
spyder-kernels
textblob
tk
tomli
wordcloud
```

We can then activate our virtual environment from within the main project folder on the current terminal session, and install all the dependencies. Keep in mind that `Activate.ps1` is meant for `PowerShell`; other shells have their own `activate` script.

Code

```
se_env/Scripts/Activate.ps1
```

```
pip install -r requirements.txt
```

Implementing the main components

Once we have a good understanding of the project's general structure and packages, we can implement the main modules, classes and functions; this way, we have clarity of what goes where.

There are multiple ways of approaching this step:

- **Implementing classes and functions using placeholders:** Each class and function is followed by a temporary `pass` statement upon initial writing. When we need to write the class or function, we simply remove the temporary statement and write out code. This approach works better when we also add docstrings for each definition; it helps us remember and bring clarity in terms of what the definition is for.
- **Implementing boilerplate code:** Boilerplate code are sections of code repeated in multiple places with little to no variation; if we declare a child class which inherits from a parent class, we would declare the class itself, include an `__init__(self)` method, and a call the parent class by including a `super().__init__(self)` method.
- **Implementing pseudocode:** An artificial and informal language usually made up of simpler code and comments. It helps with clarity on what we intend to do with our classes and functions, but is not necessarily executable to the full extent.
- **Implementing skeletons:** Similar to pseudocode, skeleton programming consists of a simpler version of our intended code, though it differs in that it can actually be compiled without errors.

For this example we'll stick with a combination of the first two approaches, and reason the code as we move forward.

1. Modules

Each package will have multiple files inside, each one representing a module. For each module, we will follow the snake case format with single leading underscore practice `_module.py`, where each file representing a module will be signaled as an internal module; a single leading underscore in front of a variable, a function, or a method name means that these objects are used internally. This also means that, when importing modules using a wildcard `*`, these will not be imported.

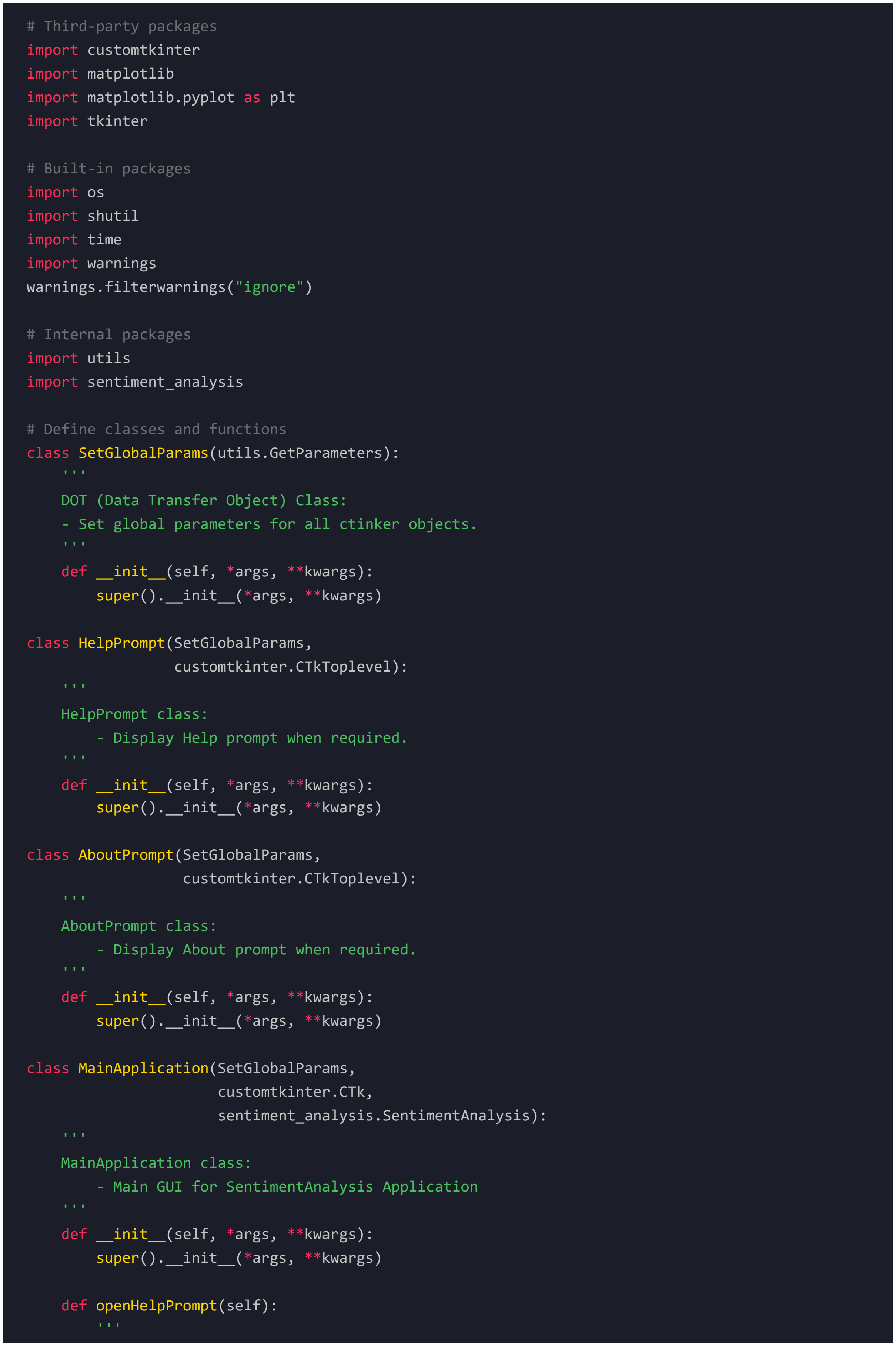
We will start by creating our modules inside each `src` package and defining boilerplate code inside them. Our definitions will not make much sense now, but will serve as our project's skeleton and will be explained later on:

1.1 Application

```
application
│   _app.py
```

Main structure for `_app.py`:

CODE



```python
# Third-party packages
import customtkinter
import matplotlib
import matplotlib.pyplot as plt
import tkinter

# Built-in packages
import os
import shutil
import time
import warnings
warnings.filterwarnings("ignore")

# Internal packages
import utils
import sentiment_analysis

# Define classes and functions
class SetGlobalParams(utils.GetParameters):
    '''
    DOT (Data Transfer Object) Class:
    - Set global parameters for all ctinker objects.
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

class HelpPrompt(SetGlobalParams,
                 customtkinter.CTkToplevel):
    '''
    HelpPrompt class:
        - Display Help prompt when required.
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

class AboutPrompt(SetGlobalParams,
                  customtkinter.CTkToplevel):
    '''
    AboutPrompt class:
        - Display About prompt when required.
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

class MainApplication(SetGlobalParams,
                      customtkinter.CTk,
                      sentiment_analysis.SentimentAnalysis):
    '''
    MainApplication class:
        - Main GUI for SentimentAnalysis Application
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

    def openHelpPrompt(self):
        '''
        Event: Open Help prompt.
        '''
        pass

    def openAboutPrompt(self):
        '''
        Event: Open About prompt.
        '''
        pass

    def returnThresholdVal(self, value):
        '''
        Event: Get threshold values and print to text log.
        '''
        pass

    def runModel(self):
        '''
        Event: Performs initial input exception handling.
        Event: Runs model using SentimentAnalysis inherited module.
        '''
        pass

if __name__ == '__main__':
    main()
```

1.2 Sentiment analysis

```
sentiment_analysis
│   _results_analysis.py
│   _results_writer.py
│   _sentiment_analysis.py
│
├──models
│   │   vader.py
```

Main structure for `_sentiment_analysis.py`:

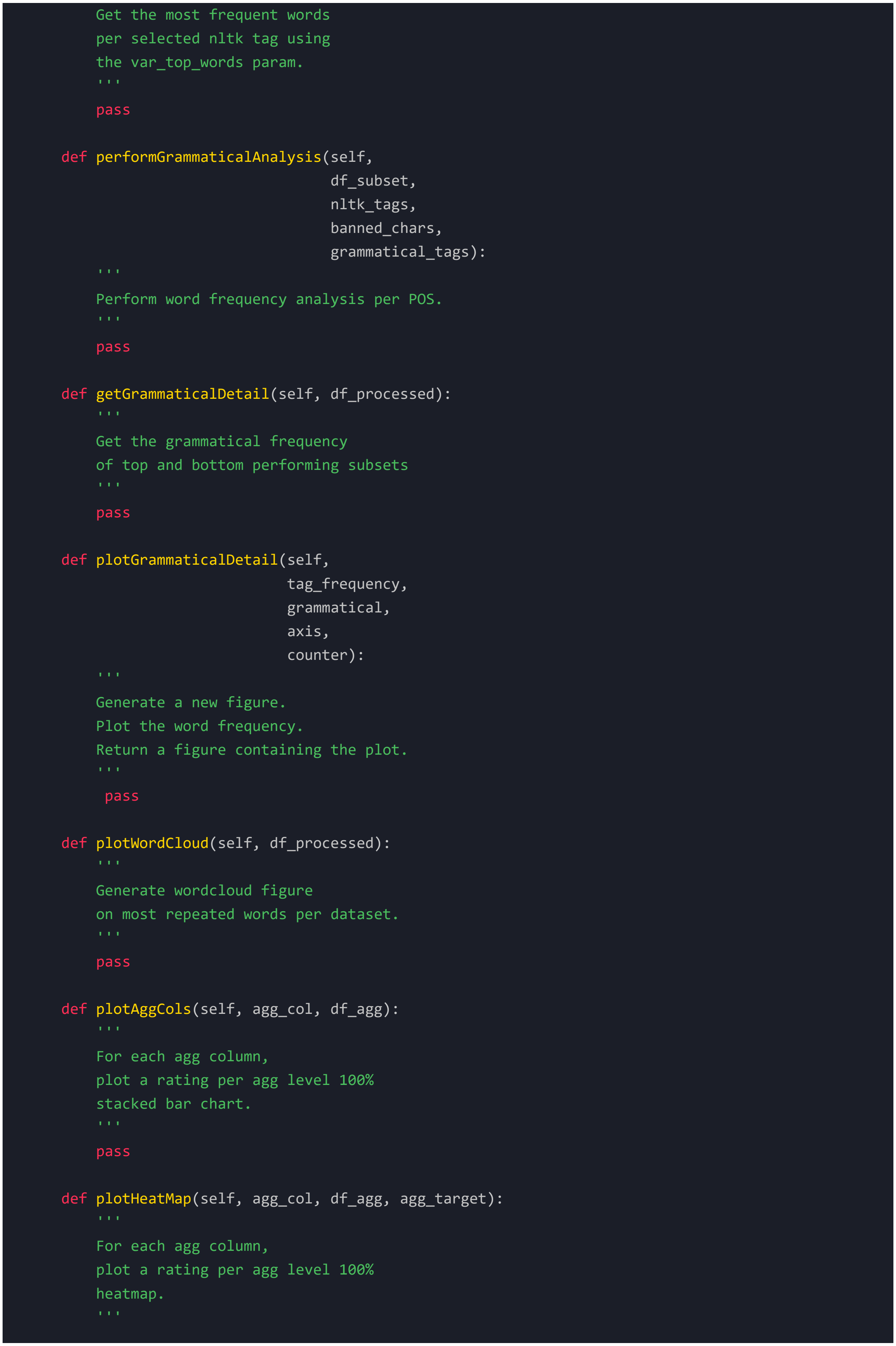
Code

```python
# Third-party packages
import numpy as np
import pandas as pd
import polars as pl
import pyarrow
from textblob import TextBlob

# Built-in packages
import os
import time
import warnings
warnings.filterwarnings('ignore')

# Internal packages
from utils import PreprocessData
from sentiment_analysis.models import vader
from sentiment_analysis.models import happy_transformer
from ._results_analysis import ResultsAnalysis
from ._results_writer import ResultsWriter

# Define SentimentAnalysis class
class SentimentAnalysis(PreprocessData,
                        ResultsAnalysis,
                        ResultsWriter):
    '''
    Perform sentiment analysis on a given data set.
    '''

    def applyModel(self, df, dataset):
        '''
        Apply sentiment analysis model depending on user's choice.
        '''
        pass

    def executeModel(self):
        '''
        Downloads datasets if user has requested Download operations.
        Loads data sets one by one and perform analysis per dataset.
        '''
        pass

if __name__ == '__main__':
    main() # type: ignore
```

Main structure for `_results_analysis.py`:

Code

```python
# Third-party packages
import matplotlib
import matplotlib.pyplot as plt
import nltk
nltk.download('punkt')
nltk.download('averaged_perceptron_tagger')
import numpy as np
import pandas as pd
import polars as pl
from scipy.stats import spearmanr
from scipy.stats import pearsonr
import seaborn as sns
from sklearn.preprocessing import MinMaxScaler
from wordcloud import WordCloud, STOPWORDS, ImageColorGenerator

# Built-in packages
import os
import shutil
import warnings
warnings.filterwarnings('ignore')

class ResultsAnalysis:
    '''
    Collect iteration information.
    Perform analyses to pass to writing.
    '''
    def setScoresComp(self, score):
        '''
        Sets sentiment tag based on compound score.
        '''
        pass

    def getPercentages(self, df_processed):
        '''
        Calculates percentages for Positive, Neutral and Negative
        based on score.
        '''
        pass

    def calculateCorrelation(self, df_processed):
        '''
        Calculates the correlation between
        the compound score and the actual rating.
            - Spearman Rank Coefficient
            - Pearson Coefficient
        Calculates the p-value associated
        with this correlation.
            - Spearman Rank Coefficient P-Value
            - Pearson Coefficient P-Value
        Provides the user two measures
        with which to trust/not trust the model results.
        '''
        pass

    def findTags(self, tag_prefix, tagged_text):
        '''
```

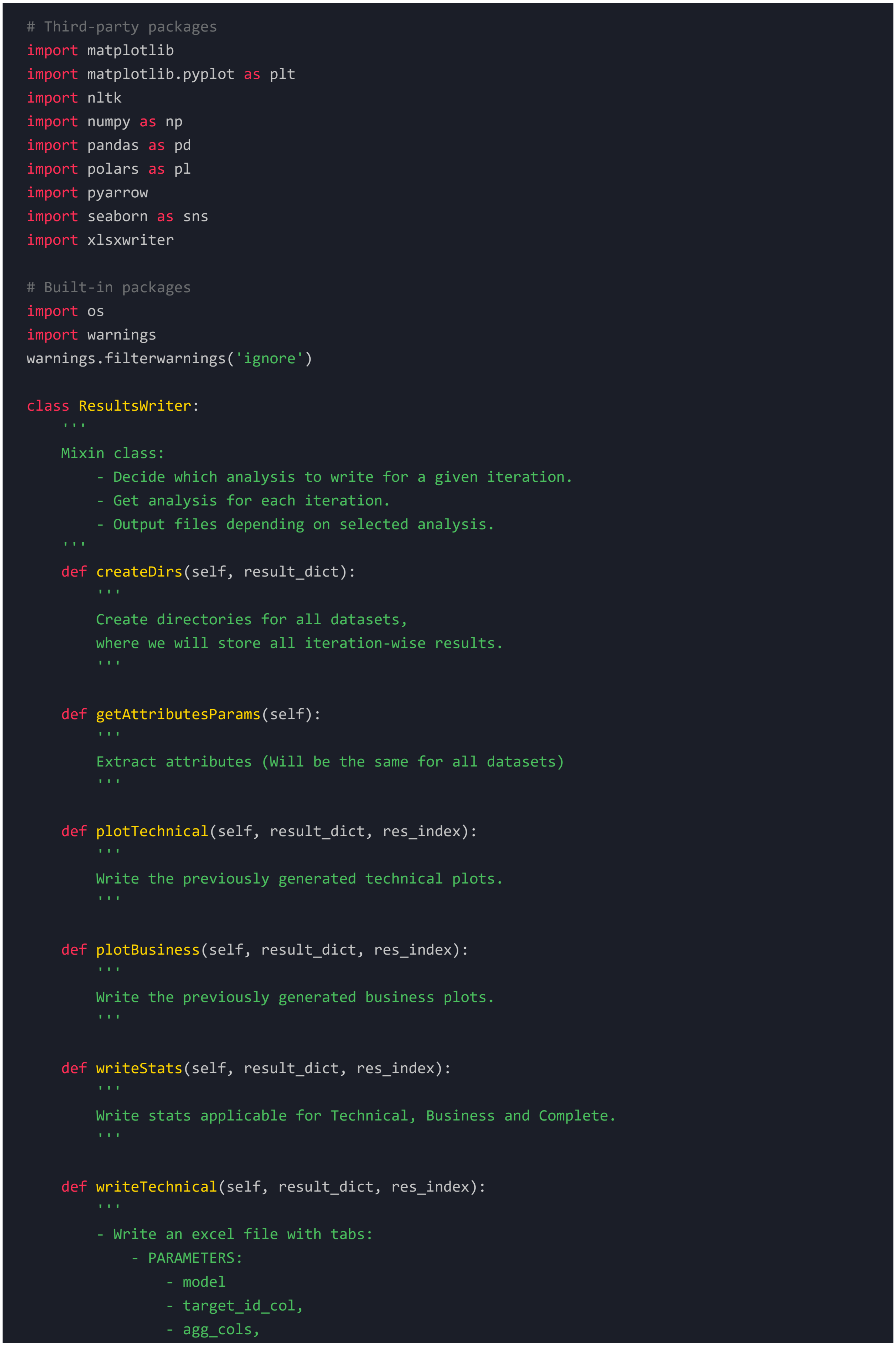


```
        Get the most frequent words
        per selected nltk tag using
        the var_top_words param.
        '''
        pass

    def performGrammaticalAnalysis(self,
                                   df_subset,
                                   nltk_tags,
                                   banned_chars,
                                   grammatical_tags):
        '''
        Perform word frequency analysis per POS.
        '''
        pass

    def getGrammaticalDetail(self, df_processed):
        '''
        Get the grammatical frequency
        of top and bottom performing subsets
        '''
        pass

    def plotGrammaticalDetail(self,
                              tag_frequency,
                              grammatical,
                              axis,
                              counter):
        '''
        Generate a new figure.
        Plot the word frequency.
        Return a figure containing the plot.
        '''
         pass

    def plotWordCloud(self, df_processed):
        '''
        Generate wordcloud figure
        on most repeated words per dataset.
        '''
        pass

    def plotAggCols(self, agg_col, df_agg):
        '''
        For each agg column,
        plot a rating per agg level 100%
        stacked bar chart.
        '''
        pass

    def plotHeatMap(self, agg_col, df_agg, agg_target):
        '''
        For each agg column,
        plot a rating per agg level 100%
        heatmap.
        '''
        pass

    def generateTechnicalCalc(self,
                              df_processed,
                              dataset,
                              score_percentages):
        '''
        For each iteration, calculates the following:
            - Total entries
            - CMP Median
            - CMP Mean
            - CMP STD
            - CMP MIN
            - CMP Q1
            - CMP Q2
            - CMP Q3
            - CMP MAX
            - SCORE Positive Perc
            - SCORE Neutral Perc
            - SCORE Negative Perc
            - Spearman Rank Corr Coef
            - Spearman Rank Corr P-Value
            - Pearson Corr Coef
            - Pearson Corr P-Value
        '''
        pass

    def generateBusinessCalc(self,
                             df_processed,
                             dataset,
                             score_percentages):
        '''
        For each iteration, calculates the following:
            - Total entries
            - SCORE Positive Perc
            - SCORE Neutral Perc
            - SCORE Negative Perc
        '''
        pass

    def generateStats(self, df_processed, agg_col_list):
        '''
        Calculate Mean and Standard Deviation
        of Compound and Rating for all
        aggregation Levels.
        '''
        pass

    def generateTechnicalPlots(self,
                               tag_frequency_top,
                               tag_frequency_bottom):
        '''
        For each iteration, generate technical plots.
        '''
        pass
```

```python
    def generateBusinessPlots(self,
                              df_processed,
                              agg_col_list):
        '''
        For each iteration, generate business plots.
        '''
        pass

    def performAnalysis(self, df_main, dataset):
        '''
        Perform analysis depending on user input:
        - Technical
        - Business
        - Visual
        - Complete
        '''
        pass

if __name__ == '__main__':
    main() # type: ignore
```

Main structure for `_results_writer.py`:

Code



```python
# Third-party packages
import matplotlib
import matplotlib.pyplot as plt
import nltk
import numpy as np
import pandas as pd
import polars as pl
import pyarrow
import seaborn as sns
import xlsxwriter

# Built-in packages
import os
import warnings
warnings.filterwarnings('ignore')

class ResultsWriter:
    '''
    Mixin class:
        - Decide which analysis to write for a given iteration.
        - Get analysis for each iteration.
        - Output files depending on selected analysis.
    '''
    def createDirs(self, result_dict):
        '''
        Create directories for all datasets,
        where we will store all iteration-wise results.
        '''

    def getAttributesParams(self):
        '''
        Extract attributes (Will be the same for all datasets)
        '''

    def plotTechnical(self, result_dict, res_index):
        '''
        Write the previously generated technical plots.
        '''

    def plotBusiness(self, result_dict, res_index):
        '''
        Write the previously generated business plots.
        '''

    def writeStats(self, result_dict, res_index):
        '''
        Write stats applicable for Technical, Business and Complete.
        '''

    def writeTechnical(self, result_dict, res_index):
        '''
        - Write an excel file with tabs:
            - PARAMETERS:
                - model
                - target_id_col,
                - agg_cols,
                - rating_col,
                - target_col.
            - RESULTS:
                - Total entries
                - CMP Median
                - CMP Mean
                - CMP STD
                - CMP MIN
                - CMP Q1
                - CMP Q2
                - CMP Q3
                - CMP MAX
                - SCORE Positive Perc
                - SCORE Neutral Perc
                - SCORE Negative Perc
                - Spearman Rank Corr Coef
                - Spearman Rank Corr P-Value
                - Pearson Corr Coef
                - Pearson Corr P-Value
        '''

    def writeBusiness(self, result_dict, res_index):
        '''
        - Write an excel file with tabs:
            - PARAMETERS:
                - model
                - target_id_col,
                - agg_cols,
                - rating_col,
                - target_col.
            - RESULTS:
                - Total entries
                - SCORE Positive Perc
                - SCORE Neutral Perc
                - SCORE Negative Perc
        '''

    def writeResults(self, result_dict):
        '''
        Create pack of analyses based on user input.
        '''

if __name__ == '__main__':
    main() # type: ignore
```

1.3 Utils

```
utils
│   _get_parameters.py
│   _preprocess_data.py
│   _string_formatting.py
```

Main structure for `_get_parameters.py`:

Code

```python
# Third-party packages
import tomli

# Main class
class GetParameters:
    '''
    Mixin class:
        - Get parameters
        - Get configuration
    '''

    def getParams(self):
        '''
        Get parameters from .toml file
        '''
        pass

    def getConfig(self):
        '''
        Get configuration from .toml file
        '''
        pass

if __name__ == '__main__':
    main() # type: ignore
```

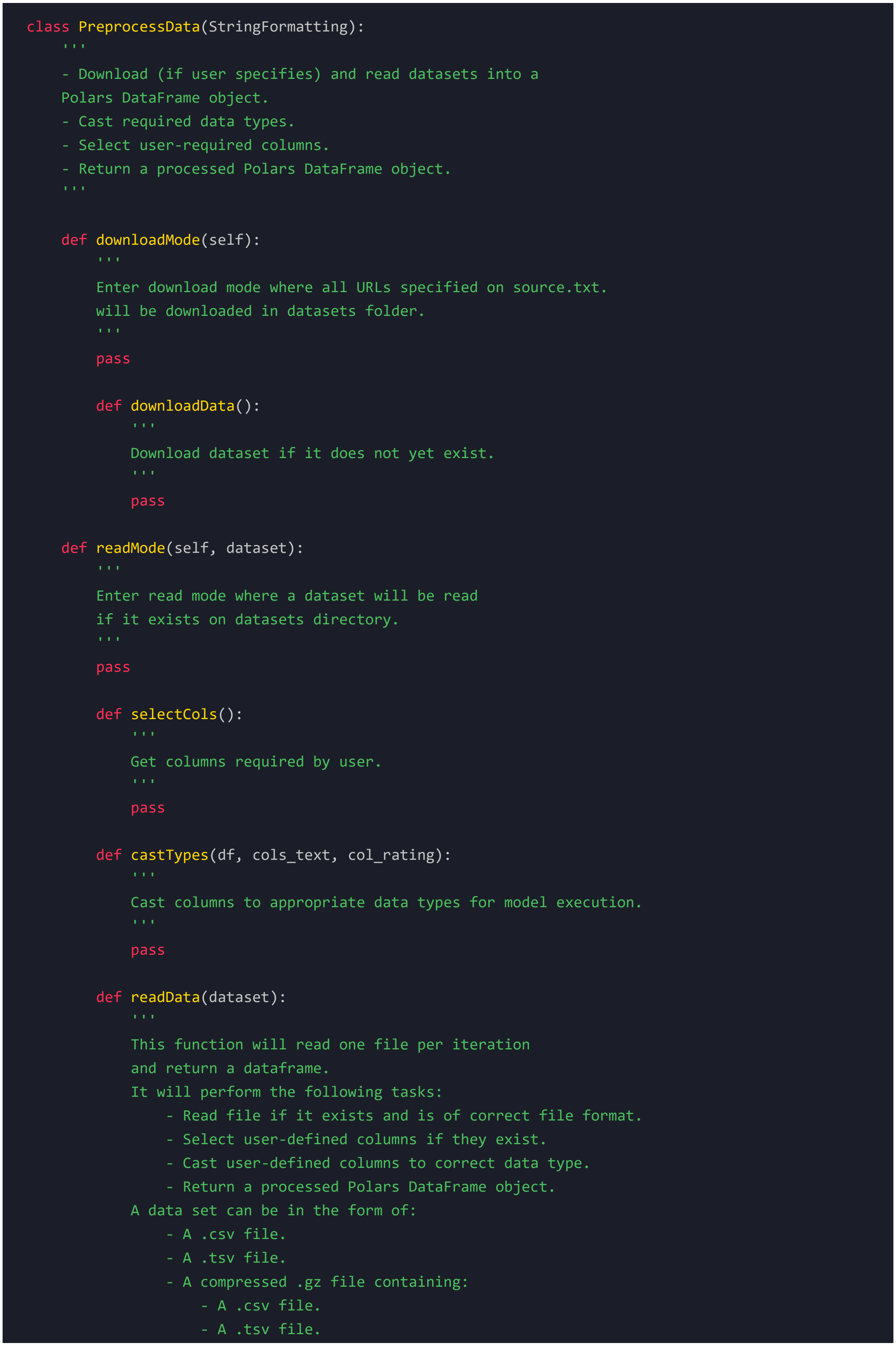
Main structure for `_string_formatting.py` :

Code

```
class StringFormatting:
    '''
    Mixin class:
        - Pad string
        - Insert log into application textlog
    '''

    def padStr(self, measure_title, value_title):
        '''
        Format a string to be inserted into log.
        '''
        pass

    def insertLog(self, *args, clear=False):
        '''
        Insert a log into textlog.
        Perform all required activities associated:
            - Enable text log.
            - If clear==True, clear the log before. Else, keep.
            - Insert all kwargs into text log.
            - Disable text log.
            - Update idle tasks.
        '''
        pass

if __name__ == '__main__':
    main() # type: ignore
```

Main structure for `_preprocess_data.py` :

Code



```
class PreprocessData(StringFormatting):
    '''
    - Download (if user specifies) and read datasets into a
    Polars DataFrame object.
    - Cast required data types.
    - Select user-required columns.
    - Return a processed Polars DataFrame object.
    '''

    def downloadMode(self):
        '''
        Enter download mode where all URLs specified on source.txt.
        will be downloaded in datasets folder.
        '''
        pass

        def downloadData():
            '''
            Download dataset if it does not yet exist.
            '''
            pass

    def readMode(self, dataset):
        '''
        Enter read mode where a dataset will be read
        if it exists on datasets directory.
        '''
        pass

        def selectCols():
            '''
            Get columns required by user.
            '''
            pass

        def castTypes(df, cols_text, col_rating):
            '''
            Cast columns to appropriate data types for model execution.
            '''
            pass

        def readData(dataset):
            '''
            This function will read one file per iteration
            and return a dataframe.
            It will perform the following tasks:
                - Read file if it exists and is of correct file format.
                - Select user-defined columns if they exist.
                - Cast user-defined columns to correct data type.
                - Return a processed Polars DataFrame object.
            A data set can be in the form of:
                - A .csv file.
                - A .tsv file.
                - A compressed .gz file containing:
                    - A .csv file.
                    - A .tsv file.
            For column selection:
                - Agg columns (max 4, min 1). Can be str, int or float type.
                - ID column. Can be str or int type.
                - Target column. Requires str type.
                - Rating column. Can be int or float type.
            '''
            pass

if __name__ == '__main__':
    main() # type: ignore
```

We may have noticed a few interesting characteristics from our modules:

We imported modules using a structured approach. It's always best practice to import modules using the following rules:

- Third-party packages first
- Built-in packages second
- Internal packages third
- All imports should ideally be listed alphabetically in ascending order.

Mixin classes don't have an `__init__(self)` method. This is because mixin classes are not meant to be initialized with arguments; instead, they are meant to use the arguments from the class inheriting the mixin class.

Mixin class methods have `self` as parameter. This is because when we call a mixin class from another class, the mixin inherits the latter's methods and attributes denoted by `self`. By including the `self` attribute in the mixin class functions, we are specifying that said function should inherit whichever methods and attributes are specified on the calling class.

We include `# type: ignore` at the end of specific lines. This statement tells our Python debugger to ignore errors on the current line we're in. There are multiple reasons why we're using this technique:

- By design, a mixin class does not explicitly inherit attributes from a "parent class". We may notice that mixin classes are not declared as a conventional child class would be declared (i.e. `MyClass(ParentClass):`)

Now that we have our modules defined, we can package them.

§

Packages

As mentioned before, we will express our packages as folders inside `src`. For a folder to be used as a package, we need to include a special file, `__init__.py`, inside each package folder. This way, we will be able to import entire packages across files without needing to import each module explicitly; when we import a folder as package from another file, the Python interpreter calls `__init__.py` which includes all imported modules as part of the package.

The basic structure of an `__init__.py` file is very simple; we import the modules we wish to include in the package, along with the classes we wish to use in other files:

```
from ._app import SetGlobalParams
```

In this case, `_app` would be our module (*file*), and `SetGlobalParams` would be a class inside the module we wish to use across our project files.

We prepend our module import with a dot `.` since, even though we're on the same directory as our modules, the Python interpreter doesn't know that. This is why we explicitly have to specify we would like to import the `_app.py` module which is located inside the current directory (`.`).

We can create an `__init__.py` file per package, and populate with our module imports.

Imports for `aplication/__init__.py`:

Code

```
from ._app import SetGlobalParams, HelpPrompt, AboutPrompt, MainApplication
```

Imports for `sentiment_analysis/__init__.py`:

Code

```
from ._results_writer import ResultsWriter
from ._results_analysis import ResultsAnalysis
from ._sentiment_analysis import SentimentAnalysis
```

Imports for `utils/__init__.py`:

Code

```
from ._get_parameters import GetParameters
from ._preprocess_data import PreprocessData
from ._string_formatting import StringFormatting
```

Note that we're not importing any external package here; we're simply importing our own modules (*files*) along with the classes we defined earlier.

§

Configuration Files

The last piece missing before we start writing our code, is to define **configuration files**. Configuration files are extremely useful when we're writing code and would like to provide a way to configure our application without messing up with the code itself. This technique provides a way for an external user, or even ourselves, to fine-tune any modifiable parameter which changes the behavior of our application's interface or even backend. It also provides a way for us to define a set of variables which will be used by our application; we define our parameter and configuration options outside the code, and write a getter function in order to read the parameters from the created files.

The idea is to leave the configuration for the main user-defined parameters in the GUI, and specific parameters such as the GUI's font family, font size, text color, and other parameters inside a configuration file. This way, we purpose the GUI exclusively for model operation, and the configuration files for the application appearance which the general user would not necessarily want to modify. In short, it keeps distractions away while keeping a backdoor for more fine-grained customization.

Also, a parameters file can be used as a collection of default values for the user-defined variables we will include later on. If the GUI were to malfunction, the user could still access the parameters file and set default values for all variables, effectively bypassing the GUI while making none to minor direct modifications to the code itself.

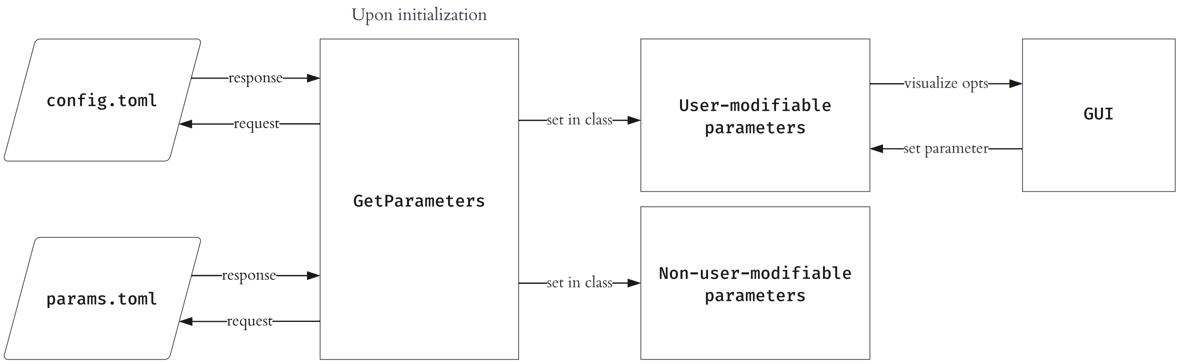


Figure 3: Configuration File Management Diagram

There are multiple file formats such as `.hcl`, `.json` and `.yaml` tailored for configuration files. In this project, we will stick with the `.toml` (*Tom's Obvious Minimal Language*) file format for both configuration and parameters files because of its multiple advantages:

- Is human-readable and supports complex configuration and settings.
- Supports comments.
- Has an easy-to-read and easy-to-parse structure.
- Has read and write capabilities.
- Has implementations in most programming languages.
- Maps unambiguously to a hash table.
- Supports 8 main native types such as key/value pairs, arrays, integers and floats, tables, and more.
- Supports sections.

1. Application configuration

The application configuration file will include parameters related to the appearance of the UI.

We can create our `config.toml` file inside our previously created `src/config` directory. We will then include the following:

Code

```
[interface]
color_theme = "blue"
front_color = "#f2f2f2"
background_color = "#1a1a1a"
geometry_width = 1416
geometry_height = 820
dot_sep = 25
radius = 0

[fonts]
text_color = "#f2f2f2"
text_placeholder_color = "#7f7f7f"
font_header_family = "Tw Cen MT"
font_header_size = 20
font_header_weight = "bold"
font_body_family = "Tw Cen MT"
font_body_size = 16
font_body_weight = "normal"
font_body_pc_family = "Tw Cen MT"
font_body_pc_size = 16
font_body_pc_weight = "normal"
font_body_pc_style = "italic"
font_code_family = "Fira Code Retina"
font_code_size = 13
font_code_weight = "normal"
```

We're dividing our content in two separate sections. This provides better organization when reading our file.

2. User parameters

The user parameters file will include default values for all user-defined parameters inside the GUI. We will use this file in order to set all options for our GUI menus.

We can create our `parameters.toml` file inside our previously created `src/config` directory. We will then include the following:

Code

```
[directories]
rdir =  "datasets"
wdir =  "outputs"
sourceurl = "source.txt"

[operation]
input_method = ["Download Mode", "Read Mode"]
model =  ["VADER", "TextBlob"]
analysis = ["Technical", "Business", "Visual", "Complete"]
chart_background = ['Transparent', 'Solid']
plot_color_scheme = ['rocket', 'rocket_r', 'mako', 'mako_r', 'flare', 'flare_r', 'crest',
'crest_r', 'magma', 'magma_r', 'viridis', 'viridis_r']
wait_time = ['0', '0.5', '1', '2', '3', '4', '5']
top_words = ['3', '4', '5', '6', '7']
nltk_threshold = [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9]

[columns]
target_id_col = "review_id"
agg_cols = ["product_id", "verified_purchase", "helpful_votes", "vine"]
rating_col = "star_rating"
target_col =  "review_body"
```

3. Getter functions

Now that we have our parameter list, we will build two getter functions inside our `_get_parameters.py` file; one for each case (*configuration and parameters*). These functions should go inside our `GetParameters` mixin class:

Code

```python
def getConfig(self):
    '''
    Get configuration from .toml file
    '''
    with open("config/config.toml", mode="rb") as f_conf:
        config = tomli.load(f_conf)

    return config
```

Code

```python
def getParams(self):
    '''
    Get parameters from .toml file
    '''
    with open("config/parameters.toml", mode="rb") as f_params:
        params = tomli.load(f_params)

    return params
```

When we initialize our application, these methods will be called, returning a dictionary of the parameters we defined.

Now, we have everything ready to start writing the frontend of our application.

§

Front-End

There are three main frameworks we can use to easily write GUIs in Python:

- `PyQT5`: A Python binding of the cross-platform GUI toolkit Qt.
- `tkinter`: The original built-in `tkinter` library with all legacy widgets, but with an outdated UI.
- `customtkinter`: A newer UI-library based on `tkinter`, maintained by TomSchimansky.

For this example, we'll be using the third option, although there are some methods of `tkinter` we'll also include.

`customtkinter` provides methods to define main and secondary application windows, include grids, and define sections. Inside each section, we can include one or more widget-style instances such as titles, labels, text inputs, option menus, radio buttons, progress bars, text prompts, and more. Widgets that accept a user input will store it as a variable we previously define.

Since we'll be including 3 main windows (*help, about, main application*), we'll need to define 3 classes which will inherit from different `customtkinter` classes.

Every `customtkinter` main application has the following generalized structure:

Code

```
import customtkinter

# Appearance settings
customtkinter.set_appearance_mode("dark")  # Modes: "System" (standard), "Dark", "Light"
customtkinter.set_default_color_theme("blue")  # Themes: "blue" (standard), "green", "dark-blue"

# Application instance for main window
app = customtkinter.CTk()

# Window geometry
app.geometry("400x780")

# Application title
app.title("CustomTkinter simple_example.py")

# Frame
frame_1 = customtkinter.CTkFrame(master=app)
frame_1.pack(pady=20, padx=60, fill="both", expand=True)

# Widget
label_1 = customtkinter.CTkLabel(master=frame_1, justify=customtkinter.LEFT)
label_1.pack(pady=10, padx=10)

# Loop calling (keeps window open until closure)
app.mainloop()
```

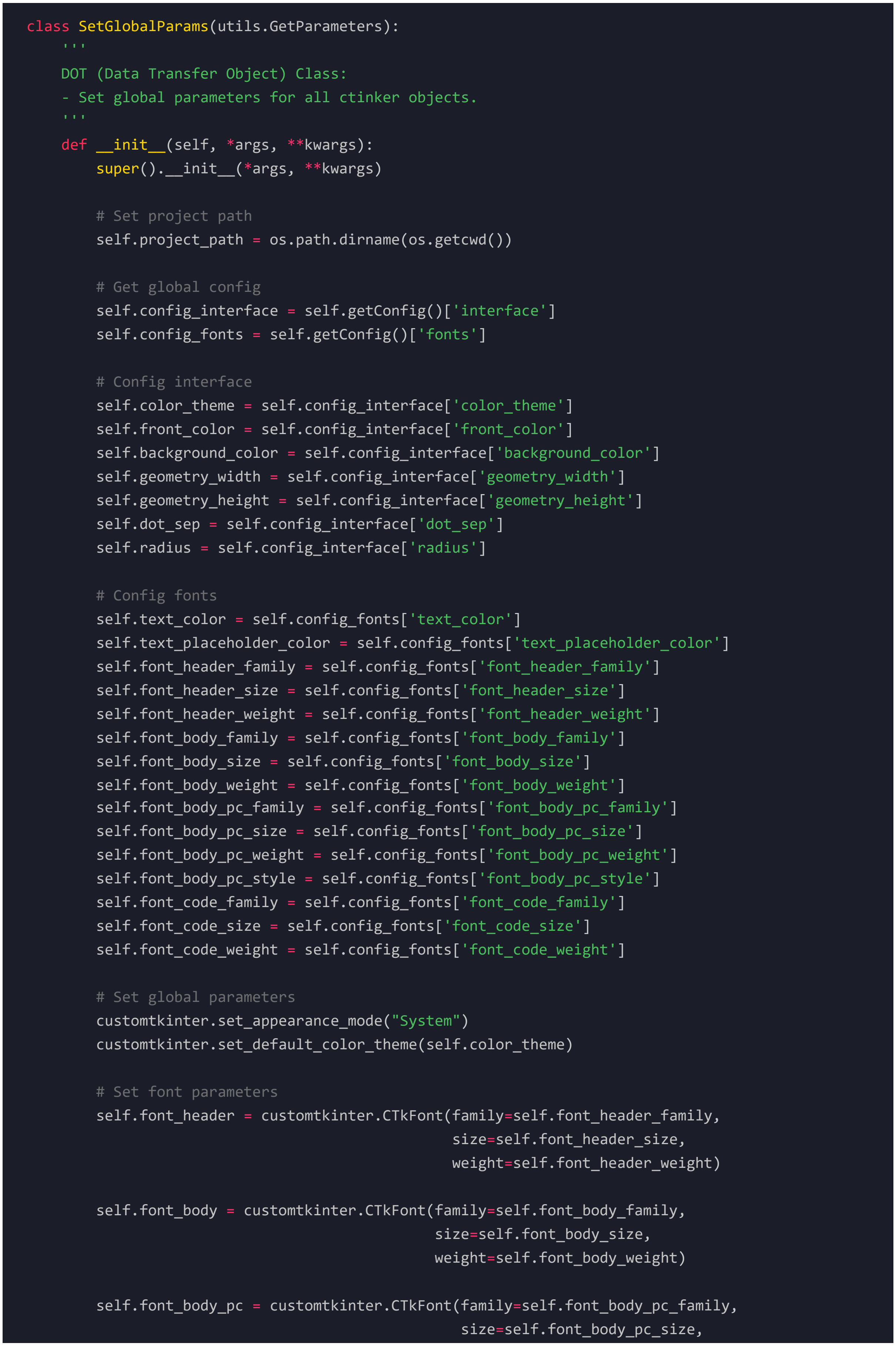
Conversely, we can also use a different class, `customtkinter.CTkToplevel`, instead of `customtkinter.CTk` in order to define secondary windows or prompts inside our main GUI.

This is as simple as a GUI can get, and from there, we can build *n* number of frames and widgets. Since we'll be building our application using a class approach, we'll do things slightly different.

1. SetGlobalParams

The first thing we'll do, is define a class which will set global parameters for the 3 GUI classes we'll be writing. We'll head to our `_app.py` module, and include the following:

Code



```python
class SetGlobalParams(utils.GetParameters):
    '''
    DOT (Data Transfer Object) Class:
    - Set global parameters for all ctinker objects.
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

        # Set project path
        self.project_path = os.path.dirname(os.getcwd())

        # Get global config
        self.config_interface = self.getConfig()['interface']
        self.config_fonts = self.getConfig()['fonts']

        # Config interface
        self.color_theme = self.config_interface['color_theme']
        self.front_color = self.config_interface['front_color']
        self.background_color = self.config_interface['background_color']
        self.geometry_width = self.config_interface['geometry_width']
        self.geometry_height = self.config_interface['geometry_height']
        self.dot_sep = self.config_interface['dot_sep']
        self.radius = self.config_interface['radius']

        # Config fonts
        self.text_color = self.config_fonts['text_color']
        self.text_placeholder_color = self.config_fonts['text_placeholder_color']
        self.font_header_family = self.config_fonts['font_header_family']
        self.font_header_size = self.config_fonts['font_header_size']
        self.font_header_weight = self.config_fonts['font_header_weight']
        self.font_body_family = self.config_fonts['font_body_family']
        self.font_body_size = self.config_fonts['font_body_size']
        self.font_body_weight = self.config_fonts['font_body_weight']
        self.font_body_pc_family = self.config_fonts['font_body_pc_family']
        self.font_body_pc_size = self.config_fonts['font_body_pc_size']
        self.font_body_pc_weight = self.config_fonts['font_body_pc_weight']
        self.font_body_pc_style = self.config_fonts['font_body_pc_style']
        self.font_code_family = self.config_fonts['font_code_family']
        self.font_code_size = self.config_fonts['font_code_size']
        self.font_code_weight = self.config_fonts['font_code_weight']

        # Set global parameters
        customtkinter.set_appearance_mode("System")
        customtkinter.set_default_color_theme(self.color_theme)

        # Set font parameters
        self.font_header = customtkinter.CTkFont(family=self.font_header_family,
                                                 size=self.font_header_size,
                                                 weight=self.font_header_weight)

        self.font_body = customtkinter.CTkFont(family=self.font_body_family,
                                               size=self.font_body_size,
                                               weight=self.font_body_weight)

        self.font_body_pc = customtkinter.CTkFont(family=self.font_body_pc_family,
                                                  size=self.font_body_pc_size,
                                                  weight=self.font_body_pc_weight,
                                                  slant=self.font_body_pc_style)

        self.font_code = customtkinter.CTkFont(family=self.font_code_family,
                                               size=self.font_code_size,
                                               weight=self.font_code_weight
                                               )

        # Set global params for other classes
        self.threshold_top = 0.70
        self.threshold_bottom = -0.70

        # Define plot parameters
        # Remove cache in order to set font attributes successfully
        try:
            shutil.rmtree(matplotlib.get_cachedir())
        except FileNotFoundError:
            pass

        plt.style.use('ggplot')
        self.color_main = '#1a1a1a'
        self.text_padding = 18
        self.title_font_size = 17
        self.label_font_size = 14
        self.subptitle_y = 0.98
```

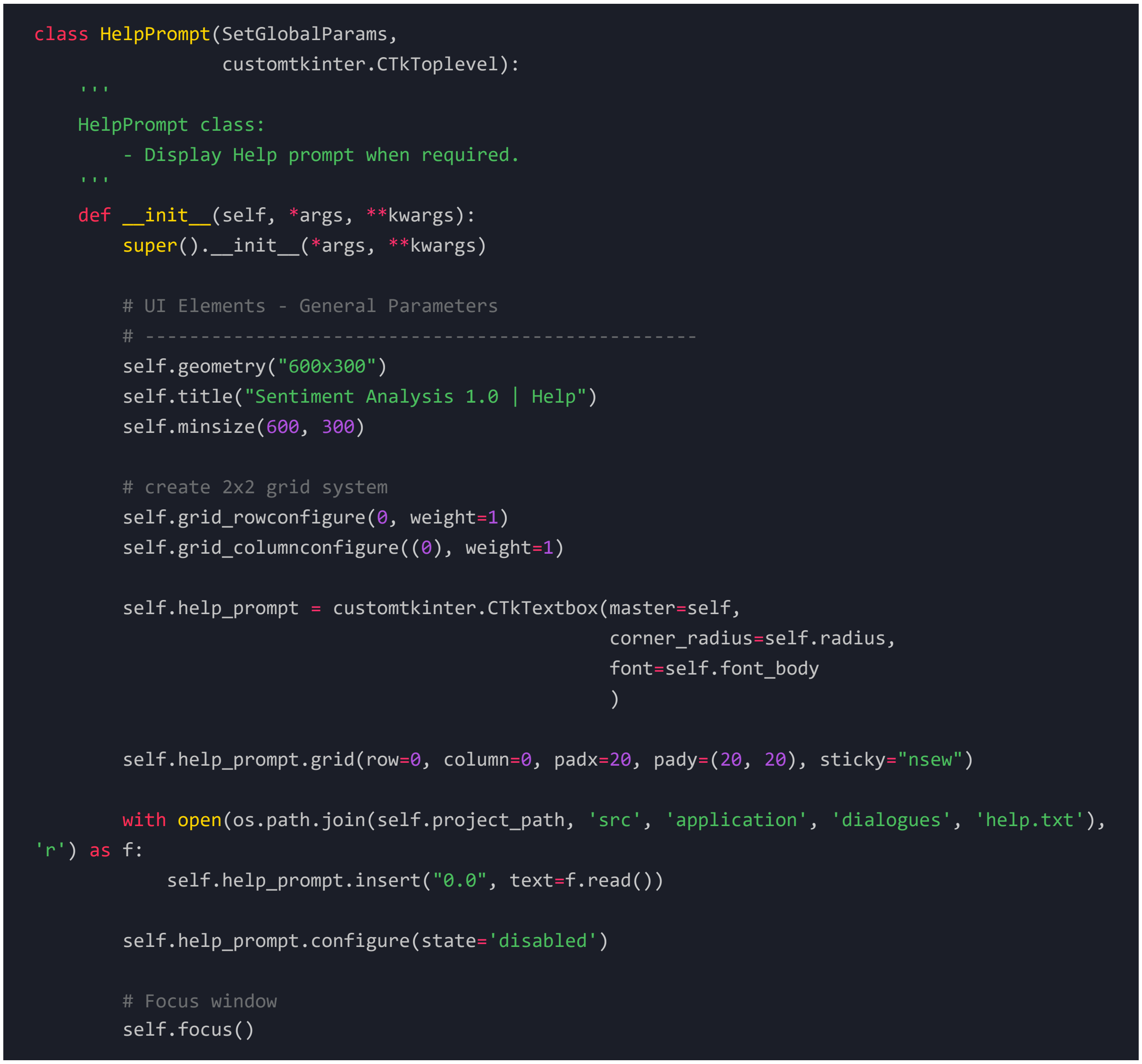
Here, we have extracted our configuration parameters defined in the `parameters.toml` file as well as some other parameters such as plot formatting, and set them as class attributes. This way, when we inherit `SetGlobalParams` from any other class, we will have access to those.

2. Help & About prompts

We can now define our popup windows, `HelpPrompt` and `AboutPrompt`. These objects will be very simple and just contain a frame and a text box widget. The text box widgets will get their text from the following files:

- `src/application/dialogues/about.txt`
    - Project Information
    - Contact Information
- `src/application/dialogues/help.txt`
    - Select Model
    - Select Analysis Type
    - Select Chart Background
    - Select Plot Color Scheme
    - Select NLTK Analysis Top N Words
    - Select NLTK Analysis Threshold
    - Select Operation Mode
    - Select Operation Time
    - Select Columns
    - Select Input Path
    - Select Output Path

Code



```
class HelpPrompt(SetGlobalParams,
                 customtkinter.CTkToplevel):
    '''
    HelpPrompt class:
        - Display Help prompt when required.
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

        # UI Elements - General Parameters
        # --------------------------------------------------
        self.geometry("600x300")
        self.title("Sentiment Analysis 1.0 | Help")
        self.minsize(600, 300)

        # create 2x2 grid system
        self.grid_rowconfigure(0, weight=1)
        self.grid_columnconfigure((0), weight=1)

        self.help_prompt = customtkinter.CTkTextbox(master=self,
                                                    corner_radius=self.radius,
                                                    font=self.font_body
                                                    )

        self.help_prompt.grid(row=0, column=0, padx=20, pady=(20, 20), sticky="nsew")

        with open(os.path.join(self.project_path, 'src', 'application', 'dialogues', 'help.txt'),
'r') as f:
            self.help_prompt.insert("0.0", text=f.read())

        self.help_prompt.configure(state='disabled')

        # Focus window
        self.focus()
```

Code

```
class AboutPrompt(SetGlobalParams,
                  customtkinter.CTkToplevel):
    '''
    AboutPrompt class:
        - Display About prompt when required.
    '''
    def __init__(self, *args, **kwargs):
        super().__init__(*args, **kwargs)

        # UI Elements - General Parameters
        # --------------------------------------------------
        self.geometry("600x300")
        self.title("Sentiment Analysis 1.0 | About")
        self.minsize(600, 300)

        # create 2x2 grid system
        self.grid_rowconfigure(0, weight=1)
        self.grid_columnconfigure((0), weight=1)

        self.about_info = customtkinter.CTkTextbox(master=self,
                                                   corner_radius=self.radius,
                                                   font=self.font_body)

        self.about_info.grid(row=0, column=0, padx=20, pady=(20, 20), sticky="nsew")
        with open(os.path.join(self.project_path, 'src', 'application', 'dialogues',
'about.txt'), 'r') as f:
            self.about_info.insert("0.0", text = f.read())

        self.about_info.configure(state='disabled')

        # Focus window
        self.focus()
```

As mentioned earlier, these windows inherit from the `customtkinter.CTkToplevel` class instead of the `customtkinter.CTk` class.

3. Main window

We can now define our main window with the following widgets:

- `CTkLabel`: A text label used for titles.
- `CTkButton`: An actionable button.
- `CTkOptionMenu`: A menu containing multiple items to select from.
- `CTkTabview`: A tab menu.
- `CTkSlider`: A slider which can be horizontal or vertical.
- `CTkEntry`: A text entry.
- `CTkTextbox`: A text box which can be used for writing or reading only.
- `CTkProgressBar`: A bar which fills up upon some event.

3.1 Variable setting

The first thing we'd like to do, is define the variables we will use for each widget. `tkinter` provides variable objects for various types such as `int`, `float`, `str` and `datetime`. These variables also have getter methods included, so if the user sets a variable using the GUI, we can retrieve that value without calling it directly.

The general syntax for a variable definition is the following:

Code

```
self.var_rdir = tkinter.StringVar(value=variable_name)
```

Since we have a parameter file `parameters.toml` and a getter function `getParams()` already in place, we can simply assign variables using the following syntax:

Code

```
self.params_directories = self.getParams()['directories']
self.var_rdir = tkinter.StringVar(value=self.params_directories['rdir'])
```

The first statement will get the `directories` section, while the second one will extract the required value.

If we want to get the parameter's value at any point in time, we can simply use the following syntax:

Code

```
self.var_wdir.get()
```

If we have a parameter containing multiple options and would like to set a default value on one of our widgets, we can use the following syntax:

Code

```
self.config_operation = self.getParams()['operation']
self.var_model =  tkinter.StringVar(value=self.config_operation['model'][0])
```

3.2 Window geometry and structure

Once we have all of our variables defined, we'll set our main window geometry, app title, and an optional favicon. For the dimensions, we're inheriting the `geometry_width` and `geometry_height` attributes from our `SetGlobalParams` class:

Code

```
self.iconbitmap('digital_assets/favicon_code_white.ico')
self.geometry(f"{self.geometry_width}x{self.geometry_height}")
self.title('Author | Sentiment Analysis 1.0')
```

Note that our icon must be in `.ico` file format. We can convert from `.png` using this link.

Once we have our main window ready, we will continue by defining our grid layout. If we recall from our GUI concept sketch, we have 2 main columns: The first one for the left side bar, and the second one containing everything else.

We can achieve this layout by specifying a grid of 2 columns, and 1 row:

Code

```
self.grid_columnconfigure(1, weight=1)
self.grid_rowconfigure(0, weight=1)
```

The `weight=1` parameter tells `customtkinter` that the section will fill the window instead of keeping its size to fit the contents.

The next thing is to start defining our sidebar frame and main frame. The general syntax for a frame is as follows:

Code

```
self.sidebar_frame = customtkinter.CTkFrame(self, width=140, corner_radius=self.radius)
self.sidebar_frame.grid(row=0, column=0, rowspan=7, sticky="nsew")
self.sidebar_frame.grid_rowconfigure(7, weight=1)
```

- The `.grid` method denotes the global position for our frame. Coordinates 0, 0 would mean a location in the first row and first column of our window.
- The `rowspan` attribute extends our frame to whichever row coordinates we desire. If we specify a span of 7, the frame will extend the full height of our window, which is what we're looking for in our sidebar.
- Finally, we set 8 rows inside our frame, which will contain each widget.

3.3 Sidebar widgets

Now that we have our grid, we can start populating with widgets:

Code

```
self.logo_label = customtkinter.CTkLabel(self.sidebar_frame,
                                         text="Sentiment Analysis 1.0",
                                         font=self.font_header)

self.logo_label.grid(row=0, column=0, padx=20, pady=(20, 10))
```

We specify a `CTkLabel` widget by defining an instance of it, and including the following attributes:

- `self.sidebar_frame`: The parent frame.
- `text`: The text to display.
- `font`: The font to use.

We then locate our widget instance in a grid by using the same coordinate principles as in the example above.

The Help & About buttons have an action associated to them; we would like for the prompts to display to the user upon button click. Hence, we will associate a command with them:

Code

```
self.help_prompt = customtkinter.CTkButton(self.sidebar_frame,
                                           text="Help",
                                           font=self.font_body,
                                           command=self.openHelpPrompt,
                                           corner_radius=self.radius)

self.help_prompt.grid(row=1, column=0, padx=20, pady=10)
```

A command or event is simply a function we declare, that will get called upon interaction with our object. The Help button would be associated with the following event:

Code

```
def openHelpPrompt(self):
    '''
    Event: Open Help prompt.
    '''
    if self.toplevel_window is None or not self.toplevel_window.winfo_exists():
        self.toplevel_window = HelpPrompt(self)
    else:
        self.toplevel_window.focus()
```

Here, we're creating an instance of the `HelpPrompt` class whenever we call the `openHelpPrompt` function. We can do the same for the About prompt.

We will now define the application appearance option menu:

Code

```
self.appearance_mode_optionemenu = customtkinter.CTkOptionMenu(self.sidebar_frame,
                                                                values=["System", "Light",
"Dark"],
                                                                corner_radius=self.radius,

command=self.changeAppearanceMode,
                                                                font=self.font_body,
                                                                dropdown_font=self.font_body)

self.appearance_mode_optionemenu.grid(row=7, column=0, padx=20, pady=(10, 40))
```

For an option menu, we need a set of possible values to display. We also need a command to execute when the user interacts with our widget.

The `changeAppearanceMode` event will look like such:

Code

```python
def changeAppearanceMode(self, new_appearance_mode: str):
    '''
    Event: Change application appearance.
    '''
    customtkinter.set_appearance_mode(new_appearance_mode)
```

3.4 Main widgets

Once we have our sidebar, we will include the following:

- Tab frame:
    - Model selection: Switch between models.
    - Analysis: The type of analysis to export, the chart background and the plot color scheme.
    - Advanced options: The top n words and score threshold to export in the grammatical analysis we will review further on.
- Operation parameters:
    - Operation mode: Read or download.
    - Operation time: Time in seconds between each text log insertion.
- Text log
- Column selection:
    - Up to 4 aggregating columns.
    - One target column.
    - One index column.
    - One rating column.
- Path selection
    - Datasets or URL file
    - Outputs for analysis export.
- Progress bars
    - Download/Load
    - Model execution
    - Analysis

3.4.1 Option menus

We can set an option menu where values are extracted from our `parameters.txt` file by using the following syntax:

Code

```python
self.model_name = customtkinter.CTkOptionMenu(self.parameters.tab("Model"),
                                                dynamic_resizing=False,
                                                values=self.getParams()['operation']['model'],
                                                corner_radius=self.radius,
                                                font=self.font_body,
                                                dropdown_font=self.font_body,
                                                width=self.option_box_width,
                                                variable=self.var_model
                                                )

self.model_name.grid(row=1, column=0, padx=20, pady=(10, 10))
```

- The `values` parameter will be set to our getter function for the parameter we're looking for.
- The `variable` parameter will be set to the previously set variable. This will change whenever the user changes option.

3.4.2 Horizontal slider

We can define a horizontal slider for our threshold values by using the following syntax:

Code

```
self.nltk_threshold = customtkinter.CTkSlider(master=self.parameters.tab("Advanced"),
                                               from_=0,
                                               to=1,
                                               variable = self.var_nltk_threshold,
                                               command=self.returnThresholdVal
                                               )

self.nltk_threshold.grid(row=3, column=0, padx=(20, 10), pady=(10, 10), sticky="ew")
```

- Since we want our values to range from 0 to 1, we set the two attributes, `from_` and `to` to reflect our desired range.
- We also set a `variable` and a `command` to execute.

Since we want our slider variable to change, but also to reflect to the user, we will define the following function:

Code

```
def returnThresholdVal(self, value):
    '''
    Event: Get threshold values and print to text log.
    '''
    self.threshold_value_bottom_curr = self.padStr('THRESHOLD TOP', f'+{round(value, 4)}')
    self.threshold_value_top_curr = self.padStr('THRESHOLD BOTTOM', round(-value, 4))
    self.insertLog(f"{self.threshold_value_top_curr}\n",
                   f"{self.threshold_value_bottom_curr}\n",
                   clear=True)
```

We can notice two new methods we included:

- `padStr`
- `insertLog`

The first method generates a justified string output filled with dot `.` characters, so that our information is presented to the user in the following format:

```
PARAMETER........VALUE
PARAMETER_2......VALUE2
```

The second method comes from our `_string_formatting.py` module and inserts an entry into the text log we will soon define.

3.4.3 Text log

A text log is a useful tool which we can use in order to present valuable information to the user. The idea is to print status updates to the user upon key progress part completions.

A text log can be defined using the following syntax:

Code

```
self.textlog = customtkinter.CTkTextbox(self.textbox_frame,
                                        width=450,
                                        wrap='word',
                                        font=self.font_code
                                        )

self.textlog.grid(row=0, column=0, padx=(20, 20), pady=(20, 20), sticky="nsew")
```

To insert an entry into our text box instance, we can use the following syntax:

Code

```
self.textlog.configure(state="normal")
self.textlog.delete("0.0", "end")
self.textlog.insert("0.0", 'Text')
self.textlog.configure(state="disabled")
self.update_idletasks()
```

- The `state` dictates if the prompt is read-only, or has the capacity to be written into. Since we don't want the user to be able to write in our log window, we need to disable it after each insertion, and enable it again before we insert our text.
- The `delete` method clears the window and makes sure we have a clean prompt before our insertion. The two parameters included denote:
  - From character `0`, line `0`
  - Up to the end
- The `insert` method inserts a line of text at position character `0` line `0`, with message `Text`, which can of course be assigned to a variable.
- The `update_idletasks` updates pending tasks when called. Without this statement, we would see the insertion reflected only after our execution concludes.

3.4.4 Text entries

A text entry can be defined using the `CTkEntry` method. Whenever the user inputs a value, it gets registered as a variable of our choice, which we can use at any time during the execution.

The basic syntax is as follows:

Code

```
self.col_entry_1 = customtkinter.CTkEntry(self.column_entry,
                                            placeholder_text="Column 1",
                                            corner_radius=self.radius,
                                            font=self.font_body_pc,
                                            placeholder_text_color=self.text_placeholder_color,
                                            textvariable=self.var_col1
                                            )

self.col_entry_1.grid(row=1, column=0, padx=(10, 10), pady=(10, 10), sticky="new")
```

- The `placeholder_text` attribute sets a temporary indicator inside the text entry.
- The `textvariable` denotes the variable we will be assigning to the text entry input.

3.4.5 Progress Bars

A progress bar is a graphical control element used to visualize the progression of an extended computer operation. We want to provide the user a way to visualize the overall progress of the execution, divided into 3 main steps:

- Download/Load
- Model execution
- Results analysis

A progress bar can be defined using the following syntax:

Code

```
self.progressbar_1 = customtkinter.CTkProgressBar(self.progress_frame,
                                                    mode='determinate',
                                                    height=self.progress_bar_height,
                                                    corner_radius=self.radius)

self.progressbar_1.grid(row=1, column=0, padx=(20, 20), pady=(10, 10), sticky="new")
self.progressbar_1.set(0) # Set to 0, since by default, it will be set to 0.5
```

- The `mode=determinate` attribute denotes that we know the length of our process in terms of a numerical value. We will calculate this further on.
- The `height` will denote the actual bar height in our GUI.
- The initial value will always be 0, which we can define using the `progressbar_1.set(0)` method.

A progress bar update event can be defined as such:

Imagine we have a DataFrame object of `len=30,000`, and we wish to iterate over all elements. Since we know the length of our object, we can define a step size scaled to a range `[0, 1]` by performing the following operation:

Code

```
total_items = len(df)
progress_2_step = 1/total_items
```

Upon each iteration, we would be increasing the step by a step size unit. We could keep count of our total progress by adding our step size on each iteration, and then setting our progress bar to this value:

Code

```
progress_2_perc = 0
self.progressbar_2.start()

for col_id, target in target_data.iterrows():
    progress_2_perc += progress_2_step
    self.progressbar_2.set(progress_2_perc)
    self.update_idletasks()

self.progressbar_2.stop()
```

This way, when our iteration concludes, our sum has reached the total number of iterations scaled to a range of `[0, 1]`, and the progress bar will reflect completion.

UI Components

Text log

We will define a `textlog` object which will display useful messages to the user. Here, the user will be able to monitor the end-to-end process.

A typical insertion has the following generalized structure:

Code

```
# Enable textlog entries
self.textlog.configure(state="normal")

# Insert the required text using the print_position attribute
self.textlog.insert(self.print_position, f"ENTERING DOWNLOAD MODE\n\n")

# Disable textlog entries
self.textlog.configure(state="disabled")

# Update idle tasks
# i.e. Make text appear during run, regardless of current process status
self.update_idletasks()
```

We will also use an alternative structure which will include a string pre-formatting function. This will be useful when we're printing a variable name along with its value to screen; it will make the output clearer.

For these two actions, we will create two separate functions by creating a `string_formatting.py` library inside our `resources` folder:

Code

Back-End

Preprocessing

We will define a `preprocessData()` function in order to either download or load data sets, depending on the user's choice.

This function will accept keyword arguments `**kwargs` which we will provide upon the function call later on.

It is bad practice to specify required parameters as part of the `**kwargs` since, if left unspecified, our program will not find them and return an error. To ensure this does not happen, we mentioned that we created a `.toml` file containing default arguments for all keyword arguments passed.

Inside `preprocessData()`, we will define 4 child functions:

- `downloadData()`

Downloading

This function will download the user-specified datasets if the mode is set to `Download Mode`. A complete data set can be in the form of a `.csv`, `.gz` or `.tsv` file.

If a dataset already exists, it will not be downloaded. Otherwise, it will be downloaded

Reading

A given dataset will be read to a `polars.DataFrame` object. All the preprocessing will be performed on this object, which will provide processing speed advantages over the traditional `pandas.DataFrame` alternative.

Default arguments

Management

There are some measures we can implement in order to avoid bugs derived from unspecified arguments. These will ensure that our program runs smoothly:

- Specifying a dictionary of default arguments: In this example, a `.toml` file with default arguments is passed. These parameters are initialized at the beginning of `main.py`, so all required arguments will have a default value without exception. These default parameter files are not meant for the user to modify. Instead, the user can change parameters by using the GUI.
- Specifying exception handling carefully: Each input must have an exception handler. If a value. We already have implemented a failsafe for default arguments, but still, the user might input arguments in incorrect forms. To counteract this, exception handles are implemented on each critical step of the downloading, reading and writing process.

Source file for target URL specification

A `.txt` file must be created inside the input directory, using the name `source.txt`. This file contains all URLs for downloading target datasets which we wish to process and analyze. If this file is not provided, the program will raise an exception.

Preprocessing data

VADER Model

https://www.youtube.com/watch?v=QpzMWQvxXWk
https://www.youtube.com/watch?v=Ew72EAgM7FM
https://towardsdatascience.com/the-most-favorable-pre-trained-sentiment-classifiers-in-python-9107c06442c6
https://www.google.com/search?q=beautiful+python+gui&tbm=isch&client=firefox-b-d&hl=en&sa=X&ved=2ahUKEwja2KT4s779AhX-2skDHWv5B2sQrNwCKAB6BQgBEPQB&biw=1920&bih=919#imgrc=IY1ipTmyw464FM&imgdii=Pu6U445c1OHxsM

Library:

- `from nltk.sentiment import SentimentIntensityAnalyzer`

Assumptions:

- Stop words are removed.
- Each word is scored and combined to a total score.\
- Context is not taken into account.

§

Conclusions

We've reviewed multiple yet simple mechanisms we can employ to make our code cleaner, more elegant, modular, usable, scalable and safer. These measures can not only help us become better programmers but better collaborators. It will make reading code a pleasure instead of an agonizing process and instantly boost our credibility.

§

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