Using Natural Language Processing to Analyse the Shape of Stories

Luca Davies
BSc. (Hons.) Computer Science

March 2020

Declaration

I certify that the material contained in this dissertation is my own work and does not contain unreferenced or unacknowledged material. I also warrant that the above statement applies to the implementation of the project and all associated documentation. Regarding the electronically submitted work, I consent to this being stored electronically and copied for assessment purposes, including the School's use of plagiarism detection systems in order to check the integrity of assessed work.
I agree to my dissertation being placed in the public domain, with my name explicitly included as the author of the work.

Name:
Date:

Abstract

This report examines the application of Natural Language Processing and Sentiment Analysis to fictional texts in an attempt to summarise narrative arcs as a curve on axes of time against positive/negative sentiment. VADER is used to process text for sentiment analysis and further experimentation is carried out to analyse how suitable VADER may be for this task. Corpora was mainly sourced from Project Gutenberg. A tool was developed to carry out a range of experiments on sentiment analysis that employed VADER as it's sentiment analysis engine. Experimentation was carried out in the context of sentiment analysis around the following topics: the coarseness of sentiment analysis; the accurarcy of VADER at sentence level via hand-tagging; sentiment analysis vs. analysis by human readers; early-modern English vs. modern English; Shakespearean comedies vs. tragedies. It was discovered that a more powerful and versatile sentiment analysis engine would likely be needed to produce more readable curves and that a more flexible tool would prove useful for processing different text styles, such as scripts.

Contents

1 Introduction

1.1 Overview

Writer Kurt Vonnegut suggested at various points in his career that all stories may be categorised into a relatively small number of basic archetypes based upon the emotional ups and downs experienced within the narrative. He gave each of these novel names such as Man-In-Hole and Boy-Meets-Girl as a simple reference for each. [2]

Literature is one of the defining features of the human race. No other creature on Earth can writes, let alone writes about itself. Humanity takes this a step further again, making up fictitious stories, some rooted in reality, some with no basis at all in which we dream and imagine worlds and situations that may never be possible to achieve. Through written word we express emotion. All emotions, happiness, sadness, anger and fear; love, hate, awe and grief – everything humans can feel, we write about. We create characters to express and receive these emotions, they act as vehicles to transfer their feelings to a reader. With all this freedom to write and create without bound, are we actually as free as we perceive?

Vonnegut suggests that all stories are members of one of a very small number of categories of story that define roughly how the emotional progression of that story pans out. Do writers naturally and unknowingly write literature that falls into these types or is each story as unique as the next, taking its readers along its own path as they go?

This concept and these questions drew me toward this project proposal. Not only is it a fascinating endeavour to map the emotions of a novel, but as an exploration of the freedom of writers to convey emotions and of how humans often generate categories and groups without even trying.

With the high-level view clarified, it's important to note the tools within natural language processing that are relevant, namely that in this study, sentiment analysis takes the spotlight. Emotional analysis is a more in-depth field that shifts focus toward the psychological analysis ([1]) and employs machine learning and artificial intelligence to further predict and understand the emotions presented in text.

1.2 Motivation

At it's core, this study is novel. It is interest driven - to attempt to show that stories can be categorised in a very simple and easy manner based upon the emotional arcs they lead readers across is an interesting new way to sort fiction. There may not be any significant *need* to categorise literature in this way, however it has the potential to lead to further studies.

1.3 Aims & Objectives

The aims of this report are as such:

- Design and develop an application to process a range of corpora to produce a graphing of the emotional arc during its literary course (as produced using SA)

- Analyse a range of corpora for compliance with Kurt Vonnegut's theories and story shapes
- Otherwise attempt to identify potential trends in the texts processed, such as obvious geometric differences between literature generally considered happy/sad
- Present graphs of texts to readers who are familiar with the text to assess if their perceptions of the text align with the SA graphs
- Assess VADER's ability to process text outside its design remit (e.g. early-modern English)

1.4 Report Structure

The reminader of this report will disucss relevant background and context **??**, the design and implementation of the Sentiplot tool (section 3), followed by a detailing of the experimentation carried out (section **??**). The report will then be concluded by an analysis of the results acquired from this experimentation in section 5.

2 Background

2.1 Overview

This chapter will examine and summarise existing literature and studies in this area and topic. That is, natural language processing and sentiment analysis as a tool for extracting statistical data that describe emotions in (mainly) fictional works of literature.

The processes involved for finding useful information included searching for online articles and pre-existing projects while searching libraries to use in the implementation, Google Scholar, Lancaster University Library OneSearch and Kurt Vonnegut's own lectures on this topic.

Existing projects will help to prove the developed application is performing up to standard (or not) and can be used as a side-by-side comparison of literature processed for this report and by these projects as well as to examine the processing of literature unavailable for the purposes of this report.

2.2 Natural Language Processing & Sentiment Analysis

Natural Language Processing (NLP) is a very broad field concerned with, at a high level, the understanding of human language by computers. It fuses linguistics with computer science to not just parse but to *understand* human language, to understand it in such a way that meaning can be deduced and emotion and sentiment can be extracted, even when not fully clear.

Via the beginnings of machine translation, NLP has existed as a research field for decades, even before the current name was coined. Breakthrough projects like ELIZA made progress in the field, but it wasn't until the 1980s that statistical methods began to be used. Prior to this, large sets of hand-written rules governed how NLP systems worked, which, although sometimes effective, limited the overall progress to the manual effort put into the models and rules. In modern NLP toolkits, models are still prevalent, but instead of them being assembled by hand, they are often formed using machine learning techniques based upon employing training data, test data and then real language data.

Sentiment Analysis (SA) is a subfield of NLP that focuses on extracting and subsequently quantifying opinion and sentiment around a topic simply by analysing text. SA is a particularly new field, and has so far mainly be used on corpora that is factual and descriptive: product/movie reviews and social media to gauge general public opinion.

2.3 Kurt Vonnegut on "The Shape of Stories"

Vonnegut described a number of potential story types as displayed below in figure something. He suggested that all stories fit into a very small number of categories, and moreover, that stories from different cultures around the world may generally trend toward different story types compared to elsewhere. In his lecture on the topic Vonnegut draws out the curves of some well known novels and stories to demonstrate his meaning. Drawing distinct curves with very defined turning points and changes in direction that match up with points in the given literature.

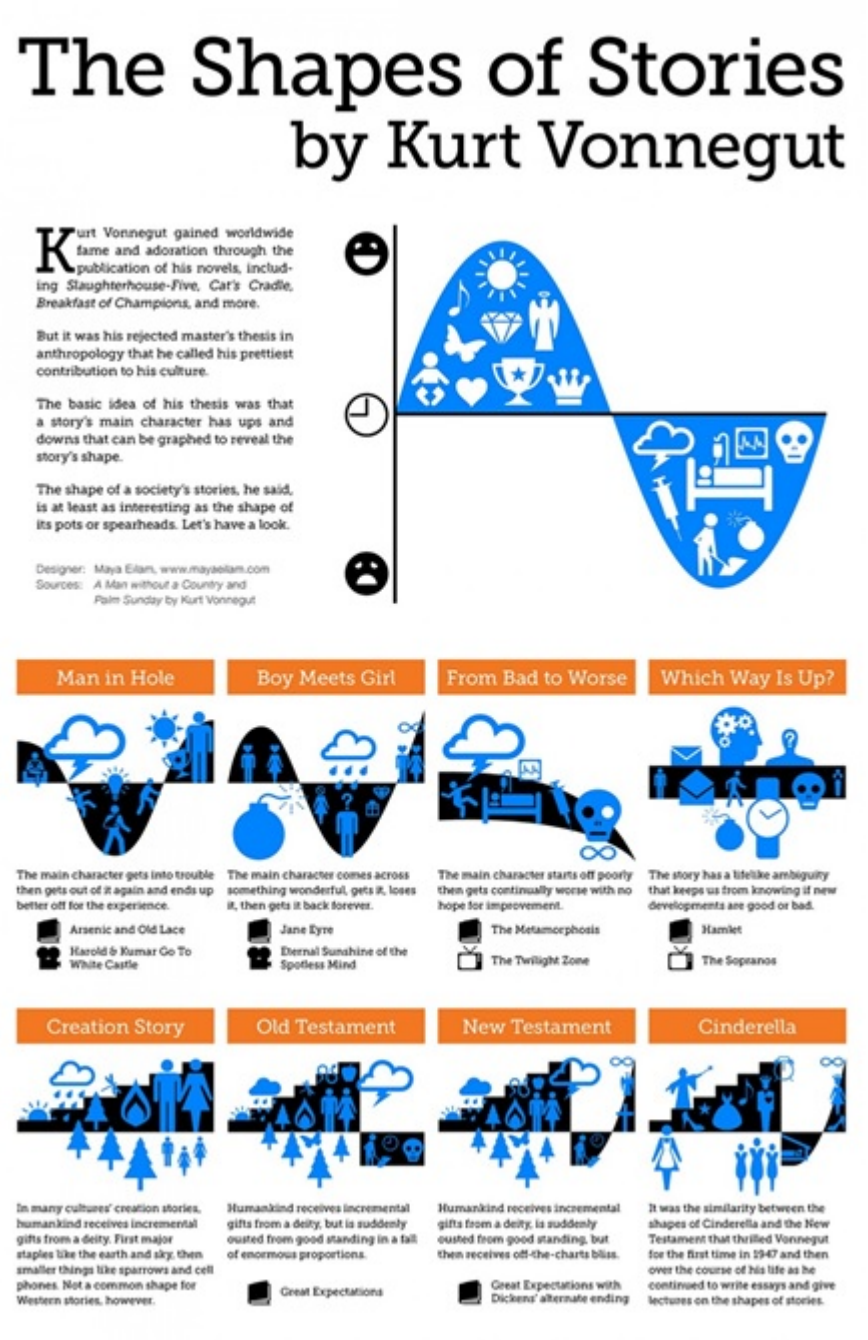


Figure 1: Vonnegut's Story Types

2.4 The Hedonometer Project

The Hedonometer project was established to gauge happiness, the world over, starting with Twitter and other social media outlets. The project's scope has since widened to process corpora direct from books, film scripts, news outlets and other foreign language literature.

3 Sentiplot Tool

This section will detail the design and implementation of the tool used to carry out this study, *Sentiplot*.

3.1 Languages & Libraries

This section briefly discusses the choice of programming language and NLP/SA tools used in the Sentiplot tool.

3.1.1 Top-level Language

When selecting which language would be most appropriate to use for this project, my major considerations were my prior knowledge of potential languages and their ease of creation of a pleasant user interface. Availability of NLP tools in each language was also to be considered, but as the end implementation shows, this was not imperative due to cross-platform and cross-language capabilities of the chosen combination of languages and tools.

A listing of considered languages follows:

- Java
  - Strong language knowledge and familiarity
  - JavaFX and Swing available for interfaces
  - Native language of Stanford CoreNLP
- Python
  - Very limited language knowledge
  - No knowledge of interface building
  - Native language of industry standard NLTK
- C# (with .NET)
  - Strongest language knowledge and familiarity
  - Extreme ease in creating interfaces via Windows Form using Visual Studio
  - Cross-platform variants of CoreNLP and VADER available via simple packages

Taking all these points into consideration C# was selected, due to its pros specific to myself and the availability of non-native libraries via APIs. This permitted me to use the full Microsoft Visual Studio suite for development, including the Windows Forms designer.

3.1.2 Natural Language Processing Tools

Various tools across a wide array of languages are freely available to provide standard NLP functions and advanced processing capabilities.

Initially a full CoreNLP pipeline was employed to process corpora but this proved to be extremely slow, loading around 2 gigabytes of models very slowly into memory before even processing anything. The pipeline was modified to tokenise and sentence-split the input only, and the actual sentiment analysis was performed by VADER.

Both the CoreNLP and VADER libraries are non-native to C# but have easy to use APIs for direct manipulation of their types and methods outside of their native environments. CoreNLP has an in-house developed API for C# and VADER has a third-party API called *VADERSharp*.

3.2 Design & Development

Sentiplot was developed over the course of two academic terms between early October 2019 and late January 2020. The first few weeks involved mainly research into what language was to be used and what NLP/SA tools or toolkits would provide the best mix of suitability-to-task and ease of use. The initial framework and basic features were developed using a waterfall type methodology before later, more experimental features were developed in a more ad hoc manner using an agile development process *after* the main program with built.

The base applicaition was projected to take 4-5 weeks to develop from scratch and the smaller experimental features added after to each take aroudn a week. In reality, this first stage of developement occupied the majority of the time from the start of November through till mid December. Then each of the experimental features pushed on frm there, rolling into the next term, rather than all being finished before the Christmas holidays. Thankfully this did not cause major issues as there was an excess of time set aside for write up in the second term. Final bits of development including housekeeping and codestyling wrapped up approaching week two of February 2020, still allowing time for this report write-up.

As in discussed in section 3.1.1, C# was the language used and Windows Forms was the user interface framework chosen. A full Visual Studio (Community) development suite was used to design, build and test the application which allowed for relatively switft and easy development due to the neat integration bewteen the technologies. Had a different, less familair language/framework been adopted, further schedule overruns may have occured. StanfordCoreNLP was at one point the NLP tool of choice, however, dificulty and delay in marrying its Java libraries to C# and setting up its processing pipeline are in large part what encouraged the eventual swap to VADER in early December.

As the language and framworks use lend themselves to it, the application is built with an object-oriented pattern in mind, however this doesn't come to light much as the application is somewhat self-contained - no other classes or applications need interface with it, Sentiplot only uses simple API calls to any external libraries.

The overall internal structure of Sentiplot is not massively complicated. It is detailed in section 3.3.

3.3 Implementation

3.3.1 Structure

The application is written in C# .NET interfacing with both Java and Python libraries via APIs as detailed in sections 3.1.1 and 3.2. Windows Forms was chosen for the interface as a quick and easy to build platform, stable on Windows with seamless integration into C# and the .NET framework.

The application is composed of two forms, each with their designer code. The first allows the user to select a file to load text from and set processing granularity. The second presents the results of the analysis in multiple ways and provides facility to save these results as images of the output graphs.

3.3.2 Sentiplot Form (Main Form)

This is the main form for the application. It is loaded on start-up and contains all needed information or otherwise calls other classes to complete its task.

Its key functions include:

- Initialising the CoreNLP pipeline ot tokenise the input text
- Generating an OpenFileDialog object to allow the user to select a *.txt* or *.html* file
- Parsing the content of the input file to prepare it for processing using regular expressions and simple character-based splitting

3.3.3 ResultsViewer

This form displays the results of VADER's processing of the input text. It displays a graph of the entire text from start to finish, a full list of all tokenised sentences and their associated sentiment scores (in tabular form) and individual graphs for each chapter in the text (HTML file only).

- Handling the output data and feeding it into the main chart and table
- Allow hiding/showing of each different type of sentiment score for the main graph
- Dynamically producing more tabs on the form to show each successive group of five chapters

3.4 User Interface

The implemented interface did not need to be excessively complex or particularly appealing as it mainly served to function as a harness to conduct the study, with more importance placed on the code-behind and results.

To provide quick results and ease of programming, I used the Windows Forms suite to produce a visually simple but functional interface. It has two screens: a screen to load the desired text to be processed and to set the granularity of the analysis, and a screen to present the processed results. The following sections provide an overview of these screens.

3.4.1 Text Selection & Options

Figure 2 shows the main presented screen, after having loaded an HTML file (Hamlet in this case) which has been parsed to produce plaintext, having stripped out all the unneeded HTML tags.

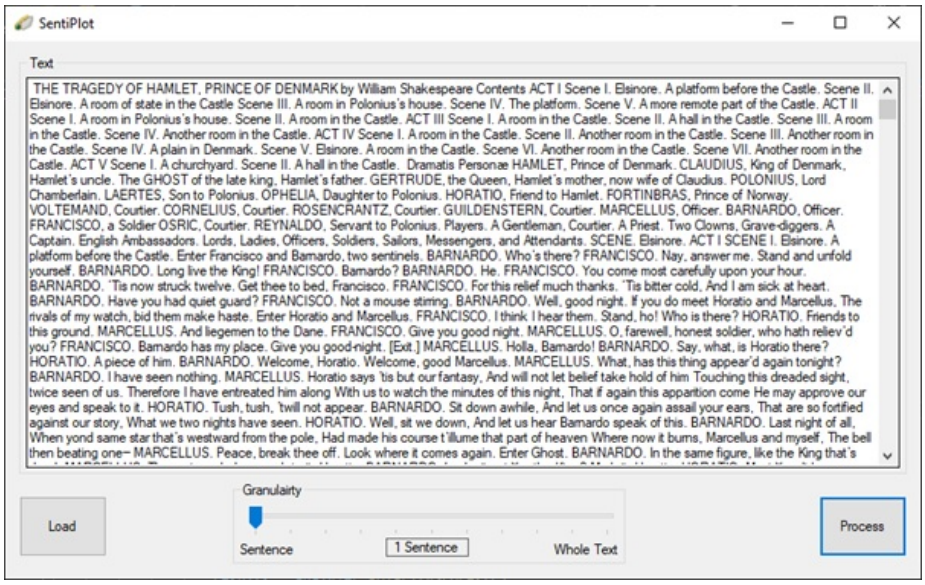


Figure 2: Main Sentiplot window

3.4.2 Results Display

Figure 3 shows the results screen for Hamlet, initially showing the graph of the entire text. The maximum and minimum points are labeled with the start of the related sentence. Hovering the mouse over these labels shows the entire sentence or sentences that produced that datapoint.

For every sentence analysed VADER returns four sentiment scores: positive, neutral and negative (each holding a -1 to 1 score regarding match to that sentiment), and compound which acts as a single representation for the sentiment in the sentence parsed. Each of these scores have their own graph which may have their visibility toggled on and off with the check boxes in the bottom left. (Default is compound alone, as it proved the most indictive of sentiment, as advised by VADER documentation.) This graph can be saved to a JPG by clicking the save button.

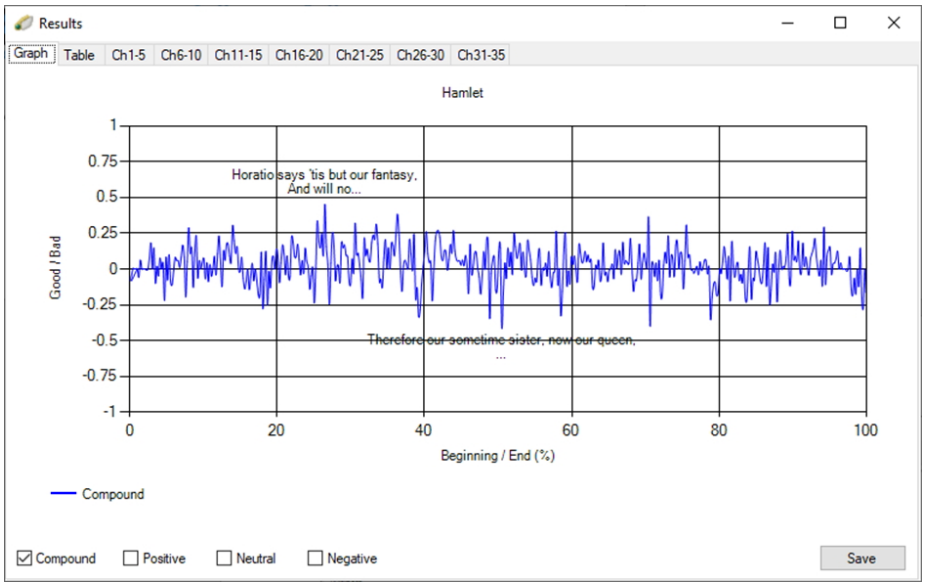
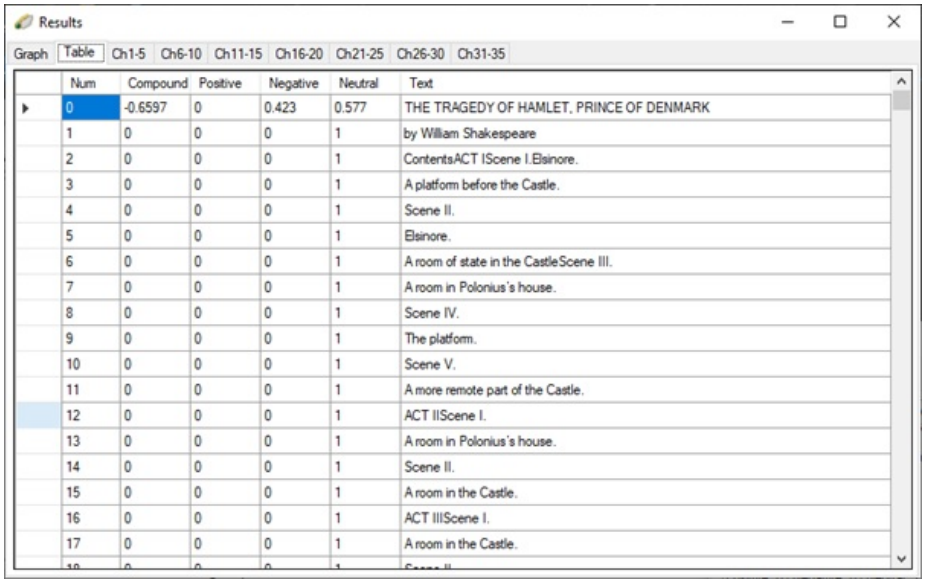


Figure 3: ResultsViewer window

Figure 4 shows the Table tab of the results screen. This simply lists each individual sentence token in the input with VADER's output value for the four scores mentioned previously. The table's default ordering in by sentence index, or the chronological order in the text, but the it may be order by any of the fields shown.



Num	Compound	Positive	Negative	Neutral	Text
0	-0.6597	0	0.423	0.577	THE TRAGEDY OF HAMLET, PRINCE OF DENMARK
1	0	0	0	1	by William Shakespeare
2	0	0	0	1	ContentsACT IScene I.Elsinore.
3	0	0	0	1	A platform before the Castle.
4	0	0	0	1	Scene II.
5	0	0	0	1	Elsinore.
6	0	0	0	1	A room of state in the CastleScene III.
7	0	0	0	1	A room in Polonius's house.
8	0	0	0	1	Scene IV.
9	0	0	0	1	The platform.
10	0	0	0	1	Scene V.
11	0	0	0	1	A more remote part of the Castle.
12	0	0	0	1	ACT IIScene I.
13	0	0	0	1	A room in Polonius's house.
14	0	0	0	1	Scene II.
15	0	0	0	1	A room in the Castle.
16	0	0	0	1	ACT IIIScene I.
17	0	0	0	1	A room in the Castle.

Figure 4: ResultsViewer window showing table

Figure 5 shows one of the chapter tabs from the results screen. Each of graphs the compound sentiment score of up to 5 chapters from the processed

text. Again, maxima and minima are labeled with their relevant sentence(s), expandable by hovering the mouse over the label.

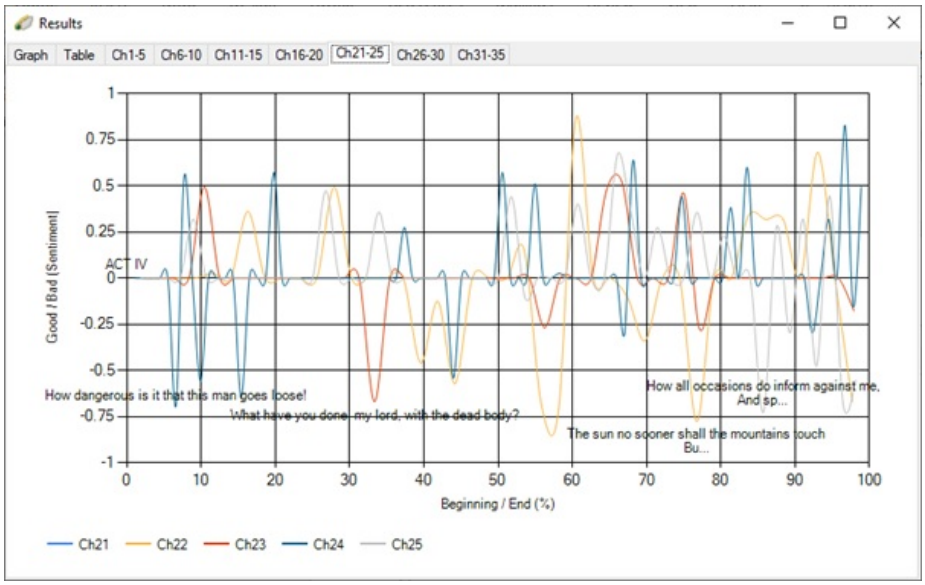


Figure 5: ResultsViewer window showing chapter graphs

4 Experimentation

The following section covers the various experimentation and analysis carried out using Sentiplot as a tool for Sentiment Analysis and graphing accordingly.

4.1 Analysis Block Size

Sentiplot incorporates one primary setting for its analysis of texts: the granularity slider. This allows the user to select varying degrees of granularity for the produced graphs (as a percentage of the text being analysed). This allowed analysis of texts at a number detail levels to find which produced the most obvious curves to conform with Vonnegut's story curves. This may have introduced a small amount of positive-results bias, accepting those granularities that appear most curve-like for a given text instead of what may have actually reflected the curve of the text.

The following options are provided:

- 1 sentence
- 0.1%
- 0.2%
- 0.5%
- 1%
- 2%
- 5%
- 10%
- 25%
- 50%
- 100%

This set of experiments varied the analysis blocksize for a given text and compared the output graphs for the entire text with a view to identifying a specific curve for the text. The comparison is qualitative, employing only human visual reference as opposed to any mathematical function. The purpose of this part of the study was as a forerunner to further analysis and experimentation to find the best setting or the best range of settings for either specific or generically for all texts to produce a coherent sentiment curve. Figure 6 show the differing graphs that may be produced by changing the granularity.

VADER is designed for parsing short lengths of text (less than 140 characters, as per a Tweet), so in order to produce more coarse graphs than single-sentence, VADER is still fed text on a per-sentence basis with the results summed up to N sentences where N is the corresponding number of sentences for a given granularity setting for a given text. The relevant data point is then plotted N sentences beyond the previous (i.e. at the end of the analysed block).

By default, every sentence of the text is plotted as its own point. This gives highly detailed graph but it very difficult to discern any sort of shape. Sentence

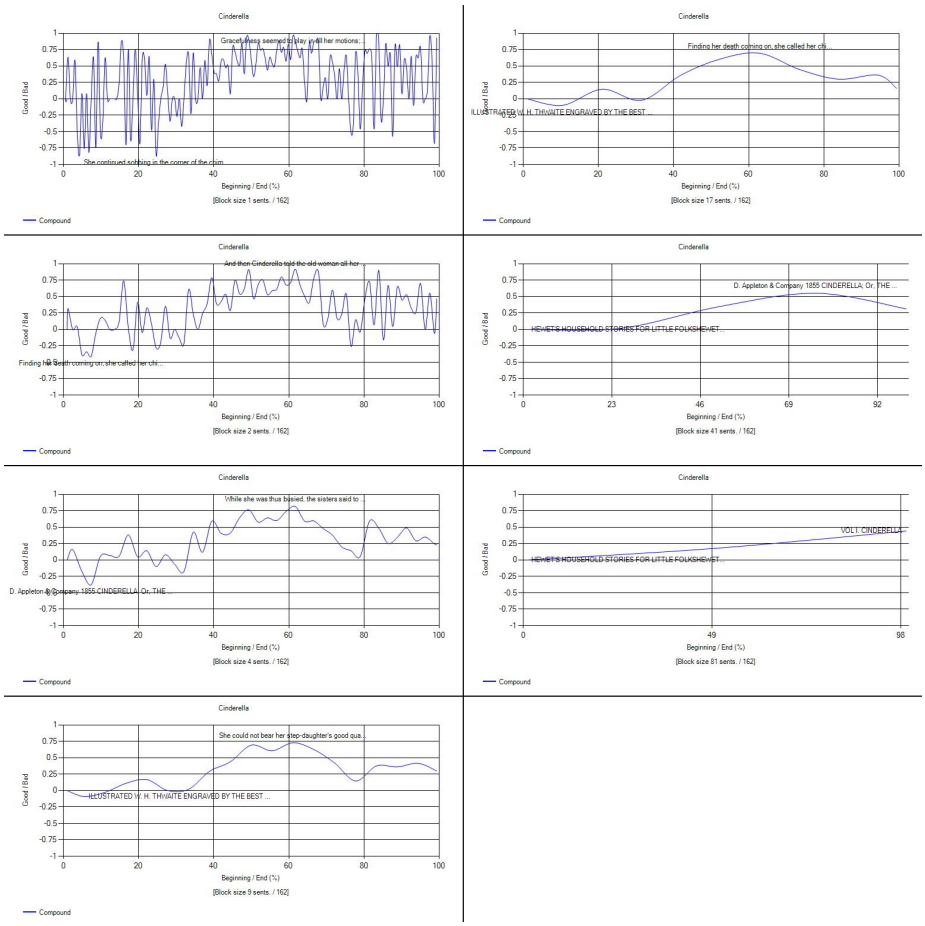


Figure 6: Each graph shows the result of decreasing the granularity of analysis and show how there appears to be a sweet spot. In this case, four of the highest options summed only a single sentence due to short length of the text. Only one of these has been included.

to sentence, sentiment can vary wildly from the most negative in one to the most positive in the next (context and corpus dependent). Due to this, the resultant graph is highly spiked and difficult to garner information from.

By contrast, using the more coarse options of 25% and upward produce graphs that do show a clear line, however, at this level of coarseness, the data is compressed so much so that much of the detail is lost, smoothing the curve that should be shown beyond useful limits.

Through trial-and-error experimentation, the ideal setting was found to lie between 0.2% and 2%, erring toward the 2% for most texts.

With this being said, it's possible, that a different tool may have been better suited to this task than VADER due to it's native design choice to parse text the length of Tweets, not entire corpora.

4.2 Hand Analysis Vs. VADER

This test was performed by selecting a 100 random sentences from two texts (Macbeth and Cinderella), analysing them each individually by hand and estimating a combined positive/negative sentiment score in the same range as that produced by VADER. I attempted to avoid trying to emulate the way VADER would process the text, instead scoring each sentence as I would as a reader of the text: "Would I feel positively and negatively after reading this sentence?" or, similar.

The motivation behind this was to understand if VADER's output results were trustful, totally incorrect, or somewhere in the middle.

VADER also lacks any context processing - it cannot understand running themes in texts in order to better understand the sentiment behind that which is being said.

4.3 Reader Analysis & Reflection

This section covers the analysis of a range of Shakespeare plays by human readers (mostly identified to be Theatre and/or Literature students) and their personal comparison of the the Sentiplot output with their own expectations of what a graph of a given play should be. The goal here was to bring a human element to the reviewing of Sentiplot and VADER. A brief background of the study, its goals, and task was given to each person who answered any of the questions provided. Some asked further questions and subsequently commented on the techniques used for analysis and graph production.

4.3.1 Reader Analysis

Readers were first asked if they felt they knew each play well enough to attempt to plot a rough arc for each in a set of axes, with a focus on any major emotional events they could identify. Some participants opted to answer questions on only a subset of the plays, as the may not have read or otherwise cannot remember the other plays. In total, 22 result sets were gathered. This allows qualitative analysis to be carried out around how effectively VADER performed from a human perspective and to attempt to gather further comment from participants on the effectiveness of SentiPlot.

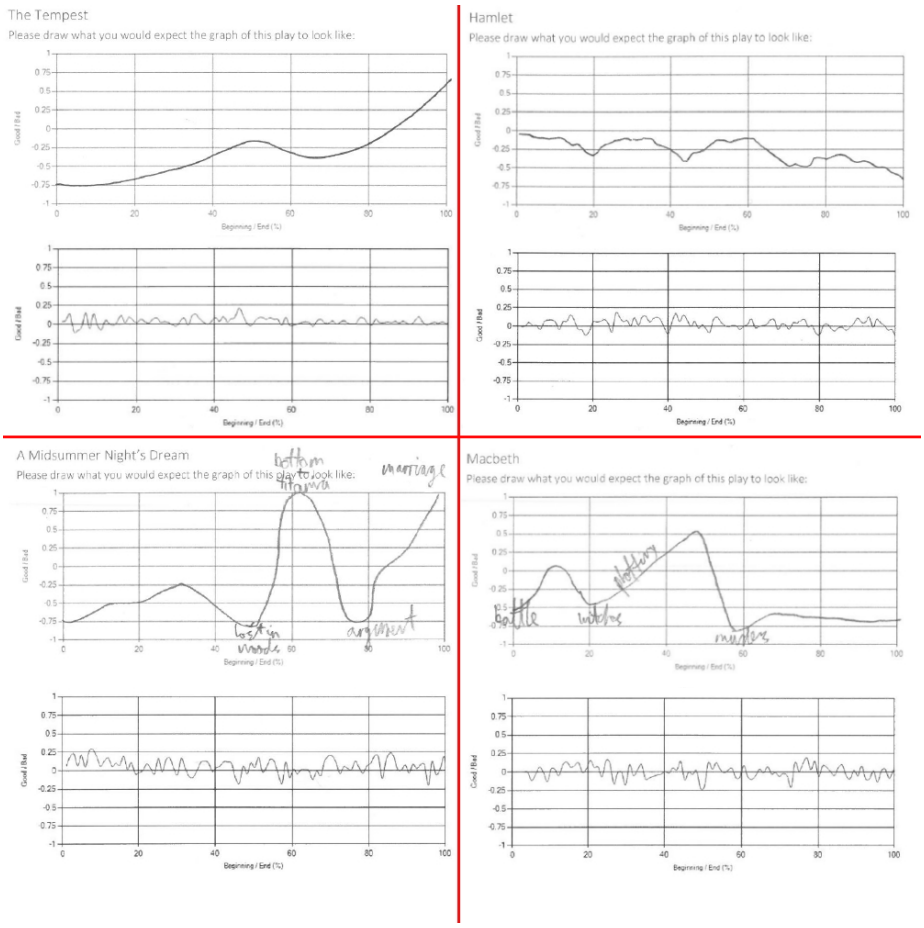


Figure 7: Readers (top of each pair) in general drew curves bearing little to no similarity to those produced by VADER (bottom in each pair)

Each participant was given a blank set of axes (with the same scale as was used for VADER's results). They were asked to draw what they thought a curve of each play would look like, based upon any and all major events they can recall. They were then asked to label and/or explain any notable troughs and peaks in their curves. A small selection of the curves drawn are shown in figure 7, paired with the corresponding output form VADER. In general, all the curves drawn by participants were grossly different to the VADER output for the same texts. All VADER's curves stayed mostly in the range of +/-0.25 on the Sentiment axis, whereas most participants drew curves using nearly the full extent of the y-axis. This is not to say that VADER doesn't register any sentences as reaching the more extreme values: when examining the per-sentence scores in the table view, it does, but these values get flattened when they are grouped together. On closer inspection, taking Macbeth as an example, approximately 30% of the sentences were outside the +/-0.25 range, however just over 60% of those *within* the range were zeros, registered by VADER as completely neutral sentences. When taking averages, these high volumes of zero-scored sentences will have

reduced the impact on the output graph of higher scores greatly.

Even with this failure, attempting to look at relative differences along the two curve sets (those drawn, and those produced by VADER) still doesn't yield much similarity. The only immediately obvious correlation is, again, in Macbeth where both VADER and a participant show a sharp dip at around the halfway mark (labeled on the drawn curve as "murder"). This is nearly the only obvious match, however.

It's also worth mentioning that Kurt Vonnegut suggested in his lecture that Hamlet ought to have a somewhat flat graph. Sentiplot supports this at least visually, however, some of the drawn graphs show a very clear descent, logically coupling Hamlet's madness with negative sentiment. Sentiplot does in fact also show some extreme peaks and troughs, however these are momentary in the overall context of the script, and thus are averaged out and do not appear in the final output. Depending on the scope at which you examine, but Sentiplot has elements of agreement with both Vonnegut's flat prediction and participant's more curved graphs.

4.3.2 Reader Reflection

Participants were later asked to comment on the similarity (or dissimilarity) between their own graphs and those from VADER. There was a general consensus that VADER's graphs lacked the ability to show various details and intricacies of the literature. Namely that they failed to show sharp spikes due to some specific events, failed to grasp that undertones present in the texts and failed to show the differentiation between specific periods of happy/sad text. Some also noted that some of VADER's graph appeared to have no correlation with the text at all, with some attributing this to a computer program's lack of the ability to experience or empathise with literary art. It was also suggested that a theatrical script is likely to be a less than ideal format for attempting to produce a curve in this way, with one participant pointing out that scripts do not contain significant amounts of description - they only contain dialogue, with a small (albeit, varying) amount of description present in the stage directions; novels on the other hand innately contain description as it is the primary information is conveyed to the reader.

4.4 Shakespeare: Comedies Vs. Tragedies

As mentioned in section 4.3, Shakespeare plays have been a key source of analysis text. These have generally yielded somewhat restricted graphs. The motivation for these tests came from the thought to force the ability to tell apart different plays by their genre. Namely to comedies *should* show generally more positive curves and similarly, tragedies *should* show more negative curves accordingly. To attempt to display this, three comedies (*Twelfth Night, The Tempest, A Midsummer Night's Dream*) and three tragedies (*Macbeth, Hamlet, Romeo & Juliet*) were processed to give their respective graphs. There is some debate on the specific genre of *The Tempest*, it now often being referred to as a "late romance", a subsection of Shakespeare's comedies leaning more toward a "tragicomedy" in genre. Nonetheless it ought to still produce a difference in curve to that of the three tragedies.

4.5 Early Modern Vs. Modern English

VADER is not trained to work on the likes of formal literature. In fact, it is trained to work on highly modern and informal text, to such an extent that it understands and can analyse Internet slang and emoji. Due to this fact, this experiment was carried out to test of VADER was able perform equally or at all as well on a different form of English, that being the Early Modern English found in the Shakespeare plays processed for sections 4.3 and 4.4.

5 Conclusion

This is a conclusion.

References

[1] Shabaz Anwar. Sentiment analysis versus emotional analysis: Same or different?

[2] Kurt Vonnegut. Lecture to case western reserve university.