

Analysis on Reflective Writing Using Natural Language Processing and Sentiment Analysis

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Abstract. Natural Language Processing (NLP) opens up the possibility for a machine to help us human process the vast data out there. There are multiple branches of NLP, but this thesis focuses on sentiment analysis, more specifically for reflective writing analysis. However, to obtain accurate results, NLP model needs to be tailored for the specific application. In this thesis, an NLP model is developed to process survey results obtained from psychology course by building a word database and categorise the level of reflection using fuzzy logic system. The main processes involved in this work are mainly performing intensive literature review on reflective writing models and to design fuzzy logic rules which can categorise the various levels of reflection demonstrated by the students. The model is then used to analyse a total of 47 reflective journals collected from the survey responses of the students from the School of Education in UTM. These surveys need to be pre-processed using some tools such as Natural Language Tool Kit (NLTK) to be fed to the developed model. There is the need to build a word database with words specific to the psychology field to improve the accuracy. From the analysis of the students' survey, most of the students exhibit level 1-2 reflection.

Keywords: Natural language processing, reflective writing

1. Introduction

Natural Language Processing (NLP) is a field of research that is mainly focusing on the application of algorithms on text or speech to obtain the desired outcome. There are many subfields in NLP such as text summarization, question answering, machine learning and sentiment analysis. Each subfield has their own individual progress, development and applications, but this work will focus mostly on sentiment analysis. The sentiment actually refers to the view or opinions expressed by certain people. There has been increasing popularity in introducing reflective writing practices in the education system with Australia leading the charge with a couple of government policies such as Early Years



Learning Framework (EYLF) and National Quality Standard (NQS) which emphasise on introducing reflective learning [1]. However there are many concerns which have limited the exposure of reflective writing practices such as the school teachers are not well trained in implementing and reviewing reflective writing and it is also quite time-consuming to manually review the reflective journals submitted by the students especially if there are many students in the class to provide timely feedback for them to develop.

There are actually many benefits of introducing reflective writing practices during early stages of education to encourage students to not only learn from a textbook but also provide them with the platform to relate with their experience and gain a new perspective which could help them to develop their critical thinking [1]. By implementing some sentiment analysis algorithm on computer systems to enable automated analysis of students' journal and highlight the reflective practices demonstrated by the students, the teachers are able to identify slower students and are able to spend more time on helping them to understand the lecture or teaching. This way, they can help to build a stronger and solid foundation that will most definitely prove to be crucial in their development in the future.

2. What Is Reflection?

2.1. Definition of Reflection

This section will cover some of the definitions of what is reflection along with the benefits and importance of reflection in a person's life. There are several works on reflective practices which carried a major impact to the definition of reflection. For example, work done by John Dewey, Donald Schon and Jack Mezirow are some of the major works in the field of reflective practices. Dewey refers to reflection as an "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and further conclusion to which it tends" [2]. While Mezirow stated that "reflection involves a critique of assumptions to determine whether the belief often acquired through cultural assimilation in childhood remains functional for us as adults" [3]. Schon introduces the concept of reflective practices and introduced two main concepts which are reflection-in-action and reflection-on-action. Reflection-in-action refers to the action of which the professional requires to think about a solution to a specific problem while facing it and solve it on the spot. Reflection-on-action, on the other hand, refers to the professionals eventually revisits the problem after the event and using their past experiences to look at the problem from different perspectives [4].

2.2. Models To Analyse Reflective Writing

The previous section provided some of the definitions of reflection defined by well-known experts and researchers in the field of reflective practices. However, to really delve into analysing reflection there is the need to have a more qualitative and quantitative approach where it is able to provide a more distinct definition into each element which exists in reflective practices. Hence arise many research works on creating conceptualise models which provide a simplified abstraction of each of the elements that form reflection. Although there are different kinds of model, they do share some common elements which are mainly description, emotions/feelings, relation, reasoning and critical reflection [5].

- **Description:** This category basically captures the basic information about the topic which is in the discussion. It happens when the subject talks or writes about the problem he/she encountered where this is the first step to reflective practices. Many models do contain this element either implicitly or explicitly.
- **Feelings/Emotions:** This category basically finds sentences which captures the writer current emotions, looking for personal response and underlying mental state of the writer.

- **Relation:** This category assess the ability of the writer to relate their experience or understanding of the problem or issue at hand.
- **Reasoning:** This category digs further into the cause of the situation after some of the factors have been identified through relation. Reasoning refers to the exploration, explanation and interrogation of that particular situation. It remains to be one of the key element in the reflection where it is required for people to link all their knowledge and question them in order to achieve a higher level of reflection.
- **Critical Reflection:** This category is the highest level of reflection where the user is able to synthesize new knowledge, gain new perspectives and gain an evolution of ideas. Critical reflection is the desired outcome after undergoing the reflective practices, many researchers see this as a way to continue the development of students by teaching them the method to learn and reflect in order to unlock their full potential.

3. Methodology

This project is mainly aimed at automating the process of analysing and grading reflective writing practices demonstrated by students. Since there is a lack of training dataset to implement machine learning approach and lack of expertise in handcrafting specific rules to detect reflective writing sentences, fuzzy logic system approach will be implemented. The fuzzy logic model will use keywords count based on the reflective keywords dictionaries created as input to the system to categorise the input texts and determine the level of reflective practices demonstrated by the writer.

The proposed system methodology could be further divided into 3 main phases, which are input survey processing, keyword dictionary creation and implementation of the fuzzy logic system. In general, the collection of survey text consists of a few stages where the key is to pre-process the text into a format readable by python. The main elements that exist in the pre-processing stage include converting the survey into a txt file format, removing invalid ASCII characters, filtering out survey written in Bahasa Malaysia and removing survey questions and headers. After completing the pre-processing stage, the survey text will be saved into an input folder where the python script will read from. Figure 1

As for the creation of reflective keywords dictionary, there are 4 main keywords dictionary that needs to be created which are cognitive, emotive, volitive and concept keywords dictionaries. The first 3 keywords dictionaries come from the definition based on Bruno's journal [15] while the last dictionary, concept keywords will be provided by the expert from UTM, Dr Narina A.Samah. The concept keywords consist of words which are closely related to the field of cognitive psychology. The definition of each of the keywords categories are stated below.

- **Cognitive words:** all the verbs, nouns and adjectives describing cognitive processes (e.g. think, mind, clever, etc.)
- **Emotive words:** all the verbs, nouns and adjectives referring to emotions and feelings (e.g. happiness, scared, etc.)
- **Volitive words:** all the verbs, nouns and adjectives indicating motivation, volition and desire (e.g. hope, will, etc.)

The difference between the current proposed method as compared to other prior works is that this is a relatively new approach using fuzzy logic to analyse reflective writing which most of the current works done are based on rule based system which utilises expert rules or sentence structure to determine the reflective writing. Besides that, the proposed architecture also makes use of part-of-speech (POS) tagging and word dictionaries of 4 different type of keywords which

indicate reflective writing and categorises the level of reflective practice demonstrated by the student.

3.1. Input Survey Acquisition And Processing

The input survey acquisition is carried out in order to collect the input dataset in order to evaluate and develop the fuzzy logic system. In this project, end of semester survey responses from students of the Faculty of Education in UTM are chosen due to the fact that the experts have access to it. Another reason that the survey responses are selected is that the survey consists of similar questions throughout the years to obtain students' feedback on the courses offered along with gauging what students have learnt throughout the semester. Hence it is possible to merge the responses from several different semesters to get a more meaningful number of the input datasets. A total of 60 surveys were collected from the Faculty of Education UTM spreading across 4 long semesters from 2016/2017 semester 1 to 2017/2018 semester 2. Each survey collected consists of 3 main questions which are listed below:

- 1) What is the most relevant concepts/theories that you can apply in your life as a learner/practitioner? and why?*
- 2) What is the muddiest concepts/theories that you feel you need to explore further? and Why?*
- 3) How do you find the classroom teaching and learning approach? Your suggestions to make it more interesting?*

After collecting those surveys which are in PDF format, it is required to convert the PDF file into TXT file due to the fact that python is unable to read in PDF file format on its own. Hence, in order to complete the conversion process automatically and easily, an online PDF to text converter is chosen. This online PDF to TXT file converter (<https://pdftotext.com/>) is chosen due to the fact that it is free and it can perform the conversion on 20 files simultaneously by uploading the PDF file and downloading the converted TXT file from the website.

Another issue encountered when processing through the collected survey forms are that certain responses in the survey are actually written in Bahasa Malaysia which is currently not supported by the POS tagger and also the dictionary created. Hence the need to remove some of the input surveys which resulted in total of 47 survey responses. Besides, the survey questions will also need to be removed to reduce the noise. The final modified survey response will then be saved into an input folder which will be the final dataset going to be utilised throughout the entire project.

3.2. Reflective Keyword Dictionary Creation

As for the proposed keyword dictionary, this project will utilise the 3 different reflective keywords definition given by Bruno [15] which are cognitive, emotive and volitive words. Due to the limited number of words for each category, the synonym and antonym are collected for each of the words given through the use of WordNet library and manually review through to remove unrelated words to obtain the final version of the dictionaries. Figure 1 illustrates an actual snippet of code to query through all the synonym and antonym for a certain seed word that is obtained from Bruno's journal.

3.3. Reflective Category Classifications

In order to design a model for reflective writing detection, it is required to first decide on a reflection model first. There are various frameworks and guidelines out there to model reflective writing such as Bain's 5Rs framework, Kembers model and etc. All these choices pose the questions of which framework would best suit to this application. Therefore, based on the literature review done and the summary from Table I and also discussions with the expert from UTM, Dr Narina, Bruno's model is chosen due to the fact that it contains all of the elements of reflection from description to critical reflection and there are only 5 different categories which are from level 0 (lowest level) to level 4 (highest level) which are listed below [14].

- **Category 0** Non-reflective practice: the written text doesn't have any mental term.
- **Category 1** Declarative reflective practice: the writer relates an event referring to mental states, but in a descriptive style.
- **Category 2** Relational reflective practice: the writer compares mental states between subjectivities, or over space and over time.
- **Category 3** Interpretative reflective practice: the subject explains a behaviour or decision by referring to the underlying mental states.
- **Category 4** Critical reflective practice: mental states are used in a critical way to get new perspectives.

The lesser the level of reflection category, the more simplified the task of classifying the reflection categories will be. This is because the number of categories needs to be lesser in order to avoid too finely graded categories which can complicate the task and analysis as there might be overlap between different categories [11].

3.4. Part-Of-Speech Tagging

POS tagger is actually a piece of software which reads in text from certain language and assigns parts of speech to each of the words or better known as tokens. There are various POS taggers out there with varying performance in terms of accuracy, speed and model size. In this project, Stanford POS tagger is chosen due to the availability of the model from The Stanford Natural Language Processing Group and it has been undergoing constant updates where the latest updates was released in 16th October 2018. Besides that, Stanford POS tagger also achieves very high accuracy of 97.24% [16] and is compatible with python.

Stanford POS English tagger utilized the Penn Treebank tag set which will tag each word or tokens with one of the 36 distinct part of speech tag available [17]. Penn Treebank tag set utilizes more fine-grained POS tags which distinguish between various forms of the basic part of speech tag. Example for a verb, Penn Treebank utilizes 6 unique tags to identify verbs in the base form (VB), verb in past tense (VBD), verbs in present participle (VBG) and so on.

3.5. Output post-processing

After obtaining the results from the fuzzy logic system, some post-processing is required to format the results into a more readable form by a human. The final output file will contain crucial information such as the input texts, the number of keywords matched, the classification category and the processing time. To improve the reader experience, several formatting is done on the output file as well such as creating a table to list down the cutoffs for various membership functions in the fuzzy logic system, highlighting keywords which matched in the keyword dictionary, inserting images to illustrate the membership function and creating a legend to show which colour represents which keyword dictionary. By creating this HTML output file, all the critical information will be located in 1 file that will ease the analysis of the results.

4. Results and Discussion

For the evaluation of this project, a total of 47 journals which went through pre-processing were used. Each of these input survey responses is fed into the system for analysis and the final reflection category are recorded. The reflective category for each of the input survey responses from various experiments using different configurations which are summarised in Table 1 and Table 2. Each of these experiments uses different set of fuzzy rules to determine the final output. Both Experiment 1 and 2 uses the same membership function range which splits each input into 5 different range while experiment 3 uses only 2 membership function for emotive, volitive and concept inputs. From the results from Table 3, it could be observed that most of the survey responses are categorised under category 1 and 2 which means that most of the students are able to relate and refer to mental states in descriptive style or compare between mental states between subjectivity or over space and time. By varying the cutoff and also fuzzy logic rules, there are some variations in the categorization of the output reflection categories but percentage wise there are not many changes in category 1 and 2. It can also be observed that by manipulating the defuzzification technique can also contribute to a minor shift in output reflection category classification which could be used to tune the model to obtain a better classification result.

Table 1. Fuzzy Rules for Different Experiments

Experiments	Rules
Experiment 1	Cognitive OR Emotive OR Volitive OR Concept
Experiment 2	Cognitive AND Emotive AND Volitive OR Concept
Experiment 3	Cognitive AND Emotive AND Volitive AND Concept

Table 2. Membership function range for categories 0-4

Experiments	Range			
	Cognitive	Emotive	Volitive	Concept
Experiment 1&2	0-100	0-20	0-40	0-15
	50-150	5-35	20-60	5-35
	100-200	20-50	40-80	20-50
	150-250	35-65	60-100	35-65
	200-400	50-80	80-120	50-80
Experiment 3	0-100	0-50	0-80	0-40
	50-150	0-80	0-120	0-80
	100-200	-	-	-
	150-250	-	-	-
	200-400	-	-	-

Table 3. Summary For Reflective Writing Categories Classifications

Experiments	Defuzzification Technique	0	1	2	3	4
Experiment 1a	Centroid	0	24	19	4	0
Experiment 1b	Mean of max	6	21	15	2	3
Experiment 2a	Centroid	1	24	14	8	0
Experiment 2b	Mean of max	5	22	12	7	1
Experiment 3a	Centroid	1	19	18	7	2
Experiment 3b	Mean of max	3	17	18	7	2

Header 0-4 represents the output category 0-4

5. Conclusion

In conclusion, a fuzzy logic system for reflective writing detection and categorisation has been successfully developed in this project by utilising fuzzy logic approach to model Natural Language Problem. The developed system has been able to analyse the input survey responses by the student and generate an output analysis of the reflection category along with several important information such as the word cloud and fuzzy logic membership function which helps to represent the analysis in a reader-friendly layout in HTML format which could be opened using any browser.

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