UNDERSTANDING HUMAN EMOTIONS

Lau Shin Rei Beth¹, Wong Jia Li Nicole¹, Pappu Amrutha¹ and See Swee Lan²

¹Raffles Girls’ School (Secondary), 20 Anderson Road, Singapore 259978
²Institute for Infocomm Research (I²R), A*STAR, 1 Fusionopolis Way, Singapore 138632

ABSTRACT

The rigorous education curriculum in Singapore and the local “kiasu” culture have many impacts on youths (aged 13 to 18). One of them is the increasing levels of stress that youths face, which may lead them to suffer from mental illnesses. The rising rates of mental illnesses such as depression in youths in Singapore have also led to a higher suicide rate in youths. Hence, it is important to have an accessible platform for youths to express their feelings as a form of therapy.

By writing Python code which encompasses deep learning neural networks, a chatbot will be created on an online chatting platform, Telegram. It uses deep learning and semantic analysis to carry out a conversation with the user and detect his/her levels of negative and positive emotions. The code makes use of API (Application Program Interface) TextBlob to measure the levels of stress that the user is facing through an engaging conversation via semantic analysis. This is done by calculating the frequency of positive or negative words used in the user’s text messages. Besides being a detector of levels of stress in the user, our chatbot also has the potential to aid in online supportive therapy.

INTRODUCTION

The present study aims to better understand the expression of emotional stress via text analysis on online platforms, which can be achieved by applying semantic analysis and deep learning. Our research question is thus as follows: How can deep learning be used to identify levels of stress in youths (aged 13 to 18 years old) in Singapore?

Since Telegram is the most popular online chatting platform [1] amongst teenagers, we therefore attempt to create a chatbot, named AngoraBot, to carry out an investigation to answer the above research question. From the online text conversation between AngoraBot and Singaporean youths aged 13-18 years old, we hope to study and gain further insight of the emotional stress levels that these Singaporean teens are facing. If many participants are identified to be emotional stressful, we hope our AngoraBot would be able to extend suitable therapeutic further assistance to them in future.

RATIONALE

A. Target Users

The target users of AngoraBot are Singaporean youths aged 13-18 years old. This group of teenagers is believed to face the most stress from the education system in Singapore, especially students who migrate and finally obtained permanent residency in Singapore as they are also learning to cope with the different cultural context.
In 21st century Singapore, teenagers display high levels of stress due to the fast-paced life that they lead, along with the demanding Asian education system and their multiple external commitments. Singapore is mainly characterised with a “kiasu” culture, which means that many Singaporeans have the fear of losing out to other people. Due to the rigorous education curriculum, youths are often feeling pressured, which may lead them to suffer from mental illnesses such as depression. Teen suicides in Singapore have hit a new high of 27 per year [2] and it has been reported that 22% of children in Singapore have considered suicide as a viable option [3]. One in ten people in Singapore suffer from a mental disorder [4]. One in seventeen people in Singapore have experienced major depressive disorder at some point of their lives[^4]. The majority of people with a mental disorder were also not seeking professional help[^4]. The average time that one with major depressive disorder took to seek help was 4 years[^4], which is a very long period of time. In that period of time, their mental health illness could worsen and even endanger their lives. Hence, we hope by detecting the stress levels of youths could render help to prevent more undesirable cases from developing further.

**B. Chatbot & Social Media**

As we know, youths are spending so much time on their mobile devices surfing online social media platforms, they are more likely to reveal their genuine feelings online. This will compel youths to talk about their problems on these online platforms rather than face to face, as online platforms are comfortable venting outlets where they can express their feelings without worry. Hence, we chose online texting as a medium for communication as youths are most familiar with these social media platforms. This will ensure that the conversation would be more natural compared to talking face-to-face with a therapist.

Since AngoraBot is not human - even though it possesses characteristics that are human-like - youth participants will not feel the pressure of being judged by the other party. Besides, because they are not actually talking to a real person, they will be assured that if they are suffering from a mental illness, it will not be considered as a stigma, and hence they are able to talk freely about their problems. This also compelled us to do analysis of one’s text messages through online platform. With these good reasoning, it is imperative that youths have a platform that they can rely on to seek help if they were to have self-harming thoughts.

AngoraBot provides an outlet for youths to talk about their problems and through opening up about their problems they might even be able to find a solution to their problems. If the user is identified to have high levels of stress, suitable medical advice will be recommended to these youths such that they can better take care of themselves. As youths’ minds are not fully developed yet, they may not be as mature as adults. Hence, these various external sources of stress make them extremely susceptible to mental illnesses, or even committing suicide. In order to prevent this from happening, AngoraBot is providing an outlet for youths to express their feelings and to detect if the youth may be suffering from any possible mental illness. This is why our project focuses on youths, instead of adults. AngoraBot can relieve their emotional stress and prevent mental illnesses from further developing.

**C. Development Platform**

Telegram was chosen as it was one of the most popular chatting applications used [5], with 100 million users worldwide at the start of 2016 and 15 billion messages sent on Telegram daily [6].
This will ensure that youths in Singapore are able to easily access this free chatting application. Since AngoraBot functions on Telegram, AngoraBot will be easily accessible to all youths. Telegram also has a Bot developer called BotFather, which helps to build and develop new bots on Telegram. BotFather allows developers to create and customize their own bots to suit various needs, which was how AngoraBot was built on Telegram. Furthermore, Telegram is compatible with Python scripts, making it easier to control and update AngoraBot via Python commands. With the popularity, accessibility and compatible features of Telegram, we were compelled to choose Telegram to develop AngoraBot.

**METHODOLOGY**

AngoraBot was created by writing three separate pieces of codes which each fulfils a unique purpose as shown below, then by combining them, it forms our prototype.

For AngoraBot to be functional, we use

1. sentiment analysis codes to detect the polarity of the user’s text messages,
2. deep learning to train and test our model to ensure that it is effective, and
3. the Bot Application Programming Interface (API) from Telegram to create our chatbot.

The TextBlob sentiment analysis function and the Tensorflow telegram chatbot code were coded in Python script separately, then combined to form a recurrent neural network model. This uses deep learning and text mining to train the AngoraBot to recognise and use Natural Language Processing (NLP), efficiently processing the user’s response and determining the most appropriate response to communicate with the user. Since we felt it would be best to keep AngoraBot’s responses consistent, we tested with a retrieval-based model with a predefined set of responses. AngoraBot is coded to ask the user questions in order to detect the positive or negative emotions in the user’s reply text messages. Sample questions of what AngoraBot may ask the user is attached in the Appendix.

**A. Sentiment Analysis**

In AngoraBot, there is a function called TextBlob which is being used for the sentiment analysis part of AngoraBot. It calculates the frequency of words with negative sentiment in one’s text and from there, it is able to identify the polarity of each word, meaning that it can tell how positive or negative one is feeling. Hence, if a person’s text has a higher percentage of negative words, the polarity of that person’s text will be more negative, showing that his/her is higher than average.

TextBlob is a Python-compatible function with an in-built library that is used to perform natural language processing tasks [7]. Textblob takes the input text and parses it into parts of a sentence. TextBlob is linked to a word lexicon library. Each word in the lexicon has scores for polarity, subjectivity and intensity [8]. This shows if the word is positive or negative, objective or subjective, and whether it will modify the next word. When the parser parses the text, the subjectivity and polarity of every adjective is aggregated, and a simple probability distribution table is formed [9]. Negation in the sentence multiplies the polarity by -0.5 and does not affect subjectivity. For modifier words such as “very”, TextBlob will ignore the polarity and subjectivity. Instead, it will just use intensity to modify the word it is describing. If negation is
combined with modifiers, in addition to multiplying the polarity by -0.5, the inverse intensity of
the modifier enters for both polarity and subjectivity. TextBlob cross-checks the sentiment of
each word and determines the overall sentiment polarity and subjectivity of a sentence,
increasing accuracy of judgment. The code used with TextBlob to determine the polarity of the
user’s text message is as shown in Figure 1.

```python
>>> from textblob import TextBlob
>>> test = TextBlob('I am very sad."
>>> test.tags
[('I', 'PRP'), ('am', 'VBP'), ('very', 'JJ'), ('sad', 'JJ')]
>>> test.sentiment
Sentiment(polarity=-0.65, subjectivity=1.0)
>>> test.sentiment.polarity
-0.65
```

Figure 1. Textblob code

This system has some limitations. It is unable to sense the user’s sarcasm and will instead just
take the message literally. There may also be some words that are used such as “lol” that are
used to express positive emotions. However, as these words may not exist in the library as they
are not proper words, but acronyms, hence their default polarity is 0.0, which may lead to
inaccurate sentiment calculations. TextBlob is also limited to measuring how negative or positive
the user is expressing himself/herself. Hence, TextBlob may not be a reliable measurement of
stress levels.

B. Deep Learning

Both the context and the user’s input are turned into vectors. This is done during data processing
phase. In order to process our data, which consists of words, it is easier to transform it into
numbers, as we will be processing numbers. We used Textblob, which is a Python library for
processing textual data, providing a simple API for completing common natural language
processing (NLP) tasks such as tokenization of the user’s input message. Textblob separates each
user’s input message via tokenization, and gives each word a value, making it into a vector. We
then associate a vector to each word in the training data.

Both vectors, which refer to the “embedded” word, are put into the many-to-one recurrent neural
network (RNN) model word-by-word. This gives us other vectors which capture the meaning of
the context and the answer, which we refer c for context and a for answer. We can choose how
large those vectors should be. We multiply c with some matrix, M to produce an answer, a. The
matrix M is learned during the training of our chatbot model, which would have been done
previously.

We then measure how accurate our predicted answer, a, is compared to the actual answer. We
apply regularisation functions, such as a sigmoid graph, to convert the measurement into an
actual probability. This will help us check if our chatbot’s answer to the user’s input message is
accurate and natural.
Below is an example of a retrieval-based model:

```python
CHAT_RESPONSES_POSITIVE = ('that's good :)', 'i'm glad', 'i see')
CHAT_RESPONSES_NEGATIVE = ('hope you feel better soon! :)', 'hang in there!')
CHAT_RESPONSES_SHAREWHY = ('why do you feel this way?', 'would you like to share why?')
```

This allows our bot to select a response from a predefined set of responses when prompted by the user, hence allowing a larger consistency in replies.

**C. Telegram Chatbot**

We used a pre-existing bot in Telegram that specialised in creating new bots (@BotFather) to help us create a bot entity. It also allowed us to add commands for easier user accessibility. For example, if the user feels uncomfortable during the user study, they can type in the ‘/’ key and select the `pause` command, which will stop the bot’s running.

We followed a simple online tutorial [10] which taught us how to build a chatbot using the the Tensorflow machine learning library in Python. This tutorial used the Cornell Movie Dialogue [11] dataset to train and test the model, which will ensure that the chatbot carries out an engaging conversation with the user.

An example of the Telegram code’s format is as follows:

```python
def start(bot, update):
    update.message.reply_text('Hello, how are you today? :)')
```

**D. Chatbot Testing**

After developing our prototype, we performed a simple prototype testing of AngoraBot to ensure that she can respond to what the user says, and to see if the conversation sounds natural. By continuously testing, we can improve AngoraBot for better communication with target users and as AngoraBot sounds less mechanical, she could give useful advice that are better acceptable by the target users.

**RESULTS**

By combining the sentiment analysis and deep learning code, an Application Programming Interface (API) was used to translate our code into code that can be used to develop our Telegram chatbot.

An example of how the chatbot, AngoraBot, communicates with the user is illustrated in Figure 2 below.
DISCUSSION

Each feature of AngoraBot has a role to fulfil in our research question and in turn, thereby benefiting the society.

A. Sentiment Analysis
As mentioned before, TextBlob identifies the polarity of the user’s text messages. As many youths tend to express their true feelings online, it would be more feasible to detect the user’s emotions through what they text on online chatting applications. This is closely linked to the problem of relatively high suicide and mental illness rates in Singapore. Chronic stress or too much stress can result in major depression, especially in youths, as their minds are not fully matured yet and hence are extremely susceptible. Stress leads to overactivity of the body’s stress-response mechanism. Sustained or chronic stress leads to elevated hormones such as cortisol, and reduced serotonin and other neurotransmitters in the brain, including dopamine, which is linked to depression. When the body’s stress response fails to shut off and reset after a difficult situation has passed, it can lead to depression [12].

Hence, when TextBlob identifies how positive or negative the user is feeling, this can be related to how stressed the user is. If the user is feeling extremely stressed, or having high levels of negative emotions, this shows the possibility of the user suffering from a mental health problem.

Depression is one of the main causes of suicide, and another is when a person needs help but they are unsure of how to get help [13]. Before it escalates to a serious case such as suicide, AngoraBot will make use of TextBlob to possibly identify if the user is facing high levels of stress, if he/she is possibly suffering from a mental illness and if they may be thinking of committing suicide. AngoraBot will be able to step in and provide aid as a conversational partner for the user to express his/her feelings freely, so as to show the user that there is someone there for him/her. Hence, since TextBlob enables AngoraBot to carry out the functions of identifying
the stress levels of the user, AngoraBot may be able to lower the cases of mental illness in Singaporean youths, as well as the frequencies of youth suicides in Singapore.

B. Deep Learning
AngoraBot makes use of deep learning, which enables it to learn from given examples by understanding the patterns in which how people converse with each other. This mimics an interactive human conversational partner, unlike other Artificial Intelligence (AI) powered bots, such as Siri, which only provides facts and data. Using deep learning, AngoraBot is able to respond to the user’s text messages by learning from how people converse from the database that it is given. This helps AngoraBot to talk to the user in a more human-like way, unlike how chatbots usually give limited and mechanical answers. This conversational partner can help the user feel like he/she is talking to a real person, which will enable him/her to trust AngoraBot and confide in AngoraBot. Figure 3 below illustrates the conversation in Telegram.

![Chatbot conversation in Telegram](image)

Figure 3. Chatbot conversation in Telegram

C. Telegram Chatbot
Since AngoraBot is readily accessible to all Telegram users, they will be able to utilise AngoraBot to relieve their stress as they carry out a conversation with our chatbot. As mentioned before, as Telegram has one of the most users, AngoraBot will thus be able to reach more people if it is based on an online chatting platform such as Telegram.

Our chatbot can be further developed into an independent application, possibly as an e-health application to help detect high levels of stress as well as to provide more information about different psychopathological issues.
CONCLUSION

A. Limitations
As AngoraBot is not trained professionally, and instead is only coded based on one database, it may be unable to facilitate a group chat well and steer it towards a certain direction. In our project, AngoraBot is only acting as a conversational partner, and since it is a one-to-one conversation, it can easily identify the amount of stress the user is facing. However, in a group chat, it will be assessing the stress levels of multiple patients. Hence, AngoraBot may not be ready to take on such a specialised role without proper testing and without professional information being used in the building of the model. Furthermore, when being put in a group chat, some patients may be sensitive about their condition and are unwilling to talk about it. AngoraBot will then be unable to identify the levels of stress that the user is facing.

As AngoraBot mainly relies on user participation, it requires users to interact with AngoraBot. However, some may feel uncomfortable answering AngoraBot’s questions as they do not trust it, which will render AngoraBot ineffective as it requires a form of input information in order to detect the emotions of the user. Without sufficient input, AngoraBot will be unable to measure the polarity of the user’s text messages and hence be unable to reply accordingly to the user.

B. Possible Extensions and Upcoming Plans
We are planning for an experiment to be carried out in order to test the accuracy of AngoraBot. Participants will also be asked to give feedback on the various features of AngoraBot, such as the user interface. Through the conversation held by AngoraBot and user, the bot can identify the stress levels of the users by analysing his/her words used in his/her text messages. All this feedback will help AngoraBot to be trained on an original database of text messages and help it to become more accurate when answering to the user’s text messages. Furthermore, the user interface can be improved to make it more appealing, which may help the user to confide more in the chatbot if they find the interface pleasant.

These 30 subjects are recruited through invitation with IRB approval. The subjects are mainly recruited from our group’s own personal connections. To ensure the accuracy of our project, subjects are ranging from 13-18 years old. 15 of them will be male and the other 15 will be female. The number of participants of each race and religion are varied, but may not be equal. These 30 people will hold a one-to-one conversation with AngoraBOT. From their text messages (which are their replies to a questionnaire asked by AngoraBot), the level of emotional stress faced by the participant can be predicted using sentiment analysis. If the participants’ stress levels are too high, suitable help will be recommended to the participants in the conversation, such as therapy and treatment options. Participants will be asked to state their level of stress before the experiment, and this will be matched to the result generated by AngoraBot.

As a machine learning technology, it has the capabilities of learning and processing new and large amounts of information. This gives much room for possible extensions for our project.
When relevant information is added to AngoraBot, it will be able to recognise key indicators of various mental health problems. This will help AngoraBot to correctly identify the mental health problem that an individual is suffering from. Specific treatment can then be suggested to the participant.

AngoraBot could also be customised for different treatments to cure different mental illnesses. For example, social support is a possible cure for depression. AngoraBot can connect people suffering from depression to engage in group discussions online so that they are able to understand each other’s conditions better.

A group chat with other patients with mental health illnesses could be created with AngoraBot as the facilitator. This could be done as part of group supportive therapy, where participants talk about their problems and others suggest possible solutions. This is a feasible option after a period of time of one-to-one conversation, as the user would have opened up to AngoraBot. It is also useful as others with experience could give advice and suggestions to the participant, to help them battle their mental illness.

AngoraBot can also be used for psychological evaluations. With more information added into AngoraBot, our chatbot can ask specific questions in order to find out the participant’s personality type. Certain personality traits can help identify whether a participant is suffering from a mental illness or not. Telegram also allows bots to engage in games with the participant. Simple games can be held during the conversation to make the conversation more interesting, as well as to test for the participant’s cognitive abilities.

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REFERENCES


Appendix

Questionnaire
Instructions: Dear Participant, please ensure that all personal electronic devices are not on your person during the course of experimentation. You are strongly encouraged to answer truthfully so that data collection is accurate. If at any point during data collection you feel that your safety is endangered, type the ‘/’ command button in the message box and select the ‘pause chatbot’ option. Thank you for your cooperation! :)

Duration of Experiment: 1h 30min time limit
Number of 5-min breaks: 3 (one every 30min to minimise prolonged exposure to screen)

Definition of stress in this context: form of negative emotion/mental pressure

Sample Questions
1. Introductory Questions
   a. Hello! How are you today? :)
   b. What’s your name?
   c. What school do you go to?
   d. How old are you?
2. Probing Questions
   a. Did anything good happen today?/Did anything unpleasant happen lately?
      i. Would you like to share what happened?
   b. From this experience, pick an emotion you feel closest to. (Happy, Sad, Angry, Fear, Disgust)
      i. (Negative) Why do you feel this way? Any upcoming events that could have caused this?
      ii. (Positive - Happy) That’s great! :)
   c. How has school been? On a scale of 1 to 5, how stressful do you think school has been lately?
   d. What are some aspects of school you find stressful?
   e. On a scale of 1 to 5, how rigorous do you think academics have been (1 being the least, 5 being the most)?
   f. Pick 3 words you associate with academics. (Radiant, Secure, Caged, Flourish, Plain, Sore)
   g. Rate these options, in the order of stress factor. (1st choice being the biggest, 5th choice being the least)
      i. Academics/CCA/External (Tuition, Music lessons, etc)/Others (specify)
   h. On a scale of 1 to 5, how stressful do you find academics?
   i. Why do you find academics stressful?
      i. On a scale of 1 to 5, how satisfied are you with your grades?
      ii. If you are dissatisfied with them, do you feel stressed about its upcoming consequences?
   j. What are some coping mechanisms you use when you are feeling stressed?
i. Do you think this is an effective method to reduce stress?

k. Other than academics, is there any aspect(s) of school you find stressful?
   i. (Yes - short answer) Would you elaborate what those aspects are?
   ii. On a scale of 1 to 5, how stressful do you think [aspect of school] is/are?
   iii. Why are you stressed in [aspect of school]?
   iv. Do you think you are coping well?

l. Are you happy today?/Are you happy generally?
   i. (Yes) Glad you are! :)
   ii. (No) Why not?

3. Concluding Questions
   a. (End of Experiment) Thanks for coming down today! Unfortunately, our experiment has come to an end, but we hope you had fun :) Please kindly fill in the feedback form below!
   b. Feedback questions
      i. From a scale of 1 to 5, was our chatbot user-friendly (1 being strongly disagree, 5 being strongly agree)?
      ii. From a scale of 1 to 5, how enjoyable was the conversation (1 being the least, 5 being the most)?
      iii. Comments

4. Small Talk (built-in ‘/’ command to pause chatbot any time for 15-min breaks/withdrawal)
   a. What do you do in your free time?
   b. What are you going to do during the holidays?
   c. What did you have for breakfast this morning?
   d. What time did you wake up this morning?
   e. What is your favourite colour?
   f. Do you have a pet?
      i. (Yes/Used to) What species is/was it?
      ii. (No) Would you want one? If so, what species?
   g. Have you been sleeping well? What is the average number of hours you sleep per day?
      i. (≥7) That’s good :)
      ii. (<7) Try to sleep more, at least 7h a day! Rest well :)
   h. Responses (by chatbot)
      i. Sorry, could you rephrase that?
      ii. Oh I see :0
      iii. That’s good :)
      iv. I’m sorry you feel that way :( 
      v. Hope you feel better soon!/Hang in there!/Jiayou!
      vi. Cool!/Nice!
      vii. You’re welcome./No worries.

Note: Questionnaire is subject to minimal change (eg. phrasing), but will circulate around the topic of academics and lifestyle. Questions are subject to deletion if deemed unnecessary.