

COSC 310
Project Report
Group 23

Group members:

Prajeet Didden

Sophia Joseph

Sarvagya Pandey

Michael Turner

Amrita Sidhu

Note: To see what's new for Assignment 3, [jump to page 11](#).

Introduction

The goal of this project is to create an interactive conversational agent, or a 'chat bot' using an object-oriented programming language. The chat bot needs to be assigned a role and is expected to respond to and hold a conversation with the user for thirty or more turns of dialogue. To create the chat bot, our team decided to make use of the Python programming language along with the help of some Natural Language Processing (NLP) frameworks and toolkits. We decided to assign the bot the role of Justin Trudeau, the current Prime Minister of Canada, with whom the user can interact with and ask questions about his personal and political interests in the past, present and the future, along with a few general questions and greetings. The GitHub Repository for this project can be found here: <https://github.com/COSC310Group23/COSC310-Interactive-Conversational-Agent>

Choice of Software Development Life Cycle (SDLC)

After some discussion, our team decided on using the **Waterfall Model** for developing the Interactive Chat Bot. Our choice was based on a few key points: Small Team size, small project size, a clear set of unchanging requirements, and familiarity with the software used for making the project. Along with these key points, we felt that organizing the workflow with the help of distinctive phases will help some of our members become used to developing software in a team environment, as opposed to having to go back on forth between development phases in other SDLCs such as the Agile model.

Phases of Development

Requirements Analysis

- **Software:** Interactive Chat Bot that can respond to user input with appropriate messages.
 - Must be created using an object-oriented programming language.
- **Role Assignment:** Chat Bot must be assigned the role of a specific person and must answer questions within the given context.
- **User Input:** User must be able to converse with the Chat Bot by entering general greetings or questions specific to the bot's assigned role.
 - User must be able to quit the software by entering a command, which must be provided to the user at the beginning of the conversation.
- **Goal:** User must be able to hold a complete and coherent conversation with the Chat Bot for a minimum of 30 turns of dialogue.

System Design

- **Programming Language:** Python will be used to develop the Interactive Chat Bot.
 - Frameworks and Toolkits such as Natural Language Toolkit (NLTK) and TensorFlow will be used to process user input and 'train' the bot's responses.
- **Role:** Chat Bot will be assigned the role of 'Justin Trudeau', Prime Minister of Canada.
- **Dialogue:** Possible variations of all possible questions and the Bot's responses will be stored in a text file.
- **I/O:** User will type their inputs into the console. The Chat Bot's response will also be printed out to the console.
 - User will be able to end the conversation by entering a command such as 'quit' into the console.

Implementation

- Create text file that contains 'patterns' that the Bot should understand and 'responses' that the Bot should output based on the most appropriate pattern.
- Implement a class that uses the NLP algorithms to get a probability for a matching tag based on a user's input
- Implement a method to take in user input, check which pattern it has the highest similarity to from all the pre-written dialogue.

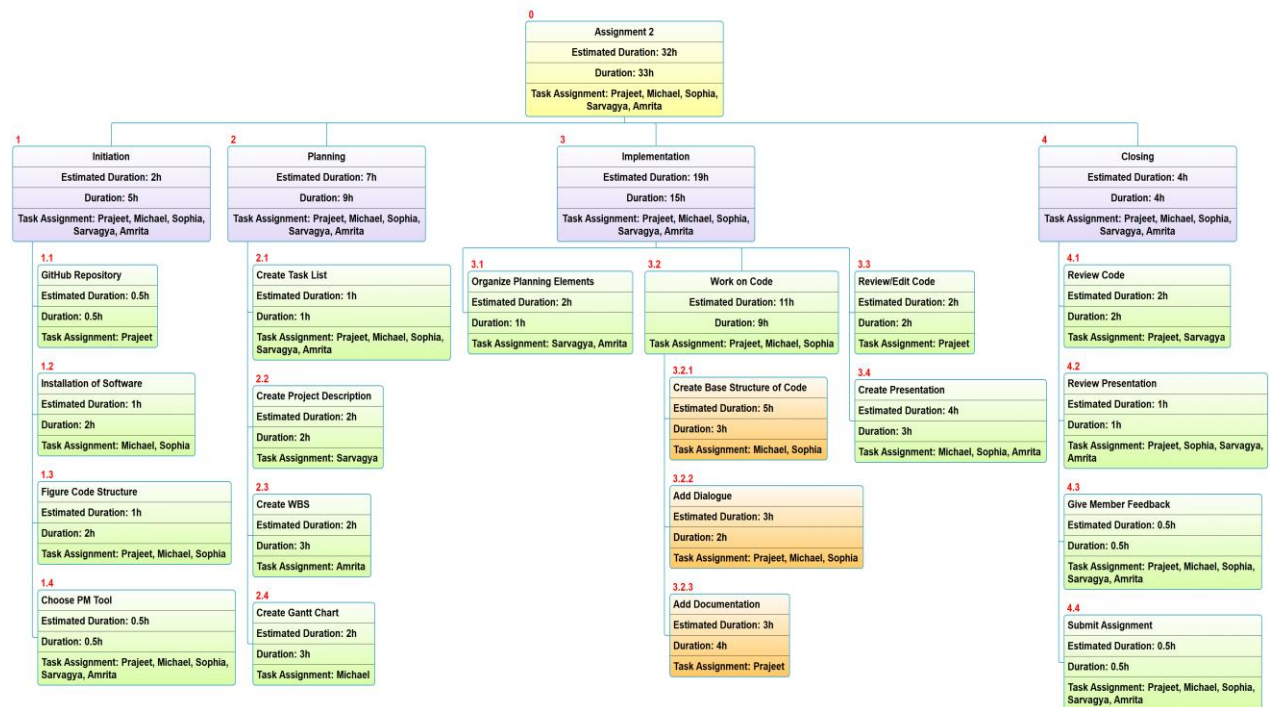
- Output a random response from the list of responses pertaining to the pattern on the console.
- Create a README file containing a brief explanation of the project and the libraries used.
- Document the code by adding comments explaining the features of various classes/methods, etc.

Testing

- Test for bot's responses by entering existing questions or 'patterns' from the text file containing all the dialogue.
 - Check if any of the existing patterns fails to generate an appropriate response.
- Test for an appropriate response when an unrecognizable pattern is entered by user.
- Test 'quit' command that ends conversation on input.
- Review Code and Documentation.
 - Check for possible grammar/language errors in the dialogue file.
 - Check for redundancies/logic errors in code.
- Check for exceptions and crashes on abnormal input.

Project Breakdown

Work Breakdown Structure



	WBS	Name	Task Assignment	Estimated Task Duration (h)	Actual Task Duration (h)	Start	Finish
0	0	Assignment 2	Prajeet, Michael, Sophia, Sarvagya, Amrita		59.5h	2021-02-22	2021-03-04
1	1	Initiation	Prajeet, Michael, Sophia, Sarvagya, Amrita		5h	2021-02-22	2021-02-22
2	1.1	GitHub Repository	Prajeet	0.5	0.5h	2021-02-22	2021-02-22
3	1.2	Installation of Software	Michael, Sophia	1	2h	2021-02-22	2021-02-22
4	1.3	Figure Code Structure	Prajeet, Michael, Sophia	1	2h	2021-02-22	2021-02-22
5	1.4	Choose PM Tool	Prajeet, Michael, Sophia, Sarvagya, Amrita	0.5	0.5h	2021-02-22	2021-02-22
6	2	Planning	Prajeet, Michael, Sophia, Sarvagya, Amrita		9h	2021-02-23	2021-02-24
7	2.1	Create Task List	Prajeet, Michael, Sophia, Sarvagya, Amrita	1	1h	2021-02-23	2021-02-23
8	2.2	Create Project Description	Sarvagya	3	2h	2021-02-24	2021-02-24
9	2.3	Create WBS	Amrita	2	3h	2021-02-24	2021-02-24
10	2.4	Create Gantt Chart	Michael	2	3h	2021-02-24	2021-02-24
11	3	Implementation	Prajeet, Michael, Sophia, Sarvagya, Amrita		22h	2021-02-26	2021-03-04
12	3.1	Organize Planning Elements	Sarvagya, Amrita	2	2h	2021-02-26	2021-02-26
13	3.2	Work on Code	Prajeet, Michael, Sophia		20h	2021-02-26	2021-02-27
14	3.2.1	Create Base Structure of Code	Michael, Sophia	4	5h	2021-02-26	2021-02-26
15	3.2.2	Add Dialogue	Prajeet, Michael, Sophia	3	4h	2021-02-27	2021-02-27
16	3.2.3	Add Documentation	Prajeet	3	4h	2021-02-26	2021-02-26
17	3.3	Review/Edit Code	Prajeet	2	3h	2021-03-01	2021-03-01
18	3.4	Create Presentation	Michael	4	4h	2021-03-04	2021-03-04
19	4	Closing	Prajeet, Michael, Sophia, Sarvagya, Amrita		3.5h	2021-03-02	2021-03-04
20	4.1	Review Code	Prajeet	2	2h	2021-03-02	2021-03-03
21	4.2	Review Presentation	Prajeet, Sophia, Sarvagya, Amrita	1	1h	2021-03-03	2021-03-04
22	4.3	Give Member Feedback	Prajeet, Michael, Sophia, Sarvagya, Amrita	0.5	0.5h	2021-03-03	2021-03-04

Gantt Chart

TASK NUMBER	WBS NUMBER	TASK TITLE	TASK PARTICIPANTS	START DATE	DUE DATE	DURATION	PREDECESSORS	WEEK 1 (Feb 22 - Mar 28)							WEEK 2 (Mar 1 - Mar 7)						
								M	T	W	TH	F	SA	SU	M	T	W	TH	F	SA	SU
1	1	Initiation				1 day															
2	1.1	GitHub Repository	Prajeet	2/22/21	2/23/21	1 day	-														
3	1.2	Installation of software	Michael, Sophia	2/22/21	2/23/21	1 day	-														
4	1.3	Figure Code Structure	Prajeet, Michael, Sophia	2/22/21	2/23/21	1 day	-														
5	1.4	Choose PM Tool	Prajeet, Michael, Sophia, Sarvagya, Amrita	2/22/21	2/23/21	1 day	-														
6	2	Planning				3 days															
7	2.1	Create List of Tasks	Prajeet, Michael, Sophia, Sarvagya, Amrita	2/23/21	2/24/21	1 day	2;3;4;5														
8	2.2	Create Project Description	Sarvagya	2/24/21	2/26/21	2 days	7														
9	2.3	Create WBS	Amrita	2/24/21	2/26/21	2 days	7														
10	2.4	Create Gantt Chart	Michael	2/24/21	2/26/21	2 days	7														
11	3	Implementation				6 days															
12	3.1	Organize Planning Elements	Sarvagya, Amrita	2/26/21	2/27/21	1 day	8;9;10														
13	3.2	Work on Code	Prajeet, Michael, Sophia	2/26/21	2/28/21	2 days	8;9;10														
14	3.2.1	Create Base Structure of Code	Michael, Sophia	2/26/21	2/27/21	1 day	8;9;10														
15	3.2.2	Add Dialogue	Prajeet, Michael, Sophia	2/27/21	2/28/21	1 day	14														
16	3.2.3	Add Documentation	Prajeet	2/26/21	2/28/21	1 day	14														
17	3.3	Review/Edit Code	Prajeet	2/28/21	3/2/21	2 days	15;16														
18	3.4	Create Presentation	Michael, Sophia, Amrita	3/2/21	3/4/21	2 days	17														
19	4	Closing				2 days															
20	4.1	Review Code	Prajeet, Sarvagya	3/4/21	3/5/21	1 day	18														
21	4.2	Review Presentation	Prajeet, Sophia, Sarvagya, Amrita	3/4/21	3/5/21	1 day	18														
22	4.3	Give Member Feedback	Prajeet, Sophia, Michael, Amrita, Sarvagya	3/4/21	3/5/21	1 day	18														
23	4.4	Submit Assignment	Prajeet, Sophia, Michael, Amrita, Sarvagya	3/5/21	3/6/21	1 day	20;21;22														

Software Limitations

- Unable to handle some synonyms.
- Unable to handle input not included in the pre-written dialogue file.
- Unable to handle complex phrases such as idioms, similes, etc.
- Unable to handle major incorrect spellings.

Sample Output

Working as Intended

```
Start talking with the bot (type quit to stop)!
You: hi
Good to see you!
You: what is your name
You can call me Justin.
You: how old are you
I just turned 49!
You: joke
Did you hear about the semi-colon that broke the law? He was given two consecutive sentences!
You: where were you born
I grew up in Ottawa
You: how many siblings do you have
I have three half siblings
You: what university did you go to?
I went to McGill University and the University of British Columbia after graduating highschool
You: what highschool did you go to
The name of my highschool is College Jean-de-Brebeuf
You: when is your birthday
I was born on December 25, 1971
You: what did you want to be when you grew up
an astronaut
You: what was your first job
camp counsellor
You: what books have you written
common ground
You: who is your favorite author
my favorite author is Stephen King!
You: what is your occupation
I am the 23rd Prime Minister of Canada.
You: who is your wife
I am current partner is Sophie Gregoire.
You: what is your party
I am the leader of the Liberal Party.
You: how can i follow you
I have a twitter. It is @justintrudeau.
You: what is your favourite restaurant
My favourite restaurant is Sakura Gardens.
You: what is your height
I am 6'2.
You: what type of music do you listen to
I enjoy music but I cannot choose which is my favourite.
You: what languages can you speak
I can speak English and French very well
You: do you think the pandemic will end in 2021?
A health official will be able to provide a better answer!
You: what are your plans after retirement?
I want to try new hobbies that I did not have the chance to do as prime minister
You: who do you think will succeed you as prime minister?
I haven't thought that far ahead. I plan to continue serving my country in the near future
You: who are you married to
I am married to Sophie Gregoire.
You: what is your favorite movie
My favorite movie is Star Wars:The Empire Strikes Back
You: what do you like doing on the weekend
I like to read during the weekends
You: do you have any hobbies that you would like to get into?
I have a few that I want to try, such as yoga and surfing.
You: tell me one idea from your bucket list
I want to try the hottest pepper in the world
You: what sports do you play
I box, run, and rock climb.
You: where do you live
I live in Ottawa.
You: what are the names of your children
From oldest to youngest, my childrens' names are Xavier, Ella-Grace, and Hadrien.
You: goodbye
Talk to you later
You: quit
```

Negative/Abnormal Behaviour

```
think to you later  
You: how many kids do you have?  
I didn't quite understand  
You: 
```

```
Start talking with the bot (type quit to stop)!  
You: 12345goodbye  
I didn't quite understand  
You: 11goodbye  
I didn't quite understand  
You: goodbye11!!  
I didn't quite understand  
You: hello?!?1  
Hi there, how can I help?  
You: When do you think the next election will take place  
I'm not sure. You should ask health officials  
You: 
```

Assignment 3

We have implemented some new features to further enhance the user's experience and to improve the flow of conversation with the chat bot. A Graphical User Interface (GUI) has been used in place of the terminal for input/output, so that the user has a more pleasant experience when talking with the bot. The bot also utilizes Stanford's CoreNLP Toolkit to make use of features such as Sentiment Analysis, which allows the bot to provide appropriate responses to statements that are not present in the question bank, and Part-of-speech(POS) tagging which helps the bot recognize certain key words as parts of speech(useful for performing other functions). Synonym recognition was also implemented with the use of NLTK's WordNet. This feature helps the bot understand a wider range of vocabulary and sentences while providing the correct response.

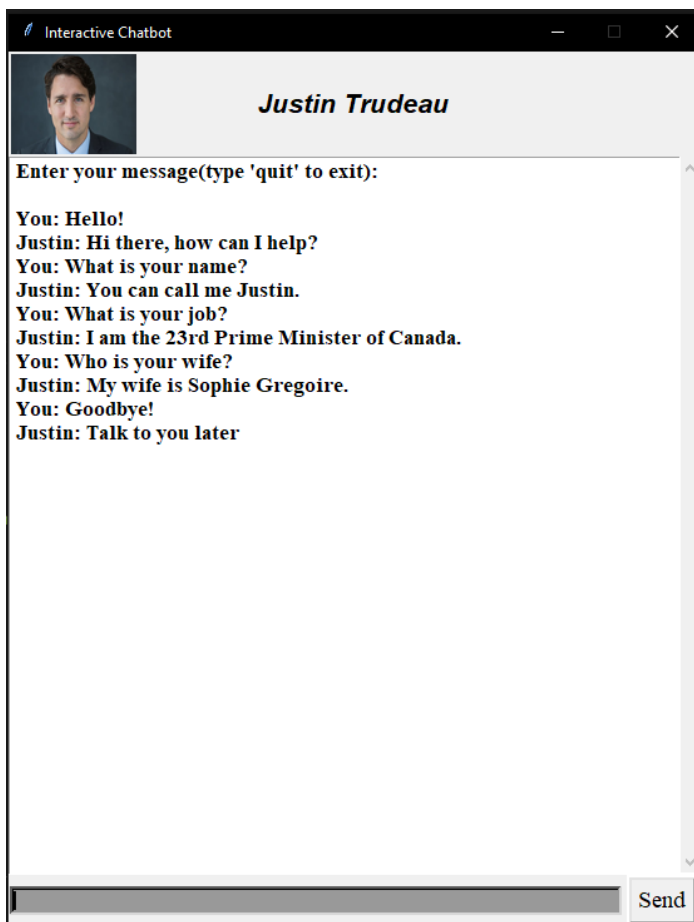
New Files

- **stanfordload.py** - Establishes connection to Stanford's CoreNLP Server
- **gui.py** - Comprises of functions that make the GUI for the chat bot
- **sentiment.py** - Contains functions that conduct sentiment analysis on the user's input statement using Stanford's CoreNLP Toolkit
- **syn_recognition.py** - Contains functions that tag parts-of-speech in user's input, and creates different sentences with different combinations of synonyms
- **test_chatbot.py** - Contains unit tests for major functions and classes to validate them

New features

Graphical User Interface (GUI)

A simple GUI was implemented to provide a much more appealing way of using the chat bot. This GUI was made using Tkinter and image functionalities from Pillow were utilized. It consists of a medium-sized window with a text box(to display the conversation), an entry box(for the user to type their message in), a 'Send' button which can be pressed to send the typed message to the bot(They can also choose to press 'Enter'), and various other smaller features such as a label containing the image and name of the person who the bot is based on, and a scrollbar for the user to access/read older sections of the conversation. Here is an image showcasing the GUI with a few turns of conversation:



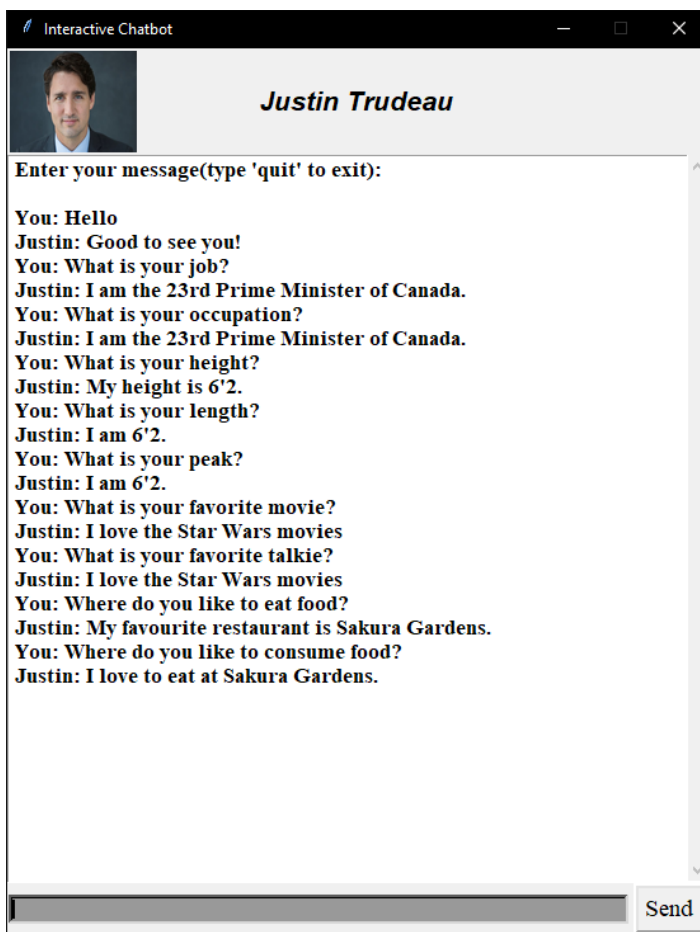
Part-of-Speech (POS) Tagging

Stanford's CoreNLP Toolkit is used to tokenize and categorize each word in the user's input sentence to specific parts of speech. If the word's POS matches with the one specified, it is placed into a dictionary of words that would be later used for another feature. The values assigned to each word is their corresponding POS, which is converted from Stanford's CoreNLP format to NLTK.WordNet's format. Here is an image displaying sample output for a possible sentence that the user could input, and its breakdown into different parts of speech, along with the dictionary of key words(Note: The following output is not visible in the final version of the application. This image is for demonstration purposes only):

```
User input: What is your job Justin?
What - WP
is - VBZ
your - PRP$
job - NN
Justin - NNP
? - .
Replacement Words(with POS tags) : {'job': 'n'}
█
```

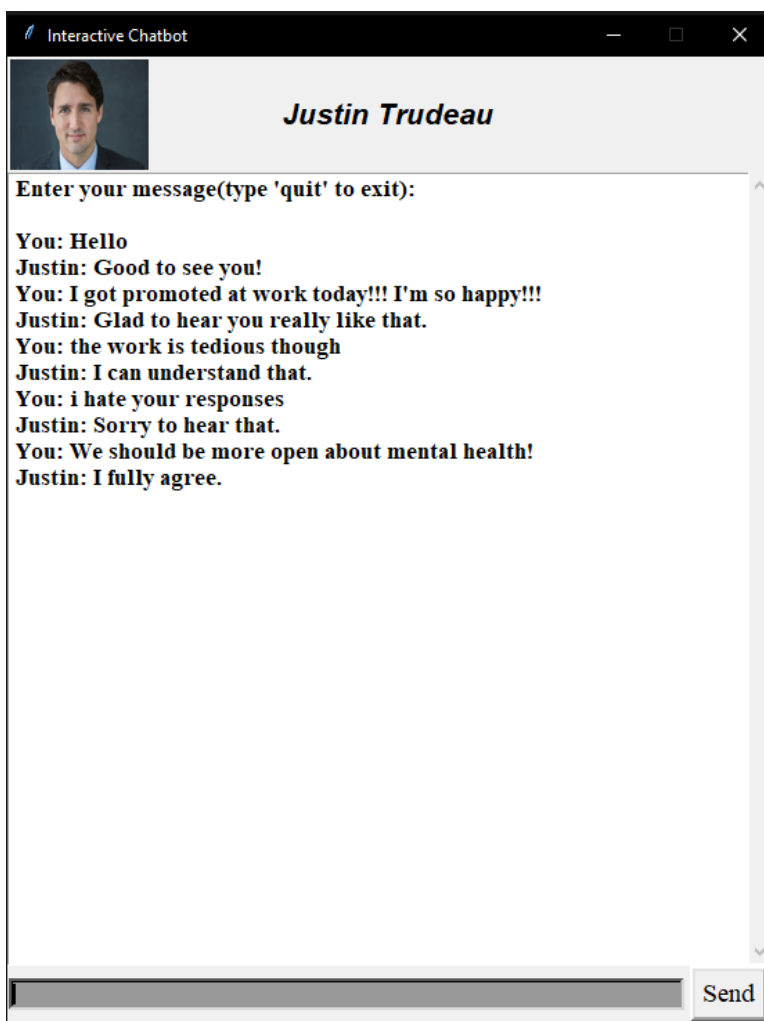
Synonym Recognition

A lexical database in the form of NLTK's WordNet is used to find synonyms of key words from the user's input sentence (see above feature on how to get these 'key words'). The original word is then replaced by each of these synonyms to form a new sentence, each of which is stored in a list. This list is returned to chatbot.py where each sentence is incrementally sent to the bot until it recognizes one and forms an appropriate response. If none of the sentences manage to get recognized, an appropriate message from the bot is shown to the user instead (Note: The first sentence in the list is always the user's original input). The following image showcases the bot's ability to recognize different words as synonyms of each other and provide the same type of response to all sentences:



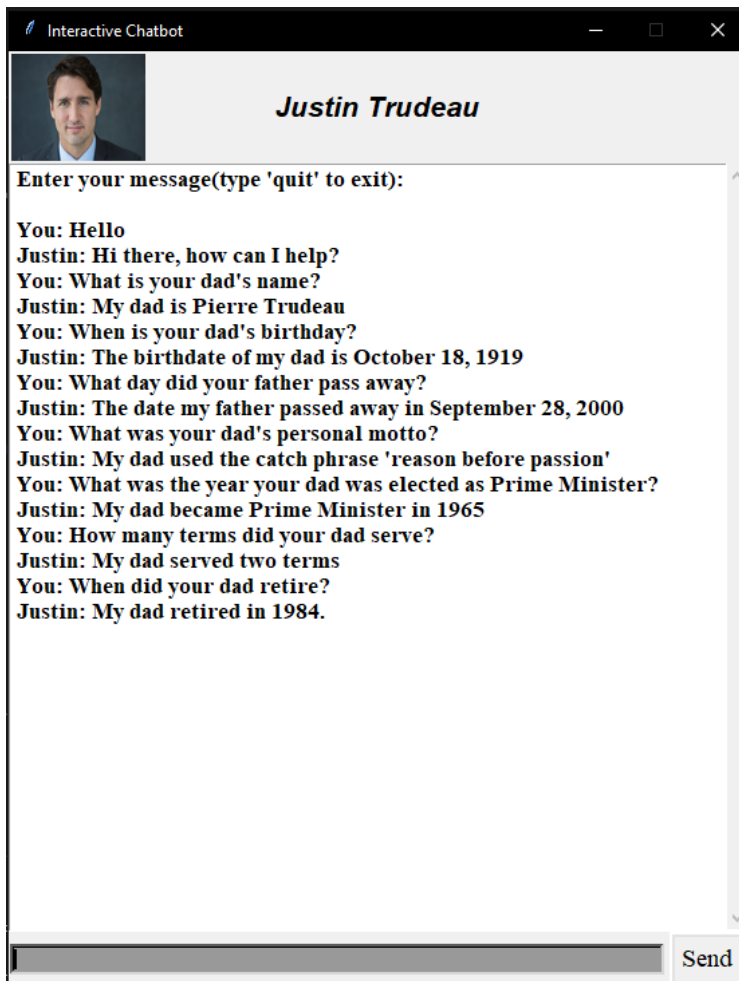
Sentiment Analysis

The CoreNLP Toolkit is also used to perform Sentiment Analysis; it detects words in the sentence that have different levels of sentiment and provides an integer value from 0-3 based on how positive or negative the sentiment is. The bot then responds appropriately based on the sentiment number generated from the sentence. Here is a sample image of the bot responding to different levels of sentiment with the user's input sentences:



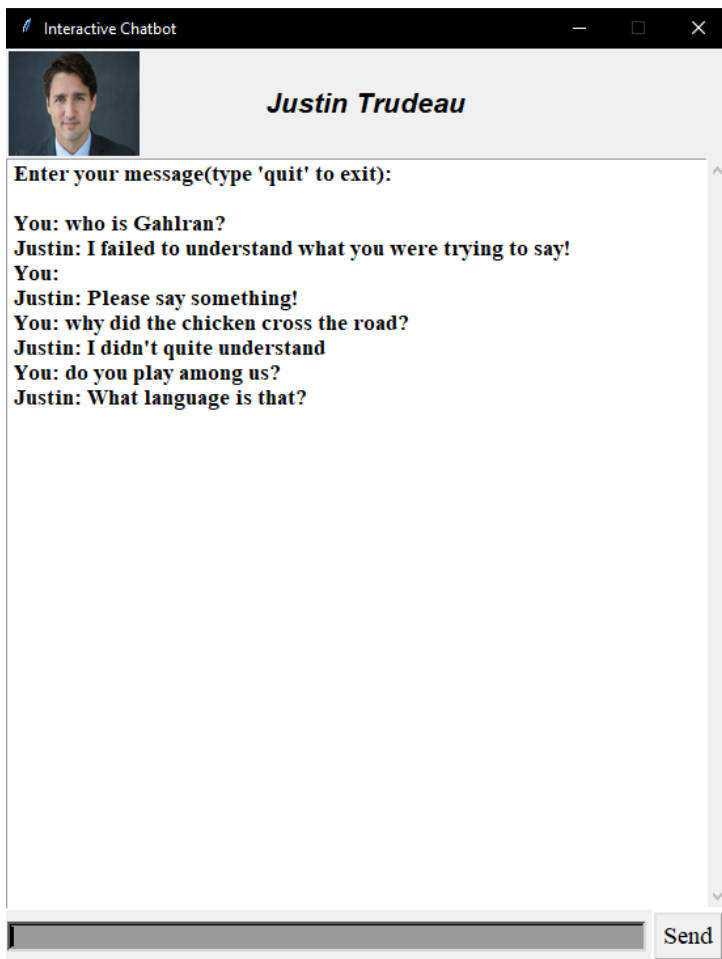
Extra Topic of Conversation

The bot now supports conversation about his father, Pierre Trudeau and his relationship with him. The following image demonstrates some new possible combinations of dialogue with the bot:



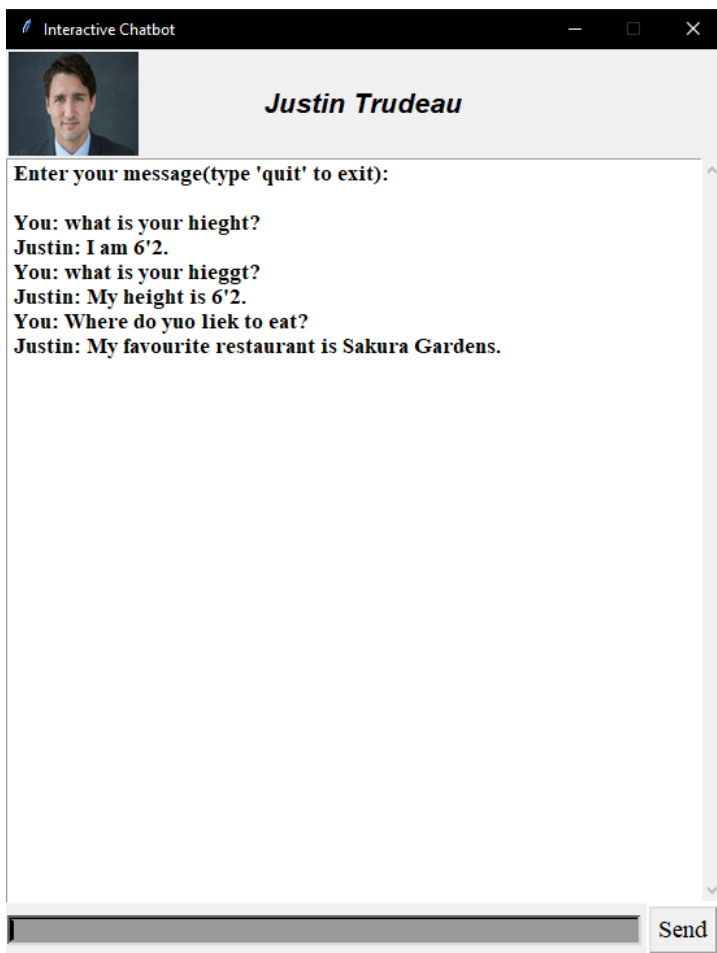
Varied 'Fail' Responses

When the bot fails to recognize a sentence input by the user, it now has the possibility to reply with 5 different responses instead of just one. The image below showcases this new feature:



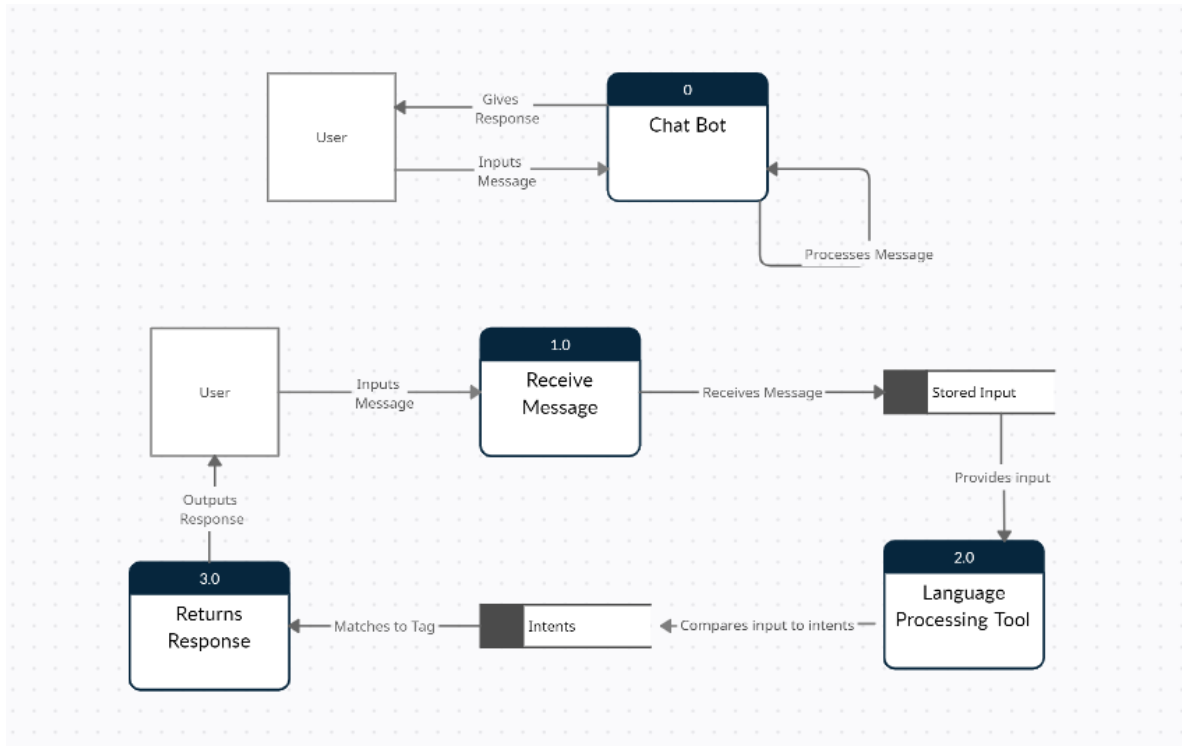
Spelling Error Detection

The Lancaster Stemmer Algorithm tokenizes the words in the user's input sentence, stems them to provide the root words, removes 'stop words' and as a result, can handle minor spelling errors. The following image shows the bot's ability to respond appropriately even if the input sentence has minor errors in spelling:

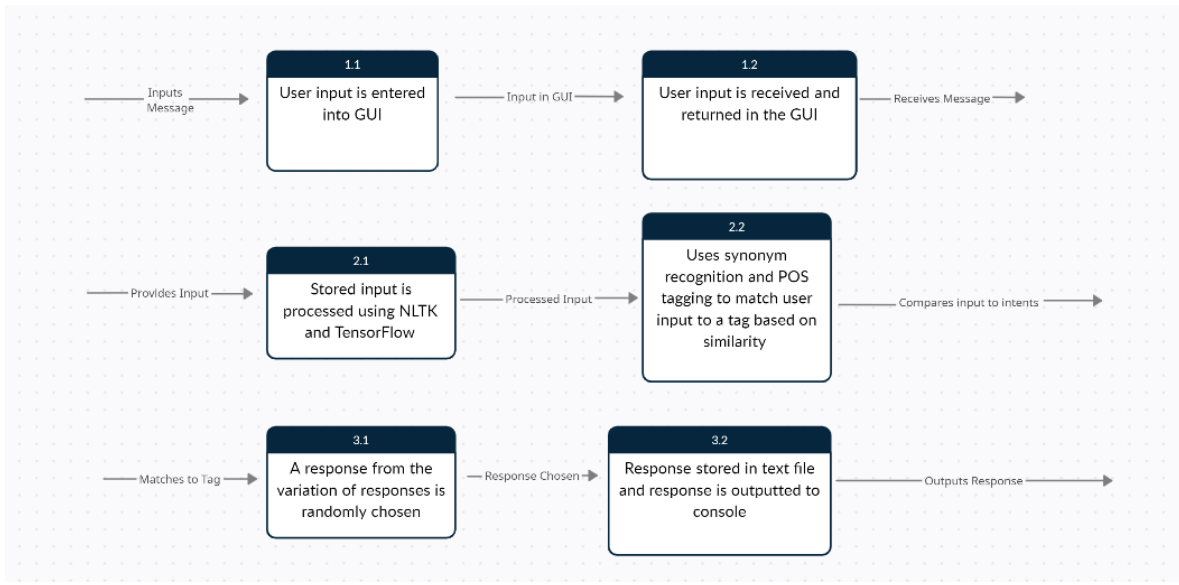


Data Flow Diagrams

Level 0



Level 1



Unit-Testing

The file test chatbot.py is used to run unit testing on the bot. The file can be run directly after the Stanford NLP server is started. There is a set up process that will load in the intents.json file to grab some expected responses that will be tested. There is a total of seven tests that are run, covering major parts of the bot's functionality.

```
def setUp(self):
    self.l = load("intents.json")
    self.data = self.l.getData()
    for t in self.data["intents"]:
        if t['tag'] == "greeting":
            self.responses = t['responses']
        if t["tag"] == "music":
            self.responsesmusic = t['responses']
```

Test Basic Chat Functionality

The test chat function tests basic chat inputs and responses. It will assert true if an input matches with an expected response. For this function we've decided to check responses for greetings. As the bot is programmed to throw out a random relative response from the matching tag, we must check if the response we receive is inside the list of responses. If it is, the function will assert it as true.

```
def test_chat(self):
    self.assertTrue(chatbot.chat("How are you") in self.responses)
    self.assertTrue(chatbot.chat("Is anyone there?") in self.responses)
    self.assertTrue(chatbot.chat("hello") in self.responses)
    self.assertTrue(chatbot.chat("good day") in self.responses)
    self.assertTrue(chatbot.chat("whats up?") in self.responses)
```

Testing Tags

Each response that we receive is related to a tag. This tag is used to output the response, so we can check if the input that we give matches the expected tag. Using assert equals we check if 'chatbot.tag' is equal to the relevant tag.

```
def test_tag(self):
    chatbot.chat("How are you")
    self.assertEqual(chatbot.tag, "greeting")
    chatbot.chat("see you later")
    self.assertEqual(chatbot.tag, "goodbye")
    chatbot.chat("how old")
    self.assertEqual(chatbot.tag, "age")
```

Testing Sentiment Analysis

Sentiment analysis works by returning a statement relevant to an input. This is tested by using assert equals as the responses are all hard coded, and work based on a scale from 0-3.

```
def test_sentiment(self):
    self.assertEqual(chatbot.chat("I love your work"), "Glad to hear you really like that.")
    self.assertEqual(chatbot.chat("I hate you"), "I can understand that.")
    self.assertEqual(chatbot.chat("I like this conversation"), "I fully agree.")
```

Testing Capitalization

For this test, we input the same statement with different capitalization. We then check if the response we receive is in the expected responses list.

```
def test_capitalization(self):
    self.assertTrue(chatbot.chat("hOW aRE yOU") in self.responses)
    self.assertTrue(chatbot.chat("HOW ARE YOU") in self.responses)
    self.assertTrue(chatbot.chat("how are you") in self.responses)
```

Testing Punctuation

Like the previous test, we input the same statement, with different punctuation and check if the expected response is in the responses list.

```
def test_punctuation(self):
    self.assertTrue(chatbot.chat("how are you.") in self.responses)
    self.assertTrue(chatbot.chat("how are you!") in self.responses)
    self.assertTrue(chatbot.chat("how are you?") in self.responses)
```

Testing Synonyms

For this test, we must put in similar sentences, with only a few words swapped around that are not in our expected inputs list. Then we can check if the response we receive is still in the responses list, telling us that replacing with synonyms worked.


```
def test_synonyms(self):
    self.assertTrue(chatbot.chat("what type of music do you listen to") in self.responsesmusic)
    self.assertTrue(chatbot.chat("what tunes do you listen to") in self.responsesmusic)
```

Testing Out of Scope Responses

This test will check that the bot gives an appropriate response if it can't understand what the input is. It asserts true if the expected response is in 'chatbot.others' list.

```
def test_failResponses(self):
    self.assertTrue(chatbot.chat("Who is Gahlran?") in chatbot.others)
    self.assertTrue(chatbot.chat("do you play among us?") in chatbot.others)
```

Sample Output (Normal Behaviour)



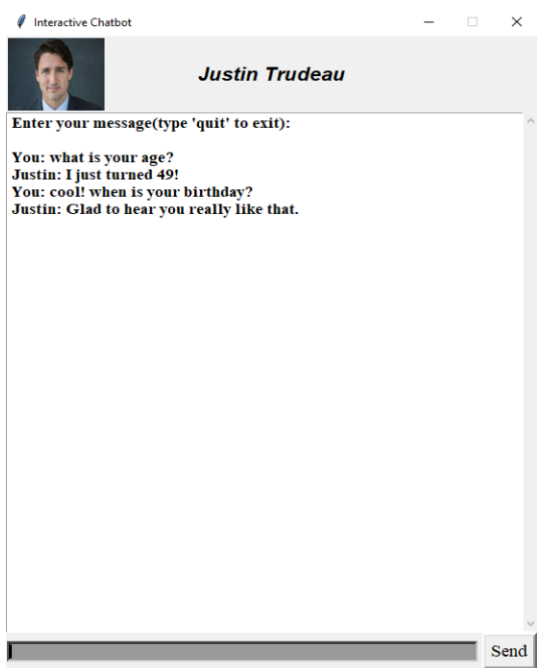
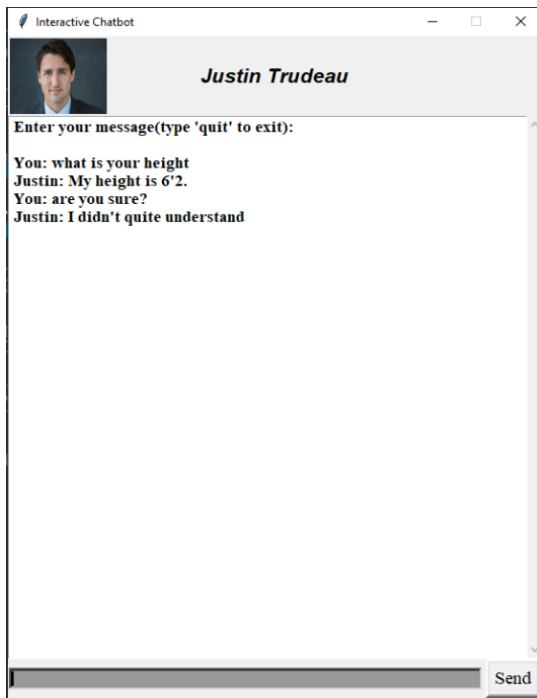
Justin Trudeau

Enter your message(type 'quit' to exit):

You: hi
Justin: Hi there, how can I help?
You: what is your name
Justin: You can call me Justin.
You: what is your age
Justin: I just turned 49!
You: what is your height
Justin: My height is 6'2.
You: where were you born
Justin: I grew up in Ottawa
You: how many siblings do you have
Justin: I have two brothers and one sister
You: TELL ME A JOKE
Justin: Did you hear about the semi-colon that broke the law? He was given two consecutive sentences!
You: what university did you go to?
Justin: I went to McGill University and the University of British Columbia after graduating highschool
You: what type of music do you listen to
Justin: I enjoy music but I cannot choose which is my favourite.
You: i hate you
Justin: Sorry to hear that.
You: what is your favourite restaurant
Justin: My favourite restaurant is Sakura Gardens.
You: i like that restaurant as well
Justin: Glad to hear you really like that.
You: what is your dad's name
Justin: My father is Pierre Trudeau
You: when is your dad's birthday
Justin: My father was born on October 18, 1919
You: what university did your dad attend
Justin: My dad studied law at the Université de Montréal
You: how many terms did your dad serve
Justin: My dad served two terms
You: Did your dad serve in the war?
Justin: My dad served in the Second World War
You: when did your dad retire
Justin: My dad retired in 1984.
You: i like this conversation
Justin: I fully agree.
You: what highschool did your go to
Justin: I attended College Jean-de-Brebeuf
You: when is your birthday
Justin: my birthday is December 25, 1971
You: what was your first job
Justin: my first job was a camp counsellor
You: what is your favorite movie
Justin: I love the Star Wars movies
You: how can i follow you
Justin: My twitter username is @justintrudeau.
You: what do you want to do after retirement
Justin: I want to relax and enjoy life more
You: how do you pass time weekends
Justin: I like to read during the weekends
You: what books have you written
Justin: the name of my book is common ground
You: what languages do you speak
Justin: I can speak English and French very well
You: do you think the pandemic will end in 2021
Justin: I'm not sure. You should ask health officials
You: i loved this conversation
Justin: Glad to hear you really like that.
You: goodbye
Justin: Goodbye!

Send

Sample Output (Abnormal/Unexpected Behaviour)



Limitations of Software

- Unable to recognize multi-sentence inputs.
- Unable to handle major spelling errors.
- Unable to understand vague questions.

Extractable Features (API)

- Getting a list of sentences with similar meanings (using synonyms) from 'syn_recognition.py'
- Getting a list of all the Nouns in each sentence from 'syn_recognition.py'
- Checking whether a sentence is a question or a sentiment using 'sentiment.py'
- Generating a sentiment score for a given sentence from 'sentiment.py'
- Generate an array of words in their root form from a given sentence using 'load.py'