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Human Language Data Processing using NLTK

Venkata Mahesh Babu Batta
https://orcid.org/0000-0002-1029-6402
M.Tech, Department of CSE
University College of Engineering, Osmania University, Hyderabad, Telangana, India

Abstract: *Natural Language Toolkit (NLTK) is a comprehensive Python library designed to facilitate the exploration, analysis, and processing of human language data. With its extensive collection of tools, NLTK provides researchers, developers, and educators with a powerful platform for tasks ranging from basic text processing to advanced natural language understanding and machine learning. The toolkit includes modules for tokenization, stemming, lemmatization, part-of-speech tagging, named entity recognition, syntactic parsing, semantic analysis, and more. Furthermore, NLTK offers access to numerous linguistic resources such as corpora, lexicons, and treebanks, making it an invaluable resource for both learning and research in the field of natural language processing (NLP). NLTK serves as an indispensable tool for unlocking the complexities of human language*

Keywords: Natural Language Processing(NLP), Natural Language Toolkit(NLTK), Python

I. INTRODUCTION

Language is one of the most intricate and fascinating aspects of human communication. Understanding and analyzing language has been a longstanding pursuit, not only for linguists but also for computer scientists and researchers in various fields. Natural Language Processing (NLP) is the branch of artificial intelligence concerned with the interaction between computers and human languages.
NLTK, or the Natural Language Toolkit, is a powerful Python library specifically designed to facilitate NLP tasks. It is used for text classification, sentiment analysis, machine translation, or any other language-related task, NLTK provides the tools and resources necessary to process and analyze textual data efficiently.

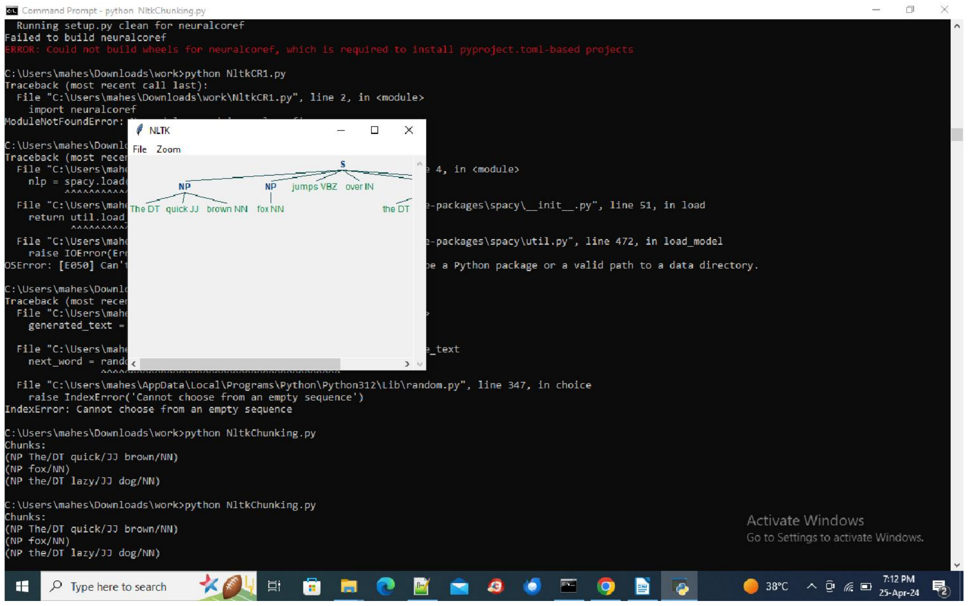
1. Chunking and Parsing: NLTK allows users to perform syntactic analysis on text through chunking and parsing. Chunking involves identifying and extracting meaningful phrases or chunks from sentences, while parsing involves analyzing the grammatical structure of sentences to determine their syntactic relationships. NLTK provides various parsers and chunkers, including regular expression-based chunkers, rule-based parsers, and probabilistic parsers, allowing for flexible and accurate syntactic analysis.

```
#python
import nltk

# Sample sentence
sentence = "The quick brown fox jumps over the lazy dog."

# Tokenize the sentence
tokens = nltk.word_tokenize(sentence)

# Part-of-speech tagging
pos_tags = nltk.pos_tag(tokens)

# Define a chunk grammar for noun phrases (NP)
chunk_grammar = r"""
NP: {
```

```
#python
import nltk

# Sample sentence
sentence = "The quick brown fox jumps over the lazy dog."

# Tokenize the sentence
tokens = nltk.word_tokenize(sentence)

# Part-of-speech tagging
pos_tags = nltk.pos_tag(tokens)

# Define a chunk grammar for noun phrases (NP)
chunk_grammar = r"""
NP: {<DT>?<JJ>*<NN>}  # Chunk sequences of DT, JJ, NN
"""

# Create a chunk parser
chunk_parser = nltk.RegexpParser(chunk_grammar)

# Perform chunking
chunks = chunk_parser.parse(pos_tags)

# Print the chunks
print("Chunks:")
for subtree in chunks.subtrees():
if subtree.label() == 'NP':  # Only print noun phrases
print(subtree)

# Visualize the parsed tree (optional)
chunks.draw()
```

This code performs the following:
1.Tokenization: Splits the input sentence into individual words (tokens).
2. Part-of-Speech Tagging: Assigns a part-of-speech tag to each token (e.g., noun, verb, adjective).
3.Chunk Grammar Definition: Defines a chunk grammar using regular expressions to specify patterns of tokens that constitute noun phrases (NPs).
4. Chunk Parsing: Uses NLTK's `RegexpParser` to parse the part-of-speech tagged tokens according to the chunk grammar and extract noun phrases.
5. Printing Chunks: Prints the extracted noun phrases.
6. Optional Visualization: Draws a visualization of the parsed tree structure (if you have the necessary visualization libraries installed).

When you run this code, you'll see the noun phrases extracted from the input sentence based on the defined chunk grammar. In this example, the chunk grammar identifies sequences of determiners (DT), adjectives (JJ), and nouns (NN) as noun phrases. You can customize the chunk grammar to extract different types of phrases based on your requirements.



```
 Running setup.py clean for neuralcoref
Failed to build neuralcoref
ERROR: Could not build wheels for neuralcoref, which is required to install pyproject.toml-based projects

C:\Users\mahes\Downloads\work>python NltkCR1.py
Traceback (most recent call last):
  File "C:\Users\mahes\Downloads\work\NltkCR1.py", line 2, in <module>
    import neuralcoref
ModuleNotFoundError:

C:\Users\mahes\Downl
Traceback (most recer
  File "C:\Users\mahe                                    e 4, in <module>
    nlp = spacy.load(
          ^^^^^^^^^^
  File "C:\Users\mahe                                    e-packages\spacy\__init__.py", line 51, in load
    return util.load_
           ^^^^^^^^^
  File "C:\Users\mahe                                    e-packages\spacy\util.py", line 472, in load_model
    raise IOError(Err
OSError: [E050] Can't                                    be a Python package or a valid path to a data directory.

C:\Users\mahes\Downl
Traceback (most recer
  File "C:\Users\mahe
    generated_text =

  File "C:\Users\mahe                                    e_text
    next_word = rand
                ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "C:\Users\mahes\AppData\Local\Programs\Python\Python312\Lib\random.py", line 347, in choice
    raise IndexError('Cannot choose from an empty sequence')
IndexError: Cannot choose from an empty sequence

C:\Users\mahes\Downloads\work>python NltkChunking.py
Chunks:
(NP The/DT quick/JJ brown/NN)
(NP fox/NN)
(NP the/DT lazy/JJ dog/NN)

C:\Users\mahes\Downloads\work>python NltkChunking.py
Chunks:
(NP The/DT quick/JJ brown/NN)
(NP fox/NN)
(NP the/DT lazy/JJ dog/NN)
```

Figure: chunking and parsing

2. Word Sense Disambiguation: Word sense disambiguation (WSD) is the task of determining the correct meaning of a word in context, particularly when the word has multiple meanings. NLTK provides methods and algorithms for performing WSD, including Lesk algorithm, which utilizes the contextual overlap between words and their surrounding words to disambiguate word senses.

Example program that demonstrates word sense disambiguation (WSD) using NLTK (Natural Language Toolkit). We'll use the Lesk algorithm, which is a simple and widely used approach for WSD. The Lesk algorithm utilizes the contextual overlap between words in a sentence and their possible senses in a lexical resource (such as WordNet) to disambiguate word senses.

```
#python
import nltk
from nltk.corpus import wordnet

# Sample sentence
sentence = "I went to the bank to deposit some money."

# Tokenize the sentence
tokens = nltk.word_tokenize(sentence)

# Perform part-of-speech tagging
pos_tags = nltk.pos_tag(tokens)

# Lesk Algorithm for Word Sense Disambiguation
def lesk_algorithm(word, sentence):
best_sense = None
max_overlap = 0
```

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```
# Get all possible senses of the word from WordNet
senses = wordnet.synsets(word)

# Iterate over each sense of the word
for sense in senses:
# Get gloss (definition) of the sense
gloss = sense.definition()

# Tokenize the gloss
gloss_tokens = set(nltk.word_tokenize(gloss))

# Calculate the overlap between gloss tokens and sentence tokens
overlap = len(gloss_tokens.intersection(set(sentence)))

# Update best sense if overlap is greater than current max_overlap
if overlap > max_overlap:
max_overlap = overlap
best_sense = sense

return best_sense

# Perform word sense disambiguation for each word in the sentence
disambiguated_sentence = []
for word, pos_tag in pos_tags:
if pos_tag.startswith('N') or pos_tag.startswith('V'):  # Consider only nouns and verbs
sense = lesk_algorithm(word, tokens)
if sense:
disambiguated_sentence.append(f"{word}({sense.name().split('.')[0]})")  # Append word with its disambiguated sense
else:
disambiguated_sentence.append(word)
else:
disambiguated_sentence.append(word)

# Print the disambiguated sentence
print("Disambiguated Sentence:")
print(".join(disambiguated_sentence))
```

This code performs the following:

1. Tokenization and Part-of-Speech Tagging: The input sentence is tokenized into words, and each word is assigned a part-of-speech tag.
2. Lesk Algorithm for WSD: The Lesk algorithm is implemented to disambiguate the senses of each word in the sentence. For each word, the algorithm finds the sense from WordNet with the highest overlap between its definition (gloss) and the context of the sentence.
3. Disambiguated Sentence: The disambiguated senses of the words are appended to form a disambiguated sentence, where each word is followed by its disambiguated sense (if available).

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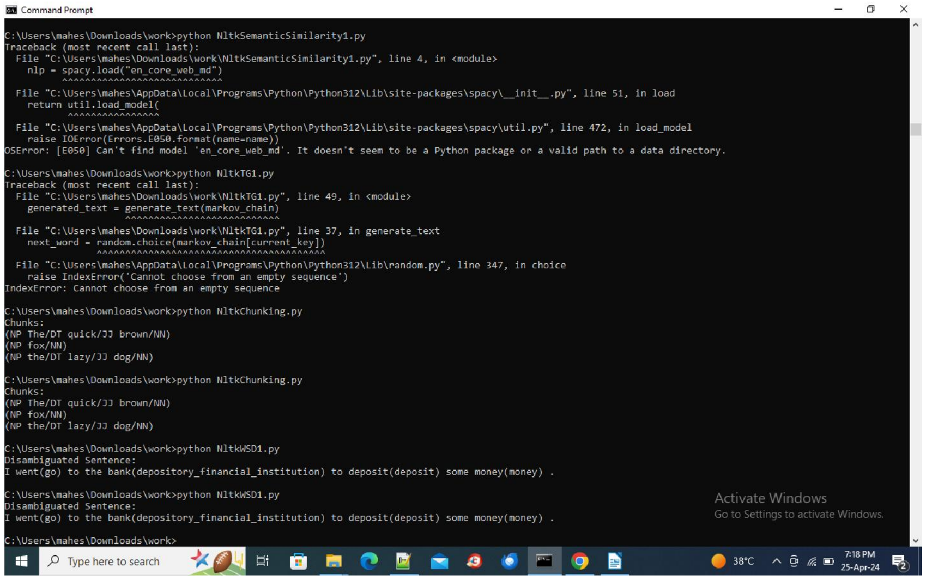

```
C:\Users\mahes\Downloads\work>python NltkSemanticSimilarity1.py
Traceback (most recent call last):
  File "C:\Users\mahes\Downloads\work\NltkSemanticSimilarity1.py", line 4, in <module>
    nlp = spacy.load("en_core_web_md")
          ^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "C:\Users\mahes\AppData\Local\Programs\Python\Python312\Lib\site-packages\spacy\__init__.py", line 51, in load
    return util.load_model(
           ^^^^^^^^^^^^^^^^
  File "C:\Users\mahes\AppData\Local\Programs\Python\Python312\Lib\site-packages\spacy\util.py", line 472, in load_model
    raise IOError(Errors.E050.format(name=name))
OSError: [E050] Can't find model 'en_core_web_md'. It doesn't seem to be a Python package or a valid path to a data directory.

C:\Users\mahes\Downloads\work>python NltkTG1.py
Traceback (most recent call last):
  File "C:\Users\mahes\Downloads\work\NltkTG1.py", line 49, in <module>
    generated_text = generate_text(markov_chain)
                     ^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "C:\Users\mahes\Downloads\work\NltkTG1.py", line 37, in generate_text
    next_word = random.choice(markov_chain[current_key])
                ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "C:\Users\mahes\AppData\Local\Programs\Python\Python312\Lib\random.py", line 347, in choice
    raise IndexError('Cannot choose from an empty sequence')
IndexError: Cannot choose from an empty sequence

C:\Users\mahes\Downloads\work>python NltkChunking.py
Chunks:
(NP The/DT quick/JJ brown/NN)
(NP fox/NN)
(NP the/DT lazy/JJ dog/NN)

C:\Users\mahes\Downloads\work>python NltkChunking.py
Chunks:
(NP The/DT quick/JJ brown/NN)
(NP fox/NN)
(NP the/DT lazy/JJ dog/NN)

C:\Users\mahes\Downloads\work>python NltkWSD1.py
Disambiguated Sentence:
I went(go) to the bank(depository_financial_institution) to deposit(deposit) some money(money) .

C:\Users\mahes\Downloads\work>python NltkWSD1.py
Disambiguated Sentence:
I went(go) to the bank(depository_financial_institution) to deposit(deposit) some money(money) .

C:\Users\mahes\Downloads\work>
```

Figure: word sense disambiguation

3. Machine Learning Integration: NLTK seamlessly integrates with popular machine learning libraries such as scikit-learn and TensorFlow, enabling users to build and train advanced NLP models using machine learning algorithms. NLTK provides utilities for feature extraction, model training, and evaluation, making it a versatile platform for developing machine learning-based NLP solutions.

```
#python
import nltk
import random
from nltk.corpus import movie_reviews
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import classification_report

# Download NLTK resources
nltk.download('movie_reviews')

# Load movie reviews dataset
documents = [(list(movie_reviews.words(fileid)), category)
for category in movie_reviews.categories()
for fileid in movie_reviews.fileids(category)]

# Shuffle the documents
random.shuffle(documents)

# Split the dataset into training and testing sets
train_docs, test_docs = train_test_split(documents, test_size=0.2, random_state=42)

# Extract features using TF-IDF vectorization
vectorizer = TfidfVectorizer(max_features=1000, tokenizer=nltk.word_tokenize)
```

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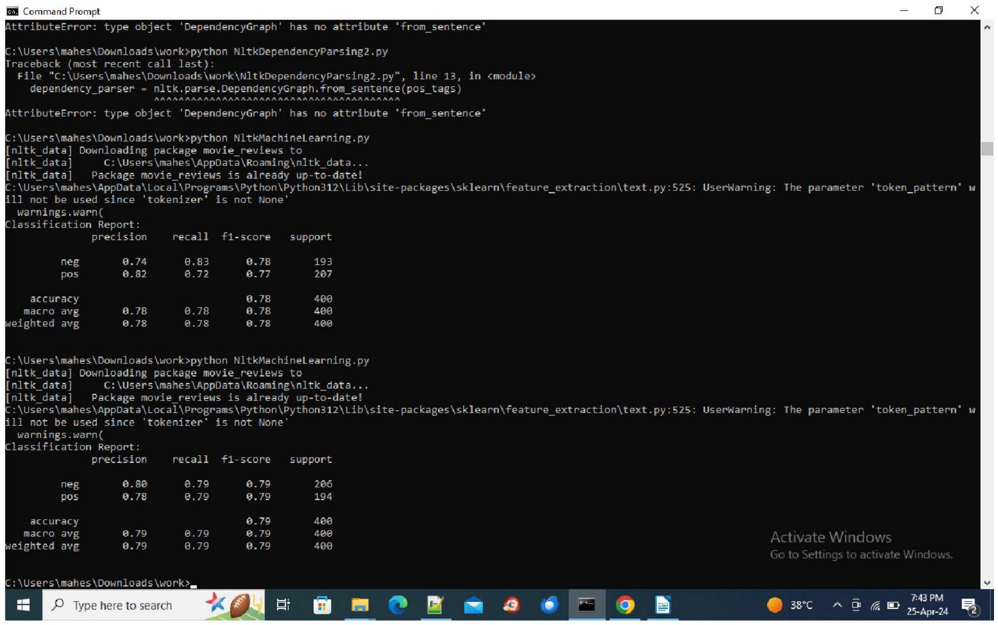
```
X_train = vectorizer.fit_transform([''.join(words) for words, label in train_docs])
y_train = [label for words, label in train_docs]

X_test = vectorizer.transform([''.join(words) for words, label in test_docs])
y_test = [label for words, label in test_docs]

# Train a Multinomial Naive Bayes classifier
classifier = MultinomialNB()
classifier.fit(X_train, y_train)

# Predict labels for the test set
y_pred = classifier.predict(X_test)

# Evaluate the classifier
print("Classification Report:")
print(classification_report(y_test, y_pred))
# code performs the following:
```

1. Loading Dataset: It loads the movie reviews dataset from NLTK's movie_reviews corpus. Each document in the dataset is a movie review labeled as positive or negative.
2. Splitting Dataset: It splits the dataset into training and testing sets.
3.Feature Extraction: It extracts features from the text using TF-IDF vectorization. The `TfidfVectorizer` from scikit-learn is used for this purpose.
4.Training Classifier: It trains a Multinomial Naive Bayes classifier using the training data.
5.Testing Classifier: It tests the trained classifier on the testing data and generates predictions.
6.Evaluation: It evaluates the performance of the classifier using classification metrics such as precision, recall, and F1-score.



```
AttributeError: type object 'DependencyGraph' has no attribute 'from_sentence'

C:\Users\mahes\Downloads\work>python NltkDependencyParsing2.py
Traceback (most recent call last):
  File "C:\Users\mahes\Downloads\work\NltkDependencyParsing2.py", line 13, in <module>
    dependency_parser = nltk.parse.DependencyGraph.from_sentence(pos_tags)
                        ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
AttributeError: type object 'DependencyGraph' has no attribute 'from_sentence'

C:\Users\mahes\Downloads\work>python NltkMachineLearning.py
[nltk_data] Downloading package movie_reviews to
[nltk_data]     C:\Users\mahes\AppData\Roaming\nltk_data...
[nltk_data]   Package movie_reviews is already up-to-date!
C:\Users\mahes\AppData\Local\Programs\Python\Python312\Lib\site-packages\sklearn\feature_extraction\text.py:525: UserWarning: The parameter 'token_pattern' w
ill not be used since 'tokenizer' is not None'
  warnings.warn(
Classification Report:
              precision    recall  f1-score   support

         neg       0.74      0.83      0.78       193
         pos       0.82      0.72      0.77       207

    accuracy                           0.78       400
   macro avg       0.78      0.78      0.78       400
weighted avg       0.78      0.78      0.78       400


C:\Users\mahes\Downloads\work>python NltkMachineLearning.py
[nltk_data] Downloading package movie_reviews to
[nltk_data]     C:\Users\mahes\AppData\Roaming\nltk_data...
[nltk_data]   Package movie_reviews is already up-to-date!
C:\Users\mahes\AppData\Local\Programs\Python\Python312\Lib\site-packages\sklearn\feature_extraction\text.py:525: UserWarning: The parameter 'token_pattern' w
ill not be used since 'tokenizer' is not None'
  warnings.warn(
Classification Report:
              precision    recall  f1-score   support

         neg       0.80      0.79      0.79       206
         pos       0.78      0.79      0.79       194

    accuracy                           0.79       400
   macro avg       0.79      0.79      0.79       400
weighted avg       0.79      0.79      0.79       400


C:\Users\mahes\Downloads\work>_
```

Figure: Machine learning integration

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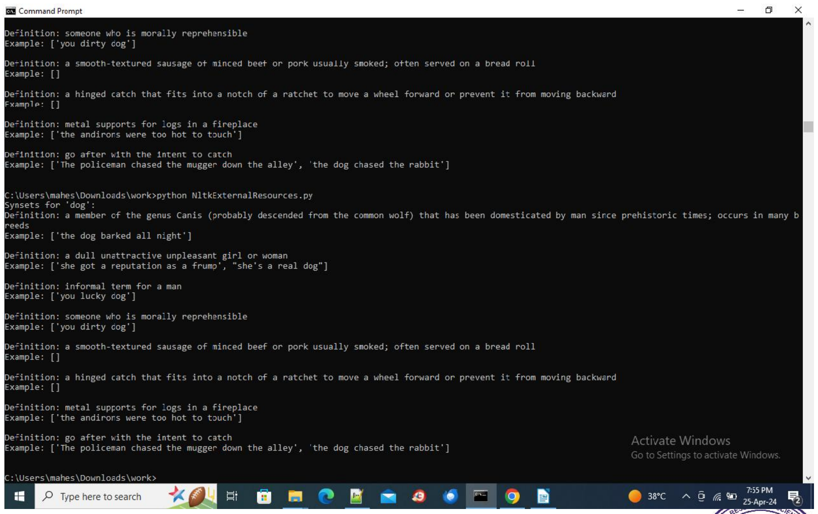
4. Integration with External Resources: NLTK facilitates access to external linguistic resources such as WordNet, a large lexical database of English, and FrameNet, a database of lexical units and their semantic frames. These resources can be leveraged for tasks such as word sense disambiguation, semantic analysis, and knowledge representation.
Integration with external resources in NLTK often involves leveraging external corpora, lexicons, or tools for various NLP tasks. One common external resource used with NLTK is WordNet, a lexical database of English words and their semantic relationships. Here's an example of how to integrate NLTK with WordNet:

```
#python
import nltk
from nltk.corpus import wordnet
# Example word
word = "dog"
# Get synsets (sets of synonyms) for the word from WordNet
synsets = wordnet.synsets(word)
# Print the definitions and examples for each synset
print("Synsets for 'dog':")
for synset in synsets:
print("Definition:", synset.definition())
print("Example:", synset.examples())
print()
# code performs the following:
```

1.WordNet Integration: It imports WordNet from NLTK's corpus.
2. Synset Retrieval: It retrieves synsets (sets of synonyms) for the word "dog" from WordNet using the `synsets()` function.
3. Printing Definitions and Examples: It prints the definitions and examples for each synset.

#run this code, see the definitions and examples for the synsets of the word "dog" from WordNet.
Integration with external resources can extend beyond WordNet to include other external corpora, lexicons, or tools. For example, you can integrate NLTK with external libraries for named entity recognition, sentiment analysis, or part-of-speech tagging, or you can use NLTK to preprocess text data before applying machine learning models from external libraries such as scikit-learn or TensorFlow. The possibilities are endless depending on your specific NLP tasks and requirements.



```
Definition: someone who is morally reprehensible
Example: ['you dirty dog']

Definition: a smooth-textured sausage of minced beef or pork usually smoked; often served on a bread roll
Example: []

Definition: a hinged catch that fits into a notch of a ratchet to move a wheel forward or prevent it from moving backward
Example: []

Definition: metal supports for logs in a fireplace
Example: ['the andirons were too hot to touch']

Definition: go after with the intent to catch
Example: ['The policeman chased the mugger down the alley', 'the dog chased the rabbit']


C:\Users\mahes\Downloads\work>python NltkExternalResources.py
Synsets for 'dog':
Definition: a member of the genus Canis (probably descended from the common wolf) that has been domesticated by man since prehistoric times; occurs in many b
reeds
Example: ['the dog barked all night']

Definition: a dull unattractive unpleasant girl or woman
Example: ['she got a reputation as a frump', "she's a real dog"]

Definition: informal term for a man
Example: ['you lucky dog']

Definition: someone who is morally reprehensible
Example: ['you dirty dog']

Definition: a smooth-textured sausage of minced beef or pork usually smoked; often served on a bread roll
Example: []

Definition: a hinged catch that fits into a notch of a ratchet to move a wheel forward or prevent it from moving backward
Example: []

Definition: metal supports for logs in a fireplace
Example: ['the andirons were too hot to touch']

Definition: go after with the intent to catch
Example: ['The policeman chased the mugger down the alley', 'the dog chased the rabbit']

C:\Users\mahes\Downloads\work>
```

Figure: Integration with External Resources

5. Customization and Extension: NLTK is highly customizable and extensible, allowing users to incorporate custom linguistic resources, algorithms, and modules into their NLP pipelines. Advanced users can extend NLTK's functionality by writing custom tokenizers, taggers, parsers, and other components tailored to their specific requirements.

Customization and extension in NLTK often involve creating or modifying functionalities to suit specific NLP tasks or requirements. One common way to customize NLTK is by extending its functionality through subclassing or by adding new modules.

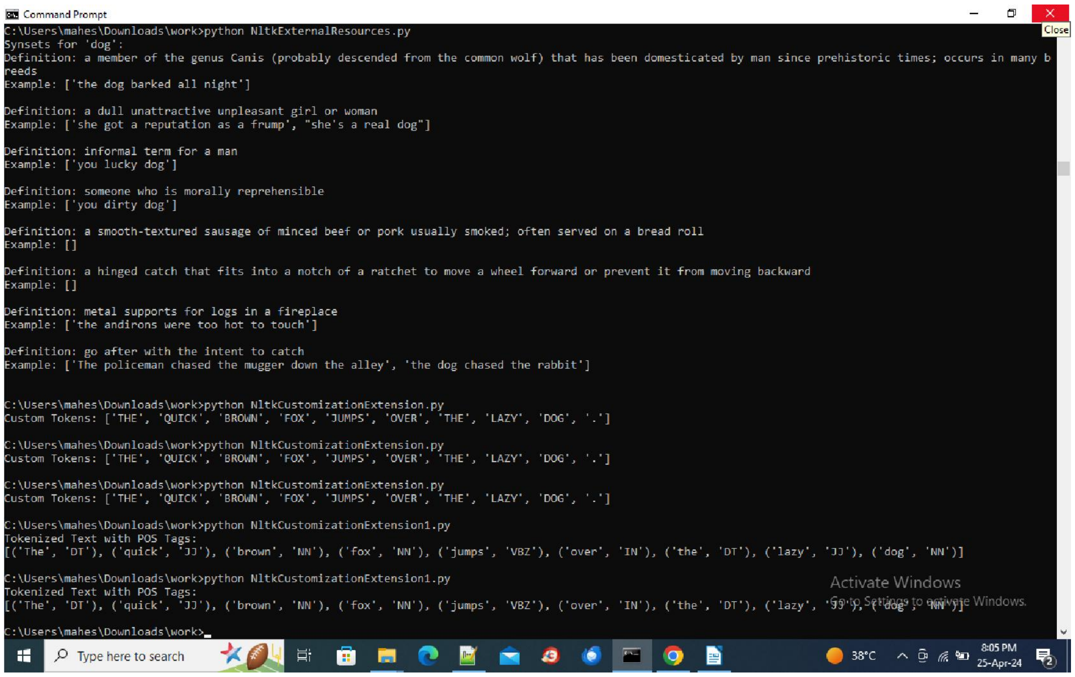
```
#python
import nltk
from nltk.tokenize import RegexpTokenizer

class CustomTokenizer(RegexpTokenizer):
def __init__(self, pattern):
super().__init__(pattern)

def tokenize_with_pos(self, text):
# Tokenize the text
tokens = self.tokenize(text)

# Tag tokens with part-of-speech tags
tagged_tokens = nltk.pos_tag(tokens)

return tagged_tokens

# Custom tokenization pattern
pattern = r'\b\w+\b'

# Create a custom tokenizer
custom_tokenizer = CustomTokenizer(pattern)

# Example text
text = "The quick brown fox jumps over the lazy dog."

# Tokenize the text using the custom tokenizer
custom_tokens = custom_tokenizer.tokenize_with_pos(text)

# Print the tokenized text with part-of-speech tags
print("Tokenized Text with POS Tags:")
print(custom_tokens)
```

In this example, subclass the `RegexpTokenizer` class from NLTK and add a new method `tokenize_with_pos()` to tag tokens with part-of-speech (POS) tags using NLTK's `pos_tag()` function.

Here's a breakdown of the code:

1. Custom Tokenizer Class: We create a new class `CustomTokenizer` that subclasses `RegexpTokenizer`.
2. Initialization: We override the `__init__()` method to pass the tokenization pattern to the parent class.
3. Tokenization with POS Tags: We define a new method `tokenize_with_pos()` that tokenizes the text using the parent class's `tokenize()` method and then tags the tokens with POS tags using NLTK's `pos_tag()` function.
4. Example Usage: We create an instance of our custom tokenizer, tokenize a sample text using the `tokenize_with_pos()` method, and print the tokenized text with POS tags.

Customization and extension in NLTK can involve various tasks such as creating custom tokenizers, parsers, classifiers, or any other NLP component tailored to specific needs. By leveraging NLTK's modular architecture and extensible design, you can build powerful and flexible NLP applications that suit your requirements.



```
C:\Users\mahes\Downloads\work>python NltkExternalResources.py
Synsets for 'dog':
Definition: a member of the genus Canis (probably descended from the common wolf) that has been domesticated by man since prehistoric times; occurs in many b
reeds
Example: ['the dog barked all night']

Definition: a dull unattractive unpleasant girl or woman
Example: ['she got a reputation as a frump', "she's a real dog"]

Definition: informal term for a man
Example: ['you lucky dog']

Definition: someone who is morally reprehensible
Example: ['you dirty dog']

Definition: a smooth-textured sausage of minced beef or pork usually smoked; often served on a bread roll
Example: []

Definition: a hinged catch that fits into a notch of a ratchet to move a wheel forward or prevent it from moving backward
Example: []

Definition: metal supports for logs in a fireplace
Example: ['the andirons were too hot to touch']

Definition: go after with the intent to catch
Example: ['The policeman chased the mugger down the alley', 'the dog chased the rabbit']


C:\Users\mahes\Downloads\work>python NltkCustomizationExtension.py
Custom Tokens: ['THE', 'QUICK', 'BROWN', 'FOX', 'JUMPS', 'OVER', 'THE', 'LAZY', 'DOG', '.']

C:\Users\mahes\Downloads\work>python NltkCustomizationExtension.py
Custom Tokens: ['THE', 'QUICK', 'BROWN', 'FOX', 'JUMPS', 'OVER', 'THE', 'LAZY', 'DOG', '.']

C:\Users\mahes\Downloads\work>python NltkCustomizationExtension.py
Custom Tokens: ['THE', 'QUICK', 'BROWN', 'FOX', 'JUMPS', 'OVER', 'THE', 'LAZY', 'DOG', '.']

C:\Users\mahes\Downloads\work>python NltkCustomizationExtension1.py
Tokenized Text with POS Tags:
[('The', 'DT'), ('quick', 'JJ'), ('brown', 'NN'), ('fox', 'NN'), ('jumps', 'VBZ'), ('over', 'IN'), ('the', 'DT'), ('lazy', 'JJ'), ('dog', 'NN')]

C:\Users\mahes\Downloads\work>python NltkCustomizationExtension1.py
Tokenized Text with POS Tags:
[('The', 'DT'), ('quick', 'JJ'), ('brown', 'NN'), ('fox', 'NN'), ('jumps', 'VBZ'), ('over', 'IN'), ('the', 'DT'), ('lazy', 'JJ'), ('dog', 'NN')]

C:\Users\mahes\Downloads\work>_
```

Figure: Customization and Extension

II. CONCLUSION

In conclusion, NLTK (Natural Language Toolkit) serves as a versatile and powerful tool for various natural language processing (NLP) tasks. NLTK provides a comprehensive set of tools and resources for tasks such as tokenization, part-of-speech tagging, syntactic parsing, named entity recognition, sentiment analysis, and more. Its extensive collection of corpora, lexicons, and algorithms make it an invaluable resource for both beginners and experienced practitioners in the field of NLP.

Overall, NLTK continues to be a foundational tool in the field of natural language processing, empowering researchers, developers, and enthusiasts to explore, analyze, and manipulate human language with ease and efficiency. As the field of NLP evolves, NLTK remains a vital resource for advancing our understanding and applications of language processing technologies.

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