Natural Language Processing (NLP)

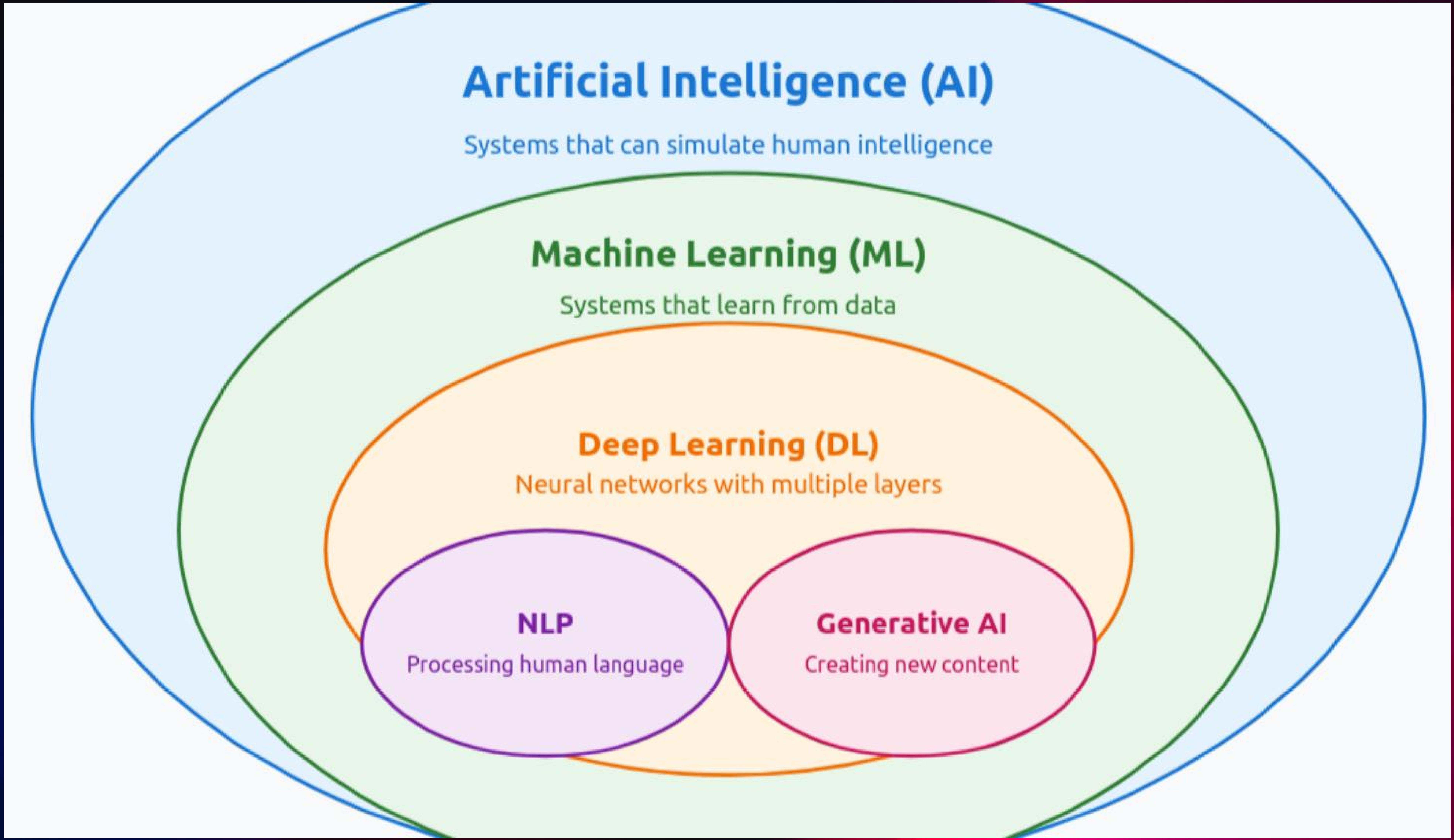
By: Eng. Shereen Ebrahim

INCEPTUM
EGYPT

INTRODUCTION

What is NLP?

- Natural Language Processing (NLP) is a field in Artificial Intelligence (AI) devoted to creating computers that use natural language as input and/or output.


Artificial Intelligence (AI)
Systems that can simulate human intelligence
Machine Learning (ML)
Systems that learn from data
Deep Learning (DL)
Neural networks with multiple layers
NLP
Processing human language
Generative AI
Creating new content

Why NLP?

- To interact with computing devices using human (natural) languages. For example, Building intelligent robots (AI). Enabling voice-controlled operation.
- To access (large amount of) information and knowledge stored in the form of human languages quickly.

NLP Tasks

- NLP applications require several NLP analyses:
- Word tokenization
- Sentence boundary detection
- Part-of-speech (POS) tagging
- to identify the part-of-speech (e.g. noun, verb) of each word
- Named Entity (NE) recognition
- to identify proper nouns (e.g. names of person, location, organization;
- domain terminologies)
- Parsing
- to identify the syntactic structure of a sentence
- Semantic analysis
- to derive the meaning of a sentence

Components of NLP

1. Computational Linguistics
2. Machine Learning
3. Artificial Intelligence
4. Computer Science
5. Speech Processing

Natural Language Pre-processing (NLP)

Natural Language Processing (NLP) involves a series of pre-processing steps to transform raw text data into a format suitable for analysis or machine learning models. These steps help
improve the quality of the data and make it easier for algorithms
to understand and process the text. Below are the key pre-processing steps used in NLP, along with explanations and example
code.

- 1. Lowercasing
- 2. Tokenization
- 3. Removing Punctuation
- 4. Removing Stopwords
- 5. Stemming
- 6. Lemmatization
- 7. Removing Numbers
- 8. Removing Extra Spaces
- 9. Handling Contractions
- 10. Removing Special Characters
- 11. Part-of-Speech (POS) Tagging
- 12. Named Entity Recognition (NER)
- 13. Vectorization
- 14. Handling Missing Data
- 15. Normalization
- 16. Spelling Correction

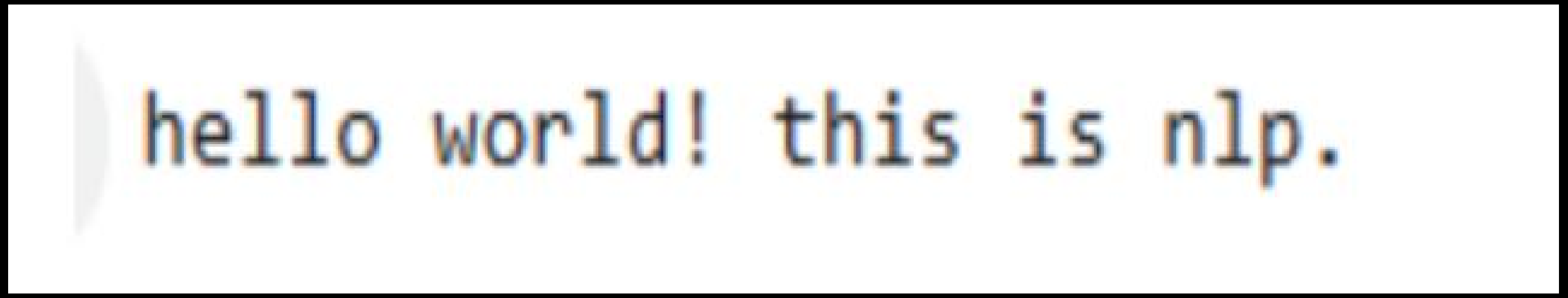
- ➢17. Handling Emojis and Emoticons
- ➢18. Removing HTML Tags
- ➢19. Handling URLs
- ➢20. Handling Mentions an Hashtags
- ➢21. Sentence Segmentation
- ➢22. Handling Abbreviations
- ➢23. Language Detection
- ➢24. Text Encoding
- ➢25. Handling Whitespace Tokens
- ➢26. Handling Dates and Times
- ➢27. Text Augmentation

1. Lowercasing

- ❑ Purpose: Converts all text to lowercase to ensure uniformity.
- ❑ Why: Reduces the vocabulary size and avoids treating the same
- ❑word in different cases as different tokens (e.g., "Apple" vs. "apple").
- ❑**EX:**

```
text = "Hello World! This is NLP."
text = text.lower()
print(text)
```

Output

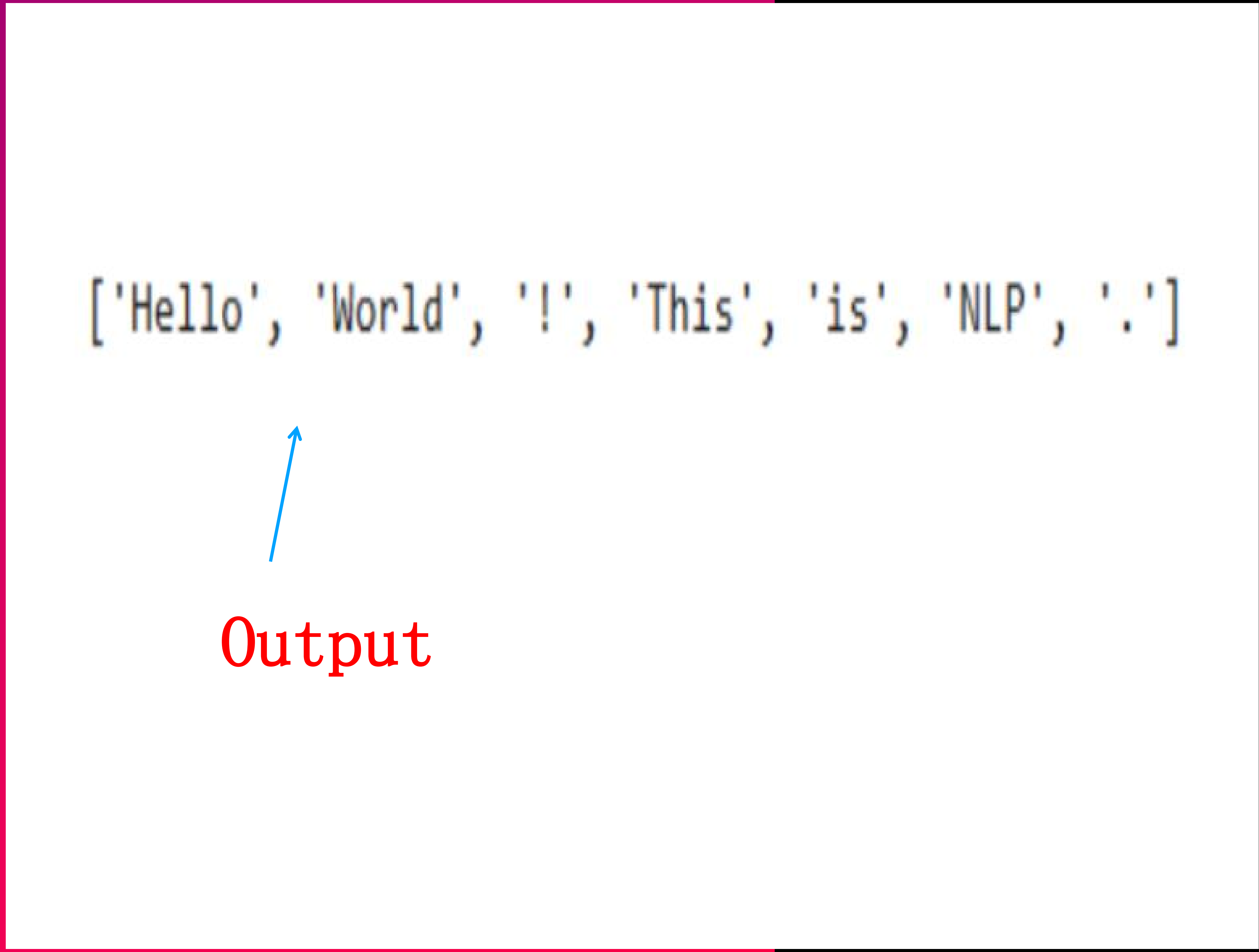


```
hello world! this is nlp.
```

2. Tokenization

- Purpose: Splits text into individual words, phrases, or sentences (tokens).
- Why: Breaks down text into manageable units for further processing.
- EX:

```
import nltk
nltk.download('punkt_tab')
from nltk.tokenize import word_tokenize
text = "Hello World! This is NLP."
tokens = word_tokenize(text)
print(tokens)
```



```
['Hello', 'World', '!', 'This', 'is', 'NLP', '.']
```

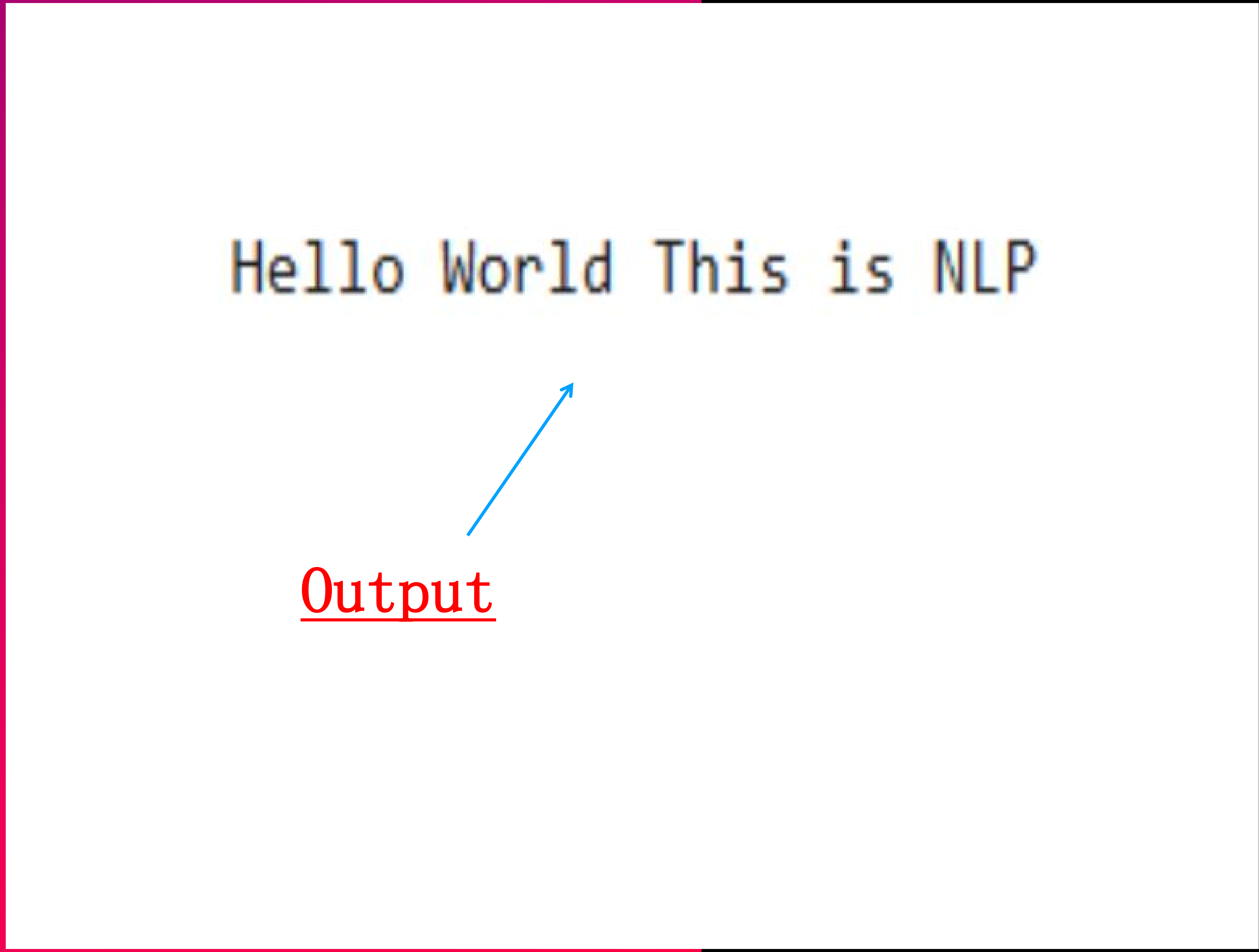
Output

3. Removing Punctuation

- ❑Purpose: Removes punctuation marks like commas, periods,
- ❑exclamation marks, etc.
- ❑Why: Punctuation often doesn' t contribute to the meaning in many NLP tasks and can add noise.

EX:

```
import string
text = "Hello, World! This is NLP."
text = text.translate(str.maketrans('', '',
string.punctuation))
print(text)
```



```
Hello World This is NLP
```

Output

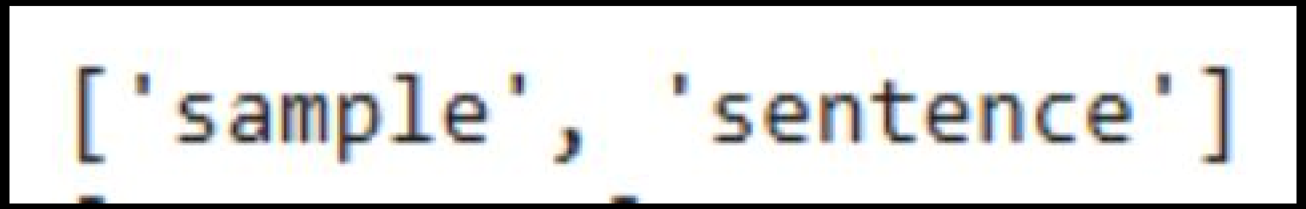
4. Removing Stopwords

❑Purpose: Removes common words like "the," "is," "and," which don't carry significant meaning.

❑Why: Reduces noise and focuses on meaningful words.

❑EX:

```
import nltk
# Download the 'stopwords' dataset
nltk.download('stopwords')
from nltk.corpus import stopwords
stop_words = set(stopwords.words('english'))
tokens = ["this", "is", "a", "sample", "sentence"]
filtered_tokens = [word for word in tokens if word.lower() not in
stop_words]
print(filtered_tokens)
```



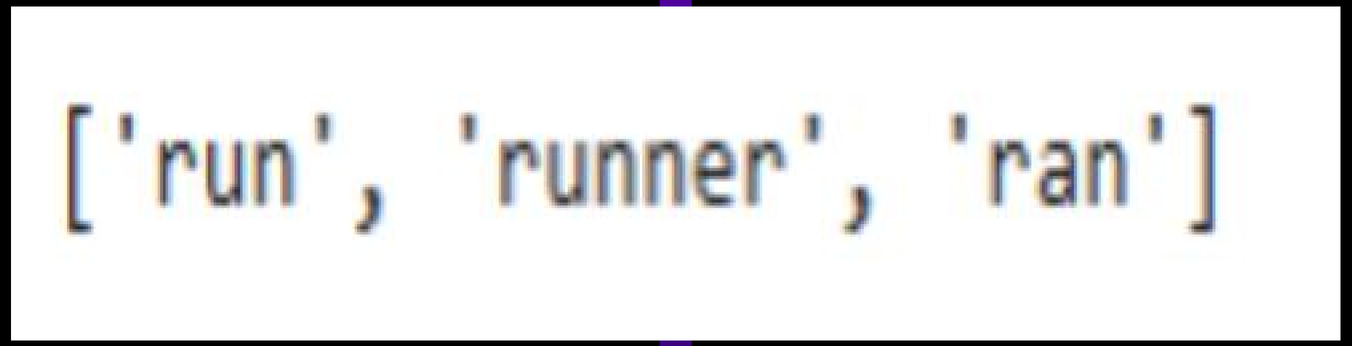
```
['sample', 'sentence']
```

Output

5. Stemming

- Purpose: Reduces words to their root form by chopping off suffixes
- (e.g., "running" → "run").
- Why: Simplifies words to their base form, reducing vocabulary size.
- EX:

```
from nltk.stem import PorterStemmer
stemmer = PorterStemmer()
words = ["running", "runner", "ran"]
stemmed_words = [stemmer.stem(word) for word in words]
print(stemmed_words)
```



```
['run', 'runner', 'ran']
```

Output

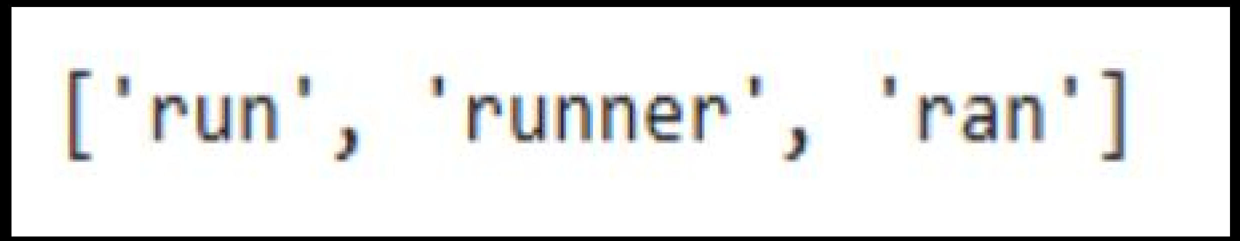
6. Lemmatization

❑Purpose: Converts words to their base or dictionary form (e.g., "better" → "good").

❑ Why: More accurate than stemming as it uses vocabulary and morphological analysis.

EX:

```
import nltk
nltk.download('wordnet')
from nltk.stem import WordNetLemmatizer
lemmatizer = WordNetLemmatizer()
words = ["running", "runner", "ran"]
lemmatized_words = [lemmatizer.lemmatize(word, pos='v') for word
in words]
print(lemmatized_words)
```



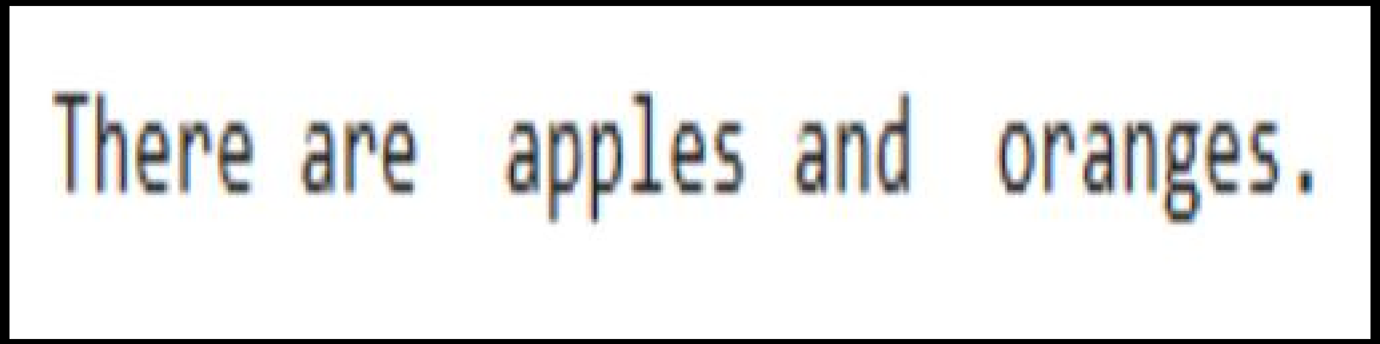
```
['run', 'runner', 'ran']
```

Output

7. Removing Numbers

- ❑Purpose: Removes numeric values from the text.
- ❑Why: Numbers may not be relevant in certain NLP tasks like sentiment analysis.
- ❑EX:

```
import re
text = ”There are 3 apples and 5 oranges.”
text = re.sub(r’\d+’, ’’, text)
print(text)
```

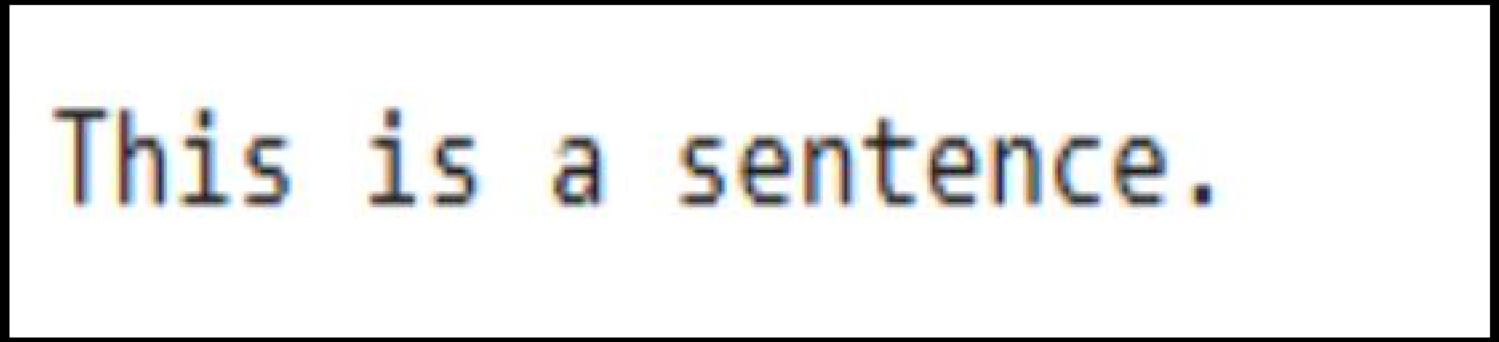


```
There are  apples and  oranges.
```

8. Removing Extra Spaces

- ❑ Purpose: Eliminates multiple spaces, tabs, or newlines.
- ❑ Why: Ensures clean and consistent text formatting.
- ❑ **EX:**

```
text = "  This is a sentence.  "
text = ' '.join(text.split())
print(text)
```

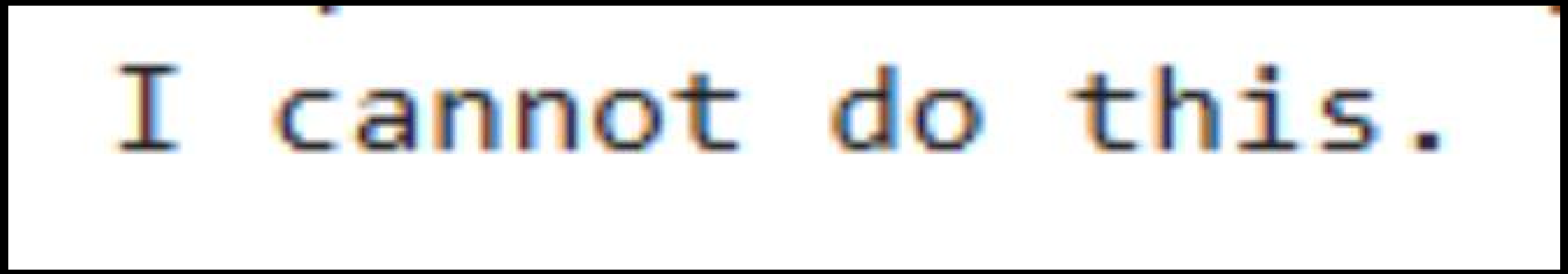


```
This is a sentence.
```

9. Handling Contractions

- ❑Purpose: Expands contractions (e.g., "can't" → "cannot").
- ❑Why: Standardizes text for better processing.
- ❑EX:

```
!pip install contractions
from contractions import fix
text = "I can't do this."
text = fix(text)
print(text)
```

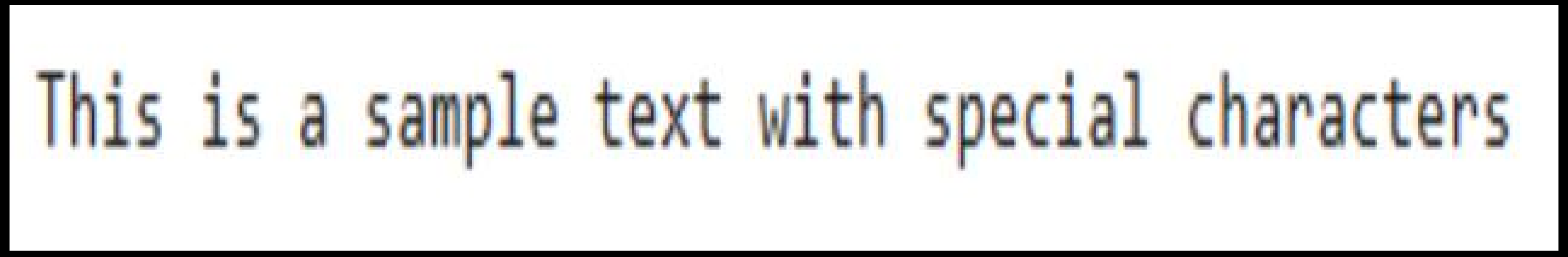


```
I cannot do this.
```

10. Removing Special Characters

- Purpose: Removes non-alphanumeric characters like @, #, $, etc.
- Why: Reduces noise and irrelevant symbols.
- EX:

```
import re
text = "This is a #sample text with @special characters!"
text = re.sub(r'[^\w\s]', '', text)
print(text)
```

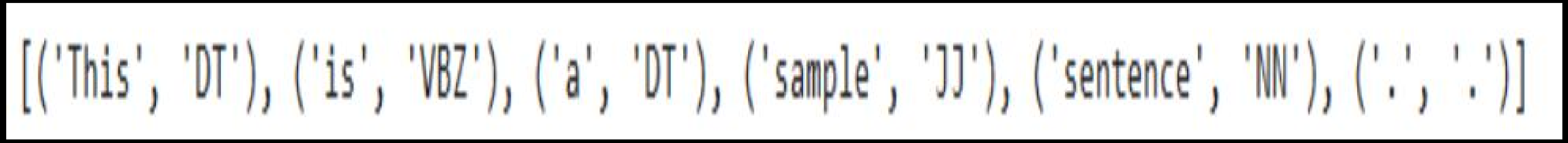


```
This is a sample text with special characters
```

11. Part-of-Speech (POS) Tagging

- Purpose: Assigns grammatical tags to words (e.g., noun, verb, adjective).
- Why: Helps in understanding the syntactic structure of sentences.
- EX:

```
import nltk
from nltk import pos_tag
from nltk.tokenize import word_tokenize
# Download the required resource
nltk.download('averaged_perceptron_tagger_eng')
tokens = word_tokenize("This is a sample
sentence.")
pos_tags = pos_tag(tokens)
print(pos_tags)
```

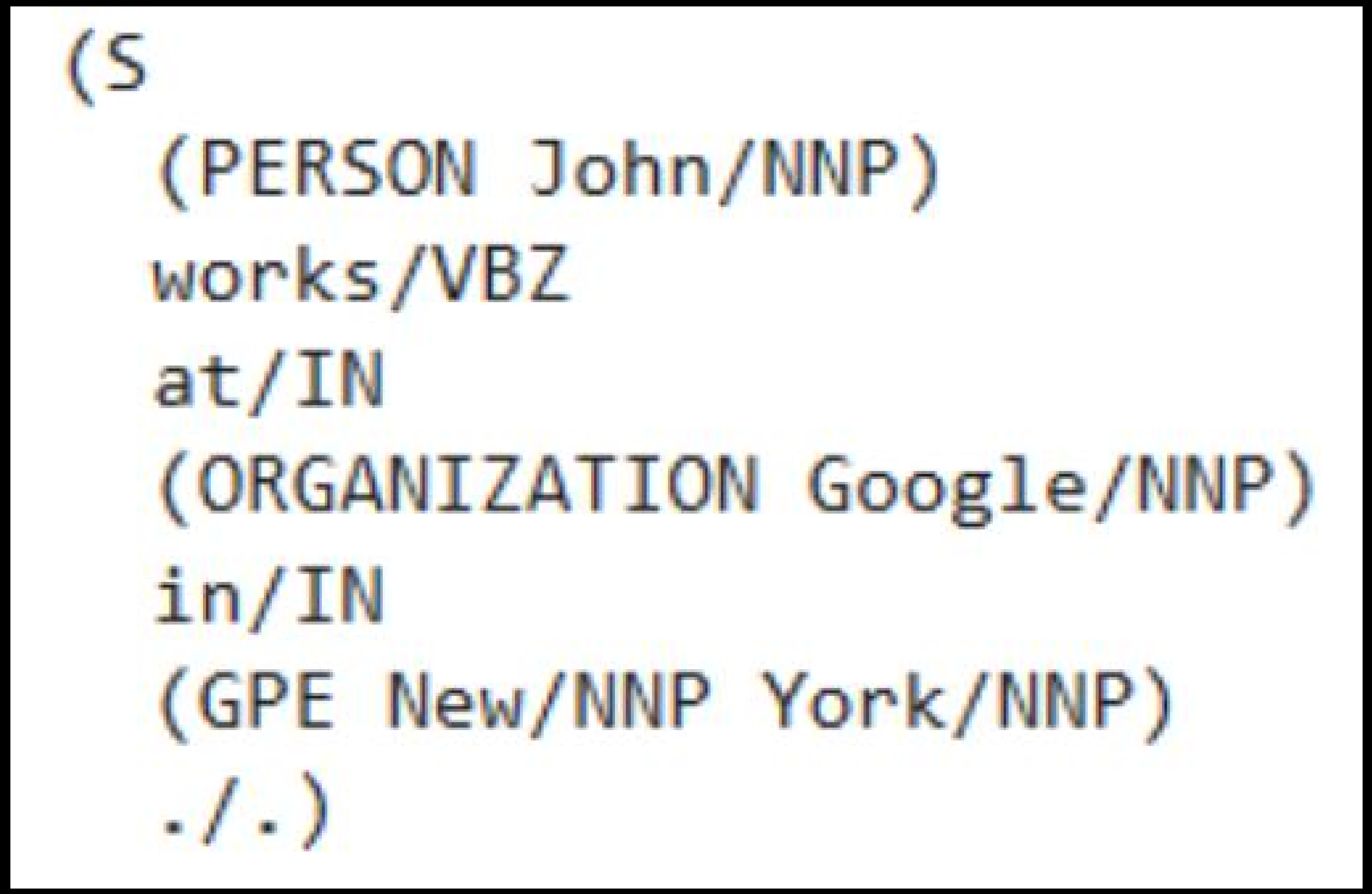


```
[('This', 'DT'), ('is', 'VBZ'), ('a', 'DT'), ('sample', 'JJ'), ('sentence', 'NN'), ('.', '.')]
```

12. Named Entity Recognition (NER)

❑ Purpose: Identifies and classifies entities like names, dates, locations, etc.
❑ Why: Useful for tasks like information extraction.
❑EX:

```
import nltk
from nltk import pos_tag, ne_chunk
from nltk.tokenize import word_tokenize
# Download the required resources
nltk.download('words')
nltk.download('maxent_ne_chunker')
nltk.download('averaged_perceptron_tagger')
# Download the 'maxent_ne_chunker_tab' resource
nltk.download('maxent_ne_chunker_tab') # This line is crucial to fix
the error.
tokens = word_tokenize("John works at Google in New York.")
pos_tags = pos_tag(tokens)
ner_tags = ne_chunk(pos_tags)
print(ner_tags)
```

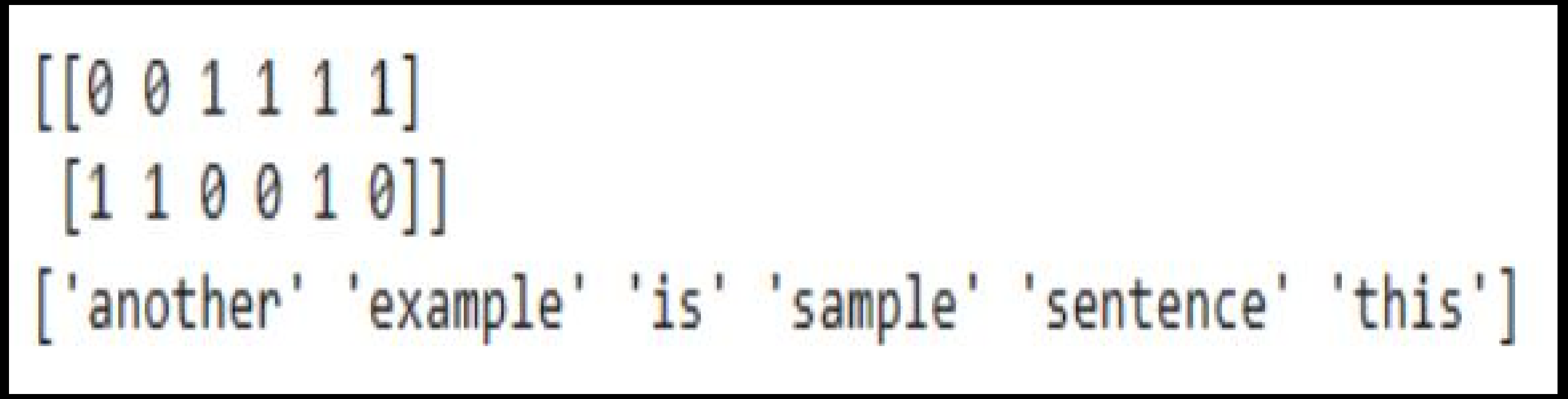


```
(S
  (PERSON John/NNP)
  works/VBZ
  at/IN
  (ORGANIZATION Google/NNP)
  in/IN
  (GPE New/NNP York/NNP)
  ./.)
```

13. Vectorization

- Purpose: Converts text into numerical vectors (e.g., Bag of Words, TF-IDF, Word Embeddings).
- Why: Machine learning models require numerical input.

```
from sklearn.feature_extraction.text
import
CountVectorizer
corpus = ["This is a sample
sentence.", "Another example
sentence."]
vectorizer = CountVectorizer()
X = vectorizer.fit_transform(corpus)
print(X.toarray()) # Output: [[1 1 1 1 0],
[0 1 1 0 1]]
print(vectorizer.get_feature_names_ou
t
```

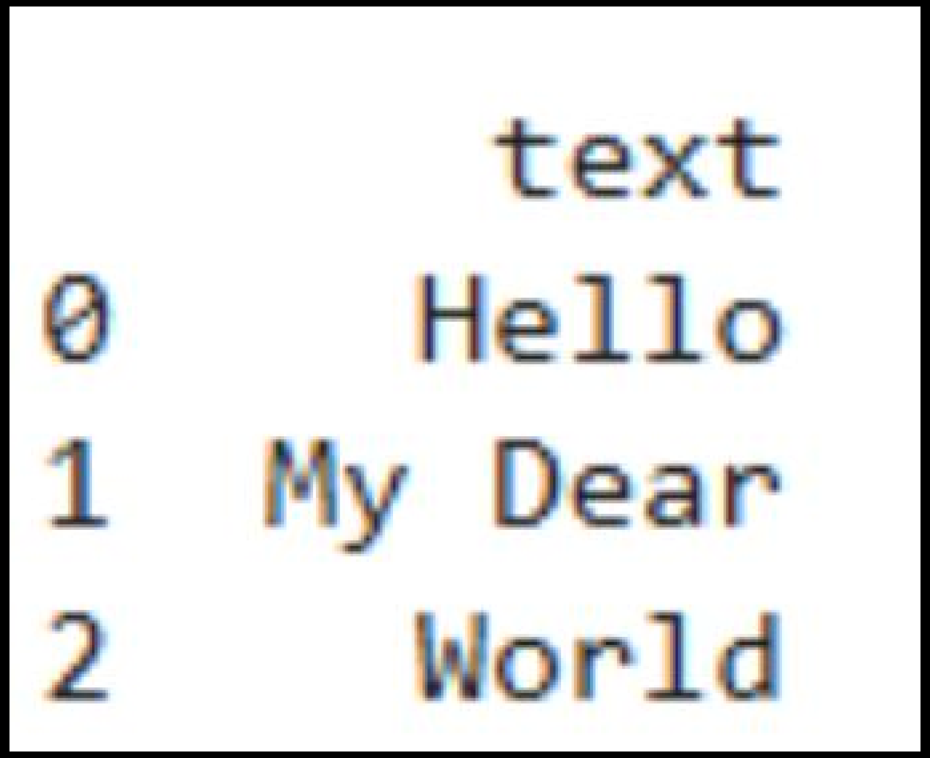


```
[[0 0 1 1 1 1]
 [1 1 0 0 1 0]]
['another' 'example' 'is' 'sample' 'sentence' 'this']
```

14. Handling Missing Data

- Purpose: Fills or removes missing or incomplete text data.
- Why: Ensures the dataset is complete and consistent

```
0import pandas as pd
data = {"text": ["Hello", None, "World"]}
df = pd.DataFrame(data)
df["text"].fillna("My Dear", inplace=True) # Fill missing values
print(df)
```

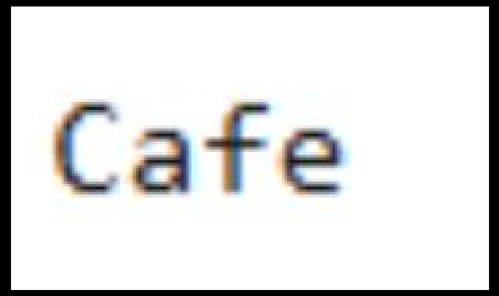


```
      text
0    Hello
1  My Dear
2    World
```

15. Normalization

- ❑ Purpose: Standardizes text (e.g., converting all dates to a single format).
- ❑Why: Ensures consistency in the dataset.
- ❑EX:

```
import unicodedata
text = "Café"
text = unicodedata.normalize('NFKD', text).encode('ascii', 'ignore').decode('utf-8')
print(text)
```

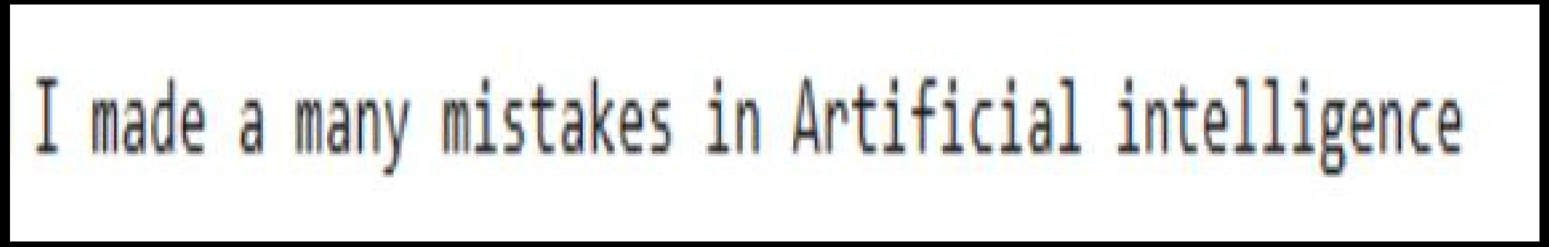


```
Cafe
```

16. Spelling Correction

❑Purpose: Corrects spelling errors in the text.
❑Why: Improves the quality of the text for analysis.
❑EX:

```
from textblob import TextBlob
text = ″I made a many mistakes in Artificial intellengence″
blob = TextBlob(text)
corrected_text = blob.correct()
print(corrected_text)
```

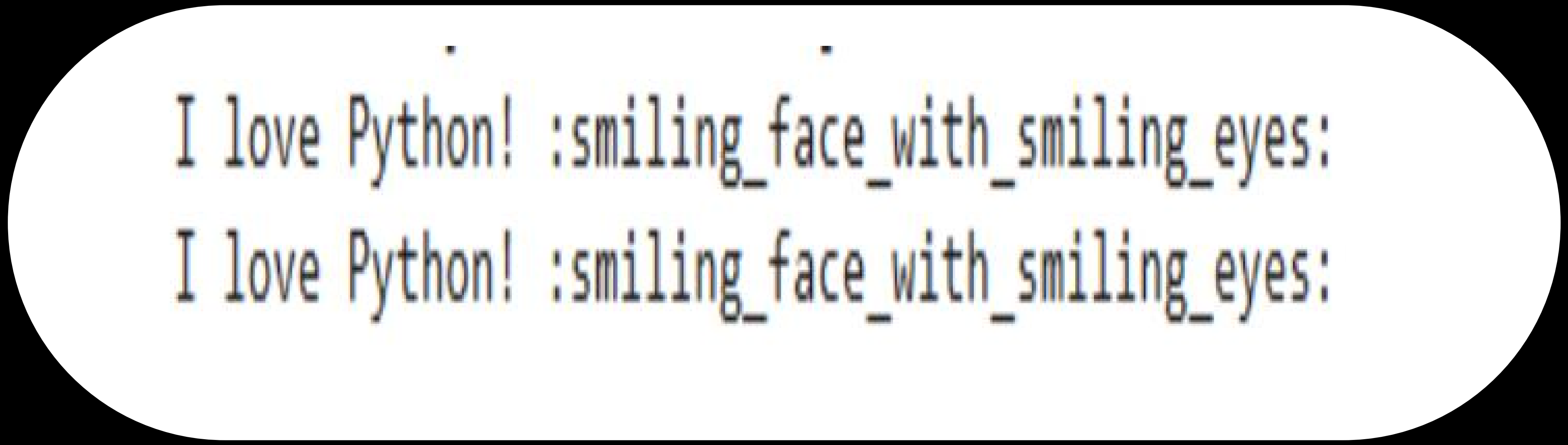


```
I made a many mistakes in Artificial intelligence
```

17. Handling Emojis and Emoticons

❑Purpose: Converts emojis and emoticons into text or removes them.
❑Why: Emojis can carry sentiment or meaning that needs to be
❑EX:
captured.

```
!pip install emoji
import emoji
text = "I love Python! ?"
# Convert emojis to text
text = emoji.demojize(text)
print(text) # Output: "I love Python!
:smiling_face_with_smiling_eyes:"
# Remove emojis
text = emoji.replace_emoji(text,
replace="")
print(text)
```

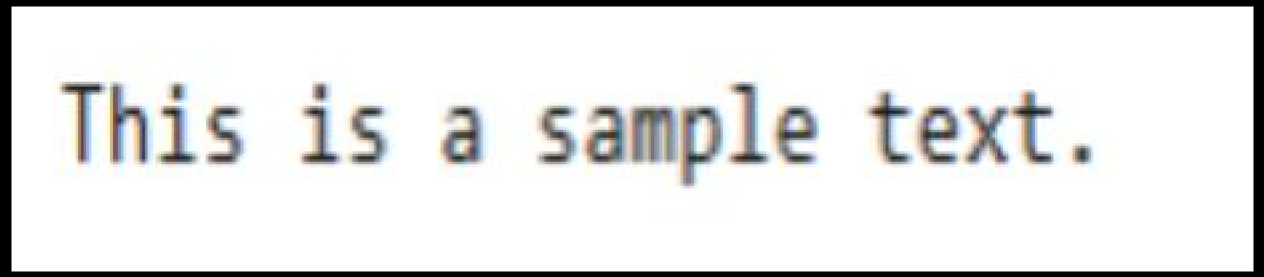


```
I love Python! :smiling_face_with_smiling_eyes:
I love Python! :smiling_face_with_smiling_eyes:
```

18. Removing HTML Tags

- ❑ Purpose: Removes HTML tags from web scraped text.
- ❑ Why: HTML tags are irrelevant for most NLP tasks.
- ❑ EX:

```
from bs4 import BeautifulSoup
text = "<p>This is a <b>sample</b> text.</p>"
soup = BeautifulSoup(text, "html.parser")
clean_text = soup.get_text()
print(clean_text)
```

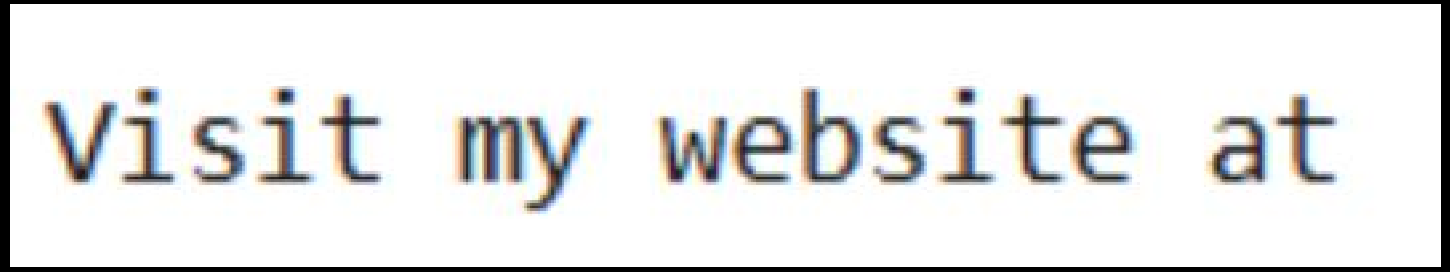


```
This is a sample text.
```

19. Handling URLs

- ❑Purpose: Removes or replaces URLs in the text.
- ❑Why: URLs are often irrelevant for text analysis.
- ❑EX:

```
import re
text = "Visit my website at https://example.com."
text = re.sub(r'http\S+|www\S+|https\S+', '', text,
flags=re.MULTILINE)
print(text)
```

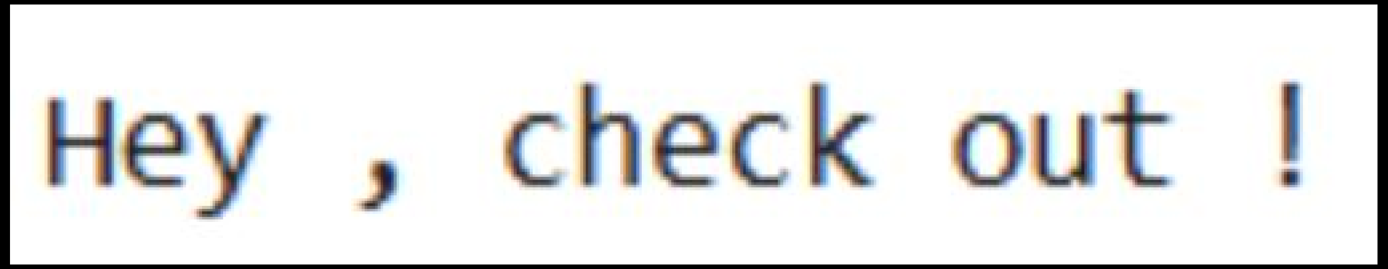


```
Visit my website at
```

20. Handling Mentions and Hashtags

- ❑ Purpose: Processes or removes social media mentions (@user) and
- ❑ hashtags (#topic).
- ❑ Why: Useful for social media text analysis.
- ❑EX:

```
text = "Hey @user, check out #NLP!"
text = re.sub(r'@\w+|#\w+', '', text)
print(text)
```



```
Hey , check out !
```

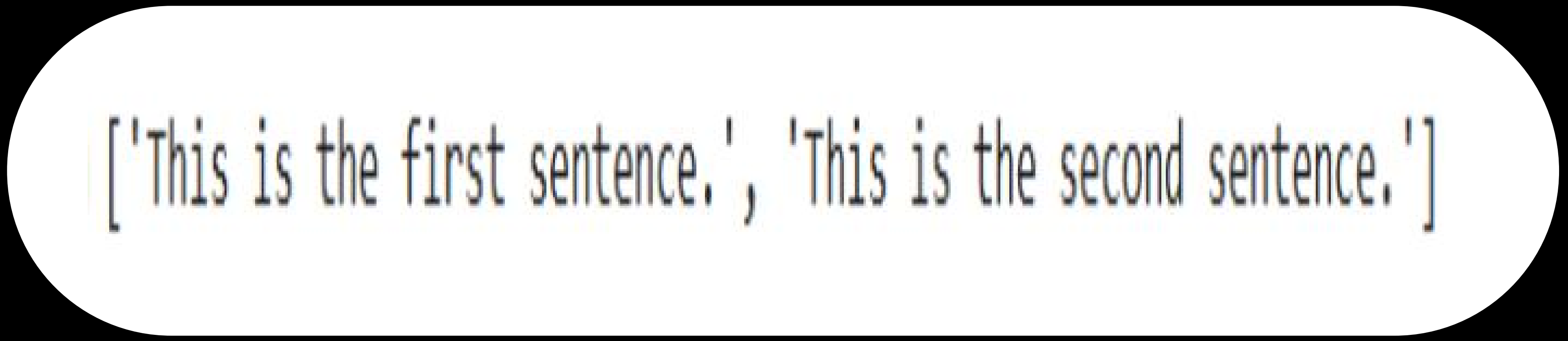
21. Sentence Segmentation

❑Purpose: Splits text into individual sentences.

❑Why: Important for tasks like machine translation or summarization.

❑EX:

```
from nltk.tokenize import sent_tokenize
text = "This is the first sentence.
This is the second
sentence."
sentences = sent_tokenize(text)
print(sentences)
```



```
['This is the first sentence.', 'This is the second sentence.']
```

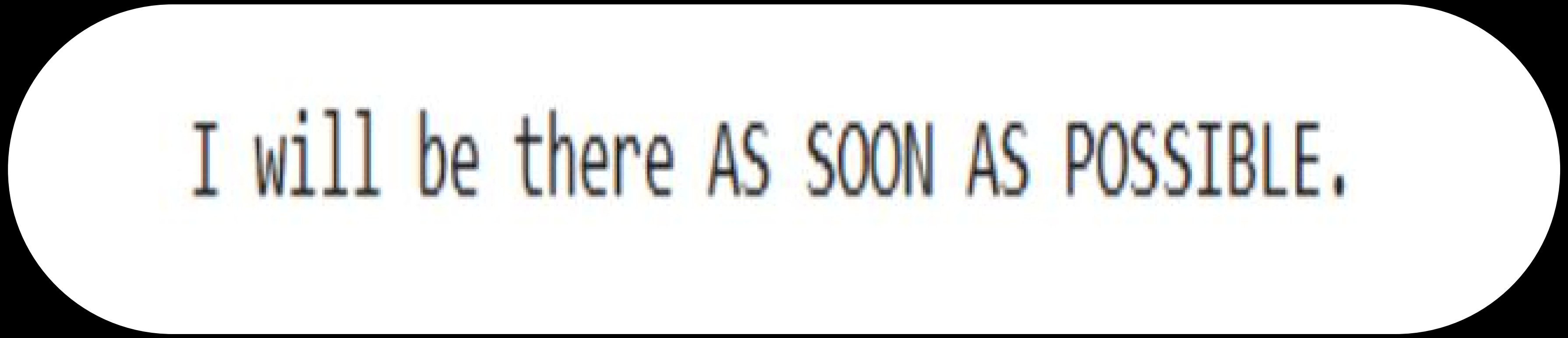
22. Handling Abbreviations

❑Purpose: Expands abbreviations (e.g., "ASAP" → "as soon as
❑possible").

❑ Why: Ensures clarity and consistency.

EX:

```
!pip install contractions
import contractions
text = "I'll be there ASAP."
expanded_text =
contractions.fix(text)
print(expanded_text)
```

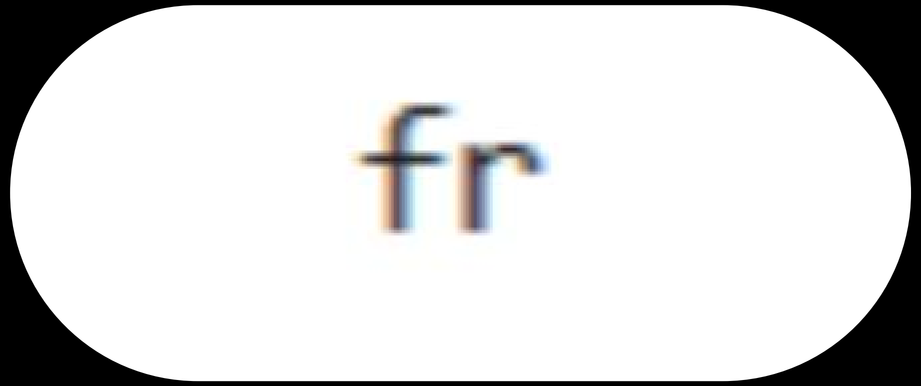


```
I will be there AS SOON AS POSSIBLE.
```

23. Language Detection

- Purpose: Identifies the language of the text.
- Why: Ensures the correct NLP model is applied.
- EX:

```
!pip install langdetect
from langdetect import detect
text = "Ceci est un texte en français."
language = detect(text)
print(language)
```



```
fr
```

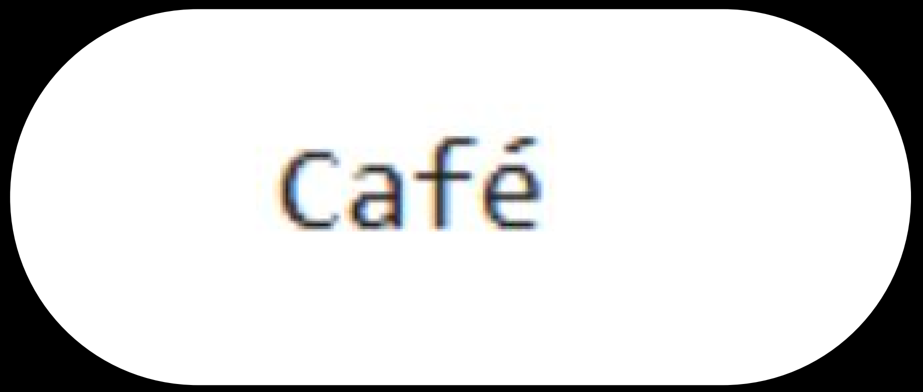
24. Text Encoding

Purpose: Converts text into a specific encoding format (e.g., UTF-8).

Why: Ensures compatibility with NLP tools and models.

EX:

```
text = ”Café”
text = text.encode(’utf-8’).decode(’utf-8’)
print(text)
```



```
Café
```

25. Handling Whitespace Tokens

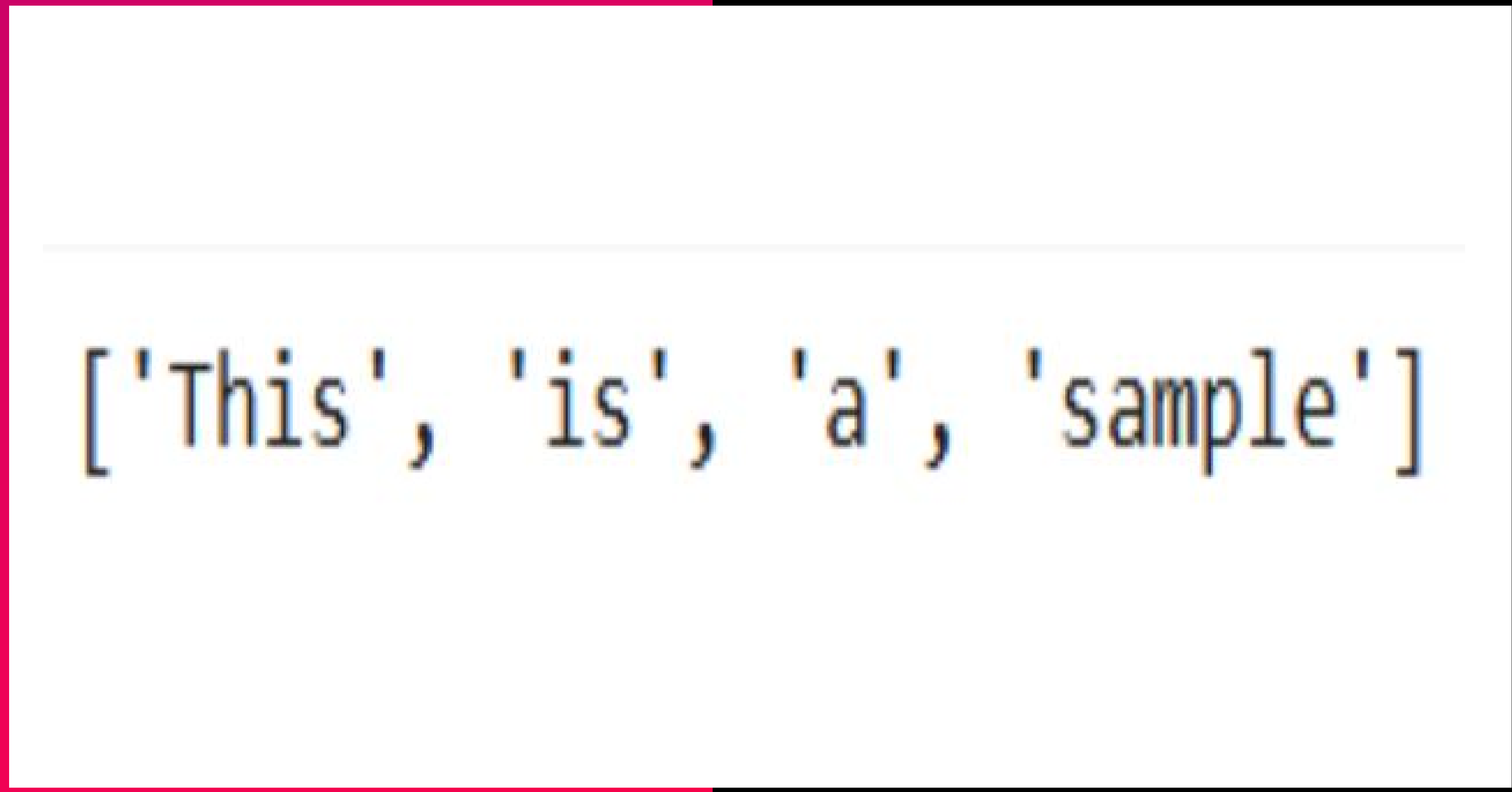
❑Purpose: Removes or processes tokens that are just spaces or empty

❑strings.

❑Why: Ensures clean and meaningful tokens.

❑EX:

```
tokens = ["This", " ", "is", " ", "a", " ", "sample", " "]
tokens = [token for token in tokens if token.strip()]
print(tokens)
```



```
['This', 'is', 'a', 'sample']
```

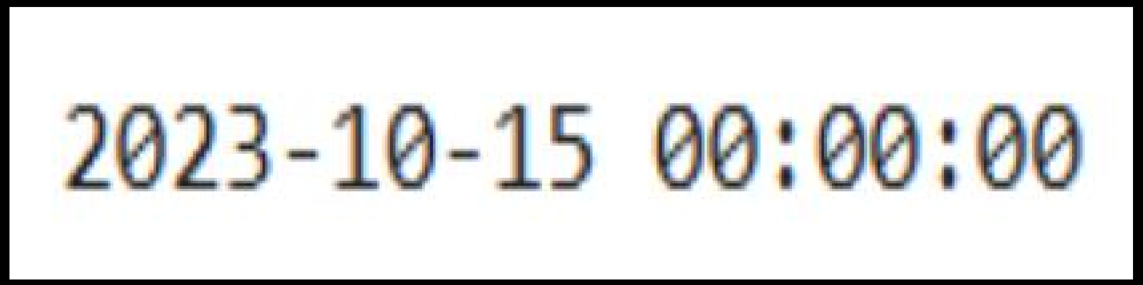
26. Handling Dates and Times

❑Purpose: Standardizes or extracts date and time formats.

❑Why: Useful for time-sensitive analysis.

❑**EX:**

```
import dateutil.parser as dparser
text = "The event is on 2023-10-15."
date = dparser.parse(text, fuzzy=True)
print(date)
```



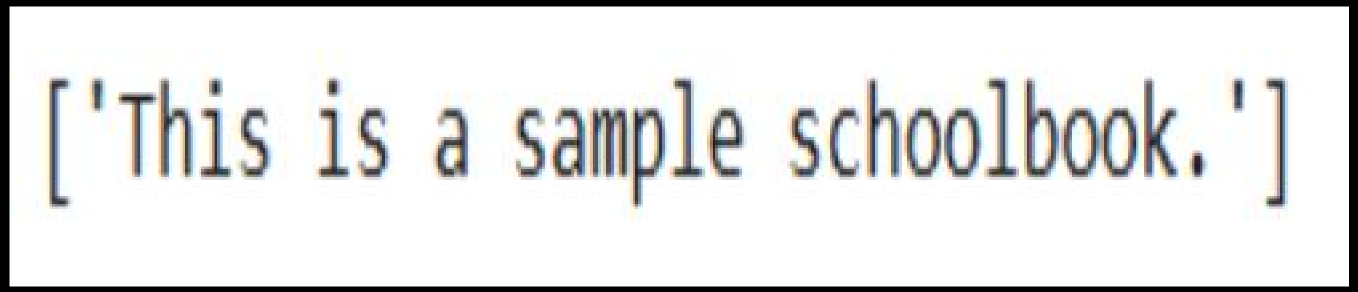
```
2023-10-15 00:00:00
```

27. Text Augmentation

- Purpose: Generates additional training data by modifying existing text

  (e.g., synonym replacement).
- Why: Improves model robustness and performance.
- **EX:**

```
#!pip install nlpaug # Install the nlpaug library
from nlpaug.augmenter.word import SynonymAug
aug = SynonymAug(aug_src='wordnet')
text = "This is a sample text."
augmented_text = aug.augment(text)
print(augmented_text)
```



```
['This is a sample schoolbook.']
```

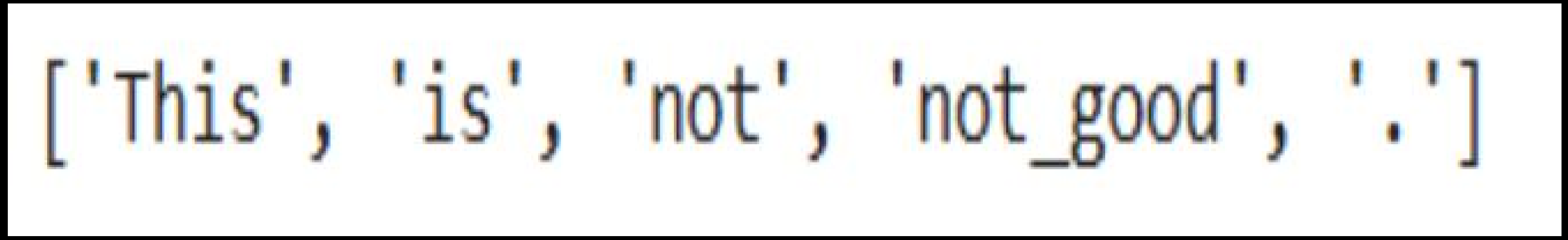
28. Handling Negations

❑Purpose: Identifies and processes negations (e.g., "not good").

❑Why: Important for sentiment analysis and understanding context.

❑**EX:**

```
from nltk import word_tokenize
text = "This is not good."
tokens = word_tokenize(text)
for i, token in enumerate(tokens):
if token == "not" and i + 1 < len(tokens):
tokens[i + 1] = "not_" + tokens[i + 1]
print(tokens)
```



```
['This', 'is', 'not', 'not_good', '.']
```

Most Important Pre-processing Steps for NLP

Tokenization

❑ Why: Tokenization is the foundation of NLP. It breaks text into meaningful units (words, sentences, etc.), which are necessary for any further processing.

❑ When: Always required, regardless of the task.

- **2. Lowercasing**

❑ Why: Ensures consistency by treating words like "Apple" and "apple" as the same. Reduces vocabulary size and computational complexity.

❑ When: Important for tasks like text classification, sentiment analysis, and information retrieval.

- **3. Removing Stopwords**

❑ Why: Stopwords (e.g., "the," "is," "and") add noise and don’t contribute much to the meaning in many tasks.

❑ When: Useful for tasks like text classification, topic modeling, and search engines.

- **4. Handling Missing Data**

❑ Why: Incomplete or missing data can lead to poor model performance.

❑ When: Critical for all tasks, especially when working with real-world datasets.

- **5. Vectorization**

❑ Why: Converts text into numerical representations (e.g., Bag of Words, TF-IDF, Word Embeddings) that machine learning models can process.

❑When: Essential for all tasks involving machine learning or deep learning models.

- **6. Removing Punctuation and Special Characters**

❑Why: Punctuation and special characters often don't contribute to

the meaning and can add noise.

❑ When: Important for tasks like sentiment analysis, text classification, and machine translation.

7. Lemmatization or Stemming

- ❑Why: Reduces words to their base forms, simplifying the vocabulary and improving consistency.
- ❑ When: Useful for tasks like information retrieval, text classification, and topic modeling.

8. Handling Contractions and Abbreviations

- ❑ Why: Expands contractions (e.g., "can't" → "cannot") and abbreviations (e.g., "ASAP" → "as soon as possible") for better understanding.
- ❑ When: Important for tasks involving informal text (e.g., social media analysis).

9. Handling URLs, Mentions, and Hashtags

❑ Why: Social media text often contains URLs, mentions (@user), and hashtags (#topic), which need to be processed or removed.

❑ When: Critical for social media text analysis.

10. Text Normalization

❑ Why: Standardizes text (e.g., converting dates, times, and numbers to a consistent format).

❑ When: Important for tasks involving structured data or time_x0002_sensitive analysis.

See you in the next session

INCEPTUM
EGYPT