Validating Python Packages for Text Analysis in Language Research

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Research Background

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Need of Research

This work is part of a research team project on "*A Convergence Study for Deep-Learning Based AI Fiction Generation with Human in the Loop.*" (funded by National Research Foundation of Korea)

How to identify linguistic patterns in human-authored AI-authored novels?

Need of Research

- Text metrics or analytics have long been used in fields such as the digital humanities to **understand and compare text corpora** (Hansen, Olsen, & Enevoldsen, 2023)

- User-friendly computer analytic tools, such as Python libraries, needed for the **automatic examination of extensive language datasets, reducing time and effort, and reproducibility** (Albrecht, Ramachandran, & Winkler, 2020).

- Many of them are not well-known in the linguistic community, and their validity is seldom assessed.

  An in-depth investigation on various text analytics libraries or packages is needed!

Why Python?

- A general-purpose, high-level programming language which is widely used in recent times and **flexibility, readability, and high level of abstraction for enhancing user productivity** (Gholizadeh, 2022; Srinath, 2017; Srinivasa, 2018).

Key Terms

Function, Module, Package, Library

- Function:
- Module: A file containing Python definitions and statements; module name.py
- Package: A collection of modules
- Library: Similar to Package

Source from https://docs.python.org/3/tutorial/index.html

Aims of Study

1. To review and validate popular Python packages for literary text analysis

2. To offer recommendations for future linguistic research

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Method

- Search Process
- Data Collection & Analysis

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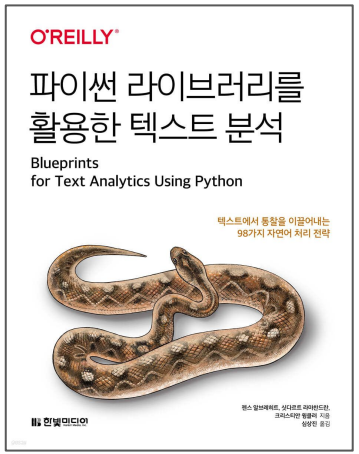
Search Process

- Searched for various Python packages for text analysis on github, google scholar, etc.
- Referred to Python programming books on text analytics such as ‘Blueprints for Text Analytics Using Python’
- Search words: python, text analysis, text analytics, linguistic feature, readability, complexity, package, library, etc.
- Search Period: September 26, 2023 ~ October 10, 2023



Data Collection & Analysis

- Referred to the github statistics (e.g., star, folk, etc.) and references
- Obtained 9 packages and targeted 5 packages for analysis:

  TextDescriptives, textstat, textacy, textcomplexity, Language Feature Toolkit (LFTK)

- Collected and examined the key linguistic features of each package with its github and PyPI page and reference(s). (Google spreadsheet for linguistic features for each package)
- Compared the packages and identified strengths and weaknesses

Results & Discussion

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Python Packages for Text Analysis

Package	(first) Release	Github Page Stars/Folks/Contributors (as of December 9, 2023)	Key Components/ Linguistic Features
textstat	June 2014	https://github.com/textstat/textstat 1K/153/37	2 components with 44 linguistic features: basics, readability
textacy	April 2016	https://github.com/chartbeat-labs/textacy 2.1K/255/30	4 components with 32 linguistic features: basics, counts, diversity, readability
TextDescritives	July 2021	https://github.com/HLasse/TextDescriptives 245/20/12	6 components with 69 linguistic features: descriptive_stats, readability, coherence, dependency_distance, pos_proportions, and quality

Python Packages for Text Analysis

Package	(first) Release date	Github Page Stars/Folks/Contributors (as of December 9, 2023)	Key Components/ Linguistic Features
textcomplexity	October 2020	https://github.com/tsproisl/textcomplexity 68/12/2	5 components with 64 linguistic features: surface, sentence, pos, dependency, constituency
LFTK (Language Feature Toolkit)	March 2023	https://github.com/brucewlee/lftk 81/26/2	4 components with 220 linguistic features: lexico-semantics, syntax, discourse, and surface

Python Packages & Linguistic Features: Google Spreadsheet

Common Features

- Mostly based on spaCy pipeline components and extensions
- A variety of linguistic features from basic descriptive statistics to readability
- A few include linguistic features such as **dependency and constituency** (e.g., **textcomplexity**); Some perform **text mining and other NLP tasks** such as entity recognition (e.g., **textaCy, LFTK**)

2.0 spaCy

Commercial open-source software or a library for advanced Natural Language Processing in Python and Cython

Github

- https://github.com/explosion/spaCy https://spacy.io/usage/linguistic-features
- https://spacy.io/usage/spacy-101
- https://spacy.io/usage/linguistic-features

Key characteristics

tokenization, lemmatization, tagging, parsing, text classification, neural network modeling, named entity recognition, text classification and multi-task learning with pretrained transformers like BERT, etc.

Reference: Honnibal, M,. Montani, I., Van Landeghem, S., & Boyd, A. (2020). spaCy: Industrial-Strength Natural Language Processing in Python. https://doi.org/10.5281/zenodo.1212303.

2.1 Textstat

Calculating statistics from text such as readability, complexity, and grade level

Github & Source Code

- https://github.com/textstat/textstat
- https://github.com/textstat/textstat/blob/main/textstat/textstat.py

Key characteristics

- 8 languages (for some features)
- **2 components with 44 linguistic features:** Basic Stats, Readability

Reference: Wikipedia

2.2 TextaCy

A Python Library that specializes in a wide range of natural language processing (NLP) such as tokenization, part-of-speech tagging, and dependency parsing

Github & Source Code

- https://textacy.readthedocs.io/en/latest/
- https://textacy.readthedocs.io/en/latest/walkthrough.html
- https://github.com/chartbeat-labs/textacy/tree/main/src/textacy/text_stats

Key characteristics

- Performing various NLP tasks, Topic modeling, and text analysis
- **4 components with 32 linguistic features**: Basics, Counts, Diversity, Readability
- Based on previous research; well-documented (See the source code)

2.3 TextDescriptives

A Python library for calculating a large variety of metrics

Github & Source Code

- https://github.com/HLasse/TextDescriptives
- TextDescriptives/src/textdescriptives/components at main · HLasse/TextDescriptives (github.com)

Key characteristics

- **7 components with 69 linguistic features**: descriptive_stats, readability, dependency_distance, pos_proportions, information theory, coherence, and quality

Reference: Hansen, L., Olsen, L. R., & Enevoldsen, K. (2023). TextDescriptives: A Python package for calculating a large variety of metrics from text. *Journal of Open Source Software, 8*(84), 5153.

Output (5 SF novels: C001 ~ C005)

textaCy

	Index Number	flesch_reading_ease	n_tokens	n_unique_tokens	n_sentences	avg_sentence_length
0	C001	83.948876	5964.0	1739.0	374.0	15.946524
	C002	83.074937	5831.0	1947.0	383.0	15.224543

TextDescriptive

	Index Number	flesch_reading_ease	n_tokens	n_unique_tokens	n_sentences	avg_sentence_length
0	C001	83.968975	5970	1736	374	15.962567
		83.087621	5840	1941	383	15.248042
		96.812400	6240	1496	571	10.928196
3	C004	89.240811	5962	1692	46	
4	C005	90.810078	5965	1553	47	

texts
(no function for type count)

	C003	93.54	6050.0	522.0	11.6
	C004	83.76	5808.0	450.0	12.9
4	C005	84.17	5747.0	458.0	12.5

For tokenization:
check stopwords, punctuations, whitespaces, contractions, etc.

2.4 Textcomplexity

A Python library for assessing **the linguistic and stylistic complexity of (literary) texts** (a special Input file needed)

Github & Source Code

- https://github.com/tsproisl/textcomplexity
- textcomplexity/textcomplexity at master · tsproisl/textcomplexity (github.com)

Key characteristics

- English, German
- **5 components with 64 linguistic features**: surface-based, sentence-based, pos-based, dependency-based and constituency-based measures
- **Core measures of lexical complexity**: Variability (TTR), Evenness (normalized entropy), Rarity (rare words), Dispersion (Gini-based dispersion), Lexical density (# of content words), Surprise (unexpected word choices), Disparity (semantically dissimilar words)

2.5 Linguistic Feature Tool Kit (LFTK)

A Python research package for extracting 220 handcrafted features (e.g. number of words per sentence, Flesch-Kincaid Readability Score) that are commonly used in computational linguistics (and language assessment/analysis)

Github & Source Code

- https://github.com/brucewlee/lftk
- List of linguistic features: Google Spreadsheet

Key characteristics

- **4 components with 220 linguistic features**: lexico-semantics, syntax, discourse, and surface
- English, General

Reference: Lee, B. W., & Lee, J. (2023). LFTK: Handcrafted Features in Computational Linguistics. In Proceedings of the 18th Workshop on Innovative Use of NLP for Building Educational Applications (BEA 2023) (pp. 1-19). Toronto, Canada: Association for Computational Linguistics.

2.5 Linguistic Feature Tool Kit (LFTK)

From basic descriptive stats to reading assessment measures

	Index Number	flesch_reading_ease	n_tokens	n_unique_tokens	n_sentences	avg_sentence_length	n_entities	readting_time_average
0	C001	84.208	6113.0	1536.0	374.0	16.344920	273.0	25.471
1	C002	81.378	5936.0	1779.0	383.0	15.498695	238.0	24.733
2	C003	102.156	6441.0	1247.0	571.0	11.280210	180.0	26.837
3	C004	88.254	6086.0	1476.0	467.0	13.032120	236.0	25.358
4	C005	88.857	5990.0	1311.0	475.0	12.610526	204.0	24.958

Conclusion & Implications

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Conclusion

Purpose of this study: What linguistic features to use for analyzing literary texts?

Summary and Conclusion

- Examined the source code and reference of each Python package for text analysis
- Packages except textstat were based on previous research
- Mostly targeted basic descriptive statistics, diversity (or complexity), and readability

Easiness: textstat > TextDescriptives > textacy > LFTK > textcomplexity

Usefulness for research: LFTK > textcomplexity > textacy > TextDescriptives > textstat

Implications

Implications for Follow-up Research

- Target a set of features among similar measures (correlation analysis)
- Focus on linguistic features that represent genre, style, diversity, coherence, cohesion, etc. (Biber & Conrad, 2009)
- Make a Python package for analyzing literary texts

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Albrecht, J., Ramachandran, S., & Winkler, C. (2020). *Blueprints for text analytics using Python*. O'Reilly Media, Inc.

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Thank you!

Materials available on _____

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TRUNAJO
Spacy-readability
Readability
TextBlob