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Exploring Functional Shifts in Pos Tagging Across Various NLP Libraries: A Study of NLTK, spaCy and Textblob

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Research Article

Keywords: Functional Shift. Garden Path Sentences, NLP Libraries, NLTK, SpaCy, TextBlob,

Posted Date: July 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10482436/v1

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Additional Declarations: The authors declare no competing interests.

Abstract

This study presents a comparative analysis of NLTK, TextBlob, and Spacy in handling syntactically complex sentences known as "garden path" sentences which is a product of functional shift in grammar. A total of 56 sentences were analyzed, with each library assessed for its accuracy in tagging various syntactic structures. The findings reveal that while NLTK and TextBlob demonstrate limitations in accurately tagging syntactic structures, Spacy showcases superior performance, tagging a significantly higher number of sentences correctly. Specifically, Spacy (32/56) outperforms NLTK (21/56) and TextBlob (21/56) in accurately identifying the parts of speech for words within syntactically complex sentences, highlighting its efficacy in handling linguistic phenomena such as garden path sentences. These findings underscore the importance of accurate syntactic analysis in NLP applications and emphasize the potential of Spacy as a robust tool for such tasks. Further research and development efforts are warranted to enhance the accuracy and efficiency of syntactic analysis in NLP, with a focus on leveraging the capabilities of advanced NLP libraries like Spacy. The study offers valuable insights for educators and researchers in computational linguistics and NLP, serving as a basis for curriculum development, research projects, and practical exercises aimed at understanding the challenges of syntactic analysis and POS tagging in real-world applications. This might help libraries that are trained in African languages such as AfriBerta, KINYaBert and Serengeti to improve on their functionalities.

Introduction

Natural Language Processing (NLP) has become a basis of modern computational linguistics, enabling machines to understand and analyze human language. Within NLP, Part-of-Speech (POS) tagging plays a major role in analyzing the grammatical structure of sentences. However, the challenges of functional shifts, where words switch between different syntactic roles within a sentence, pose a complex difficulty for NLP libraries. Understanding how various libraries address these functional shifts is essential for enhancing the accuracy and effectiveness of language processing applications.

Functional shifts refer to instances where a word or phrase transitions from one grammatical or syntactic function to another within a sentence. Functional shifts in language, exemplified by words taking on different grammatical functions within varying contexts, pose challenges for NLP models. For instance, the word ‘singing’ functions as a ‘noun’ in the sentence “singing is my hobby”. It transits to a ‘verb’ in “the bird is singing. And finally, it functions as an adjective in “the singing bird is beautiful”. Also, the word 'bank,' for instance, can be a noun (financial institution) or a verb (to tilt to one side) based on context. This suggests the relationship a word has with other words affects its syntactic function in a sentence. Therefore, POS tagging can be influenced by the linguistic context (co-text) of the word due to the company of words it keeps. Understanding how NLP libraries navigate such linguistic disparities becomes paramount for developing models that accurately interpret and generate human-like text.

Over the years, NLP libraries have evolved, each adopting distinct methodologies and algorithms in tackling the intricacies of functional shifts. Notable libraries such as NLTK, Spacy, and TextBlob have gained prominence, each offering unique approaches to POS tagging. As language is dynamic and context-dependent, the effectiveness of these libraries in capturing functional shifts becomes a critical area of investigation. The study investigates how three NLP libraries (NLTK, Spacy and Textblob) tackle these functional shifts, shedding light on the intricacies of their tagging mechanisms.

This comparative study is aimed at exploring the methodologies employed by NLTK, Spacy, and TextBlob in handling functional shifts during POS tagging. It seeks to unravel the strengths and limitations of each library, providing insights that can guide the development of more robust and context-aware language processing models. Ultimately, this research contributes to the ongoing enhancement of NLP applications, to foster a deeper understanding of how these libraries handle language functions.

Problem Statement

The study addresses the pressing issue of functional shifts in Part-of-Speech (POS) tagging within Natural Language Processing (NLP) libraries. While recent studies (Li 2022, Kumawat & Jain 2015, and Pham 2020) have reported that current POS taggers exhibit high token accuracy, challenges arise when dealing with sentences in unconventional contexts, leading to decreased sentence-level accuracy. This disparity becomes crucial, particularly in tasks like dependency parsing, where the accuracy of the entire sentence is crucial.

Aim and Objectives of the Study

The specific aim of this study is to examine how three NLP libraries handle functional shifts in text analytics. Its specific objectives are to

1. compare the tagging discrepancies among three prominent NLP libraries (NLTK, Spacy, and TextBlob).
2. identify the specific limitations of each library in dealing with functional shifts in language functions.
3. explore the efficacy of these libraries in accurately capturing and categorizing the nature of functional shifts across different languages and linguistic contexts.

Research Questions

1. How do NLTK, Spacy, and TextBlob differ in their tagging of functional shifts within sentences?
2. What are the specific limitations of NLTK, Spacy, and TextBlob in accurately handling functional shifts in language functions?
3. To what extent are NLTK, Spacy, and TextBlob effective in capturing and categorizing functional shifts across various languages and linguistic contexts?

Scope of the Study

The study focuses on Part-of-Speech (POS) tagging within the realm of natural language processing (NLP), with a particular focus on addressing the limitations three taggers: NLTK, TextBlob and Spacy in identifying the parts of speech entrenched within garden path sentences.

Significance of the Study

Examining the comparative study reveals the importance of understanding how different NLP libraries address functional shifts, as it has implications for the accuracy and robustness of language processing applications. The variability in linguistic structures and functions across languages poses a significant challenge for POS tagging systems. By comprehensively analyzing and comparing the strategies employed by various NLP libraries, researchers can gain insights into the strengths and limitations of the NLP libraries and their approaches to handling functional shifts, contributing to the refinement and enhancement of POS tagging algorithms. The research is crucial for advancing the capabilities of NLP systems, ensuring their adaptability and effectiveness across diverse linguistic structures.

Literature Review

Conceptual Review

POS tagging is an NLP tool that helps in analyzing the syntactic structure of a sentence, allowing systems to recognize relationships between words and their functions (Li et al., 2022). Secondly, it contributes to semantic analysis of meaning and context of a language. Moreover, POS tagging enhances the accuracy of NLP tasks by providing contextual information, enabling systems to make more informed decisions about word usage.

There are different approaches to POS tagging. Rule-based tagging involves applying a set of predefined rules and linguistic patterns to assign POS tags based on the context of words in a sentence (Kumawat & Jain, 2015). Statistical tagging utilizes statistical models, often based on machine learning algorithms, to predict POS tags by analyzing the probability of a word occurring with a specific tag in each context. Hybrid approaches combine rule-based and statistical methods to benefit from the strengths of both approaches, addressing challenges posed by ambiguous words and varying contexts such as garden path sentences.

Rule-based POS tagging is a linguistically grounded approach that intricately navigates through the complexities of language to assign accurate Part-of-Speech (POS) tags to words. The process begins with a meticulous check against a lexicon, where words are matched to entries (Li, Mao, & Wang, 2022). If a match is found, the add word method applies linguistic rules to determine the POS tag, and the tagged word is organized within a structured linked-list (Li, Mao, & Wang, 2022). In cases where the word does not match the lexicon, the lookup method steps in, implementing rules that include suffix/prefix checks for adjectives (Li, Mao, & Wang, 2022). Additional linguistic rules are then deployed if the tag remains uncertain, considering the word's position relative to the preceding word in the sentence (Li, Mao, & Wang, 2022). This contextual analysis is pivotal for accurate tagging, ensuring that even unknown words or instances of ambiguity are handled with precision. Specific linguistic rules, such as morphological and syntactic rules, refine the process, providing a systematic and comprehensive approach to rule-based POS tagging (Li, Mao, & Wang, 2022). In summary, the rule-based POS tagging method combines lexicon checks, morphological and syntactic rules, and contextual analysis to effectively assign POS tags (Li, Mao, & Wang, 2022). Its strength lies in its ability to handle both known and unknown words through a systematic and linguistically informed process, making it a robust approach in the realm of natural language processing.

Recently, there has been a shift towards deep learning models, particularly Transformer architectures, for POS tagging. Transformer models, with their self-attention mechanism, demonstrated superior capabilities in capturing contextual information. The proposed approach involves rule-based data preprocessing combined with a Transformer-based deep learning model, aiming to improve POS tagging accuracy (Lin et al., 2016).

In summary, the journey of POS tagging in NLP has evolved from rule-based and statistical approaches to the adoption of advanced deep learning models, notably Transformers. Challenges persist, especially in handling ambiguity and unknown words, driving ongoing research for deeper and context-aware POS tagging solutions. As NLP continues to advance, the interplay between traditional linguistic insights and cutting-edge computational models will shape the future of POS tagging.

NLP Taggers: NLTK, TextBlob & SpaCy

Conceptually reviewing three prominent Natural Language Processing (NLP) taggers—NLTK, TextBlob, and SpaCy—provides insights into their algorithms and the underlying models they employ. NLTK, a comprehensive NLP library, utilizes both rule-based and statistical approaches for Part-of-Speech (POS) tagging (Bird et al., 2009). It offers users flexibility by incorporating predefined linguistic rules and access to various statistical models.

TextBlob, another popular library, adopts a simplified rule-based tagging approach and integrates machine learning elements through a pre-trained model based on the Pattern library (Loper & Bird, 2002). This hybrid strategy aims to strike a balance between simplicity and effectiveness.

SpaCy, known for its efficiency, employs statistical models based on deep learning architectures, particularly neural networks (Honnibal & Montani, 2017). This library focuses on high-performance results in various NLP tasks, including POS tagging and leveraging pre-trained neural networks.

In summary, NLTK combines rule-based and statistical methods, TextBlob integrates a rule-based approach with machine learning elements, and SpaCy prioritizes efficiency through deep learning-based statistical models. The choice among these libraries depends on user preferences regarding simplicity, flexibility, and the desired level of sophistication in linguistic analysis.

POS TAGGING FOR THE THREE LIBRARIES			
	NLTK	**SPACY**	**TEXTBLOB**
Noun		NOUN	
Singular/ mass nouns	NN		NN
Plural nouns	NNS		NNS
Proper noun singular	NNP	PROPN	NNP
Proper nouns plural	NNPS		NNPS
Verb (base form)	VB	VERB	VB
Auxiliary		AUX	
Modal	MOD		MOD
Past tense	VBD		VBD
Gerund/ present participle	VBG		VBG
Past participle	VBN		VBN
Non-3rd person singular present	VBP		VBP
3rd person singular present	VBZ		VBZ
Particle (to infinitive)		PART	
Particle (Phrasal Verb)	RP		RP
Pronoun		PRON	
Personal pronoun	PRP		PRP
Possessive pronoun	PRP$		PRP$
Wh-pronoun	WP		WP
Possessive ending	POS		POS
Determiner	DT	DET	DT
Pre determiner	PDT		PDT
Adjective	JJ	ADJ	JJ
Comparative adjective	JJR		JJR
Superlative adjective	JJS		JJS
Adverb	RB	ADV	RB
Comparative adverb	RBR		RBR
Superlative adverb	RBS		RBS
Wh-adverb	WRB		WRB
Adposition/preposition	IN	ADP	IN
Conjunction		CONJ	

Coordinating conjunction	CC	CCONJ	CC
Subordinating conjunction	IN	SCONJ	IN
Interjection	UH	INTJ	UH
Numeral/ cardinal digit	CD	NUM	CD
Symbol	SYM	SYM	SYM
Existential there	EX		EX
Foreign word	FW		FW
Others		X	

Empirical Studies

Li, Mao, and Wang (2022) embarked on a study to underscore the crucial role of Part-of-Speech (POS) tagging in the realm of natural language processing (NLP). Their primary objective was to enhance the understanding of POS tagging challenges, especially in unconventional contexts. To achieve this, the authors proposed a novel approach combining rule-based data preprocessing with a deep learning model based on the Transformer architecture. The method involved generating all possible POS tags for each token through rule-based preprocessing, which included specific linguistic rules to prune unnecessary tags. This was followed by masking POS tags for the subsequent application in the deep learning model, leveraging Transformer architecture for prediction while utilizing contextual information efficiently.

In terms of findings, Li, Mao, and Wang highlighted that existing POS taggers, despite achieving a remarkable 97.3% token accuracy, struggle to maintain the same level of accuracy at the sentence level. This discrepancy becomes particularly crucial in tasks like dependency parsing. The authors, however, refrained from explicitly specifying the peculiarities of these limitations. The study's limitations or gaps were acknowledged by the authors, who committed to a forthcoming examination of these constraints. Specifically, they expressed their intent to identify domains where current POS taggers encounter resource limitations. The authors proposed using garden path sentences as a focal point in this exploration, presenting challenges that current POS taggers may not adequately address.

Kumawat and Jain (2015) investigated Part-of-Speech (POS) tagging in ambiguous words and unknown words. The primary concern revolved around words that could possess more than one tag, a complexity that posed difficulties for automated word taggers but was relatively manageable for human understanding when contexts were considered. They outlined three distinct approaches to POS tagging: rule-based tagging, statistical tagging, and hybrid tagging. Rule-based tagging employed handwritten rules alongside contextual information to assign POS tags, albeit with the drawback of inefficiency when encountering unfamiliar text. Statistical tagging, on the other hand, relied on the probability of a word occurring with a particular tag, with common tag instances derived from the training dataset. The stochastic approach incorporated statistical and probability measures, utilizing the n-gram approach to calculate the probability of tag sequences, labeled as Unigram, Bigram, and Trigram models.

In their findings, the authors scrutinized the resulting tagged corpora, categorizing most errors into distinct patterns. Issues related to word case exhibited the highest error rate, particularly concerning proper nouns, common nouns, and pronouns. The challenge of predicting unknown proper nouns, especially names of people and places, persisted, with limited rules available for realization. The distinction between adverbs and compounds also posed challenges for certain methods. Despite these challenges, the authors expressed optimism in the promising results obtained from their large and rich tagset, acknowledging the need for further enhancements through actions such as enlarging the training corpus and refining the lexical analysis program. The ongoing efforts in these directions were highlighted, demonstrating a commitment to addressing identified limitations.

In Pham's (2020) study on POS tagging for the English language, the author extensively covers the development and application of a rule-based POS tagger. The document elucidates the POS tagging process, emphasizing the assignment of parts of speech to words based on their definitions and relationships with surrounding words. Two primary approaches, rule-based and stochastic, are examined. The rule-based approach is detailed with the development of a POS tagger using Lex and Yacc, employing a concise set of rules and a dictionary for token sequence generation. Linguistic rules play a pivotal role in determining word parts of speech within the English language. The document examines the structural aspects of English, including its characteristics, evolution, and complexity, exploring topics such as signs in human language, word orders, and the nature of signs. Related works are referenced, highlighting various endeavors in effective rule-based POS tagger implementation and comparing rule-based and stochastic approaches in different languages. The implementation section provides coding insights into the rule-based POS tagger, elucidating the use of Lex and Yacc, lexicon construction, and the application of linguistic rules. The handling of unknown words and challenges associated with tagging processes are addressed.

Pham concludes that while the rule-based approach exhibits speed and efficiency, both rule-based and stochastic approaches encounter challenges with ambiguity and unknown words. The document suggests a hybrid approach as a potential future direction for improved tagging. The study posits that the stochastic approach demonstrates higher accuracy in determining proper tags for ambiguous or unknown words, contrasting the efficiency of the rule-based approach, which may not be the optimal method for POS tagging. In summary, Pham's work provides a comprehensive exploration of rule-based POS tagging, offering valuable insights into implementation, strengths, limitations, and potential future directions within the realm of natural language processing.

The common gap observed across the reviewed literature, including Li, Mao, Kumawat, Jain and Wang's paper on the discussion on POS tagging problems, and Pham's work, is the need for improved accuracy in POS tagging, especially at the sentence level. Current POS taggers face challenges in maintaining high accuracy across complex sentences, impacting downstream tasks like dependency parsing. The proposed study aims to address this gap by exploring the weaknesses and limitations of taggers. By leveraging linguistic rules and contextual information efficiently, this study seeks to identify the accuracy of POS tagging, particularly in handling garden path sentences ambiguous contexts, contributing to the advancement of natural language processing tasks.

This study aims to employ garden path sentences as a syntactic tool to explore and expose the limitations of current POS taggers, as highlighted in the literature. By subjecting the taggers to sentences with complex structures that may mislead or challenge traditional taggers, the study intends to identify specific domains and contexts where these taggers exhibit limitations in accurately processing language. The analysis of garden path sentences serves as a methodological approach to examine POS tagging accuracy, providing valuable insights into the areas that require improvement thereby contributing to the broader understanding and enhancement of natural language processing systems.

Methodology

This study collected about 45 sentences which are based on three different syntactic categories namely: Garden path sentences; Morphological formation (Nominalized forms) and Shift in positioning. Each of these sentences contains specific words that have unusual POS tagging. The sentences were collected from https://wordsmithingtools.com/list-of-garden-path-sentences. Each of these sentences were analyzed using the python code for NLTK, SpaCy and TextBlob. Each word was analyzed using this code. For instance, the popular garden path sentence “the old man the gate” contains two words (old and man) whose parts of speech unusual based on the contexts of occurrence (‘**old’** as a noun; ‘**man**’, as a verb).

Discussion of Findings

This study conducted a comparative analysis of three popular NLP libraries: NLTK, TextBlob, and Spacy, focusing on their performance in tagging syntactic structures such as "garden path" sentences, nominalization, and sentence positioning. The analysis revealed the understanding of the accuracy and effectiveness of these NLP libraries in handling syntactic complexities. Firstly, NLTK and TextBlob exhibited similar performance, correctly tagging 21 sentences out of 56 each. However, when scrutinizing specific syntactic structures, both NLTK and TextBlob demonstrated limitations. For instance, they correctly identified only 4 out of 21 "garden path" sentences and 3 out of 11 nominalized forms. Additionally, their performance varied concerning sentence positioning, with 14 out of 24 sentences tagged accurately.

In contrast, SpaCy showcased superior overall performance, accurately tagging 32 sentences out of 56. Notably, it demonstrated better proficiency in handling syntactic complexities, correctly identifying 5 out of 21 "garden path" sentences and 22 out of 24 sentences based on positioning. Furthermore, Spacy's capability to tag syntactic structures accurately was evident in various contexts, as exemplified by its correct identification of sentences such as "The earth turns ***round*** once" (ADVERB), "The world has a ***round*** shape" (ADJECTIVE), and "We need to ***table*** the discussion with him" (VERB).

FUNCTIONAL SHIFTS	**CORRECT TAGGING**			
	NO OF SHIFTS	NLTK	SPACY	TEXTBLOB
GARDEN PATH	21	4	5	4
NOMINALIZED FORMS	11	3	5	3
POSITIONING	24	14	22	14
TOTAL	**56**	**21**	**32**	**21**

FUNCTIONAL SHIFTS	**FAULTY TAGGING**			
	NO OF SHIFTS	NLTK	SPACY	TEXTBLOB
GARDEN PATH	21	17	16	17
NOMINALIZED FORMS	11	8	6	8
POSITIONING	24	10	2	10
TOTAL	**56**	**35**	**24**	**35**

Garden path sentences pose a significant challenge for natural language processing (NLP) libraries. In a detailed examination of garden path sentences, the study highlights the limitations of popular NLP libraries—NLTK, Spacy, and TextBlob—in accurately tagging words within these intricate linguistic constructs.

For instance, sentence 4, "The ***Complex Houses*** Married and Single Students and Their Families," presents a formidable challenge for NLP libraries due to its convoluted structure and ambiguous word usage especially in the words ‘complex’ and ‘houses’. Across all three libraries, inconsistencies in part-of-speech (POS) tagging are observed, particularly evident in words such as "Complex," "Houses," and "Married." NLTK, Spacy, and TextBlob display discrepancies in their tagging of these words, reflecting the inherent difficulty in disambiguating their grammatical roles within the sentence. While NLTK and TextBlob categorize "Complex" as an ‘adjective’ (JJ), "Houses" as a noun (NNS) and "Married" as a past tense verb (VBD), Spacy assigns them as an adjective, noun, and verb, respectively, showcasing some level of similarities in POS interpretation among the libraries. This is captured in the table below.

Sentence 4	The	Complex	Houses	Married	And	Single	Students	And	Their	Families
POS	**ART**	**NOUN**	**VERB**	**ADJ**	**CONJ**	**ADJ**	**NOUN**	**CONJ**	**POSS**	**NOUN**
NLTK	DT	JJ	NNS	VBD	CC	JJ	NNS	CC	PRP$	NNS
SpaCy	DET	ADJ	NOUN	VERB	CCONJ	ADJ	NOUN	CCONJ	PRON	PRON
TextBlob	DT	JJ	NNS	VBD	CC	JJ	NNS	CC	PRP$	NNS

Similarly, in Sentence 2, "The ***Old Dog*** the Footsteps of the ***Young***," the intricate interplay of words poses a challenge for accurate POS tagging. Notably, words such as "Old," "Dog," and "Young" present difficulties in discerning their grammatical roles within the sentence structure. While NLTK, Spacy, and TextBlob demonstrate consistency in their tagging of these words as adjective-noun-adjective (JJ-NN-JJ), their performance highlights the complexities inherent in parsing syntactically intricate sentences. This is demonstrated in the table below:

Sentence 2	The	Old	Dog	The	footsteps	Of	The	young
POS	**ART**	**NOUN**	**VERB**	**ART**	**NOUN**	**PREP**	**ART**	**NOUN**
NLTK	DT	JJ	NN	DT	NNS	IN	DT	JJ
SpaCy	DET	ADJ	NOUN	DET	NOUN	ADP	DET	ADJ
TextBlob	DT	JJ	NN	DT	NNS	IN	DT	JJ

The analysis of garden path sentences underscores the formidable challenges faced by NLP libraries in accurately tagging words within linguistically complex constructs. Despite advancements in NLP technology, the intricate ambiguities inherent in garden path sentences continue to pose significant hurdles for POS tagging algorithms, necessitating further research and development to enhance the accuracy and robustness of syntactic analysis in natural language processing.

The findings of this study underscore the importance of evaluating NLP libraries' performance in handling syntactic structures accurately. While NLTK and TextBlob offer valuable functionalities, especially in general-purpose text processing tasks, their limitations in accurately tagging syntactic complexities highlight the need for further refinement. On the other hand, Spacy's robust performance in accurately identifying syntactic structures underscores its efficacy in handling diverse linguistic phenomena, making it a compelling choice for NLP applications requiring nuanced syntactic analysis.

This comparative analysis sheds light on the strengths and weaknesses of NLTK, TextBlob, and Spacy in tagging syntactic structures. By understanding the performance characteristics of these NLP libraries, researchers and practitioners can make informed decisions when selecting tools for text processing tasks, ultimately enhancing the quality and efficiency of NLP applications.

In a comparative study evaluating the performance of popular NLP libraries—NLTK, Textblob, and Spacy—Spacy emerges as the frontrunner, particularly excelling in the categorization of words such as 'ROUND', 'TABLE', 'BANK', 'STAND', 'COOK', 'RUN', 'TRACK', and 'THAT' across various word-class categories and contextual contexts.

For instance, Spacy flawlessly records correct tagging with the word ‘round’ whenever it is positioned in different contexts.

Sentence 23	I	Need	You	To	Round	The	Table	twice
POS	**PRON**	**VERB**	**PRON**	**PART**	**INF. VB**	**ART**	**NOUN**	**ADV**
NLTK	PRP	VBP	PRP	TO	VB	DT	NN	NN
SpaCy	PRON	VERB	PRON	PART	VERB	DET	NOUN	ADV
TextBlob	PRP	VBP	PRP	TO	VB	DT	NN	NN

Sentence 24	The	Earth	Turns	Round	once
POS	**DET**	**NOUN**	**VERB**	**ADV**	**ADV**
NLTK	DT	NN	VBZ	NN	RB
SpaCy	DET	NOUN	VERB	ADV	ADV
TextBlob	DT	NN	VBZ	NN	RB

Sentence 25	The	World	Has	A	Round	shape
POS	**ART**	**NOUN**	**VB**	**ART**	**ADJ**	**NOUN**
NLTK	DT	NN	VBZ	DT	NN	NN
SpaCy	DET	NOUN	VERB	DET	ADJ	NOUN
TextBlob	DT	NN	VBZ	DT	NN	NN

Sentence 26	You	Need	To	Move	Round	The	table
POS	PRO	VB	PART.	VB	PREP	ART	NOUN
NLTK	PRP	VBP	TO	VB	NN	DT	NN
SpaCy	PRON	VERB	PART	VERB	ADP	DET	NOUN
TextBlob	PRP	VBP	TO	VB	NN	DT	NN

Sentence 27	He	Won	The	third	round
POS	**PRO**	**VB**	**ART**	**ADJ**	**NOUN**
NLTK	PRP	VBD	DT	JJ	NN
SpaCy	PRON	VERB	DET	ADJ	NOUN
TextBlob	PRP	VBD	DT	JJ	NN

Spacy's remarkable performance is evident in its ability to accurately determine the part-of-speech (POS) of words, showcasing versatility and precision across multiple word-class categories. Specifically, Spacy outperforms NLTK and

Textblob in discerning the POS of words like 'ROUND', which can function as an adjective, noun, preposition, adverb, and verb. While NLTK and Textblob only recognized 'ROUND' in the context of verb and noun, Spacy's comprehensive understanding of contextual distinctions enables it to categorize 'ROUND' accurately across diverse linguistic contexts.

Moreover, Spacy's proficiency extends to the accurate categorization of 'THAT' in its various grammatical roles, including as a relative pronoun, subordinate conjunction, demonstrative pronoun, and demonstrative adjective. Unlike NLTK and Textblob, which exhibit limitations in recognizing the deep usage of 'THAT', Spacy demonstrates robustness in determining its POS regardless of contextual variations, thereby enhancing the accuracy and reliability of syntactic analysis. This is demonstrated in the table below:

Sentence 42	**That**	**Book**	**Is**	**mine**
POS	**DEM ADJ**	**NOUN**	**VB**	**PRO**
NLTK	DT	NN	VBZ	JJ
SpaCy	DET	NOUN	AUX	PRON
TextBlob	DT	NN	VBZ	JJ

Sentence 43	**That**	**Is**	**My**	**book**
POS	**DEM PRO**	**VB**	**PRO**	**NOUN**
NLTK	DT	VBZ	PRP$	NN
SpaCy	PRON	AUX	PRON	NOUN
TextBlob	DT	VBZ	PRP$	NN

Sentence 44	**I**	**Know**	**That**	**Love**	**Is**	**Blind**
POS	**PRO**	**VB**	**SUB CONJ**	**NOUN**	**VB**	**ADJ**
NLTK	PRP	VBP	**DT**	NN	VBZ	RB
SpaCy	PRON	VERB	SCONJ	NOUN	AUZ	ADJ
TextBlob	PRP	VBP	**DT**	NN	VBZ	RB

Sentence 45	**This**	**Is**	**The**	**Boy**	**That**	**won**	**The**	**game**
POS	**DEM PRO**	**VB**	**ART**	**NOUN**	**REL PRO**	**VB**	**ART**	**NOUN**
NLTK	DT	VBZ	DT	NN	WDT	VBD	DT	NN
SpaCy	PRON	AUX	DET	NOUN	PRON	VERB	DET	NOUN
TextBlob	DT	VBZ	DT	NN	WDT	VBD	DT	NN

In essence, the findings of this study underscore Spacy's superiority in part-of-speech tagging, particularly in its adeptness at discerning the POS of words like 'ROUND' and 'THAT' across diverse linguistic contexts. By leveraging

Spacy's advanced capabilities in syntactic analysis, NLP practitioners can enhance the precision and efficiency of text processing tasks, ultimately advancing the capabilities of NLP applications in various domains.

Conclusion

The findings of this study shed light on the performance of different NLP libraries, namely NLTK, TextBlob, and SpaCy, in tagging functional shifts, which are known for their syntactic complexity. In comparison to existing literature, such as the studies by Li, Mao, and Wang (2022), Kumawat and Jain (2015), and Pham (2020), which generally focus on broader aspects of POS tagging challenges, the present study offers specific insights into the challenges posed by functional shifts.

Firstly, the study reveals that all three NLP libraries struggle to accurately tag words in garden path sentences, particularly those that are syntactically ambiguous. This finding aligns with the broader literature, which acknowledges the challenges of ambiguity and unknown words in POS tagging, as highlighted by Kumawat and Jain (2015) and Pham (2020). However, the present study goes a step further by specifically identifying garden path sentences as a significant hurdle for current POS taggers.

Secondly, the study shows that SpaCy outperforms NLTK and TextBlob in tagging garden path sentences, especially in terms of accurately identifying the POS of words such as "ROUND," "TABLE," "BANK," "STAND," "COOK," "RUN," "TRACK," and "THAT" in various contexts. This finding underscores the importance of library choice in handling syntactically complex sentences, a factor that has not been extensively explored in previous literature.

The findings of this study contribute to the existing literature by providing a focused examination of the challenges posed by garden path sentences in POS tagging. By highlighting the limitations of current NLP libraries and showcasing the superior performance of SpaCy in this regard, the study offers valuable insights that can inform future research and development efforts in natural language processing.

Implications

The implications of the findings regarding functional shifts and their challenges in accurate part-of-speech (POS) tagging are multifaceted and extend to various domains within natural language processing (NLP) and computational linguistics.

1. Algorithmic Improvement: The observed discrepancies in POS tagging among different NLP libraries underscore the need for continued algorithmic refinement. Developers can use these findings to enhance existing algorithms or develop new ones that better handle syntactically complex sentences, thereby improving the accuracy and robustness of NLP applications.

2. Application Performance: In practical applications such as text processing, machine translation, and sentiment analysis, accurate POS tagging is crucial for understanding the semantics and context of text. The limitations identified in the study highlight potential shortcomings in current NLP applications and suggest areas for improvement to enhance overall performance and user experience.

3. Language Understanding: Functional Shifts represent a particular linguistic phenomenon that challenges both human comprehension and computational linguistics. By studying how NLP libraries handle these sentences, researchers gain insights into the mechanisms underlying language understanding and the computational processes involved in parsing syntactically complex structures.

4. Interdisciplinary Research: The findings bridge the gap between linguistics and computer science, highlighting the interdisciplinary nature of NLP research. Linguistic theories regarding sentence structure and ambiguity intersect with

computational techniques for text analysis, offering opportunities for collaboration and knowledge exchange between linguists, computer scientists, and NLP practitioners.

5. Educational Insights: The study provides valuable insights for educators and researchers in computational linguistics and NLP. It serves as a basis for curriculum development, research projects, and practical exercises aimed at understanding the challenges of syntactic analysis and POS tagging in real-world applications.

In conclusion, the implications of the findings extend beyond the specific context of the study, offering valuable insights into the complexities of natural language processing and the ongoing quest to develop more accurate and robust computational models for language understanding.

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