

A Systematic Review of Spelling Corrector for African Languages

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ABSTRACT

This systematic review examines the state of spell correctors for African languages, addressing their linguistic diversity challenges. It aims to answer key questions about the methodologies, efficacy, and constraints of these spell correctors. An extensive literature search was conducted across various academic databases, including Google Scholar, Springer, and Science Direct. Studies were selected based on pre-defined criteria, targeting research articles and conference papers on spell correction in African languages. Data extraction and quality assessment were performed independently by multiple reviewers to ensure accuracy and minimize bias. The review analyzed algorithms used, language coverage, performance metrics, and available linguistic resources. Findings indicate that spell correctors for African languages are still in their infancy compared to those for more widely spoken languages. The review highlights the need for comprehensive resources and advanced algorithms to improve these tools' efficacy. Future research should focus on larger datasets, cross-lingual approaches, and increased community involvement to enhance the development and performance of spell correctors for African languages. These advancements could significantly improve linguistic support and technology integration for African languages, fostering greater inclusivity and accessibility.

KEYWORDS

Spelling corrector
African Languages
Datasets
Metrics

1. INTRODUCTION

Spell corrector, integral components of modern text processing, significantly enhance writing quality and comprehension across global languages. However, when considering the linguistic diversity of African languages, which according to Ethnologue's Geographical Distribution of Living Languages encompasses 2,058 distinct languages as reported by (Blommaert, 2007). The Language Families in Africa is as shown in Figure 1 below. The development and implementation of effective spell corrector present unique challenges and opportunities. This systematic review explores the current state of spell corrector technology specifically tailored to African languages, addressing their importance in ensuring accurate and accessible digital content, and fostering communication and education across the continent. Spell correctors play a pivotal role in ensuring the accuracy of written content, particularly in languages that are not widely covered by major technology platforms. For African languages, which often lack substantial digital infrastructure and resources, spell correctors are essential tools that maintain and improve the quality of the written language (Andrade, Teixeira, Xavier, Oliveira, Rocha, & Evsukoff, 2012). They aid in standardizing the language, which is crucial for educational materials, formal communication, and media publications. By improving spelling accuracy, these tools also help preserve the integrity and richness of African languages, making sure that subtle linguistic nuances are captured correctly (Finch, Coyle, & Peck, 2017). This is particularly significant in languages with complex orthographies or those that use diacritical marks to denote different sounds. Spell correctors are more than just tools for correcting textual errors; they are also instrumental in making written content more accessible to the speakers of various African languages. By simplifying the process of writing correctly, these tools encourage more people to use their native languages online and in digital communications (Nguyen, Salopek, Zhao, & Jin, 2017). This increased engagement helps in promoting and normalizing the use of African languages in digital spaces, contributing to their longevity and relevance. Furthermore, with correct spelling facilitated by these tools, speakers from students to professionals are more likely to use their language confidently, increasing overall literacy and boosting educational outcomes. One of the primary challenges in developing spell correctors for African languages lies in the continent's vast linguistic diversity. Africa is home to thousands of languages, spanning several major language families. This diversity, while a cultural asset, poses

significant challenges for standardization and digitization. Each language often with its own distinct grammar, syntax, and orthographic rules requires a unique approach to spell correction. For example, tonal languages, such as Yoruba, require spell correctors that can accurately identify and suggest corrections based on tonal differences, not just alphabetical errors.

Developing technological solutions that can effectively address the complexities of each language demands extensive linguistic research and a deep understanding of local nuances, which can be resource intensive. The development of effective spell correctors for African languages is further hampered by a lack of comprehensive language resources. Unlike widely spoken European languages, many African languages do not have extensive digital corpora, dictionaries, or standardized orthographies readily available. This scarcity is a significant impediment to training the sophisticated algorithms needed for accurate spell checking and correction. Machine learning models, which underpin most modern spell-correcting tools, require large amounts of textual data to learn from. For African languages, gathering this data often means extensive fieldwork collecting texts, transcribing spoken language, and validating with native speakers which is both time consuming and costly (Wanjawa, Wanzare, Indede, McOnyango, Ombui, & Lawrence., 2022), (Berez, Mulder, & Rosenblum, 2010) [31]. Moreover, there is also the challenge of encompassing regional variations and dialects within the same language, adding another layer of complexity to the resource acquisition process. Table 1 below shows the different African language family and the examples of languages in each family (Heine & Nurse, 2000).

This review work is aim to answer the following research questions:

- What are the methodologies used for spelling correction?
- What is the efficacy, and constraints of current spell correctors for African languages?

2. LITERATURE REVIEW

The review analyzed various aspects such as algorithms used, language coverage, performance metrics, and the availability of linguistic resources. What are the methodologies, efficacy, and constraints of current spell correctors for African languages?

Few review works has been done in spell checking and correct-

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ing African languages. In (Zukarnain, Abbas, Wayan, Trisetiyarso, & Kang, 2019), the article examined various works that has been done in different types of languages excluding English. Like Thailand, Malaysia, Africa, India, China, Arabia, Japan and Indonesia. Systematic literature review method was used for published paper from 2008 – 2018 and there were a total of 23 papers that represented each language and provided an overview of the methods used. It was reported that the result shows that each language has a different Spelling Check approach and the most used method was said to be the Damerau-Levenshtein edit distance algorithm. (Neti, 2017) reviewed some few works (Ndaba, 2015) and (Jones, Podile, & Puttkammer, 2005) done in isiXhosa language and the research concluded that morphological analysis can be of great benefit for spell checking purposes in languages that of high agglutinative and conjunctively in writing style.

Table 1: Major African Language Families and Examples of Languages (Greenberg, 1963)

Language Family	Examples of Languages
Afroasiatic	Arabic Amharic Somali Hausa
Niger-Congo	Swahili Yoruba Igbo Zulu
Nilo-Saharan	Luo Maasai Kanuri
Khoisan	Nama Xoo

2.1 Existing Spell Corrector Technologies for African Languages

The development of spell corrector technologies for African languages is relatively nascent compared to those available for many European languages. Despite this, various efforts have been made to create reliable and efficient spell correctors that cater specifically to the linguistic features of African languages. These technologies often utilize different approaches, such as rule-based algorithms and machine learning models, to address the unique challenges presented by the diverse linguistic landscape of the continent. For instance, spell correctors for widely spoken African languages like Swahili (Twaakyondo, 2017), Hausa, and Yoruba are gradually gaining attention. These technologies typically integrate with popular text editors and online platforms, enhancing the writing experience for users. Some academic research projects have also led to the development of prototypes that focus on less-resourced languages, demonstrating a growing awareness of the need for such tools. The successes of spell corrector technologies in African languages include the ability to handle basic orthographic errors, which significantly aids in communication and education. In languages with standardized orthographies, such as Swahili, spell correctors have been successful in achieving high accuracy levels. These tools help preserve language integrity and promote literacy by providing feedback that encourages correct spelling practices. However, the limitations are notable, especially for languages with complex morphologies or those without a widely accepted standard orthography. The linguistic diversity of Africa poses a significant challenge, as many languages are under-resourced and lack the extensive corpora necessary to train effective spell correctors. Additionally, the socio-linguistic factors such as code switching (mixing of languages), often seen in African commu-

nication patterns, further complicate the development of robust spell correction tools.

2.2 Factors Influencing Spell Correction Accuracy in African Languages

2.2.1 Phonetics and phonology:

The phonetic and phonological properties of African languages significantly influence the design and efficacy of spell correctors. African languages often exhibit features such as tonality, vowel length, and nasalization, which are crucial for meaning but challenging for spell correction systems. For example, tonal differences can alter meanings dramatically, making it essential for spell correctors to accurately recognize and process these nuances. Moreover, many African languages display a high degree of phonological processes such as assimilation, where the sound of one letter can influence the adjacent sound. This aspect can lead to variations in spelling, resulting in heightened complexity for spell checking technologies. Effective spell correctors for these languages must therefore incorporate sophisticated phonological models that can accurately interpret and suggest corrections based on these intricate rules.

2.2.2 Morphology and Syntax:

Morphology is the study of the structure of words and syntax the arrangement of words and phrases to create well-formed sentences are crucial factors affecting spell correction accuracy in African languages. Many African languages are agglutinative, meaning they often form words by stringing together several morphemes (word units) (Maryamawit, 2022), (Aronoff & Fudeman, 2022). This characteristic can lead to lengthy words with complex constructions, posing substantial challenges for spell correction systems. For effective spell checking, it is essential that algorithms understand and correctly handle various morphological rules specific to each language. For instance, in languages such as Kiswahili, prefixes and suffixes play significant roles and can change meanings depending on their arrangement. Acknowledging these morphological structures ensures spell correctors not only identify spelling mistakes but also offer correct contextual substitutions.

2.2.3 Lexicon And Frequency of Use:

The richness of the lexicon and the frequency of word use are additional vital aspects that influence spell corrector performance in African languages. Many African languages have extensive lexicons with a wealth of synonyms, often reflecting subtle differences in meaning and context. Spell correctors must have comprehensive databases that are regularly updated to include these lexical items. Moreover, the frequency of word usage can vary significantly, with many terms used only in specific regions or contexts. For example, certain terminologies might be prevalent in urban areas while entirely absent in rural settings. Spell correctors need to be adaptable and context-aware, possessing capabilities to learn from user interactions to enhance their predictive accuracies over time. By addressing these phonetic, morphological, syntactic, and lexical challenges, spell correctors for African languages can significantly improve, making them more reliable and beneficial for users (Aronoff & Fudeman, 2022). These advancements not only aid personal communication but also support educational programs and professional settings, fostering broader literacy and digital inclusion across the continent. Most African languages are still low-resource in terms of obtaining sufficient data for research. Although some direct links to free Arabic datasets that can be utilized for research purposes were listed, more of these efforts are still needed in other languages (Kuznetsov & Urdiales, 2021), (Malema & Rammidi, 2019) and (David & Ssali)

2.2 Case Studies of Spelling Corrector Implementation in African Languages

The implementation of spell correctors in African languages has seen several significant successes that highlight the potential of technology in preserving and promoting linguistic diversity. For instance, the development of spell correctors for languages like Swahili, Yoruba, and Amharic has greatly enhanced text accuracy and user experience. In Kenya, a Swahili spell corrector was integrated into popular word processing software, substantially improving written communication for millions of Swahili speakers. This tool uses a comprehensive database of Swahili words and applies morphological rules that are unique to Swahili, ensuring a high degree of accuracy. Similarly, in Nigeria, developers launched a Yoruba spell corrector that has been incorporated into various educational and communication platforms. This corrector not only checks spelling but also provides suggestions for grammatical structuring, aiding in the education sector by helping students learn and interact in their native language more effectively. Meanwhile, Ethiopia celebrated the development of an Amharic spell corrector, which is now used by governmental agencies in digital communications. This initiative not only facilitates clearer communication but also supports the use of Amharic in formal settings, thus reinforcing its status as an official language of Ethiopia (Demilie & Salau, 2022).

3. METHODOLOGY

In this research work, we are conducting a systematic review on previous efforts that has been done in the area of spell correction in African languages to see how real word errors detection and correction has been done in a space of ten years between the year 2013-2023 in other to familiarize ourselves with the techniques that has been used in the past decade in the area of spell checking African languages.

3.1 Procedure for Searching

Finding the appropriate article or journal requires first identifying the literature source. The only search engines used in the study's documents are Science Direct and Google Scholar and this is because the duo gives excellent access to high rated, interdisciplinary, peer reviewed literatures as well as ensuring a thorough and interdisciplinary utilizing Science Direct, Springer and Google Scholar for systematic reviews provides access to extensive, peer-reviewed, interdisciplinary, and comprehensive

literature from Elsevier, ensuring a thorough and latest compilation.

Boolean operators (AND and OR) are used in the keyword column to filter the search results. If a keyword contains two words, then use AND; if a keyword contains just one word, then use OR. The keyword combinations are "Spelling checker in West African languages," "Spell Corrector in East Africa, spelling correction in South Africa," "Spelling Corrector in African languages," and "Spell Checker in North Africa languages."

3.2 The Inclusion Criteria

The inclusion criteria from the search mechanism, which consists of three stages, must be applied in the second step. The first step involves looking up articles and journals. Every document we locate satisfies our initial objectives, despite the differences in search methodology between Science Direct, Springer and Google Scholar. The search is modified until it yields the anticipated quantity of journals / articles (no more than 100). The documents or articles we gather span the years 2013 through 2023. We gathered 30 papers and an article, excluding a duplicate. Subsequently, we incorporate the article by means of a title and abstract filter. The policy definition will define additional titles and properties. For instance, we search it for the terms "language" and "country." If necessary, we will then record it in the "Candidate Study" status after that. Lastly, we go through each candidate document and filter it by reading the conclusions and abstract. The country, language, and methodology are defined using a matrix, which is then saved in the chosen articles folder for this paper.

3.3 Extraction of Data

The study literature reviewed was 30 articles of all resources and criteria. Out of the reviewed documents, only 20 were related based on titles and language within Africa continent. Out all the articles only 16 was used in this research. Table 2 shows the describe the data used which includes the languages involved, the article where it was published as well as the number of time a particular work was published in a language while Table 3 shows the various techniques that were used by the authors in the reviewed works.

3.4 Evaluation of Quality

According to [34], the reviewed articles for the final sample must undergo an in-depth quality assessment. Each article's quality was assessed based on the research purpose using the

Table 2: Data Description

Language	Article	Number of Articles
Setswana	(Kuznetsov & Urdiales, 2021) and (Malema & Rammidi, 2019)	2
Dinka	(David & Ssali, 2022)	1
Tigrigna	(Kiros & Aray, 2021)]	1
Dawurootsuwa	(Gamu & Woldeyohannis, 2023)	1
Igala	(Ayegba et al., 2017).	1
Hausa	(Salifou & Naroua, 2014)	1
Afaan Oromo	(Dawit, 2022)	1
isiZulu	(Ndaba, 2015)	1
Amharic	(Tilahun, 2020), (Maryamawit, 2022)	2
Other Ethiopian Languages	(Demilie & Salau, 2022)	1
Yoruba	(Fasidi & Adebayo, 2018), (Asahiah et al., 2023), (Fasidi & Adebayo, 2019)	3
Amazigh	(Chaabi & Allah, 2022)	1
Wolof	(Cisse & Sadat, 2023)	1

Table 3: Techniques used in the Reviewed work

Languages	Techniques	Articles
Setswana	Transformer Part of speech tagger, Rule-base	(Kuznetsov & Urdiales, 2021) (Malema & Rammidi, 2019)
Dinka	Dictionary Lookup edit distance	(David & Ssali, 2022)
Tigrigna	Dictionary lookup Levenshtein edit distance	(Kiros & Aray, 2021)
Dawurootsuwa	Dictionary Morphological rules	(Gamu & Woldeyohannis, 2023)
Igala	Dictionary Similarity.	(Ayegba et al., 2017)
Hausa	Trie and Hash Edit distance	(Salifou & Naroua, 2014)
Afaan Oromo	Levenshtein edit Dictionary lookup N-gram	(Dawit, 2022)
isiZulu	Trigrams and four- grams	(Ndaba, 2015)
Amharic	Dictionary lookup Levenshtein edit Deep Learning	(Tilahun, 2020) (Maryamawit, 2022)
Other Ethiopian Languages	Dictionary lookup	(Demilie & Salau, 2022)
Yoruba	Interpolation algorithm Edit distance N-gram, Diacritic language model	(Fasidi & Adebayo, 2018), (Fasidi & Adebayo, 2019) (Asahiah et al., 2023),
Amazigh	N-gram Damerau-Levenshtein algorithm	(Chaabi & Allah, 2022)
Wolof	Trie data structure Weighted Levenshtein distance	(Cisse & Sadat, 2023)

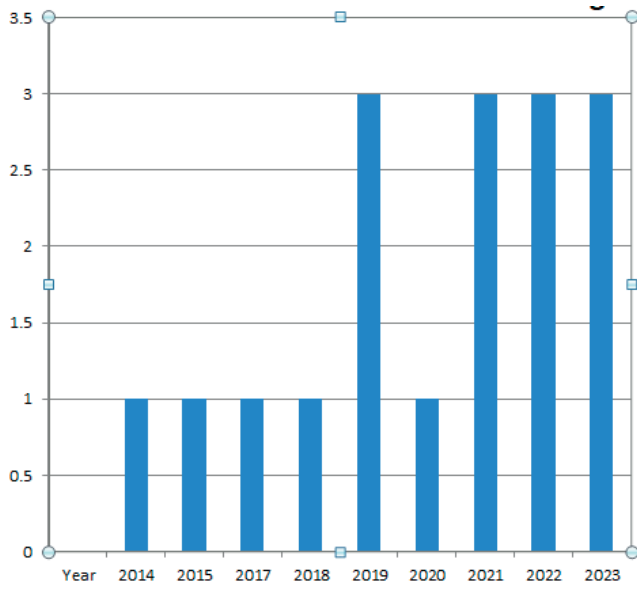


Figure 1 Relevant articles distribution by Year

criteria listed in Table 4 in order to ensure it is reliable. Each researcher objectively reviewed the articles using the quality evaluation criteria, quantified on a rating measure (Bad = 1, Fair = 2, and Good = 3). When an article meets the quality evaluation criteria specified in Table 4, it is assigned a rating for the article. Take for example, if an article adequately addresses EQ1 (Does the study adhere to the specified inclusion and exclusion criteria?), it receives a rating of 3 = “Good”; if the answer is satisfactory, it gets a rating of 2 = “Fair”; and if it fails to address the question, it gets a rating of 1 = “Bad.” This process is repeated for the remaining EQ questions. The final score is then calculated as shown in Table 5.

The chart in Figure 1 shows graph of relevant articles by year which indicated the frequency of published work on spell checking African languages.

4. DISCUSSION

The journey towards the successful implementation of spell correctors for African languages has provided valuable insights and lessons. One primary lesson is the critical need for extensive

Table 4: Evaluation of Quality Criteria

S/N	Questions
EQ1	Does the study adhere to the specified inclusion and exclusion criteria?
EQ2	Is there evidence that the design aligns with specific development concepts or ideas?
EQ3	Does the paper present a quantitative or qualitative analysis of performance evaluation based on experimentation?
EQ4	Are the study’s findings in line with the primary objective?
EQ5	Is the paper published in a well-recognized and reputable source?

Table 5: Evaluation of Quality Outcome

S/N	Type of Paper	Author	Year	RQ1	RQ2	RQ3	RQ4	RQ5	Score
1	Journal	(Kuznetsov & Urdiales, 2021)	2021	3	3	3	3	3	15
2	Journal	(Malema & Rammidi, 2019)	2019	3	2	3	3	3	14
3		(David & Ssali, 2022)		3	3	3	2	3	14
4	Journal	(Kiros & Aray, 2021)	2021	3	2	3	2	3	13
5	Journal	(Gamu & Woldeyohannis, 2023)	2023	3	3	3	3	3	15
6	Journal	(Ayegba et al., 2017).	2017	3	3	3	3	3	15
7	Journal	(Dawit, 2022)		3	2	3	3	3	14
8	Journal	(Salifou & Naroua, 2014)	2014	3	2	3	2	3	13
9	Journal	(Ndaba, 2015)	2015	3	3	3	2	3	14
10	Journal	(Tilahun, 2020)	2020	3	2	3	3	3	14
11	Journal	(Demilie & Salau, 2022)	2022	3	3	3	2	3	14
12	Journal	(Fasidi & Adebayo, 2018)	2018	3	3	3	2	3	14
13	Journal	(Asahiah et al., 2023)	2023	3	2	3	3	3	14
14	Journal	(Fasidi & Adebayo, 2019)	2019	3	3	3	2	3	14
15	Journal	(Chaabi & Allah, 2022)	2022	3	3	3	2	3	14
16	Journal	(Cisse & Sadat, 2023)	2023	3	3	3	2	3	14

and representative linguistic data (Kiros & Aray, 2021), (Ndaba, 2015), (Maryamawit, 2022). Early versions of some spell correctors lacked accuracy due to insufficient input from native speakers, resulting in databases that did not adequately reflect current usage and regional variations (Ndaba, 2015). Addressing this issue meant involving more linguistic experts and native speakers in the development process to create a more robust database. Another important lesson learned is the necessity of cultural sensitivity and the adaptability of technology to different linguistic contexts. For example, developers found that direct translations of technological terms from European languages often failed to resonate with local users. This led to innovations in language usage, with new, culturally resonant terms being coined in collaboration with local community. Furthermore, it became evident that technological solutions need to be scalable and flexible to adapt to the multiple dialects and scripts used across the continent. The inclusion of user feedback mechanisms has been crucial in refining spell correctors to better meet the linguistic and practical needs of native speakers.

4.1 Future Trends in Spell Correctors for African Languages

4.1.1 Artificial Intelligence, Machine Learning and Deep learning

Looking ahead, artificial intelligence (AI), machine learning (ML) and deep learning are set to play pivotal roles in the development of spell correctors for African languages. These technologies allow spell correctors to learn from ongoing user input (Maryamawit, 2022), continuously improving their accuracy and effectiveness. ML algorithms can analyze vast amounts of text data, identifying common errors and learning contextual nuances of various languages. This capability could lead to more personalized and context-aware spell checking, which would be particularly beneficial for languages with rich idiomatic expressions and extensive dialectal diversity. The application of AI can also extend to predictive typing and auto-correction features, which can significantly enhance the writing experience for users (Kuznetsov & Urdiales, 2021). By integrating AI-driven

tools, spell correctors can better understand and predict user intentions, thereby offering corrections and suggestions that are contextually appropriate and useful.

4.1.2 Collaboration with Linguists and Language Experts

As technology continues to evolve, the collaboration between tech developers and linguistic experts is increasingly important. Linguists and language experts bring an essential understanding of grammatical rules, syntax, and cultural nuances, which are crucial for developing effective spell correctors. Their expertise ensures that technological solutions are linguistically sound and culturally appropriate, enhancing user acceptance and effectiveness. Moreover, such collaborations can help tackle the challenge of under-resourced languages by creating high-quality linguistic databases that can be used not only for spell checking but also for other linguistic applications. These partnerships can lead to the development of open-source platforms where resources can be shared and accessed globally, accelerating the development process and reducing costs.

4.1.3 Potential Applications beyond Spell Checking

The technology behind spell correctors has potential applications that extend far beyond simple spell checking. For instance, it can be used in voice recognition systems, aiding in the development of speech-to-text applications that recognize and accurately transcribe African languages. This would be particularly transformative in regions with high illiteracy rates, where speech-based technologies could facilitate better access to information. Furthermore, enhanced spell checking technology can be integrated into educational software, providing tools that support language learning and literacy. It can also play a crucial role in content creation, where accurate and accessible language tools can encourage more individuals to create content in their native languages, thus enriching the digital ecosystem with a diverse range of voices and perspectives.

Furthermore, the evolution of spell correctors for African languages is a testament to the transformative power of technology when coupled with cultural understanding and linguistic expertise. As these tools continue to evolve through AI and collaborative efforts, they promise not only to enhance communication

and education but also to empower linguistic diversity across Africa.

5. CONCLUSION

In sum, the development and refinement of spell correctors for African languages are critical for promoting linguistic diversity and enabling more accurate and accessible communication in these languages. The systematic review highlights the challenges of linguistic complexity and limited technological integration but also underscores the progressive solutions being spearheaded by both local and international technologists and linguists. As African language digital content expands, the importance of robust, linguistically sensitive spell correctors cannot be overstated. It is crucial that stakeholders continue to invest in and prioritize these tools, ensuring that the richness of African languages is preserved and celebrated in the digital age. Thus, advancing spell corrector technology not only enriches local communication but also brings global recognition to these diverse languages

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