Practical Approach on Implementation of WordNets for South African Languages

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Abstract

This paper proposes the implementation of WordNets for five South African languages, namely, Sepedi, Setswana, Tshivenda, isiZulu and isiXhosa to be added to open multilingual WordNets (OMW) on natural language toolkit (NLTK). The African WordNets are converted from Princeton WordNet (PWN) 2.0 to 3.0 to match the synsets in PWN 3.0. After conversion, there were 7157, 11972, 1288, 6380, and 9460 lemmas for Sepedi, Setswana, Tshivenda, isiZulu and isiXhosa respectively. Setswana, isiXhosa, Sepedi contains more lemmas compared to 8 languages in OMW and isiZulu contains more lemmas compared to 7 languages in OMW. A library has been published for continuous development of African WordNets in OMW using NLTK.

1 Introduction

WordNet consists of information about adverbs, adjectives, verbs and nouns in English and it organizes the words according to the notion of a synset. A synset can be defined as a set of words that are interchangeable in certain context. For example, the set {house, home, building} form a synset since the words can be used interchangeably referring to the same concept. Synsets can be linked to each other by means of semantic relations such as meronymy (leaf-tree), hyponymy versus hyponymy relation (flower-rose). The interlinked synsets create a strong semantic network that allows researchers (a) to automatically expand their search queries in information retrieval tasks (Azad and Deepak, 2019; Abbache et al., 2016), (b) to artificially expand their dataset by making use of data augmentation in natural language processing (NLP) tasks (Marivate and Sefara, 2020), (c) to improve cybercrime investigation in social network mining tasks (Iqbal et al., 2019).

WordNets have been applied in many domains such as machine learning classification to improve the performance of classification algorithms. An example is the role of WordNets is to increase the amount of NLP task data via data augmentation (Marivate and Sefara, 2020). This has been done for many well-resourced (European) languages. For low-resource languages such as South African languages, few studies have been done to build WordNets under low resources. African WordNets (Bosch and Griesel, 2017; Griesel et al., 2019) is a project that develop aligned WordNets for African languages spoken in South Africa. Initially, the project included five languages Sepedi, Setswana, Tshivenda, isiXhosa and isiZulu. During the development, DEBVisDic (WordNet editor) was used to build semantic networks. Due to limited resources, the expand model was followed during the development of the African WordNets. The expand model in WordNets creation is when the structure of Princeton WordNet is used to create other WordNets in other languages.

The goal of this paper is to build a multilingual lexical database with WordNets for South African languages based on the Princeton WordNet 3 to be utilized using the Python NLTK\(^1\) library via open multilingual WordNets (OMW)\(^2\). We utilize the WordNets previously built by Bosch and Griesel (2017) for Sepedi, Setswana, Tshivenda, isiXhosa and isiZulu, to be compatible with OMW standard. The main contributions of this paper are as fol-

\(^1\)http://www.nltk.org/
\(^2\)http://compling.hss.ntu.edu.sg/omw/
A Python library has been released to allow inspection and improvement of the resource. The library can be found on Github\(^3\) and Python repository\(^4\).

- We released and published the data set (Sefara et al., 2020).

The outline of this paper is as follows: In Section 2 we discuss literature review of WordNets and their applications. Section 3 describes the methodology taken to create the resource. Section 4 concludes the paper with future work.

## 2 Literature Review

This section discusses the current WordNets and their applications in various domains.

### 2.1 WordNets

Bond and Foster (2013) created OMW that support more than 150 languages. OMW is made by combining WordNets published with open source licenses, Wiktionary data, and Unicode Common Locale Data Repository. The aim of OMW is to provide access to WordNets in multiple languages. All the WordNets in OMW are linked to PWN (Miller, 1995). The OMW and PWN can be accessed through NLTK.

EuroWordNet is a project created by Vossen (1998) to build multilingual WordNets for European languages based on PWN. The goal of EuroWordNet is to create multilingual database, build WordNets independently, obtain compatibility across languages, and to maintain language-specific relations.

Postma et al. (2016) created an open WordNet for Dutch that contains a total of 117,914 synsets using data from Cornetto database, open source resources, and the PWN. Authors also created a Python module\(^5\) that can be applied to NLP applications.

ElKateb et al. (2006) proposed the development of WordNet for Arabic language using PWN for English as basis. Authors constructed the Arabic WordNet by using methods used to develop the EuroWordNet (Vossen, 1998). Regragui et al. (2016) added new content to Arabic WordNet that improved the performance of NLP applications such as question answering.

Bosch and Griesel (2017) discussed methods to build WordNets for low-resourced languages when the development of WordNets for South African languages was initiated using expand model based on PWN version 2. Authors created a total of 53982 synsets, 9279 definitions and 28853 usage examples. Due to low-resource environment, identification and translation of appropriate synsets was done by a human expert. One of the method is that authors used bilingual dictionaries to transfer information from dictionary to WordNet then a linguists make final approval for inclusion in the WordNets.

The Finnish WordNet is a lexical database for Finnish based on PWN structure (Lindén and Carlson, 2010). All word senses in PWN were translated into Finnish to make FinnWordNet. The PWN word senses were translated by a human translator to validate the quality of the content. The translation process is explained by (Lindén and Carlson, 2010). FinnWordNet has 117659 synsets and freely available under Creative Commons 3.0 license.

### 2.2 Applications of WordNets

Baccianella et al. (2010) annotated all the synsets of WordNet (Miller, 1995) with respect to the notions of positivity, negativity, and neutrality to create new dataset called SentiWordNet, an improved lexical resource that is designed to support opinion mining applications and sentiment classification. Authors published the dataset on Github\(^6\).

Siddharthan et al. (2018) uses WordNet to create WordNet-feelings which is a new dataset that categorises word senses as feelings. Authors created ten categories and manually annotated the dataset by adding new categories and definitions.

WordNets are used as data sources in search and information retrieval tasks when building a query (Azad and Deepak, 2019). Abbache et al. (2016) improved the performance of information retrieval system for Arabic language by using WordNet and association rules to expand the search query. In their methodology, authors removed stop words (functional words) from the query before extracting and selecting synonyms using Arabic WordNet as the main source for word selection.

Marivate and Sefara (2020) used WordNet to

\(^3\)https://github.com/JosephSefara/AfricanWordNet

\(^4\)https://pypi.org/project/africanwordnet

\(^5\)https://github.com/cltl/OpenDutchWordnet

\(^6\)https://github.com/aesuli/SentiWordNet
create data augmentation technique for NLP classification applications. Authors compared the technique with semantic similarity augmentation and round-trip augmentation. The WordNet-based augmentation improved the performance of the classification models when using Wikipedia dataset. The same WordNet-based augmentation was used by Zhang et al. (2015) to train a temporal convolutional network that learns text understanding from character level input up to an abstract text concepts. Hasan et al. (2020) applied semantic similarity of WordNet to manage the ambiguity in social media text by selecting informative features to enhance semantic representation.

3 Methodology

This section discusses the design and implementation of the WordNets for South African languages. It first discusses sense map preparation, then WordNets conversion, and finally implementation.

3.1 Sense map preparation

In this section, we explain the sense map preparation process.

We used the sensemap(5WN) published on PWN website for versions 2.0, 2.1, and 3.0. Sense map simply list each 2.0 noun sense (encoded as a sense key) paired with its mapping to one or more 2.1 noun senses. We converted all the polysemous (nouns and verbs) and monosemous (nouns and verbs) to 2.1. Then lastly, we converted 2.1 synsets to 3.0. We used the 3.0 sense maps to convert all the synsets from 2.1 to 3.0. The synsets that are not in all the sense maps are used as is.

Algorithm 1 illustrates the steps taken during conversion of the sense maps. The algorithm was run twice, for first time to convert 2.0→2.1 then duplicate offset targets in 2.1 were removed. The second time to convert 2.1→3.0 then duplicate offset target in 3.0 were also removed. Table 1 shows a sample of the converted offsets that will later be used to match every synset in African WordNets from 2.0 to 3.0.

Table 1 shows a sample format of sense mapping that are later used to convert the WordNets from 2.0 to 3.0.

| 2.0     | 2.1     | 3.0     |
|---------|---------|---------|
| 12976279-n | 13571065-n | 13752172-n |
| 12976532-n | 13571318-n | 13752443-n |

3.2 WordNets conversion

This section discusses conversion of African WordNets to PWN 3.0 and explain OMW format.

We collected the WordNets created by Bosch and Griesel (2017) from South African Centre for Digital Language Resources (SADiLaR). SADiLaR is a national center supported and funded by the South African Department of Science and Innovation. The WordNets are in the form of XML format based on PWN version 2.

We used a library called BeautifulSoup to extract all the synset offset ID, part-of-speech tag, lemma, and word form since the WordNets are in XML format. Table 2 shows the number of synsets before and after conversion to 3.0 excluding the synsets that do not exists in PWN. There is an increase in number of synsets, isiZulu increased by 90, isiXhosa by 150, Sepedi by 101, Setswana by 240, and Tshivenda by 16. The increase is caused by synsets that have multiple mappings in PWN 3.0. We saved the new synsets in a format that is supported by OMW. The OMW format is as follows:

offset-pos langcode:lemma wordform

Algorithm 1: Sense map conversion

| Input: s: sense map file |
| Output: ˆs list containing pair of source and target offset ID |

```python
1 def mono(s):
2     Let F ← Open(s) be a to file reader;
3     for line in F :
4         SourceOffset ← use regular expression to match source offset ID from line;
5         TargetOffset ← use regular expression to match target offset ID from line;
6         ˆs ← [Sourceoffset, Targetoffset];
7     return(ˆs);
```

Table 1: Sample of the sense mapping

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offset-pos langcode:lemma wordform
where offset is the unique ID (linking to the PWN), langcode is the universal language code\(^\text{10}\), word-form is the written word, and pos is the part-of-speech.

| Table 2: Conversion of synsets |
|------------------------------|
| Language | Original Synsets | New Synsets |
|-----|----------------|-------------|
| isiZulu | 9026 | 9116 |
| isiXhosa | 13731 | 13881 |
| Sepedi | 10647 | 10748 |
| Setswana | 22234 | 22474 |
| Tshivenda | 1581 | 1597 |

An example of the formatted synsets is depicted in Figure 1 that is compatible with OMW in NLTK. OMW consists of 29 languages in NLTK as shown in Table 3. There are 8 languages in OMW that contains lemmas less than that of Setswana, isiXhosa, and Sepedi. isiZulu contains more lemmas than 7 languages in OMW while Tshivenda contains the smallest lemmas than all other languages.

| Table 3: OMW in NLTK |
|----------------------|
| Language | Lemma | Language | Lemma |
|-----|-------|----------|-------|
| eng | 147306 | glg | 23124 |
| fin | 129839 | ell | 18225 |
| jpn | 89637 | arb | 17785 |
| tha | 80508 | fus | 17560 |
| cmn | 61532 | tsn | 11972 |
| fra | 55350 | xho | 9460 |
| por | 54069 | nso | 7157 |
| cat | 46531 | bul | 6720 |
| pol | 45387 | zul | 6380 |
| nld | 43077 | als | 5988 |
| ita | 41855 | swe | 5824 |
| slv | 41032 | heb | 5325 |
| ind | 36954 | dan | 4468 |
| spa | 36681 | nbo | 4186 |
| zsm | 33932 | nno | 3387 |
| hrv | 29010 | qcn | 3206 |
| eus | 26240 | ven | 1288 |

3.3 Implementation

This section discuss implementation of African WordNets in NLTK.

Total of 5 files (sample shown in Figure 1) have been created that consists of the 5 languages to be added to NLTK. The files have been named according to the following format:

- Sepedi: wn-data-nso.tab
- Setswana: wn-data-tns.tab
- isiXhosa: wn-data-xho.tab
- isiZulu: wn-data-zul.tab
- Tshivenda: wn-data-ven.tab

where each file resides in a directory inside OMW corpus in NLTK and the directory name is named according to the ISO language code. The ISO language code for Sepedi is nso, Setswana is tsn, isiXhosa is xho, isiZulu is zul, and Tshivenda is ven.

A Python helper library\(^\text{11}\) has been created to install these African WordNets to OMW in NLTK. The African WordNets can be used like other WordNets on OMW. For example, the library has to be imported to the environment then the following statements shows the lemma names of the word ‘entity’ in Setswana:

```python
>>> from nltk.corpus import wordnet
>>> import africanwordnet
>>> wordnet.synset(‘entity.n.01’).lemmas(‘tsn’)
[Lemma(‘entity.n.01.selo’),
 Lemma(‘entity.n.01.sengwe’)]
```

Listing 1: Lemma example

The following statement is used to view the synsets of the isiZulu word ‘iqoqo’ (means collection):

```python
>>> from nltk.corpus import wordnet
>>> import africanwordnet
>>> wordnet.synsets(‘iqoqo’, lang=’zul’)
[Synset(‘whole.n.02’),
 Synset(‘conspectus.n.01’)]
```

\(^\text{10}\)https://www.loc.gov/standards/iso639-2/php/code_list.php

\(^\text{11}\)https://pypi.org/project/africanwordnet
The following statement is used to view the hypernyms of the isiXhosa word 'omisa' (means dry).

```python
>>> from nltk.corpus import wordnet
>>> import africanwordnet
>>> synsets = wn.synsets('omisa', lang=('xho'))
>>> for synset in synsets:
...    for hypo in synset.hyponyms():
...        for lemma in hypo.lemmas('xho'):
...            print(lemma)

Lemma('hebhest.n.01.tthalofo')
Lemma('commandment.n.01.molao')
Lemma('commandment.n.01.taelo')
Lemma('commission.n.06.taelo')
Lemma('injunction.n.01.taelo')
Lemma('order.n.01.taelo')
Lemma('summons.n.02.tagafalo')
```

Listing 3: Hyponym example

The following statement is used to view the hypernyms of the isixhosa word 'omisa' (means dry).

```python
>>> from nltk.corpus import wordnet
>>> import africanwordnet
>>> synsets = wn.synsets('omisa', lang=('xho'))
>>> for synset in synsets:
...    for hypo in synset.hyponyms():
...        for lemma in hypo.lemmas('xho'):
...            print(lemma)

Lemma('dry.v.01.omisa')
Lemma('change.v.01.guqula')
Lemma('change.v.01.tshintsha')
Lemma('change_integrity.v.01.guqula_ifezeko')
```

Listing 4: Hypernyms example

4 Conclusion and Future Work

This paper presented the implementation of African WordNets to be used in NLTK via OMW. We discussed the conversion of PWN sense maps from 2.0 to 2.1 to 3.0. There was an increase of synsets during conversion. We proposed an algorithm that helps to convert synsets from PWN 2.0 to 3.0. A Python library has been made available\(^\text{(12)}\) to utilize the WordNets.

The future work will focus on

- improving conversion of PWN sense maps from 2.0 to 3.0 so that all synsets are available in 3.0. Kim et al. (2018) proposed automatic mapping of synsets using bilingual dictionaries. Due to limited bilingual dictionaries this method could not be utilized.

- evaluation of the African WordNets using various evaluation methods. Ramanand and Bhattacharyya (2007) proposed a method to evaluate synsets using dictionary definitions since currently there are no enough dictionaries for these languages this method could not be utilized.

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