1. Introduction

Word Sense Disambiguation (WSD) is the ability to identify the meaning of words in context in a computational manner (Navigli, 2009). It is one of the toughest areas in natural language processing (NLP). Recently, a lot of research has been done for making powerful WSD systems with supervised, semi-supervised and unsupervised techniques. In WSD, the heuristics of choosing the most frequent sense is often found to be very hard for any WSD system. The WordNet First Sense (WFS) baseline is the most powerful baseline in WSD, even though it does not consider the context while assigning the senses. This baseline can be created by considering the sense-annotated statistics. For English, WFS baseline is created by using the frequencies of word senses from the sense-annotated SemCor corpus. Senses that have not occurred in SemCor are ordered arbitrarily. This WFS baseline is a very strong baseline in English WSD. Considering both precision and recall, only 5 of 26 systems in the Senseval-3 English all-words task were able to beat this baseline. Our goal is to create a WFS baseline for Indian language WordNets. We focus on Hindi language as the actual usage. This is because Hindi WordNet was built using a dictionary where words were picked up according to the alphabetical order.

The rest of the paper is organized as follows. Section 2 gives a detailed description of Hindi WordNet. Hindi WordNet synset ranking methodology is explained in section 3. Section 4 gives the statistics of the ranked synsets. Section 5 highlights the performance of WFS baseline on various domains. Discussion is given in section 6, followed by the conclusion.
3. Synset Ranking Methodology

For HWN synset ranking, we split the word-senses into three groups. Three human experts, who are native speakers of the language, were asked to rank the word-senses with the help of a synset ranking tool. This tool is developed for ranking the synsets of words of all POS categories. The screenshot of the tool is shown in figure 1. The tool provides the following functionalities to human experts.

- **Insert Ranking**: An input box is provided for the word and its POS. For a given input word and its POS, the tool displays all the synsets of that word extracted from Hindi WordNet with its default ranking. The tool also provides the frequencies of word-senses extracted from the sense-annotated corpus of various in-house datasets. Experts have been asked to rank the senses of a word based on this information and also his/her intuition. If the experts get confused or are unable to rank the synsets of a word, then he/she can skip the word from its ranking for the moment and move on to the next word.

- **Display Ranking**: An expert can see the already ranked synsets by providing a word and its POS.

- **Reset Ranking**: The experts have been given the facility of resetting the previous synset ranking of a word.

- **View Skipped Words**: All words which have been skipped by the experts are displayed for further discussion with other experts, leading to their ranking.

- **View Ranked Words**: The tool displays the words which are already ranked by the experts.

- **View Statistics**: The tool also provides statistics of the ranked synsets of words by all the experts who participated in the ranking process.

For some Hindi words, we can find different spelling variations. For example, the word ठंडा (ThaMDaa, cool) can be written as ठण्डा (ThaNDaa) or ठन्डा (ThanDaa). In such cases, the experts have been asked to rank the synsets of only one variation of such words. The same ranking will be given to the other variants of the word automatically.

4. Statistics of Synset Ranking

The statistics of synset ranking is shown in Table 2. As we can see in Table 2, we have ranked the synsets of 16516 nouns, 3575 adjectives, 208 adverbs and 1449 verbs till date. We are still in the process of ranking the newly-made synsets. These rankings have been made available on the website of CFILT.

| POS  | Synsets | Total Words | Polysemous Words |
|------|---------|-------------|------------------|
| Noun | 29104   | 78837       | 16516            |
| Adjective | 6178    | 18792       | 3575             |
| Adverb | 482     | 1936        | 218              |
| Verb  | 6354    | 4816        | 1538             |
| Total | 39069   | 104381      | 21847            |

Table 1: Statistics of Hindi WordNet

Table 2: Statistics of ranked synsets

```java
| POS    | Words whose synsets are ranked |
|--------|-------------------------------|
| Noun   | 16516                         |
| Adjective | 3575                      |
| Adverb  | 208                           |
| Verb    | 1449                          |
```

3 http://www.cfilt.iitb.ac.in/Downloads.html
### Table 3: Performance of WFS baseline on WSD datasets

| Dataset | Precision | Recall | F-score |
|---------|-----------|--------|--------|
| Health  | 62.29     | 58.10  | 60.12  |
| Tourism | 67.81     | 64.07  | 65.88  |
| News    | 58.32     | 52.53  | 55.28  |

### Table 4: Performance of WSD algorithms on Health dataset

| Algorithm | NOUN | ADV | ADJ | VERB | Overall |
|-----------|------|-----|-----|------|---------|
| WFS (our) | 58.69| 76.64| 58.73| 64.31| 60.12   |
| EM-Context| 59.82| 67.80| 56.66| 60.38| 59.63   |
| EM        | 60.68| 67.48| 55.54| 25.29| 58.16   |
| RB        | 35.52| 45.08| 35.42| 17.93| 33.13   |

5. **Performance on WSD task**

In order to see how well the synsets are ranked, we check the performance of the WSD task. In this the first listed sense, i.e. WordNet First Sense (WFS) is given to all words irrespective of the context in which they appear in the corpus. We considered standard datasets available freely for Hindi-Health, Hindi-Tourism, Hindi-News domains. The results are obtained in terms of precision, recall and f-score and are given in Table 3. F-score of WFS baseline on Health, Tourism and News domains was found to be 60%, 65% and 55% respectively.

We also compared this WFS baseline against some WSD algorithms as listed below:

- **EM-Context**: It is context-aware unsupervised WSD algorithm by Bhingardive et al., (2013) which uses Expectation Maximization (EM) algorithm for finding the sense distribution.

- **EM**: It is a basic EM based algorithm by Khapra et al., (2011) which does not consider context while finding the sense distribution.

- **RB**: It is the Random Baseline where senses are randomly assigned to words.

The results of these WSD algorithms are shown in Table 4 and Table 5. As we can see in the tables, WFS baseline beats all WSD algorithms even though it assigns senses irrespective of context. Hence, it is clear that HWN synset rankings given by human experts are of good quality and thus can be used in other NLP applications too.

6. **Discussion**

While ranking the HWN synsets, human experts faced some difficulties which are mentioned below. The solutions which were applied to such cases are also given.

- **Synset ranking of highly polysemous words**: For example, निकलना (nikalanaa) (31 senses), निकालना (nikaalanana) (31 senses), लगना (laganaa) (25 senses), बखार्स्त करना (barkhaasta karanaa) (21 senses), etc was found to be too tedious. For such words, the human experts were allowed to rank the top 10 most frequent senses of the words while rest of the senses were ranked according to the order given in the dictionary.

- **Insertion of synset members**: While ranking the synsets of words such as अकड़ना (akadana) the figurative sense comes above the literal/physical sense of the word.

Hindi vocabulary has a number of foreign language words, mostly taken from English and these find a place in Hindi WordNet as well. The ranking of such words has been done based on the usage and it is observed that many times this may not necessarily match those found in English WordNet. An example of such a case is the word अकड़ना (academy), a word borrowed from English. The first sense assigned to this word in HWN (ID:10350) does not correspond to the first sense in EWN (ID:08296219). This is because the first sense found in English WordNet has negligible usage in India. The reason for this phenomenon may have historical roots.

During the synset ranking process, various HWN synsets have been validated. Some of the examples are listed below.

- **Insertion of synset members**: While ranking the synsets of words such as निकलना (nikaalanana), the experts added बखार्स्त करना (barkhaasta karanaa) as a new synset member in the same synset (ID:11385).

- **Reordering of synset members**: In this, for example, the position of the word तनना could be changed.
We presented our work on manually ranking the synsets of Hindi WordNet. Human experts ranked the synsets of a given word by using the synset ranking tool which is developed for the ranking process. The tool provides the information about words and their senses and also the frequencies of word-senses extracted from the sense-annotated corpus. The created rankings are evaluated on WSD task and it is observed that WSD, when assigning the first ranked sense i.e. WFS, can outperform the other WSD algorithms which have been proposed earlier. This process of ranking has led to the validation of HWN. The created rankings can also be used in other NLP applications viz., Machine Translation, Information Retrieval, Sentiment Analysis, etc. The ranking tool created by us can be easily extended for ranking synsets of other Indian language wordnets.

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| Algorithm    | NOUN | ADV | ADJ | VERB | Overall |
|--------------|------|-----|-----|------|---------|
| WFS (our)    | 69.22| 78.69| 53.85| 58.04| 65.88   |
| EM-Context   | 62.90| 62.54| 53.63| 52.49| 59.77   |
| EM           | 63.88| 58.88| 55.71| 35.60| 58.03   |
| RB           | 33.83| 38.76| 37.68| 18.49| 32.45   |

Table 5: Performance of WSD algorithms on Tourism dataset
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