Mapping it differently: A solution to the linking challenges

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Abstract

This paper reports the work of creating bilingual mappings in English for certain synsets of Hindi wordnet, the need for doing this, the methods adopted and the tools created for the task. Hindi wordnet, which forms the foundation for other Indian language wordnets, has been linked to the English WordNet. To maximize linkages, an important strategy of using direct and hypernymy linkages has been followed. However, the hypernymy linkages were found to be inadequate in certain cases and posed a challenge due to sense granularity of language. Thus, the idea of creating bilingual mappings was adopted as a solution. A bilingual mapping means a linkage between a concept in two different languages, with the help of translation and/or transliteration. Such mappings retain meaningful representations, while capturing semantic similarity at the same time. This has also proven to be a great enhancement of Hindi wordnet and can be a crucial resource for multilingual applications in natural language processing, including machine translation and cross language information retrieval.

1 Introduction

Wordnets are online lexical resources which are easily accessible, free to use, and fairly accurate. They play a dominant role in the field of text processing applications, such as machine translation, information extraction, information retrieval and natural language understanding systems. Among the Indian language wordnets, Hindi wordnet[1] was the first one to come into existence from the year 2000 onwards. It was inspired by the English WordNet[2] which contains nouns, verbs, adjectives and adverbs organized into synonym sets called synsets, each representing one underlying lexical concept (Fellbaum, 1998). Different relations like hypernymy, hyponymy, etc. link the synonym sets to each other. Soon, other Indian language wordnets started getting created, with Hindi wordnet as the pivot, inheriting all the relations. Hindi wordnet is linked to the English WordNet and the other Indian language wordnets are linked to Hindi wordnet, in turn. This has led to the creation of a wide grid of shared concepts, thus creating an important knowledge base for the NLP community. To achieve maximum linkage between the English and Hindi wordnets, the policy of having direct and hypernymy linkage (Saraswati et al, 2010) has been adopted. However, it was observed that the hypernymy linkage does not lead to an accurate word and concept in all cases. Thus, to overcome this challenge the idea of creating complimentary bilingual mappings in English came up.

The roadmap of the paper is as follows: Section 2 presents a comprehensive view of related work done earlier, while in Section 3 the need for this approach is discussed. Section 4 deals with the methodology. Section 5 presents the qualitative analysis of the challenges encountered and the solutions put forth. In Section 6 the interface used for this task is discussed. The overall statistics is given in Section 7 and Section 8 mentions some of the words sent to the English WordNet. Section 9 winds up the paper with the conclusion and future work.

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[1] http://www.cfilt.iitb.ac.in/wordnet/webhwn/
[2] http://wordnet.princeton.edu/

2 Related Work

Wordnets have been built for around 100 different languages. Efforts towards mapping synsets across wordnets have been going on for a while in various parts of the world. Many languages have been trying to link their wordnets to the English WordNet for a universal set of linked concepts, enabling translation on the lexical level as well as cross-lingual WSD and other applications. Usually, a concept in one wordnet is directly linked to a similar one in the English WordNet, but in many cases, some kind of mapping is required. CoreNet (Kang et al, 2010) has made one such effort. It is a multilingual lexico-semantic network constructed in KAIST for the Korean, Chinese, and Japanese languages and many of its words/concepts have been linked to the English WordNet. To ameliorate translation problems between CoreNet (mostly written in Korean) and the English WordNet and to enhance recall of WordNet equivalents, the two are partially indirectly linked via KorLex (Yoon et al., 2009) to the English WordNet. When this kind of indirect mapping is also not available, the concepts in CoreNet are manually mapped to the concepts in the English WordNet. In EuroWord-Net (Vossen et. al., 1999)[3], multilinguality is achieved by storing the language-specific wordnets in a central lexical database in which equivalent word meanings across the languages are linked to a so-called Inter-Lingual-Index (ILI) to get a comprehensive conceptual match of concepts across languages. Another effort towards wordnet linking can be found in the MultiWordNet (Pianta et. al., 2002)[4] which aligns the Italian and the English language wordnets.

Another such effort to create a multilingual wordnet is WWDS (Redkar et. al., 2015). A similar task was performed for Basque Wordnet (Pociello et. al., 2010). Bilingual mappings are a special case of wordnet linkage by which Hindi wordnet deals with this problem. Here, the concepts are translated, and, at times, the synset members are translated / transliterated, in English and this task is carried out manually. To the best of our knowledge this is a novel method and has not been implemented elsewhere.

3 Motivation - Need for Bilingual Mapping

The task of linking synsets of Hindi wordnet to those of the English WordNet has been undertaken to create valuable parallel data for various NLP applications. However, languages are mirrors of the society in which they develop and are used. They are, therefore, unique and specific to particular geographical regions and cultural milieus. When two languages, which are as far set apart as Hindi and English, have to be linked at the conceptual level, along with word transfers, it is bound to throw up the challenge of lexical and conceptual gaps. To overcome these challenges, the idea of having two types of linkages – direct and hypernymy – has been followed. Direct linkage provides exact matching concept and lexical item/items in English. For example, for the Hindi word *गंधयुक्त* (*gandhayukta*), which means

- जो गंध से युक्त हो
- which fragrance with is
- *jo gandha se yukta ho*
- which has fragrance,

there is a direct linkage to the English synset of *odorous* which means *having a natural fragrance*. Those concepts in Hindi for which there are no direct linkages in the English WordNet, we adopted the EuroWordnet methodology to link them to a hypernymy synset in English. The idea was that instead of having no linkage at all there would be at least a super-ordinate concept and lexical item/items with which the Hindi concept could be linked. This would provide translation candidates which could be exploited for various NLP tasks. An example of this is the concept of *सदावर्त* (*sadaavarta*), which means

- लिए गए व्रत के अनुसार गरीबों में एक निश्चित समय सीमा तक प्रतिदिन भोजन और अन्य जरूरी वस्तुएँ बाँटने का कार्य
- taken vow according to poor people a definite time period till daily food and other essential items distribution work
- *liye gaye vrat ke anusaar gareeboM meM ek nishchit samaya siimaa tak pratidin bhojan aur anya zaroorii vastueM baaMtane kaa kaarya*
- the act of distributing food and other essential items to poor people for a specific time period according to a vow undertaken.

Although the Hindi concept is very specific, yet it has been linked to the synset of *charity* which means *'an activity or gift that benefits the public at large'* and is marked as a hypernymy linkage.

However, consider the example of the synset *छेदन* (*chhedan*), which means

- छेद करने की क्रिया
- make hole act
- *chhed karane kii kriyaa*
- act of piercing.

In the absence of a matching synset in the same POS category in the English WordNet, it had been given a hypernymy linkage to the English synset of *deed*, which means *something that people do or cause to happen*. What this would have implied was that each time the Hindi word *छेदन* would occur in the corpus, the parallel English word *deed* would be its lexical counterpart in English. This is not only too far-fetched but may prove to be insufficient in the translation process. It is in such cases that the hypernymy linkage was substituted for a bilingual mapping. Thus, for *छेदन* the lexical item was kept as *piercing* and the gloss as *the act of piercing*. Moreover, the proper nouns in Hindi wordnet, also pose a problem with hypernymy linkage. It is because of these issues that the idea of creating bilingual mappings of the Hindi synset into English was adopted. Here, mapping indicates the linking of two data-sets, in this case, between Hindi Wordnet and the data set containing English translations of glosses and words.

4 Method

The method adopted for creating bilingual mappings is translation / transliteration of the synset member and the translation of the gloss in English. For this we search various lexical resources
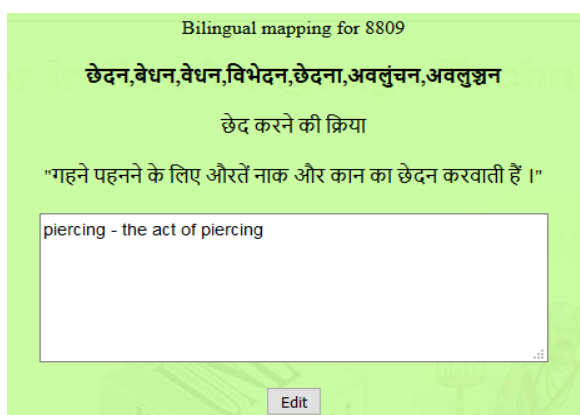
Screenshot 1: Bilingual mapping creation interface for lexicographers

and look for valid usages on the internet. After verifying, we create the bilingual mapping. As far as possible, we do not coin words for this purpose, but there are some exceptions. The mapping is created in a dialogue box where the lexicographer manually types the required text, which is then stored in the database of Hindi wordnet.

Users can see the mappings on the online Hindi wordnet interface by querying for the English linkage. In cases where the hypernymy linkage is too distant then it is removed but where the hypernymy is close-enough, it is retained along with the mapping (see Screenshot 2). The retention of hypernymy linkage is also motivated by the fact that it may prove useful for the general users, who may not be familiar with the language and the culture it represents.

5 Challenges and Solutions

For the creation of mappings we have divided words into four major categories based upon the problems faced. These categories and their treatment are as follows:

5.1 Words / Concept not available in English WordNet

There are two types of methods used to deal with such cases. These are the following:

a. Transliteration - When no suitable word in the English WordNet is found to represent the Hindi concept, we transliterate the word and translate the gloss accordingly. For example, *पदयात्रा* (*padayatra*), which means

- किसी विशेष उद्देश्य (विशेषकर राजनैतिक या धार्मिक) से पैदल की जानेवाली यात्रा
- Some special purpose (especially political or religious) for being done foot journey
- *Kisii vishesh uddeshya (visheshkar raajnaitik yaa dhaarmik) se paidal kii jaane walii yaatraa*
- a foot journey undertaken for some special purpose (especially political or religious).

This word had initially been given a hypernymy linkage to *hike* which had the gloss as

a long walk usually for exercise or pleasure. This was found to be inadequate to convey the sense of the Hindi synset. Thus, the hypernymy linkage was removed and a bilingual mapping was created. The synset member was transliterated as *padayatra*, as found in Wikipedia[5], and the gloss was translated as *a journey undertaken for some special purpose (especially political, religious).*

b. Translation - the synset members are translated along with the gloss in English. An example is *अप्सरा* (apsaraa), which means

- स्वर्ग में इंद्र की सभा में नाचने-गाने वाली सुंदरियाँ
- heaven in Indra's court dancing singing beautiful ladies
- *Swarga meM Indra kii sabhaa meM naachane-gaane walii sundariyaan*
- beautiful ladies who dance and sing in Indra's court in the heaven.

Initially, it had been given the hypernymy linkage to the synset of *nymph* which means *a minor nature goddess usually depicted as a beautiful maiden.* This has now been given a bilingual mapping, where the word has been translated as *celestial dancer* and the gloss has been translated as *beautiful ladies who dance and sing in heaven in the court of Indra,* which is much more precise.

5.2 Required sense missing in the English WordNet

Here, the synset is present in the English WordNet, but the given sense/s does not match the one required for the Hindi synset. For example, *फूँकना* (phuunkana), which means

- फूँक मार कर दहकाना या प्रज्ज्वलित करना
- by blowing to ignite or to aflame
- *phuunk maar kar dahakaanaa yaa prajjawalit karanaa*
- to light or inflame by blowing.

Although, the English WordNet has four senses of the word *ignite* but this particular sense is not there. So we assigned the word *ignite* as the bi-

lingual mapping and translated the gloss as *cause to start burning by exhaling hard through mouth.* Thus, an accurate meaning transfer is obtained.

5.3 Culture Specific Words

These are the words specific to Indian culture and hence not found in the English WordNet. For example, *बिछिया* (bichhiyaa), which means

- पैर की उँगलियों में पहनने का छल्ला
- toes in wearing ring
- *pair kii ungaliyoM meM pahanane kaa chhallaa*
- ring worn on toes.

This has a hypernymy linkage to *jewelry*, which means *an adornment (as a bracelet or ring or necklace) made of precious metals and set with gems (or imitation gems).* This gloss does not convey the meaning accurately. Since the word *toe ring* is commonly used for this object and its sense is found in other lexical resources[6], we assigned it as the bilingual mapping with the gloss translated as *a ring worn on any of the toes.*

5.4 Language Specific Words

There are many words in Hindi wordnet which capture the peculiar grammar of the language. It is but natural that their counterparts will not be available in English. Hence, these words require bilingual mappings. There are three categories of such words. These are as follows:

5.4.1 Causative Verbs

As the name implies, causative verbs indicate an action that the subject does not directly perform, but rather causes to happen, perhaps by causing some other agent to perform the action. Such verbs are a well-known feature of Hindi and are represented in English as a phrase. For example, *बरसाना* (barsaanaa), which means

- बादल से जल नीचे गिराना
- cloud from water below make fall
- *baadal se jal neeche giraanaa*
- to cause to rain.

For such a sense, finding even a hypernymy linkage was difficult. So we assigned it a bilingual mapping as *to make it rain* with the gloss translated as *to make water fall from clouds.*

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[5] https://en.wikipedia.org

[6] http://www.thefreedictionary.com/

5.4.2 'Be' Form of Conjunct Verbs

A large number of Hindi verbs are formed by conjoining a noun or an adjective with a verb. Such verbs are called conjunct verbs. The most common verb used to form conjunct verbs is *करना* (to do/to make). Many conjunct verbs have corresponding intransitive forms which employ *होना* (to be). Hindi wordnet stores these intransitive forms which do not have corresponding English verbs. This is because English makes use of a phrase to convey the same meaning. In such cases, bilingual mapping is the only option. Take the example of *अर्पित होना* (*arpit honaa*)**,** which means

- किसी के द्वारा श्रद्धापूर्वक देवता, समाधि आदि पर कुछ रखा जाना
- By someone respectfully deity, tomb, etc. on something to be kept
- *Kisii ke dvaaraa shraddhaapuurvak devataa, samaadhi aadi par kuchhh rakhaa jaanaa*
- be offered (something) by someone respectfully to a deity or on a tomb, etc.

Since such a sense does not exist in the English WordNet, the word is translated as *to be offered* and the gloss has been translated as *be offered (something) by someone respectfully to a deity or on a tomb, etc.*

5.4.3 Idiomatic Expressions

Idioms are words, phrases, or expressions that are either grammatically unusual or their meaning cannot be taken literally. They are highly culture specific and so they require special treatment, becoming perfect candidates for bilingual mapping, specifically those not available in English. For example, *हाथ खुला होना* (*haath khula honaa*), which would literally mean "to have an open hand", but the idiomatic sense is

- दान, व्यय आदि के संबंध में उदार प्रवृति होना
- donation, expenditure, etc. with respect to generous tendency be
- *daan, vyaya, aadi ke saMbandha meM udaar pravritti honaa*

- to be of generous tendency towards donation, expenditure, etc.

It had a hypernymy linkage to *be* which means *have the quality of being*. This was too distant in meaning, did not convey the metaphorical sense, and would not have been accurate in translation. So it has been given the bilingual mapping as *to be big spender* with the gloss translated as *to be generous with respect to donation, expenditure, etc.*

5.5 Words for which Hypernymy Relation Unavailable

Wordnet does not have hypernymy relation for adjectives and adverbs. Thus these words in the Hindi wordnet when not linked to direct English words, do not have an option of hypernymy linkage. In such cases, they have to be invariably given bilingual mappings.

5.5.1 Adjectives

Those Hindi adjectives, which are participial adjectives in English, especially those which are formed by the present participle '-ing' and the past participle '-ed', rarely find exact matching synsets in English. All such adjectives are being assigned bilingual mappings in Hindi wordnet. An example of this is *आत्मवंचक* (*aatmavaMchaka*), which means

- स्वयं या अपने आप को धोखा देनेवाला
- self or to one self deceiving
- *swayam yaa apane aap ko dhokhaa dene waalaa*
- self deceiving.

Here the words translates to *self-deceiving* and the gloss is *who deceives oneself.*

5.5.2 Adverbs

Adverbs also do not have hypernymy relation. Hence, those Hindi adverbs which do not have a direct linkage to English, have to be given bilingual mappings. For example *सालों-साल* (*saaloM-saal*), which means

Part of Speech	Total Synsets in HWN	Direct Linkages	Hypernymy Linkages	Bilugual Mappings	Total Linkages
Noun	29070	11582	8184	2110	21876
Adjective	6171	3541	0	331	3872
Verb	3303	1992	207	129	2328
Adverb	475	343	0	27	370
Total	39019	17458	8391	2597	28446

Table 1: POS wise statistics for HWN

- कई साल तक
- many years till
- *kaii saaloM tak*
- of many years

has the bilingual mapping as *of many years.* Here the gloss is omitted because the synset member, which is a phrase in itself, is also the gloss.

5.6 Proper Nouns

Hindi wordnet has more than 16,000 proper nouns, most of which are names of persons, places and organizations specific to India. All such words could not have been given a place in the English WordNet, making linkage difficult. Initially they were given hypernymy linkages to very distant synsets. For example, names of political leaders were linked to the synset of *leader* and characters from Indian epics and mythology were given hypernymy linkages to the synset of *mythical being.* It was felt that such names are better *transliterated* as they would occur in the corpus in the same manner. Thus, such entries are being transliterated with their glosses translated as per Hindi. We have currently mapped over 1,800 such proper nouns, and the work is going on. Some such examples are:

1. *सरदार वल्लभ भाई पटेल* (*sardaar vallabh bhai patel*), which has a gloss as
- भारत के स्वतन्त्रता संग्राम सेनानी जो स्वतन्त्र भारत के प्रथम गृहमंत्री तथा उपप्रधानमंत्री बने
- India of freedom fight soldier who free India of first home minister and deputy prime minister became
- *Bhaarat ke svatantrataa saMgraam senaanii jo savatantra bhaarat ke pratham grihamantrii tathaa upa-pradhaanmantrii bane*
- a freedom fighter of India who became the first Home Minister and Deputy Prime Minister of independent India.

This is assigned the bilingual mapping as *Sardar Vallabh Bhai Patel, Sardar Patel - a freedom fighter of India who became the first Home Minister and Deputy Prime Minister of independent India.*

2. *भारतीय वाणिज्य एवं उद्योग महासंघ* (*bhaaratiiya vaaNijya evam uddyog mahaasaMgha*) has a gloss as
- भारत की व्यापारिक संस्थाओं की एक मंडली
- India of business organizations of an association
- *Bhaarat kii vyaapaarik saMsthaaoM kii ek maMdalii*
- an association of business organizations of India.

It has been given a hypernymy linkage to the synset of *organization* which means *an organization formed by merging several groups or parties.* This is also assigned a bilingual mapping as *Federation of Indian Chambers of Commerce - an association of business organizations of India.*

6 Bilingual Mapping Interface

Hindi and English wordnets are in both MySQL and file format (text). Hindi wordnet is accessible via an online interface, which provides a login facility to administrators, thus enabling features like adding / editing of a bilingual mapping between Hindi and English over the web interface itself. We currently store the mappings
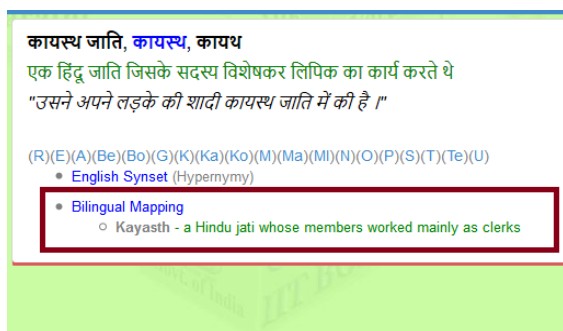
based on Hindi wordnet IDs as pivot. Mapping IDs are provided serially. While querying the database for a linkage, the interface also looks for a mapping, which, if present, is shown on the interface.

The bilingual mapping is stored in the database in the following format:

<word1, word2, ... , wordN> - <gloss>;<example> (for N number of words)

The lexicographers are familiar with this format, and update the database accordingly.

Following are some screenshots of the bilingual mapping interface for mapping / addition and querying of bilingual mapping.

कायस्थ जाति, कायस्थ, कायथ
एक हिंदू जाति जिसके सदस्य विशेषकर लिपिक का कार्य करते थे
"उसने अपने लड़के की शादी कायस्थ जाति में की है ।"

(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma)(Ml)(N)(O)(P)(S)(T)(Te)(U)
- English Synset (Hypernymy)
- Bilingual Mapping
  - Kayasth - a Hindu jati whose members worked mainly as clerks
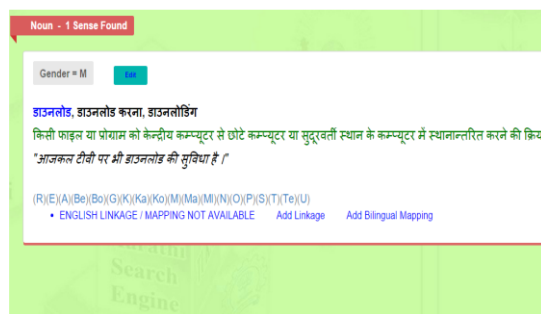
Screenshot 2: Bilingual mapping querying

7 Statistics

The above statistics show that maximum numbers of synsets have direct linkages with the English WordNet. Although, around 8,000 hypernymy linkages have been done, yet these are under review. Some of these have been converted to bilingual mappings. Since assigning mappings is a very recent activity, the numbers are likely to go up as the task proceeds. A bulk of this would comprise of proper nouns which consists mainly of names of persons, places and organizations.

8 Words sent to the English WordNet for Inclusion

As a corollary to the linkage task, it was observed that there are many English language concepts that are missing in the English WordNet and can be easily assimilated therein. These concepts are available in other English dictionaries. We have sent lists of such words to the English WordNet team and have received assurance that these would be looked into. As and when such senses would be made available in the English WordNet, they will be utilized for the Hindi-English linkage task. Some examples of such words are given below:

1. page (Computer Science) - A quantity of memory storage equal to between 512 and 4,096 bytes.
2. flying - The piloting or navigation of an aircraft or spacecraft
3. occupier - one who seizes possession of and maintains control over forcibly or as if by conquest.
4. crisp - conspicuously clean or new

Noun - 1 Sense Found

Gender = M   Edit

डाउनलोड, डाउनलोड करना, डाउनलोडिंग
किसी फाइल या प्रोग्राम को केन्द्रीय कम्प्यूटर से छोटे कम्प्यूटर या सुदूरवर्ती स्थान के कम्प्यूटर में स्थानान्तरित करने की क्रिया
"आजकल टीवी पर भी डाउनलोड की सुविधा है ।"

(R)(E)(A)(Be)(Bo)(G)(K)(Ka)(Ko)(M)(Ma)(Ml)(N)(O)(P)(S)(T)(Te)(U)
- ENGLISH LINKAGE / MAPPING NOT AVAILABLE   Add Linkage   Add Bilingual Mapping

Screenshot 3: Bilingual mapping addition

5. shakingly - in a shaking manner
6. in hand - owned by or in possession

9 Conclusion and Future Work

In this paper we have discussed the process of creating bilingual mappings of the synsets of Hindi wordnet into English, the methods adopted and the tool used in creating them. It was observed that the problems occurred due to conceptual and lexical gaps between Hindi and English languages. The main problem areas are the following:

- Words/ Concept not available in English WordNet

- Required sense missing in the English WordNet

- Culture specific words

- Language specific words
  - Causative Verbs
  - Be' Form of Conjunct Verbs
  - Idioms

- Words for which Hypernymy Relation Unavailable
  - Adjectives
  - Adverbs

- Proper nouns

An online linking facility has been provided to incorporate the bilingual mappings in Hindi wordnet, which can be easily accessed by a user.

By using this method, it is hoped that the task of linking two language concepts can be accomplished with a high degree of accuracy. The

bilingual mappings in English can help clarify the Hindi concept for the lexicographers of the wordnets of the other Indian languages, who may not be very proficient in Hindi. Furthermore, in future, such a strategy may be adopted by wordnets of other Indian languages while linking their wordnets to Hindi wordnet. We can also provide the semantic and lexical relations that such mappings would carry. These mappings can also be tested on a small corpus to verify whether they provide better translation outputs than hypernymy linkages. As the task progresses we may come across other categories of concepts where such mappings may prove to be useful. Above all, it presents an interesting scenario in which two different languages are brought together in conceptual unity. This may in itself offer future research possibilities.

10 Acknowledgement

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