Lexical Resources for Hindi Marathi MT
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Abstract
In this paper we describe some ways to utilize various lexical resources to improve the quality of statistical machine translation system. We have augmented the training corpus with various lexical resources such as IndoWordnet semantic relation set, function words, kridanta pairs and verb phrases etc. Our research on the usage of lexical resources mainly focused on two ways such as augmenting parallel corpus with more vocabulary and augmenting with various word forms. We have described case studies, evaluations and detailed error analysis for both Marathi to Hindi and Hindi to Marathi machine translation systems. From the evaluations we observed that, there is an incremental growth in the quality of machine translation as the usage of various lexical resources increases. Moreover usage of various lexical resources helps to improve the coverage and quality of machine translation where limited parallel corpus is available.

Keywords: Statistical Machine Translation, IndoWordnet, Lexical Resources.

1. Introduction
Machine Translation (MT) is the process of translating text or speech from one natural language to another with the help of machines. There are many ongoing attempts to develop MT systems for various Indian languages using rule-based as well as statistical-based approaches. Since India is rich in linguistic divergence there are many morphologically rich languages quite different from English as well as from each other, there is a great need for machine translation between them (Nair et.al, 2012). It has 22 scheduled languages, which are written in 10 different scripts. This paper discusses various approaches used in Indian language to Indian language MT systems especially in Marathi to Hindi Statistical MT system and vice versa to improve the quality of machine translation.

For example, consider the translated Hindi output from Marathi-Hindi SMT system for the Marathi sentence, Marathi - ह्या करणास्त्रव तो नाराज होता.
Hindi - यह फलस्वरूप वह नाराज हौ |
{hyā karnaastav to naraz hota} {yah phalswaroop vah naraz ho}

Here the Marathi word “करणास्त्रव”{karnaastav} is wrongly mapped to Hindi word “फलस्वरूप”{phalswaroop} and the verb “होता”{hota} is wrongly mapped to “हौ”{ho gaya}.

In order to learn various inflected and verb forms, lexical resources can play a major role. The detailed analysis about various linguistic phenomena and how the lexical resources can be used for improving the translation quality is explained in the following sections.

In the case of Marathi, a single noun can have more than 200 forms that are either adjectives or adverbs. Similarly, a verb may exhibit over 450 forms. Also the language is covering about 10,000 nouns and over 1,900 verbs. Moreover 175 postpositions can be attached to nominal and verbal entities. Some postpositions can occur in compound forms with most of the other postpositions. In addition, there are many kinds of derivable words such as causative verbs like ‘करावने’, i.e. ‘to make (someone) to do (something)’, which is derivable from root ‘करने’ i.e. ‘to do’, and abstract nouns like ‘घरपन’ i.e. ‘homeliness’, which is derivable from ‘घर’ i.e. ‘home’[Veena et.al., 2005].

Major difficulties in Machine Translation are handling the structural difference between the two languages and handling the ambiguities.

1.1 Challenge of Ambiguity
There are two types of ambiguity: structural ambiguity and lexical ambiguity.

1.1.1 Lexical Ambiguity
Words and phrases in one language often have multiple meaning in another language. For example, in the sentence,
Marathi - आले होते मस्तून काम झाले
{aalे hote mastun kaam jhale} {aale hote mehnaam kaam jchale}

Hindi - अदरक था इसलिए काम हुआ |
{aadark tha isliye kaam hua} {aadark tha isliye kaam hua}

English - Ginger was there so the work has done or

Hindi - आए थे इसलिए काम हुआ |
{maenne photo nikala} {maenne photo nikala}

English - came thatsy work was done

Here in the above sentence “आले”{aal}, has ambiguity
in meaning. It is not clear that whether the word “आँले”{aale}, is used in Hindi as the “ginger” (“अंदक”/aadark/ sense or the “आम”/aayen), sense. This kind of ambiguities will be clear from the context.

1.1.2. Structural Ambiguity
In this case due to the structural order there will be multiple meanings. For example,

Marathi - तिथे लढ़ा मुली आणि मुले होती.
{tithe lath multi aani mulen hoti}
{There were fat girls and boys there}

Here from the words “लढ़ा मुली आणि मुले” {lattha multi aani mulen } it is clear that fat girls but it is not clear that boys are fat, since in Marathi to represent tall girls and boys only one word “लढ़ा” {lattha} {tall} is being used. It can have two interpretations in Hindi and English according to its structure.

Hindi - वहं मोटी लड़कियाँ और लड़के थे।
{vahan moti ladkiyam our ladkem the }
{There were fat girls and boys there}

or

Hindi - वहं मोटी लड़कियाँ और मोटे लड़के थे।
{vahan moti ladkiyam our mote ladkem the }
{There were fat girls and fat boys there}

To generate appropriate Machine Translations by handling this kind of structural ambiguity is one of the big problems in Machine Translation.

1.2 Structural Differences
In the case of Marathi – Hindi machine translation both languages follow the same structural ordering in sentences, such as Subject- Object-Verb (SOV). Even though there is ordering similarity, there are morphological and stylistic differences which have to be considered during translation. Marathi is morphologically more complex than Hindi, wherein there are a lot of post-modifiers in the former as compared to the later (Dabre et al, 2012, Bhosale, 2011).

For example, the word form “हस्तिनापुरच्या”{hustinapoorchya} [of / about the hustinapur] is derived by attaching “च्या”{chyaas} as a suffix to the noun “हस्तिनापुर” {hustinapur}[a place in India] by undergoing an inflectional process. Marathi exhibits agglutination of suffixes which is not present in Hindi and therefore these suffixes have equivalents in the form of post positions. For the above example, the Hindi equivalent of the suffix “च्या”{chyaas} is the post position “के”{ke} which is separated from the noun “हस्तिनापुर”{hustinapur}. Hence the translation of “हस्तिनापुरच्या”{hustinapoorchya} will be “हस्तिनापुर के”{hustinapur ke}.

Consider an example for word ordering .

Hindi- गद-मुक्तेश्वर हिंदुओं का पावन तीर्थ है।
{gad-mukteshwar hinduom ka paavan teerth hai }
{Yesterday the pooja which happens in the month of sravan for married women got completed}

Marathi- गदमुक्तेश्वर हिंदूच्या पावन तीर्थ आहे.
{gadmukteshwar hindoonche pavit teerth aah}

Since the word order is same for both the languages it is an advantage for statistical machine translation during alignment. And it will improve the quality of translation.

1.2.1 Participial Constructions
Constructions in Hindi having Participials in Marathi
Example: Hindi:

Joe laddka ga rha thaa vah chala gayaa
jo ladkaa gaa raahaa thaa wah chalaa gayaa
rel. boy sing stay+perf.+cont. be+past walk go+perf.
The boy who was singing, has left.

Marathi (Direct Translations):

१०००००००० काळे मंगलावरीची पूजा होती.
{kaal mangalgowrichi pooja hoti}

For example, the word form “हस्तिनापुरच्या”{hustinapoorchya} [of / about the hustinapur] is derived by attaching “च्या”{chyaas} as a suffix to the noun “हस्तिनापुर” {hustinapur}[a place in India] by undergoing an inflectional process. Marathi exhibits agglutination of suffixes which is not present in Hindi and therefore these suffixes have equivalents in the form of post positions. For the above example, the Hindi equivalent of the suffix “च्या”{chyaas} is the post position “के”{ke} which is separated from the noun “हस्तिनापुर”{hustinapur}. Hence the translation of “हस्तिनापुरच्या”{hustinapoorchya} will be “हस्तिनापुर के”{hustinapur ke}.

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{Yesterday the pooja which happens in the month of sravan for married women got completed}

Marathi (Actual Translations):

१०००००००० काळ मंगलावरीची पूजा होती.
{kaal mangalgowrichi pooja hoti}

For example, the word form “हस्तिनापुरच्या”{hustinapoorchya} [of / about the hustinapur] is derived by attaching “च्या”{chyaas} as a suffix to the noun “हस्तिनापुर” {hustinapur}[a place in India] by undergoing an inflectional process. Marathi exhibits agglutination of suffixes which is not present in Hindi and therefore these suffixes have equivalents in the form of post positions. For the above example, the Hindi equivalent of the suffix “च्या”{chyaas} is the post position “के”{ke} which is separated from the noun “हस्तिनापुर”{hustinapur}. Hence the translation of “हस्तिनापुरच्या”{hustinapoorchya} will be “हस्तिनापुर के”{hustinapur ke}.

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{gadmukteshwar hindoonche pavit teerth aah}

2. Difficulties in SMT approach
As described in section 1 there are many structural differences between languages. The statistical approach tries to generate translations based on the knowledge and statistical models extracted from parallel aligned bilingual text corpora. Statistical models take the assumption that every word in the target language is a translation of the source language words with some probability (Brown et al., 1993). The words which have the highest probability will give the best translation. Consistent patterns of divergence between the languages (Dorr et al., 1994, Dave et al., 2002, Ramanathan et al., 2011) when translating from one language to another, handling reordering divergence are one of the fundamental problems in MT (Kunchukuttan and Bhattacharyya 2012, Och and Ney, 2001, Koehn, 2007).

In the case of Marathi, Hindi even though both the language follows same word order there are structural difference between the language and in the generation of word forms due to the morphological complexity as described in section 1. In order to overcome this difficulty and make the machine to learn different morphological word forms lexical resources can play a major role. Different word forms such as verb phrases, morphological forms etc can be used. Also the SMT system lacks in vocabulary due to the small amount of parallel corpus. Comparative performance studies conducted by Och and Ney have shown the significance of adding dictionary words into corpus and the improvement in the translation quality in their paper (Och, Ney 2003). In order to increase the coverage of vocabulary we have used IndoWordnet. IndoWordnet(Bhattacharyya, 2010) is a lexical database for various Indian languages, in which Hindi wordnet is the root and all other Indian language wordnets are linked through the expansion approach. Words and its concepts are stored in a structure called the Lexical Matrix, where rows represent word meanings and columns represents the forms. The extraction of bilingual mapped words and its usage in machine translation is described in the experimental section 3. The comparative performance analysis with phrase based model and the phrase based model after augmenting various lexical resources is described in section 4.

3. Experimental Discussion

We now describe the development of our Marathi- Hindi and Hindi- Marathi SMT system1 (Sreelekha, Dabre and Bhattacharyya 2013), the experiments performed and the comparisons of results, in the form of an error analysis. For the purpose of constructing with statistical models we use Moses and Giza++2. We have conducted various experiments to improve the quality of machine translation by utilizing various lexical resources.

Our experiments are listed below:

1. SMT system with an uncleaned corpus
2. SMT system with a cleaned corpus
3. Corpus with IndoWordnet extracted words
4. Corpus with Function words and Kridantha pairs
5. Corpus with verb phrases

3.1.1 SMT system with an uncleaned corpus

We have used 50000 corpus of Tourism and Health provided by ILCI consortium. There were many misalignments, wrong and missing translations in the corpus. It affected the translation and the quality was not good. For example, sentence from the corpus where the translation is wrong.

Hindi:
मणिपुर के द्वारा उत्तर-पूर्वी राज्य में पौले खेल का अस्तित्व कायम रहने के लिए, संसार आधुनिक पौले के जन्म का ऋण है, क्योंकि आज यह पूरी दुनिया में खेला जा रहा है।

Equivalent Marathi Translation (wrong)
मणिपुर के द्वारा उत्तर-पूर्वी राज्य में पौले खेल का अस्तित्व कायम रहने के लिए, संसार आधुनिक पौले के जन्म का ऋण है, क्योंकि आज यह पूरी दुनिया में खेला जा रहा है।

English: Today Polo is being played all over the world. It's credit goes to retaining the existence of the game of Polo in the remote hills of Manipur of north eastern India.

The comparative performance results of cleaned corpus over uncleaned corpus were shown in the Table 4, 5, 6 and 7. From the error analysis we came to a conclusion that in order to improve the translation quality we need to provide a well cleaned parallel corpus for training.

3.1.2 SMT system with cleaned corpus

We have corrected the misalignments between parallel sentences which improves the learning of word to word alignments. Sometimes we had to correct source sentences even. For example, for the above sentence Hindi:
मणिपुर के द्वारा उत्तर-पूर्वी राज्य में पौले खेल का अस्तित्व कायम रहने के लिए, संसार आधुनिक पौले के जन्म का ऋण है, क्योंकि आज यह पूरी दुनिया में खेला जा रहा है।

Correct Marathi Translation
मणिपुर के द्वारा उत्तर-पूर्वी राज्य में पौले खेल का अस्तित्व कायम रहने के लिए, संसार आधुनिक पौले के जन्म का ऋण है, क्योंकि आज यह पूरी दुनिया में खेला जा रहा है।

1 http://www.cfilt.iitb.ac.in/SMTSystem
2 http://www.statmt.org/
We have removed the stylistic constructions from the parallel corpus which prevent the learning of grammatical structures. Removed the unwanted characters and wrong translations and corrected the missing translations and phrases. The resultant machine translation system’s quality improved more than 40%. The statistics of corpus used are shown in Table 1 and the results are shown in the Tables 4, 5, 6 and 7. During error analysis we came to know that the machine lacks in sufficient amount of vocabulary and hence we investigated on the usage of IndoWordnet to improve the quality of machine translation.

3.1.3 Corpus with IndoWordnet extracted words

We have extracted a total of 437832 parallel Marathi-semantic and lexical relations as described in section 2. We have used an algorithm to extract the bilingual words from IndoWordnet. Bilingual mappings are generated using the concept-based approach across words and synsets (Mohanty et.al., 2008). For a single word considered it’s all synset word mappings and generated that many entries of parallel words.

For example, the word अन्तिहीन (antaheen) has the following equivalent synset words in IndoWordnet.

\{
\text{अन्तिहीन: anantu asamapya antaheen anant antaheen anavasaan}
\}
\{\text{endless: endless not-ending endless infinite endless not-ending}\}

We augmented the extracted parallel words into the training corpus. It helped in improving the translation quality to a great extent. The statistics of Wordnet synsets used are shown in Table 2 and the results are shown in the Tables 4, 5, 6 and 7. During the error analysis we observed that even though the machine translation system is able to give considerably good quality translation, it lacks in handling case markers and inflected forms. One of the advantages is that it helped the machine to handle word sense disambiguation well, since the synsets covers all
common forms of a word.

3.1.4 Corpus with Function words and Kridantha pairs

Marathi and Hindi have 7 types of kridanta forms, its' post position, pre-position and inflected forms. We have augmented kridanta, akhyat, function words, suffix pairs etc into the training corpus. This helped in machine translation system to infer the grammatical structures and hence the quality of translation improved.

Sample Marathi-Hindi kridanta form pair is,

अयळां पाहिजे : ना चाहिए
{aayla pahiye : na chaahiye}

The statistics of function words used are shown in Table 2 and the results are shown in the Tables 4, 5, 6 and 7. From the error analysis we came to a conclusion that translation system is facing difficulties in handling verbal translations because of the morphological phenomena.

3.1.5 Corpus with verb phrases

In order to overcome the verbal translation difficulty we have extracted Marathi- Hindi parallel verbal forms and its translations which contains various phenomena. We have augmented the 4471 entries of verbal translations into the training corpus.

Sample Marathi-Hindi verb form pair is,

जरूर करवा लै : अवस्य करवून घ्या
{zaroor karva lem : avasyu karvoon ghya}

The statistics of function words used are shown in Table 2 and the results are shown in the Tables 2, 4, 5, 6 and 7. The error analysis study has shown that the quality of the translation has been improved drastically.

4. Evaluation

We have tested the translation system with a corpus of 100 sentences taken from the ‘EILMT tourism health’ corpus as shown in Table 3. We have used various evaluation methods such as subjective evaluation, BLEU score (Papineni et al., 2002), METEOR and TER (Agarwal and Lavie 2008). But we gave importance to subjective evaluation to determine the fluency (F) and adequacy (A) of the translation, since for morphologically rich languages subjective evaluations can give more accurate results comparing to other measures. Fluency is an indicator of correct grammatical constructions present in the translated sentence whereas adequacy is an indicator of the amount of meaning being carried over from the source to the target. Marathi Hindi Bilingual experts have assigned scores between 1 and 5 for each generated translation, on the basis of how much meaning conveyed by the generated translation and its grammatical correctness. The basis of scoring is given below:

- 5: The translations are perfect.
- 4: One or two incorrect translations and mistakes.
- 3: Translations are of average quality,
- 2: The sentence is barely translated.
- 1: The sentence is not translated or the translation is gibberish.

$S1, S2, S3, S4 and S5$ are the counts of the number of sentences with scores from 1 to 5 and $N$ is the total number of sentences evaluated. The formula (Bhosale et al., 2011) used for computing the scores is:

$$A/F = 100 \times \frac{(S5 + 0.8 \times S4 + 0.6 \times S3)}{N}$$

We consider only the sentences with scores above 3. We penalize the sentences with scores 4 and 3 by multiplying their count by 0.8 and 0.6 respectively so that the estimate of scores is much better. The estimate may vary from person to person as these scores are subjective, in which case an inter annotator agreement is required. We do not give these scores, since we had only one evaluator. The results of our evaluations are given in Table 4, 5, 6 and 7.

5. Error Analysis

We have evaluated the translated outputs of both Marathi to Hindi and Hindi to Marathi Statistical Machine Translation systems in all 5 categories as explained in Section 3. The detailed error analysis is shown in Table 8 and 9 for a sentence exhibiting a variety of linguistic phenomena and how the quality of Machine Translation system changes by augmenting various lexical resources. The results of BLEU score, METEOR and TER evaluations are displayed in Tables 6 and 7 and the results of subjective evaluations are displayed in Table 4 and 5.

We have observed that the quality of the translation is improving as the corpus is getting cleaned as well as more lexical resources are used. Hence there is an incremental growth in adequacy, fluency, BLEU score, METEOR score and in TER score. The fluency of the translation increased up to 83% in the case of Marathi to Hindi and up to 85% in the case of Hindi to Marathi.

Also we have observed that the score of Hindi to Marathi translation quality is slightly higher than that of Marathi to Hindi translation. Since Marathi is morphologically richer than Hindi and Marathi have more agglutinative suffixes attached, while in Hindi it is not present, as explained in above section 1.2. Therefore these Marathi suffixes have Hindi equivalents in the form of post positions. So during alignment from Hindi to Marathi, Hindi word can align to the words with agglutination in Marathi, since it is a single word. But on the other hand while aligning form Marathi-Hindi the agglutinative word can map to only root words, there is a chance to miss out the post position mapping, since it is separate words. So it will improve the translation quality of Hindi- Marathi SMT as compared to Marathi-Hindi SMT.

For example, during Hindi-Marathi Translation, in Hindi-Marathi alignment the noun “हस्तिनापुर”
{hustinapur} can easily align to “हस्तिनापुरच्या” [{hustinapoorchya}], since it is a single word. But in Marathi-Hindi alignment, “हस्तिनापुरच्या” [{hustinapoorchya}] may be map to “हस्तिनापुर” [{hustinapur}] and there is a possibility to drop down the post position “के” [{ke}] which is a separate word from the noun “हस्तिनापुर” [{hustinapur}]. These features will have impact on the translation quality and hence the inflected forms may not translate properly from Marathi to Hindi. On the other hand, Hindi to Marathi translation system will not face this difficulty because of alignments. Thus there is an improvement in quality of Hindi-Marathi MT comparing to Marathi-Hindi MT.
| Marathi-Hindi Statistical MT System | Adequacy | Fluency  |
|-----------------------------------|----------|----------|
| With Uncleaned Corpus             |          |          |
| With Tuning                       | 20.6%    | 30.8%    |
| Without Tuning                    | 17.8%    | 24%      |
| With Cleaned Corpus               |          |          |
| With Tuning                       | 58.6%    | 68.3%    |
| Without Tuning                    | 54%      | 64%      |
| With Wordnet                      |          |          |
| With Tuning                       | 72.4%    | 80%      |
| Without Tuning                    | 69.6%    | 78.2%    |
| With Function Words, kridanta pairs|          |          |
| With Tuning                       | 78%      | 81%      |
| Without Tuning                    | 75%      | 80%      |
| With verb Phrases                 |          |          |
| With Tuning                       | 83%      | 88%      |
| Without Tuning                    | 80%      | 85%      |

Table 4: Results of Marathi-Hindi SMT Subjective Evaluation

| Hindi-Marathi Statistical MT System | Adequacy | Fluency  |
|------------------------------------|----------|----------|
| With Uncleaned Corpus              |          |          |
| With Tuning                        | 22.87%   | 31.3%    |
| Without Tuning                     | 20.56%   | 28%      |
| With Cleaned Corpus                |          |          |
| With Tuning                        | 59%      | 72.21%   |
| Without Tuning                     | 53%      | 65%      |
| Corpus with Wordnet                |          |          |
| With Tuning                        | 73%      | 83%      |
| Without Tuning                     | 70.01%   | 80.04%   |
| Corpus with Function words, kridanta pairs |          |          |
| With Tuning                        | 79.36%   | 87.21%   |
| Without Tuning                     | 76%      | 85.68%   |
| Corpus with verb Phrases           |          |          |
| With Tuning                        | 85.01%   | 89.32%   |
| Without Tuning                     | 82%      | 86.34%   |

Table 5: Results of Hindi-Marathi SMT Subjective Evaluation

| Hindi-Marathi Statistical MT System | BLEU score | METEOR | TER  |
|------------------------------------|------------|--------|------|
| With Uncleaned Corpus              |            |        |      |
| With Tuning                        | 1.96       | 0.124  | 45.06|
| Without Tuning                     | 1.26       | 0.127  | 44.55|
| With Cleaned Corpus                |            |        |      |
| With Tuning                        | 7.76       | 0.193  | 84.05|
| Without Tuning                     | 3.97       | 0.190  | 83.92|
| Corpus with Wordnet                |            |        |      |
| With Tuning                        | 11.78      | 0.225  | 82.91|
| Without Tuning                     | 9.31       | 0.217  | 84.30|
| With Function Words, kridanta pairs|            |        |      |
| With Tuning                        | 12.21      | 0.274  | 83.79|
| Without Tuning                     | 9.25       | 0.214  | 85.06|
| With verb Phrases                  |            |        |      |
| With Tuning                        | 18.15      | 0.281  | 77.94|
| Without Tuning                     | 10.26      | 0.261  | 85.48|

Table 6: Results of Hindi-Marathi SMT BLEU score, METEOR, NER Evaluations

| Marathi-Hindi Statistical MT System | BLEU score | METEOR | TER  |
|------------------------------------|------------|--------|------|
| With Uncleaned Corpus              |            |        |      |
| With Tuning                        | 1.86       | 0.119  | 50.32|
| Without Tuning                     | 1.10       | 0.105  | 49.52|
| Corpus with Cleaned Corpus         |            |        |      |
| With Tuning                        | 8.01       | 0.171  | 78.32|
| Without Tuning                     | 4.22       | 0.160  | Infinity|
| Corpus with Wordnet                |            |        |      |
| With Tuning                        | 11.54      | 0.278  | 80.75|
| Without Tuning                     | 9.78       | 0.226  | 77.30|
| Corpus with Function Words, kridanta pairs |          |        |      |
| With Tuning                        | 12.20      | 0.283  | 81.19|
| Without Tuning                     | 10.46      | 0.263  | 81.19|
| Corpus with verb Phrases           |            |        |      |
| With Tuning                        | 17.80      | 0.288  | 80.36|
| Without Tuning                     | 13.70      | 0.265  | 81.48|

Table 7: Results of Marathi-Hindi SMT BLEU score, METEOR, NER Evaluations
| Sr. No. | Source Sentence | Explanation of phenomena |
|---------|-----------------|--------------------------|
|        | Hindi           |                          |
| 1      | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन के समय बनवाया गया था और 1886 में जनता के लिए खुला था। | 1. Many words are wrongly translated. 2. Function words not translated: के। 3. Verb translation has tense problem: था not translated. 5. Insertion case: के शेड डाला, गवताल। 6. Conjunction not translated. |
|        | भद 1886। |                          |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले। |                          |
|        | In 1986 the national central museum was established during the visit of the Prince of Wales and in 1886 was opened for the public. |                          |
|        | साली वह जनतासाठी खुला था। |                          |
|        | साली वह जनतासाठी खुला था। |                          |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुला होता। | 1. Many words are wrongly translated. 2. Function words not translated: के। 3. Verb translation has tense problem: था not translated. 5. Insertion case: के शेड डाला, गवताल। 6. Conjunction not translated. |
|        | भद 1886। |                          |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले। |                          |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुले होता। |                          |
|        | साली वह जनतासाठी खुला होता। |                          |
|        | साली वह जनतासाठी खुला होता। |                          |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुले होता। | “दर्शनचा” suffix addition is missing. |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले होता। |                          |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुले होता। | “दर्शनचा” suffix addition is missing. |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले होता। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुले होते। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले होता। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुले होते। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले होता। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |
|        | केंद्रीय सरकारी संग्रहालय 1876 में देल्स के राजकुमार के भारत दर्शन वेळी घेतलेला होती 1886 मध्ये जनतासाठी खुले होते। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |
|        | भद्दी घेतलेला के शेड डाला गेला। 1886 साली जनतासाठी खुले होता। | “वेल्स येशील” got translated correctly. Verb "होता" didn’t get translated. |

Table 8: Hindi- Marathi SMT Error Analysis
| Sr. No. | Sentence | Explanation of phenomena |
|---------|----------|--------------------------|
| 1       | Source Sentence: Marathi | एयादा भरतपुरमध्ये एका ठिकाणापासून दूरस्थीकडे जायासाठी टॅक्सी, सायकलरिक्शा व आंटीरिक्शा यासारखे वाहतुकीचे अनेक पर्याय घेऊ शकतो. |
|         | Meaning  | In Bharatpur for going from one place to another can bring taxi, cycle rickshaw or auto rickshaw. |
|         | With Tuning | कोई भरतपुरमध्ये एक स्थान दूरस्थी आणि जाणे टॅक्सी, सायकलरिक्शा व आंटीरिक्शा यासारखे ह्यांच्या कार्य केवळ विकल्प सकते हैं। |
|         | Without Tuning | कोई भरतपुरमध्ये एक स्थान दूरस्थी आणि जाणे टॅक्सी, सायकलरिक्शा व आंटीरिक्शा यासारखे ह्यांच्या कार्य यासारखे वाहतुकीचे केवळ विकल्प सकते हैं। |
|         | With Tuning | कोई भरतपुर में एक स्थान से दूरस्थी आर्थिक उद्देश्यों द्वारा परिवहन पानी से कर सकता है। |
|         | Without Tuning | कोई भरतपुर में एक स्थान से दूरस्थी आर्थिक उद्देश्यों द्वारा परिवहन पानी से कर सकता है। |
|         | With Tuning | कोई भरतपुर में एक स्थान दूरस्थी और टॅक्सी, रिक्षा और अटो रिक्षा जैसी यातायात कई विकल्प ले। |
|         | Without Tuning | कोई भरतपुर में एक स्थान से कहीं और जाने के लिए टॉक्सी, रिक्षा और अटो रिक्षा जैसी यातायात के कई विकल्प से कर सकता है। |
|         | With Tuning | कोई भरतपुर में एक स्थान दूरस्थी और जाने के लिए टॉक्सी, रिक्षा और अटो रिक्षा जैसी यातायात के कई विकल्प से कर सकता है। |
|         | Without Tuning | कोई भरतपुर में एक स्थान दूरस्थी और जाने के लिए टॉक्सी, रिक्षा और अटो रिक्षा जैसी यातायात के कई विकल्प से कर सकता है। |
|         | With Tuning | कोई भरतपुर में एक स्थान दूरस्थी और जाने के लिए टॉक्सी, रिक्षा और अटो रिक्षा जैसी यातायात के कई विकल्प से कर सकता है। |
|         | Without Tuning | कोई भरतपुर में एक स्थान दूरस्थी और जाने के लिए टॉक्सी, रिक्षा और अटो रिक्षा जैसी यातायात के कई विकल्प से कर सकता है। |

Table 9: Marathi – Hindi SMT Error Analysis
6. Conclusion
In this paper we have mainly focused on the usage of various lexical resources for improving the quality of Machine Translation. We have discussed the comparative performance of Statistical Machine Translation with various lexical resources for both Marathi – Hindi and Hindi-Marathi. As discussed in the experimental section, SMT, although lacks the ability to handle rich morphology it can overcome by using various lexical resources, which will help the machine to improve the translation quality.

In our experiments we have used various measures to evaluate such as BLEU Score, METEOR, TER and Fluency and Adequacy using subjective evaluation. We can see that there is an incremental growth in both Marathi- Hindi and Hindi Marathi systems in terms of BLEU-Score, METEOR, and TER evaluations. Also our subjective evaluation results shows promising scores in terms of fluency and adequacy. This leads to the importance of utilizing various lexical resources for an efficient Machine Translation system. Thus we can come to a conclusion that various lexical resources can play an important role in providing good machine translation system for morphologically rich languages.

Our future work will be focused on investigating more lexical resources for improving the quality of Statistical Machine Translation systems and there by develop an accurate MT system for both Marathi- Hindi and Hindi-Marathi Machine Translation.

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