

Machine Translation for Tibetan Buddhist Texts

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Abstract— This paper presents our attempt at training a model focusing on the translation of religious Tibetan texts to the English language. Tibetan is an extremely low-resource language and presents its own unique challenges in all stages of the development of a high accuracy machine translation model. In this paper, we explore the ethical considerations of translating religious texts, provide an in-depth view of our model creation procedure and follow up with discussions, results and conclusions. In support, we utilize various resources including scheduling conversations with a native speaker and the exploration of open source parallel Tibetan corpora.

I. INTRODUCTION

A. Overview

Our project aims to increase the accessibility of Tibetan religious texts by training a machine translation model specifically to translate religious Tibetan texts to English. Tibetan religions, in particular Buddhism, have a long tradition of translation of texts. While this work was not created within the context of these traditions, it was certainly inspired by them and we hope it will increase accessibility to Tibetan religious texts and inspire others do undergo similar projects.

We have created our Tibetan to English machine translation models in PyTorch and have leveraged the BART architecture in the HuggingFace transformers library to make the training and architecture more straightforward. By creating these models, we hope to motivate scholars to study not only these texts but Tibetan as a whole. Having a readily available set of translated discourses could create an on-ramp for further language uses

because increased access could lead to increased interest, especially in the English-speaking community. Currently, while there has been some interest in machine translation for Tibetan-Chinese and vice versa, the same interest has not been reflected in Tibetan-English machine translation. We attempted to find open-source Tibetan NLP material, but we were unable to find any projects attempting to translate Tibetan-English nor could we find papers specifically discussing Tibetan-English machine translation.

While our model tackles this difficult task in creating a translator for Tibetan-English, it is by no means a perfect or even accurate model. In the final iteration of our model, we were only able to achieve a 23.01% BLEU score, which means that our model has low-quality output. This is caused by several factors, from the difficulty to preprocess Tibetan sentences to the lack of Tibetan-English data freely available online and our overall knowledge of the Tibetan language. While it may seem that we were unable to fully accomplish our lofty goal of creating a Tibetan-English translator it is important to note that we are treading in nearly uncharted territory. We hope that our endeavor may help future projects in this field and provide insight into the current state of Tibetan-English machine translation.

B. Related Work

As a whole, not much work has been done in the area of machine translation (MT) or even Natural Language Processing (NLP) as a whole for the Tibetan language. There are a few papers exist which concern morphological segmentation and parts of speech (POS) tagging for the Tibetan language [3] [4]. In recent years there has considerable interest in Chinese to Tibetan machine translation [1] [2]. For example, “A Chinese to Tibetan Machine Translation System with Multiple Translating Strategies” discusses an approach of

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machine translation from Tibetan to Chinese. The paper makes 3 different translations models, Ruled Based MT, Example Based MT, and Statistical Based MT, and compares the results. Noticeably missing from this is a Neural Network MT. However, Neural Network MT wasn't prevalent at that time of its authorship. Nonetheless, the paper concludes, given this data (after processing), that the Statistical Based MT, implemented with conditional random fields, is indeed the best performing option. This is perhaps to be expected. However, as is alluded to above it is unknown whether a Neural Network MT would give a better performance here.

The paper "Tibetan-Chinese Neural Machine Translation based on Syllable Segmentation" explores four different methodologies for Tibetan to Chinese machine translation. Chinese and Tibetan are genetically related sharing the same proto-family, the Sino-Tibetan language family. This may mean that the results of this paper may not be fully reflected within our own project. However, there are several important findings that Lai, Zhao, and Bao discovered over the course of their experiment, particularly on the impacts of different models. In 2018, the statistical models were the preferred model type for Tibetan translation tasks, based on the linguistic characteristics of Tibetan. Lai, Zhao, and Bao test whether this is truly the most accurate and efficient model for these tasks by testing Seq2Seq, RNNSearch, Fairseq, and Transformer models against one another. Although each model has its own specific architecture that makes it difficult to normalize settings across all four, the researchers had the same basic parameters (same vocabulary size and training iterations). They also trained each model on two different corpora, one processed based on word segmentation and one processed based on character segmentation (or syllable segmentation). Each model's performance scores were measured by the BLEU index.

The first model discussed is the Seq2Seq model, or a sequence to sequence model, which is a model that takes in a sequence as input and outputs a sequence as well. The basic idea of a Seq2Seq model is to map the input sequence to the output sequence by taking the input through an LSTM which cre-

ates a vector of weighted sums during the encoding process and returns the words with the highest probability of occurring in the decoder process. The second model tested is the RNNSearch model that adds an attention mechanism, a mechanism that retains the values calculated by the encoding process to train another model which associates the values with output sequences. The new model produces word vectors and then uses these vectors to produce the next word. Although Fairseq models essentially have the same structure as the RNNSearch, where both employ encoder-decoders with attention mechanisms, Fairseq models use CNNs to map the input to the output sequence, which also allows for all the calculations of input sequences to run in parallel. The final model that they tested was the transformer model, which uses the attention mechanism without a CNN or RNN structure. Instead, transformers use a self-attention mechanism that relates all the words in the sentence to one another, where order doesn't matter. Out of these four models, the transformer model trained on the syllable parsed corpus performed the best. For each model tested, they performed substantially better with the syllable parsed corpus than the word parsed corpus. This means that one way we might look to improve our own project's accuracy is to use a character segmented corpus rather than a word segmented corpus.

Unfortunately, no such papers exist for Tibetan to English machine translation. In fact, to our knowledge this is the first such Tibetan to English machine translation system developed. Nonetheless, the findings from the Chinese to Tibetan machine translation have given us a starting point for our investigation.

II. ETHICAL CONSIDERATIONS

Care must be taken when approaching culturally and spiritually important texts for use in a computational domain. To that end we authors acknowledge our place as outsiders of the Buddhist tradition and outline our ethical approach for translating these texts as said outsiders.

First, we acknowledge that it would be improper to consider our translations as genuine sutras. Regardless of our quantitative results, we authors are not in a qualified position to declare something

as an honest translation of a Tibetan Buddhist text. To that end, we have instead given our translations to someone who can give a more qualified opinion of the accuracy of our translation. To this end, we asked a Native Tibetan Speaker who holds a Master’s degree in Buddhist theology and philosophy and a current PhD candidate in Tibetan History to assess our results. This approach to invite someone directly in the Tibetan community to assess our results was inspired by Bird’s paper [7] which suggests including a "human in the loop" as a key step in the process to decolonizing Natural Language Processing research.

Second, we acknowledge that there are certainly Indo-Tibetan texts that would be inappropriate to translate. These texts, namely the Tantric (esoteric) texts, we understand are meant for a select subset of advanced practitioners and translating these texts for the masses could be spiritually dangerous. Knowing this, we have refrained from including and Tantric texts within our training data.

Lastly, we acknowledge this is a tool to help bridge the language gap between practitioners both in and out of the Tibetan culture. We authors want to emphasize that this is just a tool. We make no claims that this tool will solve or fix the underlying social injustice issues within Tibetan community and diaspora. While we hope this tool can bring the community closer together and aid in prosperity, we make no claims that it will be able to do so.

III. PROCEDURE

A. Data and Pre-processing

To train our model, we acquired publicly available English to Tibetan parallel corpora. The non-profit 84000 provided 80 English to Tibetan parallel texts on their website [8]. All 80 of these texts were expert translations of Indo-Tibetan Buddhist texts originally written in Tibetan. For our model we used all 80 of these provided texts. 84000 is still actively creating more translated texts, so our model was only trained on to their most recent release which from the time of this papers’ publication was March 2021.

Before using 84000’s corpora however, we pre-processed the provided data to meet our model’s need. The provided files from 84000 were in a .tmx file format, a very standard parallel corpus

file format [9]. For our approach, we scraped all 80 .tmx files for both its English and Tibetan contents and placed them line by line into two large .txt files. One .txt file contained the English lines, and the other .txt file contained the Tibetan translation. We made careful assurance that the lines remained in exactly one to one correspondence with their translations. That is, a newline character was used to distinguish two separate lines of translation, but the same line number in each file corresponds to the exact translation provided by 84000. Therefore, the total line numbers in the two .txt files were necessarily the same since one line in one file corresponds to exactly the same line of translated text in the other file. Two such .txt file were made for each of the 80 .tmx files, a Tibetan and an English .txt file for each. After all 160 .txt files were generated, two large .txt file were generated by concatenating all the Tibetan .txt files and all the English .txt files. These last two large .txt files are what was fed into the model. The first few lines of our two large .txt files are shown below in figure 1.

Note in the the figure, the left hand side represents the source language (Tibetan) expressed in the Tibetan Unicode standard. On the right is the expert English translation provided by 84000. There is a one to one mapping between lines. This is, the Tibetan text on line one exactly corresponds to the English on line one. Of course, these are two separate files, and this picture simply reflects the view of the first few lines as would be seen if opened in a simple text editor.

Note that it was not strictly necessary to separate the creation of the large .txt files into the smaller components. However, giving the limited data we had this method proved useful to see how much individual texts contributed to the model.

B. Model Design

We used a 6 layer Transformer model that used a multi headed attention mechanism and a switchout transform. Each layer of the transformer model can be divided into an encoder and decoder layer. The encoding layer consists first of a self attention layer, an attention aspect which focuses on the encoded sentence, and then outputs to a feed forward layer. The multi part of the multi headed attention means that each head will

<p>འདྲི་སྒྲུབ་དག་གིས་མོས་པ་དུས་གཅིག་ན། བརྩམ་ལྷན་འདས་རྒྱལ་ཡོང་ཁལ་ན་བླ་ཚོ་དང་ཡོང་ཡོང་ཉི་ཤེ་ཨོ་ཁཞི་ཤིང་རྒྱ་ཆོས་ཀྱི་དབྱིངས་ཀྱི་ཉིང་ཡོང་ཁལ་བཟངས་ན། འདྲི་སྒྲུབ། རྟེན་མོས་ཆེན་པོ་བསྐྱེད་དང་ལྷན་ཤེས་ཀྱི་ཕྱུ་ལ་མོགས་པ་དགེ་སྤྱོད་ཏི་ཧཱ་མྱོང་གི་དགེ་སྤྱོད་གི་དགེ་འདུན་ཆེན་པོ་མཉམ་པ་ཅད་ཀྱང་དགྲ་བཅོམ་པ་ཟག་པ་ཟད་པ། སྒྲིན་ཁོངས་པ་མེད་པ་དབང་དང་ལྷན་པར་རྒྱུད་པ། མཉམས་ཤིན་ཏུ་རྒྱས་པར་གྱོད་པ། ཤེས་རབ་ཤིན་ཏུ་རྒྱས་པར་གྱོད་པ། ཅང་ཤེས་པ་སྒྲུབ་པོ་ཆེན་པོ་བྱ་བ་བྱས་པ། བྱེད་པ་བྱས་པ། ལྷན་པོར་ལ་བདག་གི་དོན་རྗེས་སུ་མོབ་པ། ལྷིད་པ་ལྷན་ཏུ་ལྷོར་བའོངས་སུ་ཟད་པ། ལང་དག་པོའི་ཤེས་པས་མཉམས་ཤིན་ཏུ་རྒྱས་པར་གྱོད་པ། འཇམ་དཔལ་ལ་གཞིན་ཏུ་ལྷུང་པ་དང་། མོར་དཔལ་དང་། མངས་རྒྱས་དཔལ་དང་། ལྷན་ཏུ་བྱ་ལ་པོ་དང་། ལྷན་ལང་དག་འགགས་</p>	<p>Thus have I heard, at one time, the Bhagavat was dwelling on the Vulture Peak Mountain in Rājgir, on a summit of infinite gems, in the Womb of Dharmadhātu Palace, together with a great assembly of twenty-five thousand monks. All of them were arhats who had exhausted their outflows. They were without afflictions and controlled. Their minds were perfectly liberated, and their wisdom was perfectly free. They were knowledgeable great elephants who had accomplished what needed to be done. They had laid down their burden and fulfilled their own benefit. They had destroyed the bonds of existence and, thanks to their correct knowledge, their minds were perfectly liberated. youthful Mañjuśrī, Dhanaśrī, Buddhiśrī, Bhaiṣajyārāja, and Bhaiṣajyasamudgata. All of them were turning the Dharma wheel that does not turn back.</p>
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Fig. 1. The first few lines of our fully concatenated parallel corpus

encode the information in parallel and then the results will be concatenated and passed to the decoder. Figure one demonstrates this process.

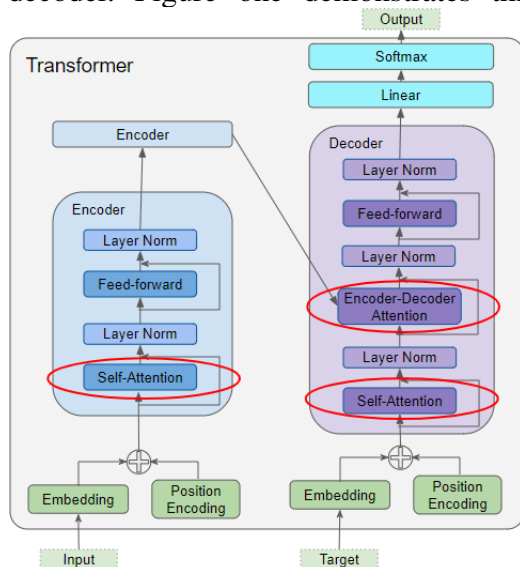


Fig 2. Overview of a Transformer model [11]

To prevent overfitting and to augment the data, we added in a switchout transform which will randomly switch out words in the source and target sentence. This also has the added advantage of augmenting the data even further which is especially important for our problem as religious Tibetan has a relatively small corpus, around 30 thousand words. We also attempted to use masking, however we found it to be ineffective. Masking hides tokens from the model by replacing the tokens with a <mask> token. Tibetan tokens are not separated in the same way that Latin languages

separate their tokens. For example, a line in our test corpus translated to “Having the altruistic intention of excellent bodhicitta.” However, the Tibetan word is only one token. Therefore, the mask would not help the model learn at all, as the entire sentence would be marked as <mask> and there would not be enough context for our model to discover the meaning. As a result, we did not use any form of masking in our model. Switchout does not create the same problem as there is always a token to take its place.

After implementing our transformer model with switchout we tuned hyper parameters to maximize our Transformer model. We manually tuned the following hyperparameters: dropout, label smoothing, rnn size, the number of transformer layers and the number of heads of the attention model.

We used four different metrics to evaluate our results: accuracy, predicted score, perplexity and bilingual evaluation understudy (BLEU). The validation accuracy tells us how well we are learning our training data, the predicted score tells us the average log likelihood for each word, the perplexity tells us how well the model predicts the data and the bleu score evaluates the quality of the translation. Together, these metrics provide us with a decent picture of how well our model is performed.

IV. RESULTS

Validation	Ave. Pred. Score	PPL	BLEU
40.32%	-1.69	5.41	23.01%

Tibetan sentences instead of segmenting each word since preprocessing these sentences to word-to-word mappings would require extensive knowledge of the Tibetan language which our team did not have. On top of this, a Chinese-Tibetan model might perform overall better than a Tibetan-English one since Chinese and Tibetan are part of the same language family, and it is likely that characters may map to one another and the same preprocessing techniques can be used in both languages. Therefore, while comparing our model to Lai, Zhao, and Bao’s [2] model may be helpful to give a general baseline on how other Tibetan translators are performing, it should not be considered where our model must perform.

Another issue with our data that may be remedied in future iterations is the corpora we chose to train and test our model on. Since we trained on sentences in our testing set, it is very possible that the model may have read some of the initial characters and assumed that the entire sentence would be a sentence from our training data that began with the same characters. This may explain why our model overpredicts the sentence “Our blessed one” with such a low perplexity. As stated above, this issue might be remedied if we could preprocess our data so that words mapped to words but since we are limited by our ability to do such, we could consider training our model on a different corpus altogether. Instead of using the translated Buddhist sutras to train our model, we could use a more general Tibetan-English corpus to train our model and then use transfer learning to fine-tune our model to religious texts. However, at this current time, the translated sutras provided by 84000 [8] are some of the only parallel translations available on the internet.

Perhaps the best way to translate Tibetan to English would be to take another approach to our model design altogether and abandon the tested Transformer model. We could build an Encoder-Decoder structure based on Back Translation which would help deal with the lack of Tibetan-English translations. In this model, we would mix Tibetan and English sentences together to train the model [10]. This would help to increase the size of our training data since it would no longer just be Tibetan sentences. Since this type

of model has yet to be tested for Tibetan-English, it’s uncertain whether this change could actually improve our translation accuracy and BLEU score, however based on papers written on Back Translation, this design looks promising.

VI. CONCLUSION

As mentioned in our introduction, developing a machine learning model for Tibetan Buddhist texts is a challenging task primarily due to the extremely low resources available. We overcame many obstacles while training our model while following a well defined ethical approach and using only publicly available resources. However, our 6 layer transformer model with switch out was unsuccessful at translating religious Tibetan to English. The translated output does not match closely enough in either pure accuracy or in the meaning of the passage to be useful in translating religious Tibetan texts to English, as expanded upon in the results section.

Additionally, we explored the ethical considerations of translating such texts and deeply reflected on those, amongst our procedure and findings. We faced an ethical dilemma in this part of our research project as to whether certain religious texts should or should not be translated given their sacredness. Another hurdle we overcame was employing switchout over masking as masking tends to hide tokens. We also realized that initially the result for perplexity seemed to demonstrate a strong model but further investigation brought forth that lower perplexity was actually a sign of accuracy. To be able to do a real world sense check and valuable input, we have scheduled a meeting with a native Tibetan speaker, through which we hope to be able to further enhance our model and increase accuracy of the same.

To conclude, while our work is not successful, using transformer models might show promise if new approaches can find a way to add more training data or stop repeated tokens along with insights that may come from completing primary diligence in the form of conversations with native speakers.

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