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An evaluation of Google Translate for Sanskrit to English translation via sentiment and semantic analysis

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ABSTRACT

Google Translate has been prominent for language translation; however, limited work has been done in evaluating the quality of translation when compared to expert translators. Sanskrit, one of the oldest written languages in the world was added to the Google Translate engine in 2022. Sanskrit is known as the mother of North Indian languages such as Hindi, Punjabi, and Bengali. Sanskrit has been used for composing sacred Hindu texts such as the Bhagavad Gita and the Upanishads. In this study, we present a framework that evaluates Google Translate for Sanskrit using the Bhagavad Gita. We first published a translation of the Bhagavad Gita in Sanskrit using Google Translate and then compared it with selected prominent translations by experts. Our framework features a BERT-based language model that implements sentiment and semantic analysis. The results indicate that there is a low level of similarity between the Bhagavad Gita by Google Translate and expert translators in terms of sentiment and semantic analyses. We found major inconsistencies in the translation of philosophical terms and metaphors. We further implemented a qualitative evaluation and found that Google Translate was unsuitable for the translation of certain Sanskrit words and phrases due to the poetic nature, contextual significance, metaphor and imagery. The mistranslations are not surprising since the Bhagavad Gita is known as a difficult text not only to translate but also to interpret since it relies on contextual, philosophical and historical information. It is difficult to distinguish different names and philosophical concepts such as karma and dharma without knowing the context and having a background of Hindu philosophy. Our framework lays the foundation for the automatic evaluation of other languages that can be translated by Google Translate.

1. Introduction

Deep learning methods have proven to be powerful in handling data in different formats such as numerical, textual, video, audio, and image in large volumes (Najafabadi et al., 2015). *Natural language processing* (NLP) (Manning and Schutze, 1999) is a field of artificial intelligence that empowers machines to process, interpret and understand text and language just as humans. NLP applications include sentiment analysis (Chandra and Kulkarni, 2022; Dang et al., 2020), topic modelling (Kirill et al., 2020; Egger, 2022), speech translation (Bertoldi et al., 2007; Nakamura et al., 2006), named entity recognition (Mikheev et al., 1999; Marrero et al., 2013), etc. NLP combines the field of computational linguistics with deep learning, statistics, and machine learning (Nadkarni et al., 2011). In the last decade, a variety of deep learning models have been applied for NLP that have boosted the field with a number of innovations (Socher et al., 2012). Semantic and sentiment analysis are two of the most prominent NLP applications in the social media and marketing sector. It has shown that sentiment analysis can also be used for predictive modelling for election outcomes via the US 2020 general elections (Chandra and Saini, 2021).

Language translation models use computer systems to translate text in a source language to an equivalent text in the target language (Garg and Agarwal, 2018). An efficient translation model is a key to many trans-lingual applications (Mizera-Pietraszko, 2010), cross-language information retrieval (Oard and Diekema, 1998), computer-assisted language learning (Beatty, 2013), etc. In the past, numerous methods have been proposed that either improve the quality of the generated translations (Johnson et al., 2007) or study their robustness by evaluating their performance for different target languages (Bisang et al., 2022). Deep learning models are machine learning models that

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have been prominent for language modelling. *Neural machine translation* (NMT) (Kalchbrenner and Blunsom, 2013; Zhang and Zong, 2020) uses a deep learning model (recurrent neural network (RNN)) to predict the likelihood of a sequence of words which typically models an entire sentence in a single integrated model (Sutskever et al., 2014; Sennrich et al., 2015). On the other hand, the *Transformer* (Vaswani et al., 2017) is an attention-based deep learning model that remains a dominant architecture for several language pairs (Barrault et al., 2019). The self-attention layers of the Transformer model learn the dependencies between words in a sequence by examining links between all the words in the paired sequences and by directly modelling those relationships (Wdowiak, 2021). Language translation is perhaps one of the most difficult modelling tasks considering the fluidity of human language (Mathur et al., 2020). Deep learning models such as the *bidirectional encoder representations from Transformer* (BERT) (Devlin et al., 2018), have achieved state-of-the-art results in language modelling tasks (Tenney et al., 2019; Kitaev et al., 2020) that motivates its usage in our study.

The *Bhagavad Gita* (translates as the *song of God*) is a sacred Hindu text (Gandhi, 2010; Hiltebeitel, 1976) that captures the essence of Hindu philosophy (Dasgupta, 1975). The *Mahabharata*, one of the earliest and largest epics written originally in Sanskrit in the style of narrative poetry, features the Bhagavad Gita as a chapter that captures a philosophical conversation between Lord Krishna and Arjuna about duty and ethics (*karma* and *dharma*) in the context of the *Kurushetra war* (Rajagopalachari, 1970). The Bhagavad Gita shares the themes in a style similar to the Upanishads (Rao, 2002; Gough, 2013), a collection of philosophical and sacred texts from Hinduism that predates and also influenced Greek philosophy (Lomperis, 1984; Scharfstein, 1998). In the past, NLP has been utilized to decipher and evaluate translations of major Hindu texts. Chandra and Ranjan (2022) used BERT-based topic modelling to map the topics between the Bhagavad Gita and the *Upanishads*. Moreover, Chandra and Kulkarni (2022) implemented semantic and sentiment analysis on different translations of the Bhagavad Gita as a means to evaluate the quality of translations.

In May 2022, Google added support for the Sanskrit language in its addition of 24 languages (Caswell and Bapn, 2022) to *Google Translate*, making a total of 133 languages worldwide. The team developed a new monolingual language model learning approach for zero-resource translation (Siddhant et al., 2020); i.e., translation for languages with no in-language parallel text and no language-specific translation examples (Zhang and Zong, 2016; Zhao et al., 2015). The model was trained to learn representations of under-resourced languages directly from monolingual text using the *masked sequence-to-sequence* (MASS) task. MASS adopted the encoder–decoder framework for reconstructing a sentence fragment given the remaining part of the sentence. The encoder takes a sentence with a randomly masked fragment (several consecutive tokens) as input, and its decoder predicts the masked fragment (Song et al., 2019).

In the past, some studies have analyzed the translation quality of Google Translate using computational models. Xiaoning et al. (2008) used Google Translate in cross-lingual information retrieval in order to translate the queries from English to Chinese, where a Kullback–Leibler (KL) divergence model was used for information retrieval. Li et al. (2014) compared Google Translate with human (expert) translation for Chinese to English translation and reported that Google Translate was highly correlated with the human expert. Zand Rahimi et al. (2017) studied the English-Persian translation of Google Translate. Kalchbrenner and Blunsom (2013) compared the accuracy of machine translation and reported that NMT improved the semantic aspects of the translation, despite some limitations. Md Abdur et al. (2019) compared the English translations from *Baidu* and Google Translate and reported that there is a scope for improvement for both, and one is not necessarily superior to the other. Patil and Davies (2014) evaluated the accuracy of Google Translate in medical communication and found that Google Translate was not accurate when it comes to medical phrases, and hence should not be blindly trusted. The authors also found that European languages performed better than other languages and thus confirmed the presence of a translation bias. It is important to note that not many studies evaluated the quality of translations of Google Translate for low-resource languages (Ranathunga et al., 2021), i.e. languages with data scarcity such as Sanskrit.

In this paper, we present a framework that evaluates the quality of Google Translate by focusing on the Sanskrit language. In this study, we first published a Sanskrit-to-English translation of the Bhagavad Gita using Google Translate. Our proposed framework extends the methodology by Chandra and Kulkarni (2022) that compared selected translations of the Bhagavad Gita using semantic and sentiment analysis. This study performs sentiment analysis via a BERT-based model to compare the Bhagavad Gita translation by Google Translate with translation by known experts. We further extract keywords to analyze the central themes in the respective translations. Although the study's main aim is to evaluate the quality of Sanskrit translations by Google Translate, our framework is designed to be easily extended to other languages to evaluate Google Translate. Finally, we qualitatively evaluate selected Google Translate verses of the Bhagavad Gita with the help of a Sanskrit translator. The significance of the topics covered in the paper is in terms of the assessment of translation quality which has a wide range of implications in automatic and real-time translation systems. Poor translations can cause confusion, misinterpretations, and at times conflicts between individuals/organizations and it is essential for translation engines to be evaluated.

The rest of the paper is organized as follows. Section 2 provides an overview of the framework used for analysis. Section 3 presents the analysis of the results. Section 4 gives a detailed discussion, and Section 5 concludes the study.

2. Methodology

2.1. Data extraction and processing

The Bhagavad Gita is divided into 18 chapters, each containing a sequence of questions and answers between Lord Krishna and Arjuna on various subjects, including the philosophy of karma (action) and dharma (ethics and duty). This organization is symbolic because the Mahabharata war lasted 18 days (Rajagopalachari, 1970). In this study, we use three different Bhagavad Gita translations (Mahatma Gandhi Gandhi and Desai, 1946, Eknath Easwaran Easwaran, 1985, and Sri Purohit Swami Swami, 1937) to compare with the translation by Google Translate. We selected these prominent translations from different historical periods. In order to prevent any translation biases, we picked the translations where the translators were from a Hindu background. We processed the raw data from the three sets of translations using the methodology described by Chandra and Kulkarni (2022) where semantic and sentiment analysis was implemented for comparing selected translations of the Bhagavad Gita.

2.2. Google translate

Google Translate is a free-to-use web-based translation tool developed by Google in April 2006 (Och, 2006). It is a multi-lingual NMT that translates texts, websites, and documents from a given language to a target language as specified by the user (Sommerlad, 2021). Even though Google Translate (Och, 2006; Turovsky, 2016) has made significant advances in recent years (as of December 2022), it only covers 133 written languages all over the world (Google Translate Team, 2022). Note that Google Translate does not cater to automatic speech recognition i.e. spoken languages, it is a text-based translation tool. There are challenges faced by Google Translate due to data scarcity, the absence of digitized data for languages (low-resource languages), and the absence of translated texts. Hence, a roadblock exists in the development of functional translation models for low-resource languages such as

Sanskrit verse	Translated verse	Pre-Processed Verse
न मां कर्माणि लिम्पन्ति न मे कर्मफले स्पृहा ।इति मां योऽभिजानाति कर्मभिर्न स बध्यते ॥ १४ ॥	I am not tainted by Me, nor do I desire the fruits of my actions. 14	I am not tainted by Me, nor do I desire the fruits of my actions.
यदृच्छालाभसंतुष्टो द्वन्द्वातीतो विमत्सरः ।समः सिद्धावसिद्धौ च कृत्वापि न निबध्यते ॥ २२ ॥	He is satisfied with the gain of chance and is transcended by duality and free from envy and is equal to perfection and incompleteness and is not bound by doing so. 22	He is satisfied with the gain of chance and is transcended by duality and free from envy and is equal to perfection and incompleteness and is not bound by doing so.

Fig. 1. Original Sanskrit script (Devanagari) of the Bhagavad Gita with translation and further processing.

Sanskrit (Caswell and Liang, 2020). Sanskrit is an ancient language used for the composition of key Hindu texts; however, there are only about 24,821 Sanskrit speakers (based on the 2011 census McCartney, 2022) who are mostly in remote and rural communities of India. The lack of data is a problem for language identification models since it forces them to learn to translate from a limited monolingual text. To overcome these challenges, Google made several modifications to the basic architecture of Google Translate which included *back translation* to overcome the lack of parallel (translated) data (Caswell and Liang, 2020). *Back translation* is a localization quality control method where content is translated back to its original language and then compared to the source (Edunov et al., 2018).

2.3. Google translate - Bhagavad Gita

We translated all 18 chapters of the Bhagavad Gita from Sanskrit to English using the Google Translate's *application programmer interface* (API). We extracted all the verses from the Sanskrit Bhagavad Gita[2] available on the *Bhaktivedanta Vedabase* from Swami Prabhupada who translated the Bhagavad Gita in 1968 (Prabhupada, 1972). Note that the Sanskrit language is written using the Devanagari script (Bright, 1996) which can be directly used as an input to Google Translate API. We pre-processed the data with the following steps:

1. Arranged the verses chapter-wise in different files;
2. Removed verse numbering in Bhagavad Gita;
3. Converted verses to a single line;
4. Added the original Sanskrit version to the file.

Fig. 1 shows an example of the above pre-processing process. It shows the Sanskrit script (Devanagari) of the Bhagavad Gita with processed translation. Finally, we published the translation by Google Translate online via Github.[3]

2.4. Sentiment and semantic analysis

A word embedding is used for the representation of words from the text in the form of a real-valued vector so that it can be used for processing by statistical and deep learning models (Li and Yang, 2018). The real-valued vectors used for word embedding are selected to preserve the semantic and syntactic qualities of the word appearing in a text corpus (Ghannay et al., 2016). A number of word embedding models exist that have certain strengths and weaknesses (Wang et al., 2019). Mikolov et al. (2013) introduced *Word2Vec* model for word embedding using a shallow neural network model. Thus, a simple cosine function can be used to test the level of similarity between two words. Cosine similarity is a metric to measure the text similarity between two documents irrespective of their size. A word is represented in a vector form and the text documents are represented in n-dimensional vector space. The cosine similarity metric measures the cosine of the angle between two n-dimensional vectors projected in a multi-dimensional space.

BERT is a transformer-based model introduced by Devlin et al. (2018) to capture contextual information in a word or a sentence using masked language modelling (MLM). Note that BERT is a pre-trained model that has been trained from unlabelled data extracted from the *BooksCorpus* featuring 800 million words, and the *English Wikipedia* featuring 2,500 million words. Since BERT gives context-enriched embedding, it outperformed traditional NLP models such as Word2Vec on text processing tasks such as semantic and sentiment analysis (Shen and Liu, 2021). The word embeddings generated by Word2Vec are context-independent and cannot address the problem of polysemous words (Shen and Liu, 2021). The embedding generated by BERT, on the other hand, is context-dependent, i.e., the same word can have multiple vector representations depending upon the context in which it is being used (Shen and Liu, 2021).

Sentiment analysis, also referred to as opinion mining and emotion analysis, identifies the emotional tone behind a body of text (Medhat et al., 2014). Recent innovations involve machine learning and deep learning to mine text for sentiment, and subjective information (Zhang et al., 2018). Sentiment analysis systems help in gathering insights from unorganized and unstructured text. It can be applied to varying scopes such as document, paragraph, sentence, and sub-sentence levels (Medhat et al., 2014). There are primarily three different types of approaches currently in use for performing sentiment analysis. Rule-based sentiment analysis approaches are based on predefined lexicon-based rules (Asghar et al., 2017); whereas, automatic sentiment analyst approaches are based on models that learn from data, i.e. machine learning (Mohammad, 2016). Finally, hybrid sentiment analysis approaches combine rule-based and automatic approaches (Appel et al., 2016). In addition to identifying sentiment, it can also extract the polarity (i.e. the measure of positivity and negativity), and the subject and opinion holder within the text (Feldman, 2013).

Semantic analysis, on the other hand, is the process of drawing meaning from text. Semantic analysis is key to contextualization that helps disambiguate language data so that text-based NLP applications can be more accurate (Goddard, 2011). It allows computers to understand and interpret text by analyzing their grammatical structure and identifying relationships between individual words in a particular context (Nasukawa and Yi, 2003). It is the driving force behind machine learning tools such as chatbots, search engines, and text analysis applications (Medhat et al., 2014; Maulud et al., 2021).

2.5. Framework

We present a framework that compares translations and implements sentiment and semantic analysis, adopted from Chandra and Kulkarni (2022) (Fig. 2). We utilize this framework by comparing the Bhagavad Gita translated from Sanskrit to English by Google Translate with three expert-based translations. Our framework provides further insights into the various themes discussed by these different translations. We extracted the Bhagavad Gita Sanskrit slokas (verses) from Bhaktivedanta

[2] https://vedabase.io/en/library/bg/1/1/

[3] https://github.com/sydney-machine-learning/Google-Sanskrit-translate-evaluation/tree/main/BG-Google-Translated

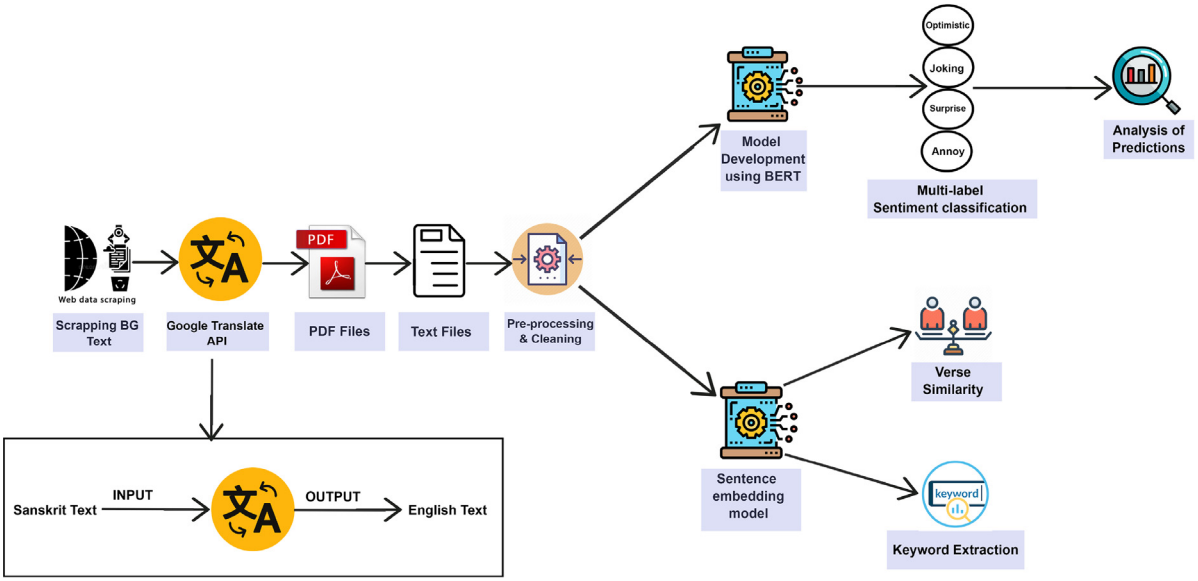


Fig. 2. Framework showing major components that include using Google Translate for translating the original Sanskrit version of the Bhagavad Gita to English. We use semantic and sentiment analysis to compare the Google Translate version with translations from the literature that includes translations by Mahatma Gandhi and Eknath Easwaren.

Vedabase[4] using web data scrapping process and use the text as input to the Google Translate API, which gives the corresponding English translated text as an output. We then store the output as text and printable document format (PDF) format. Afterwards, we use the text files for pre-processing, where we remove verse numbers, symbols, etc. Our framework implements the BERT-base model for sentiment analysis by predicting the sentiments of different verses of the four translations. We use multi-label sentiment classification in our framework where a verse can be both empathetic and optimistic, simultaneously. We then train our sentiment analysis component in the framework using an expert-labelled *SenWave* dataset (Yang et al., 2020) which features 10 different sentiments labelled by a group of 50 experts for 10,000 tweets worldwide during the COVID-19 pandemic. We fine-tuned (trained) the BERT-base sentiment analysis model using the SenWave dataset so that it can recognize the respective sentiments in a multi-label setting, originally used for COVID-19 sentiment analysis (Chandra and Krishna, 2021) and for Bhagavad Gita sentiment analysis (Chandra and Kulkarni, 2022). The conventional sentiment polarity score has ambiguity due to varied expressions that feature metaphor, humour, and expressions hard for machines to understand. Hence, multi-label sentiment classification provides further insights. We compare verse-by-verse and chapter-by-chapter sentiments of the chosen translations as shown in Fig. 2.

Furthermore, we apply semantic analysis to reveal the variations in the translations so that we get an indication of how similar or different the expert-based translations are when compared to the Google Translate version of the Bhagavad Gita. We perform semantic analysis through a sentence embedding model (MPNet (Song et al., 2020)) which is based on the BERT model as shown in the framework (Fig. 2). MPNet sentence embedding model generates high-quality embedding for our encoded verses of the Bhagavad Gita. We use the *uniform manifold approximation and projection* (UMAP) (McInnes et al., 2018) dimensionality reduction technique to visualize the high-dimensional vectors. We investigate the nature in terms of the similarity of the chapters based on data visualization through the plot of the first two dimensions obtained from UMAP.

Furthermore, we extract keywords from the text to examine the major topics using *KeyBERT* which provides the keywords that describe significant themes (Fig. 2). We note that various other techniques can be used, such as *rapid automatic keyword extraction* (RAKE) (Rose et al., 2010), *yet another keyword extractor* (YAKE) (Campos et al., 2020), and term frequency-inverse document frequency (TF-IDF) (Salton, 1984). However, these are based on statistical characteristics, unlike KeyBERT which is based on the semantic similarity of the text. Hence, we use KeyBERT as it considers the text's semantic aspects.

2.6. Experimental setup

We train the BERT (base) model on the SenWave dataset by pre-processing the tweets as done by Chandra and Kulkarni (2022). We utilize a trained model from a previous study about sentiment analysis of the Bhagavad Gita (Chandra and Kulkarni, 2022) via the GitHub repository.[5] The SenWave dataset consists of 10,000 tweets that were labelled according to 10 different sentiments by experts. The additional label known as "official report" about COVID-19 was deleted in data processing. This is a multi-label sentiment classification problem where the tweets express emotions such as "optimistic", "pessimistic", "anxious", and "thankful" and more than one sentiment label can be found in a tweet, simultaneously.

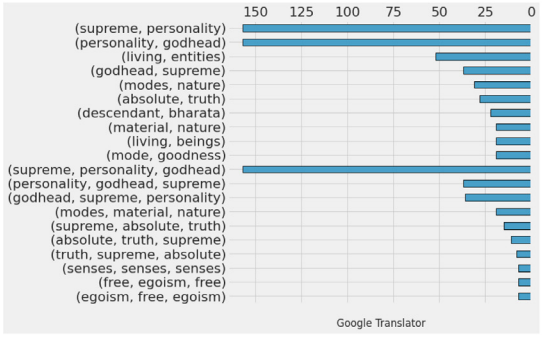
3. Results

3.1. Data analysis

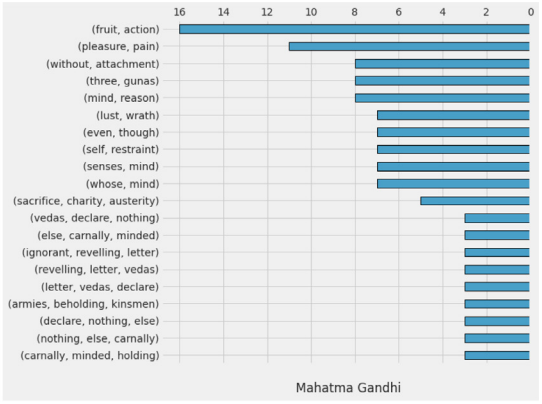
The *n-gram* (Robertson and Willett, 1998) in NLP provides a statistical overview of a text through a continuous sequence of words and elements. We first present the top-ten *bigrams* and *trigrams* for the different Bhagavad Gita translations (including Google Translate) as shown in Fig. 3. We observe that the concept of a "supreme spirit", or the "Atman" is mentioned in all the translations, but the path taken to achieve this realization varies between them. Eknath Easwaran's translation 3(c) features bigrams [supreme, goal], [selfless, service], and [selfish, attachment], thus stressing the importance of selfless service devoid of selfish attachments and desires. We note that Chapter 3 is titled "Selfless Service" by Eknath Easwaran's translation. The Google Translate version in Fig. 3(a) features the bigrams [supreme, personality], [personality, godhead] which overlap with top bigrams

[4] https://vedabase.io/en/library/bg/1/1/

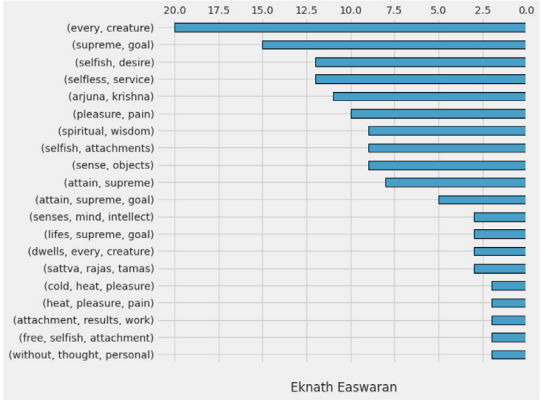
[5] https://github.com/sydney-machine-learning/sentimentanalysis_bhagavadgita



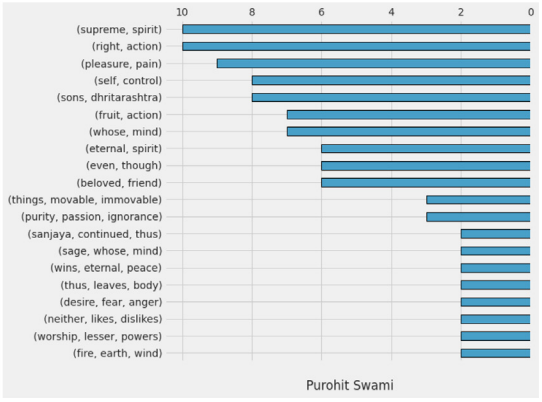
(a) The Bhagavad Gita translations by Google Translate.



(b) The Bhagavad Gita translation by Mahatma Gandhi.



(c) The Bhagavad Gita translation by Eknath Easwaran.



(d) The Bhagavad Gita translation by Sri Purohit Swami.

Fig. 3. Visualizations of top 10 bigrams and trigrams for different Bhagavad Gita translations.

in Eknath Eashwaren and Sri Purohit Swami, which distinguishes the Mahatma Gandhi translation.

In general, the different translations have used slightly different combinations of words to describe similar themes. Google Translate features [supreme, personality], [personality, godhead], and [living, entities] as the top 3 bigrams and different permutations of [supreme, personality, godhead] as the top 3 trigrams. Mahatma Gandhi's translation features [fruit, action], [pleasure, pain], and [without, attachment] as the top three bigrams and [sacrifice, charity, austerity], [vedas, declare, nothing] and [else, carnality, minded] as the top three tri-grams. Eknath Easwaran's translation features [every, creation], [supreme, goal], and [selfish, desire] as the top three bigrams and [attain, supreme, goal], [senses, mind, intellect] and [dwells, every, creation] as the top three trigrams. Shri Purohit Swami's translation features [supreme, spirit], [right, action], and [pleasure, pain] as the top three bigrams and [thing, movable, immovable], [purity, passion, ignorance] and [sanjaya, continued, thus] as the top three trigrams. Hence, a mere word-to-word comparison through bigrams and trigrams reflects differences in the translations.

3.2. Sentiment analysis

Next, we use the BERT model for verse-by-verse sentiment analysis of the respective Bhagavad Gita translations.

We visualize chapter-wise sentiment analysis for all four translations as depicted by Figs. 5 and 6 along with cumulative sentiment analysis for all the chapters as depicted by Fig. 4. In cumulative sentiment analysis (Fig. 4), we observe that *thankful*, *anxious*, *sad*, and *denial* are the least expressed sentiments across all four translations, whereas *optimistic* is the most expressed. We also observe that sentiments *surprise* and *annoyed* are under-expressed. In contrast, sentiment *empathetic* is over-expressed by Google Translate when compared to the other

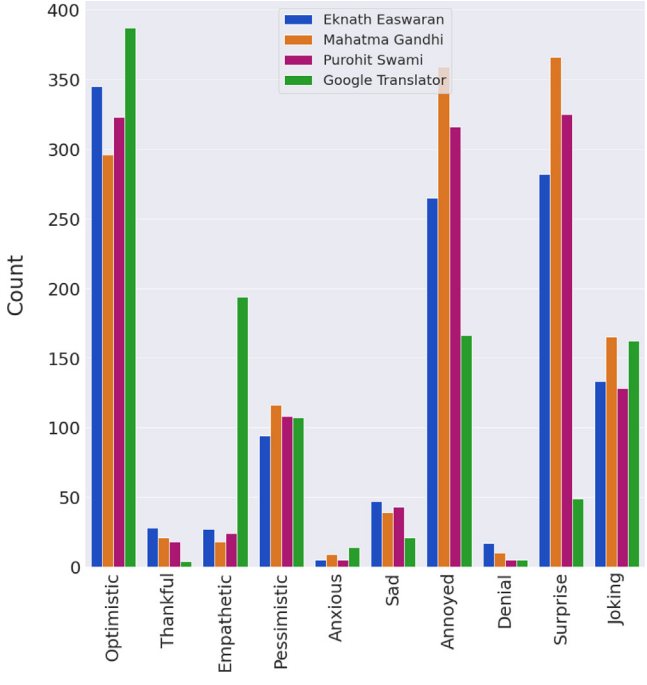


Fig. 4. Cumulative sentiments of the chapters.

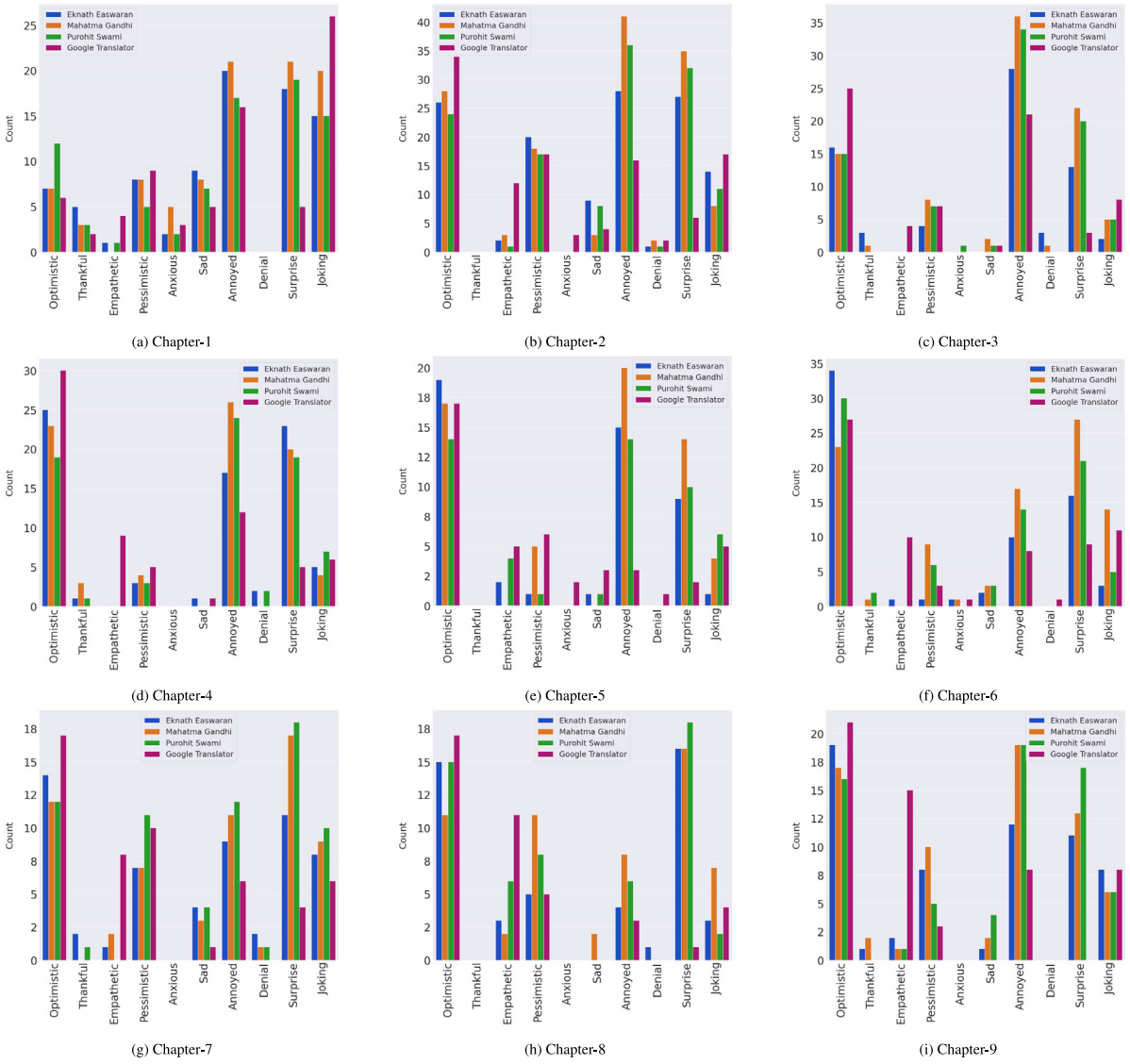


Fig. 5. Chapter-wise sentiment analysis of Chapter 1–Chapter 9.

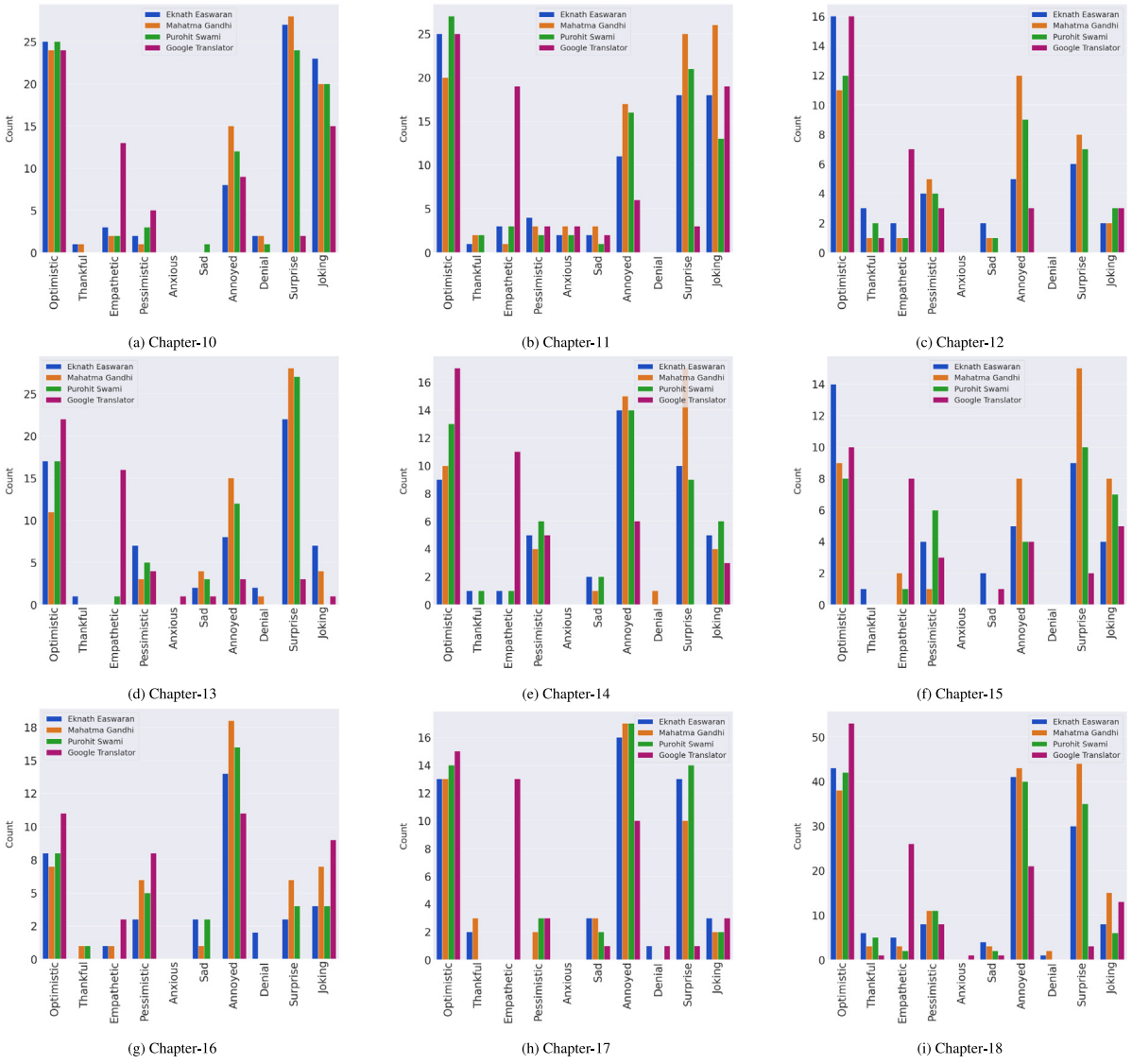
three translations. The sentiments *optimistic*, *pessimistic*, *joking*, and *anxious* are equally expressed in all four translations. We further note that *optimistic*, and *empathetic* are the leading sentiments for Google Translate while *annoyed*, *pessimistic* and *surprise* are leading sentiments for Mahatma Gandhi's version. This indicates that Google Translate leads to optimistic sentiments and Mahatma Gandhi's version leads to pessimistic sentiments.

Fig. 7 displays a heat map showing the frequency of a specific sentiment in each translation of all the verses compared to the other sentiments. We observe that in the case of Google Translate in Fig. 7(a), *empathetic* is the key sentiment in addition to the sentiments *optimistic*, *annoyed* and *joking*, which are key sentiments for the rest of the three translations as shown by Figs. 7(b)–7(d). We further observe that the sentiment combination [*optimistic*, *empathetic*] are the leading combinations of sentiments of Google Translate. In the other three versions, the leading combinations of sentiments are [*annoyed*, *surprise*] followed by [*surprise*, *optimistic*] and [*annoyed*, *optimistic*]. It is also important to note that for Google Translate, the sentiments such as *thankful* and *denial* are the least expressed sentiments. In contrast, the sentiments such as *denial* and *anxious* are the least expressed sentiments in the other three versions.

Finally, we measure the diversity and similarity of sentiments expressed with verse-by-verse comparison for all four translations. Table 1 shows the Jaccard similarity score computed on the predicted sentiments for three pairs of texts focusing on Google Translate (GT) for the selected chapters. The score is highest for Eknath Easwaran and Google Translate (GT-Easwaren), indicating they had the highest overlap in the predicted sentiments. The comparison of Gandhi-Easwaren presents the baseline from a previous study by Chandra and Kulkarni (2022). We find that GT-Easwaren has a much lower score, hence a much lower similarity. This indicates that Google Translate has not been as effective as human experts in translating the Bhagavad Gita.

3.3. Semantic analysis

Next, we provide the semantic analysis of the texts and compare the four translations. Using the MPNet-base model, we encode all the verses and present the verse-by-verse cosine similarity, grouped by chapter, for the three translations with Google Translate. We report both the mean and standard deviation of the score. In Table 2, we observe that Chapter 3 is semantically most similar, whereas Chapter 17 is semantically least similar. Further, in the pair-wise comparison, Google Translate and Shri Purohit Swami's translations are most similar. These two translations also have the highest Jaccard similarity score for the predicted sentiments (Table 1). We finally compare Gandhi-Easwaren to show a baseline from previous study (Chandra and Kulkarni, 2022),



(a) Chapter-10 (b) Chapter-11 (c) Chapter-12

(d) Chapter-13 (e) Chapter-14 (f) Chapter-15

(g) Chapter-16 (h) Chapter-17 (i) Chapter-18

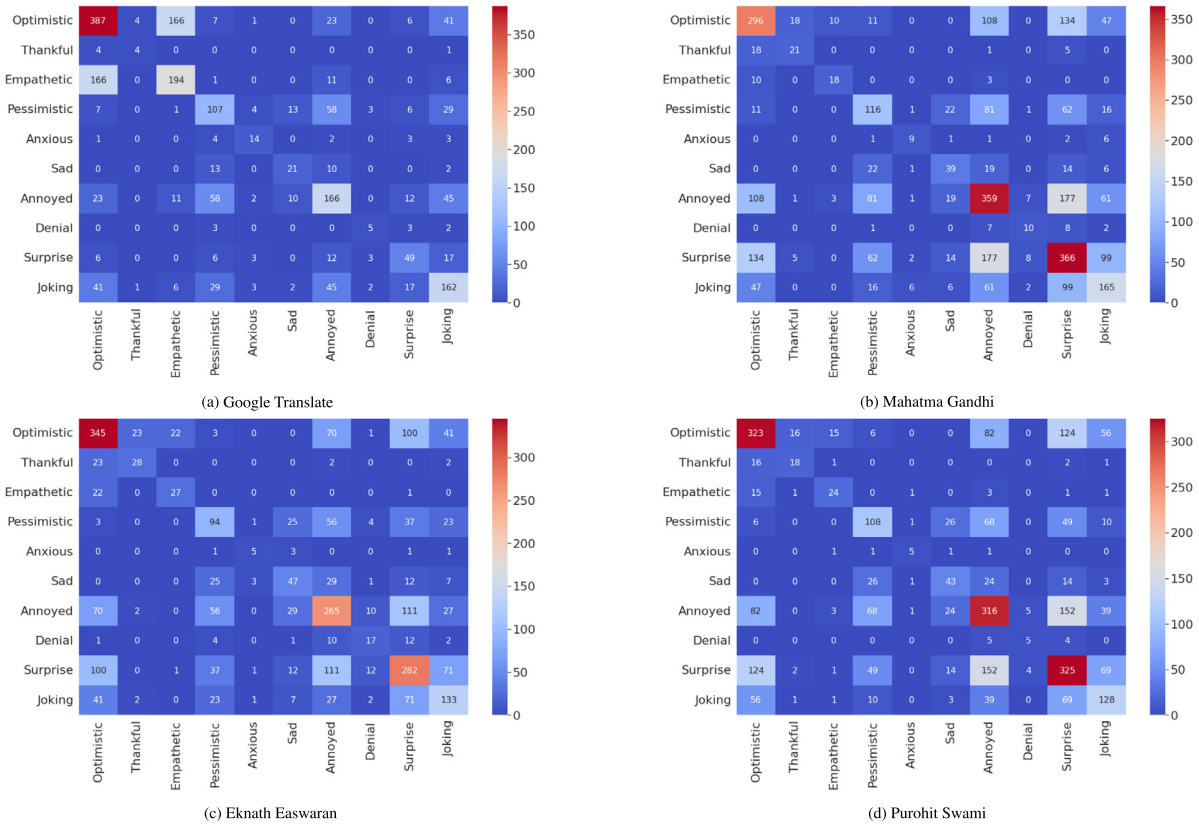
Fig. 6. Chapter-wise sentiment analysis of Chapter 10–Chapter 18.

Table 1
Sentiment analysis of selected pairs of translations by Google Translate (GT) with Jaccard similarity score of the predicted sentiments for selected Chapters. We provide the mean of the scores at the bottom and a lower score indicates lower similarity. The comparison of Gandhi–Easwaren shows the baseline from the previous study (Chandra and Kulkarni, 2022).

Chapters	GT-Gandhi	GT-Purohit	GT-Easwaren	Gandhi–Easwaren
Chapter 3	0.42	0.388	0.412	0.604
Chapter 5	0.374	0.373	0.401	0.568
Chapter 7	0.353	0.363	0.393	0.559
Chapter 8	0.341	0.362	0.377	0.547
Chapter 9	0.331	0.353	0.348	0.501
Chapter 10	0.324	0.351	0.357	0.523
Chapter 11	0.309	0.324	0.350	0.507
Chapter 12	0.315	0.323	0.357	0.500
Chapter 15	0.309	0.319	0.354	0.494
Chapter 16	0.316	0.328	0.359	0.500
Chapter 17	0.323	0.332	0.355	0.510
Average	**0.338**	**0.347**	**0.369**	**0.526**

Table 2
Semantic analysis using cosine similarity score for comparing selected chapter pairs of the translations. The mean score is given with standard deviation (in brackets) for all the verses in the respective chapters at the bottom (*). The lower score indicates less similarity. The comparison of Gandhi–Easwaren shows the benchmark from the previous study (Chandra and Kulkarni, 2022).

Chapters	GT-Gandhi	GT-Purohit	GT-Easwaren	Gandhi–Easwaren
Chapter 3	0.52(0.156)	0.58(0.148)	0.59(0.120)	0.63(0.133)
Chapter 5	0.34(0.082)	0.61(0.133)	0.51(0.187)	0.63(0.129)
Chapter 7	0.35(0.194)	0.56(0.232)	0.35(0.100)	0.70(0.144)
Chapter 8	0.36(0.086)	0.34(0.104)	0.38(0.098)	0.66(0.123)
Chapter 9	0.33(0.108)	0.36(0.113)	0.35(0.103)	0.68(0.126)
Chapter 10	0.33(0.121)	0.37(0.118)	0.38(0.093)	0.76(0.096)
Chapter 11	0.36(0.118)	0.38(0.108)	0.38(0.105)	0.71(0.109)
Chapter 12	0.35(0.122)	0.40(0.159)	0.35(0.118)	0.61(0.120)
Chapter 15	0.40(0.135)	0.39(0.129)	0.37(0.142)	0.69(0.116)
Chapter 16	0.38(0.126)	0.37(0.128)	0.41(0.089)	0.66(0.096)
Chapter 17	0.30(0.077)	0.35(0.128)	0.33(0.115)	0.65(0.111)
Average	**0.34(0.111)**	**0.43(0.142)**	**0.40(0.110)**	**0.67(0.119)**



(a) Google Translate (b) Mahatma Gandhi

(c) Eknath Easwaran (d) Purohit Swami

Fig. 7. Heat Map of different Bhagavad Gita translations showing the correlatons between the two major sentiments in multi-label classification.

where we find that GT-Easwaren has a much lower similarity that shows that Google Translate has not been as effective when compared to human experts.

Next, we present some of the semantically most similar verses in Table 3. In Chapter 3 - Verse 13, we observe that all translations have conveyed a similar meaning; however, the choice of words is different. Our framework assigns a high similarity score to all three pairs. In Chapter 11 - Verse 21 and Chapter 12 - Verse 19, we observe that Google Translate and Eknath Easwaran have used somewhat similar words and thus have obtained a higher similarity score (Score 2). We present some of the semantically least similar verses in Table 4. We observe that for Chapter 12 - Verse 19, Google Translate and Eknath Easwaran convey very different themes and thus have been given a very low similarity score.

In addition, we examine the semantic score by showing actual verses from translated versions of a chosen chapter. We select Chapter 12 because it includes the least verses, making it easier to include it in the paper. Table 5 presents arbitrarily selected verses from Chapter 12 with the cosine similarity score. We also present the mean and standard deviation of the scores to give a sense of the general semantic similarity of the verses in the chapter for the comparison of chosen translations.

4. Qualitative evaluation

We further evaluate selected verses from Google Translate in comparison with expert translations, with the help of a Sanskrit researcher, Sushrut Badhe[6] who has published a translation of the Bhagavad Gita in 2015 (Badhe, 2015). The unique part of this translation was that the rhythm and rhyme were maintained in the English translation following the original Sanskrit version. We note that the rhythm and rhyme are the key attributes of the Bhagavad Gita in Sanskrit since it was written to be sung and remembered through oral traditions for thousands of years. In consultation with Sushrut Badhe, we provide the following analyses of selected chapters and verses included in the paper.

4.1. Semantically most similar verses

Table 3, we show selected semantically most similar verses using three expert translations (Gandhi, Easwaren, and Swami) and Google Translate (GT), with accompanying original Sanskrit verses in Fig. 8. In Chapter 3: Verse 13, we find that both GT-Gandhi (i.e. GT vs Gandhi) and GT-Swami are more semantically similar than GT-Easwaran. However, the GT version merges both lines of the verse and gives a confusing answer and loses contextual significance entirely. The original Sanskrit verse (Chapter 3: Verse 13) of the Bhagavad Gita implies that those who consume the food that is a remainder after performing sacrifice are freed of all their sins, whereas those who cook and consume only for themselves end up consuming only sin. We find that Google Translate conveys the wrong meaning. The word *santo*, which is significant and refers to the saints and spiritual-minded people; has been omitted arbitrarily in the translation. The translations of Easwaran, Gandhi, and Swami, though semantically dissimilar do not lose contextual significance.

In Chapter 8: Verse 21 of Table 3, the values of cosine similarity for all three combinations are nearly equal with GT-Easwaran showing the maximum semantic similarity. In this case, all four translations are contextually significant. Google Translate has accurately translated the word *punyo* (Fig. 8) as “pious” . Easwaren and Gandhi have translated it as “sweet”, whereas Swami has omitted its translation. In this verse, Google Translate appears to be the most accurate. In Chapter 11: Verse 21, both GT-Swami and GT-Easwaran are more semantically similar than GT-Gandhi. The translations of Easwaren, Gandhi and Swami are contextually significant. The GT version is incorrect and bereft of logical sense or contextual significance.

[6] https://en.wikipedia.org/wiki/Sushrut_Badhe

Table 3
Semantically most similar verses using the cosine similarity (score) using selected translations for comparison (Gandhi, Easwaren, Swami) vs Google Translate (GT).

Chapter	Verse	GT	Gandhi	Easwaran	Swami	GT-Gandhi	GT-Easwaran	GT-Purohit
3	13	Those who eat the remains of the sacrifice are freed from all sins and enjoy the sins of the sinners who cook for their own sake	The righteous men who eat the residue of the sacrifice are freed from all sin, but the wicked who cook for themselves eat sin.	The spiritually minded, who eat in the spirit of service, is freed from all their sins; but the selfish, who prepare food for their own satisfaction, eat sin.	The sages who enjoy the food that remains after the sacrifice is made are freed from all sin: but the selfish who spread their feast only for themselves feed on sin only.	0.919	0.705	0.836
7	9	I am pious and fragrance on the earth and I am the effulgence of fire and I am the life of all living beings and I am the austerities of all living beings.	I am the sweet fragrance in earth; the brilliance in fire; the life in all beings; and the austerity in ascetics.	I am the sweet fragrance in the earth and the radiance of fire; I am the life in every creature and the striving of the spiritual aspirant.	I am the Fragrance of earth, the Brilliance of fire. I am the Life Force in all beings, and I am the Austerity of the ascetics.	0.862	0.873	0.855
12	12	Knowledge is the best way to practice knowledge and meditation is superior to meditation. From meditation, renunciation of the fruits of action is attained by renunciation.	Better is knowledge than practice, better than knowledge is concentration, better than concentration is renunciation of the fruit of all action, from which directly issues peace.	Better indeed is knowledge than mechanical practice. Better than knowledge is meditation. But better still is surrender of attachment to results, because there follows immediate peace.	Knowledge is superior to blind action, meditation to mere knowledge,renunciation of the fruit of action to meditation, and where there is renunciation peace will follow.	0.681	0.739	0.813
17	16	The mind, grace, silence, self-control and self-control is called the mental state of self-realization.	Serenity, benignity, silence, self-restraint, and purity of the spirit—these constitute austerity of the mind.	Calmness, gentleness, silence, self-restraint, and purity: these are the disciplines of the mind.	Serenity, kindness, silence, self-control and purity – this is austerity of mind.	0.569	0.669	0.554

Table 4
Semantically least similar verses using the cosine similarity (score) using selected comparisons (Gandhi, Easwaren, Swamni) vs Google Translate (GT).

Chapter	Verse	GT	Gandhi	Easwaran	Swami	GT-Gandhi	GT-Easwaran	GT-Swami
11	41	O Krishna, I thought that I was a friend, O Krishna, O friend of the demigods.	If ever in carelessness, thinking of You as comrade, I addressed You saying, 'O Krishna!', 'O Yadava!' not knowing Your greatness, in negligence or in affection,	Sometimes, because we were friends, I rashly said, Oh, Krishna! Say, friend! casual, careless remarks. Whatever I may have said lightly, whether we were playing or resting, alone or in company, sitting together or eating,	Whatever I have said unto You in rashness, taking You only for a friend and addressing You as 'O Krishna! O Yadava! O Friend!' in thoughtless familiarity, no understanding Your greatness;	0.36	0.38	0.48
17	26	This is used in the same way as the truth, O son of Pth, and in the praiseworthy action, which is used in the same way as the words of the Lord.	SAT is employed in the sense of 'real' and 'good'; O Arjuna, SAT is also applied to beautiful deeds.	Sat means that which is; it also indicates goodness. Therefore it is used to describe a worthy deed.	'Sat' means Reality or the highest Good, and also, O Arjuna, it is used to mean an action of exceptional merit.	0.37	0.39	0.36

In Chapter 12: Verse 19 of Table 3, GT-Swami and GT-Easwaran are more semantically similar than GT-Gandhi. The translations of Gandhi, Easwaren, and Swami are contextually significant. GT version, *"Knowledge is best way to practice knowledge and meditation is superior to meditation. From meditation, renunciation of fruits of actions is attained by renunciation".*, is bereft of logic and contextual significance.

In Chapter 17: Verse 16 of Table 3, GT-Easwaran is most semantically similar. The translations of Easwaren, Gandhi and Swami are contextually significant. GT version has only literal word-to-word translation which does not convey a clear meaning and lacks contextual significance. The word *manaprasada* (Fig. 8) is wrongly translated as "the mind, grace" and this affects the logical meaning of the translation.

4.2. Semantically less similar verses

Table 4 presents selected less similar verses, having low cosine scores of semantic similarity with the original shown in Fig. 9. In both verses, we find that GT only gave a literal translation that was of no contextual significance or meaning.

In Chapter 11: Verse 41 of Table 4, GT-Swami is most similar in terms of its cosine value of semantic similarity. The GT version, *"O Krishna, I thought that I was a friend, O Krishna, O friend of the demigods"*, does not convey a logical sense and is incorrect.

In Chapter 17: Verse 26, GT-Easwaran is most similar in terms of its cosine value of semantic similarity. The Google Translate version, *"This is used in the same way as the truth, O son of Pritha, and in the praiseworthy action, which is used in the same way as the words of the Lord".*, lacks both logic and contextual significance.

4.3. Chapter 12: Arbitrarily selected verses

Chapter 12 of the Gita is considered to be one of the important chapters as it contains the verses that are relevant to the crux of the teaching of the Gita – the way of *bhakti* (devotion). We review five arbitrary verses from Chapter 12 (Table 5). In general, we find that the translations of Easwaren, Gandhi and Swami did not lose contextual significance. However, on the contrary, we find that GT conveyed no contextual meaning in all five verses.

Chapter 12: Verse 1, GT-Swami is most similar in terms of its cosine value of semantic similarity. The translations of Easwaren, Gandhi and Swami are contextually significant. The GT version, *"Those devotees who are constantly engaged in worshipping You, who are also the most unmanifest of the unmanifest, who are the best in yoga?"* is bereft of logical or contextual significance.

Chapter 12: Verse 8, GT-Easwaran is most similar in terms of its cosine value of semantic similarity. The GT version, *"Concentrate on*

Table 5
Semantic similarity of verses selected from Chapter 12 with cosine similarity (score) using selected translations (Gandhi, Easwaren, Swamni) to compare with Google Translate (GT). We also provide the score mean and standard deviation (in brackets) of the scores at the bottom (*).

Chapter	Verse	GT	Gandhi	Easwaran	Swami	GT-Gandhi	GT-Easwaran	GT-Swami
12	1	Arjuna said: Those devotees who are thus constantly engaged in worshiping You, who are also the most unmanifest of the unmanifest, who are the best in yoga?	Of the devotees who thus worship You, incessantly attached, and those who worship the Imperishable Unmanifest, which are the better yogins? The Lord Said:	ARJUNA Of those steadfast devotees who love you and those who seek you as the eternal formless Reality, who are the more established in yoga?	"Arjuna asked: My Lord! Which are the better devotees who worship You, those who try to know You as a Personal God, or those who worship You as Impersonal and Indestructible?	0.52	0.68	0.70
12	8	Concentrate on Me in Me in Me, fix your mind on Me. You will live in Me. In Me alone, there is no doubt that there is no doubt about it.	On Me set your mind, on Me rest your conviction; thus without doubt shall you remain only in Me hereafter.	Still your mind in me, still your intellect in me, and without doubt you will be united with me forever.	Then let your mind cling only to Me, let your intellect abide in Me; and without doubt you shall live hereafter in Me alone.	0.61	0.67	0.60
12	13	He is not hated by all living beings, friendly and compassionate.	Who has ill-will towards none, who is friendly and compassionate, who has shed all thought of 'mine' or 'I', who regards pain and pleasure alike, who is long-suffering;	That one I love who is incapable of ill will, who is friendly and compassionate. Living beyond the reach of I and mine and of pleasure and pain,	He who is incapable of hatred towards any being, who is kind and compassionate, free from selfishness, without pride, equable in pleasure and in pain, and forgiving,	0.34	0.21	0.39
12	15	He who is freed from all joy, anger, fear and anxiety, who is not afraid of the world and who is not afraid of this world.	Who gives no trouble to the world, to whom the world causes no trouble, who is free from exultation, resentment, fear and vexation,—that man is dear to Me.	Not agitating the world or by it agitated, they stand above the sway of elation, competition, and fear: that one is my beloved.	He who does not harm the world, and whom the world cannot harm, who is not carried away by any impulse of joy, anger or fear, such a one is My beloved.	0.70	0.50	0.70
12	20	Those who worship this nectar of religious principles as described above are very dear to Me and are very dear to Me.	They who follow this essence of dharma, as I have told it, with faith, keeping Me as their goal,—those devotees are exceeding dear to Me.	Those who meditate upon this immortal dharma as I have declared it, full of faith and seeking me as lifes supreme goal, are truly my devotees, and my love for them is very great.	Verily those who love the spiritual wisdom as I have taught, whose faith never fails, and who concentrate their whole nature on Me, they indeed are My most beloved."	0.69	0.61	0.66

Chapter	Verse	Devanagari	English Transliteration
3	13	यज्ञशिष्टाशिनः सन्तो मुच्यन्ते सर्वकिल्बिषैः। भुञ्जते ते त्वघं पापा ये पचन्त्यात्मकारणात्।।	yajñaśiṣṭāśinaḥ santo mucyante sarvakilbiṣaiḥ bhuñjate te tv aghaṃ pāpā ye pacanty ātmakāraṇāt
7	9	पुण्यो गन्धः पृथिव्यां च तेजश्चास्मि विभावसौ। जीवनं सर्वभूतेषु तपश्चास्मि तपस्विषु।।	puṇyo gandhaḥ pṛthivyāṃ ca tejaś cāsmi vibhāvasau jīvanaṃ sarvabhūteṣu tapaś cāsmi tapasviṣu
12	12	श्रेयो हि ज्ञानमभ्यासाज्ज्ञानाद्ध्यानं विशिष्यते। ध्यानात्कर्मफलत्यागस्त्यागाच्छान्तिरनन्तरम् ।।	śreyo hi jñānam abhyāsāj jñānād dhyānaṃ viśiṣyate dhyānāt karmaphalatyāgas tyāgāc chāntir anantaram
17	16	मनःप्रसादः सौम्यत्वं मौनमात्मविनिग्रहः। भावसंशुद्धिरित्येतत्तपो मानसमुच्यते।।	manaḥprasādaḥ saumyatvaṃ maunam ātmavinigrahaḥ bhāvasaṃśuddhir ity etat tapo mānasam ucyate

Fig. 8. An extension of semantically most similar verses across translations in Table 3 showing original Sanskrit verses from the Bhagavad Gita (Prabhupada, 1972) in Devanagari and English transliteration.

Chapter	Verse	Devanagari	English Transliteration
11	41	सखेति मत्वा प्रसभं यदुक्तं हे कृष्ण हे यादव हे सखेति। अजानता महिमानं तवेदं मया प्रमादात्प्रणयेन वापि।।	sakheti matvā prasabhaṃ yad uktaṃ he kṛṣṇa he yādava he sakheti ajānatā mahimānaṃ tavedaṃ mayā pramādāt praṇayena vāpi
17	26	सद्भावे साधुभावे च सदित्येतत्प्रयुज्यते। प्रशस्ते कर्मणि तथा सच्छब्दः पार्थ युज्यते।।	sadbhāve sādhubhāve ca sad ity etat prayujyate praśaste karmaṇi tathā sacchabdaḥ pārtha yujyate

Fig. 9. Semantically least similar verses across translations in Table 4 showing original Sanskrit verses from the Bhagavad Gita (Prabhupada, 1972) in Devanagari and English transliteration.

Chapter	Verse	Devanagari	English Transliteration
12	1	एवं सततयुक्ता ये भक्तास्त्वां पर्युपासते। येचाप्यक्षरमव्यक्तं तेषां के योगवित्तमाः।।	evaṃ satatayuktā ye bhaktās tvāṃ paryupāsate ye cāpy akṣaram avyaktaṃ teṣāṃ ke yogavittamāḥ
12	8	मय्येव मन आधत्स्व मयि बुद्धिं निवेशय। निवसिष्यसि मय्येव अत ऊर्ध्वं न संशयः।।	mayy eva mana ādhatsva mayi buddhiṃ niveśaya nivasiṣyasi mayy eva ata ūrdhvaṃ na saṃśayaḥ
12	13	अद्वेष्टा सर्वभूतानां मैत्रः करुण एव च। निर्ममो निरहङ्कारः समदुःखसुखः क्षमी।।	adveṣṭā sarvabhūtānāṃ maitraḥ karuṇa eva ca nirmamo nirahaṃkāraḥ samaduḥkhasukhaḥ kṣamī
12	15	यस्मान्नोद्विजते लोको लोकान्नोद्विजते च यः। हर्षामर्षभयोद्वेगैर्मुक्तो यः स च मे प्रियः।।	yasmān nodvijate loko lokān nodvijate ca yaḥ harṣāmarṣabhayodvegair mukto yaḥ sa ca me priyaḥ
12	20	ये तु धर्म्यामृतमिदं यथोक्तं पर्युपासते। श्रद्दधाना मत्परमा भक्तास्तेऽतीव मे प्रियाः।।	ye tu dharmyāmṛtam idaṃ yathoktaṃ paryupāsate śraddadhānā matparamā bhaktās tetīva me priyāḥ

Fig. 10. Semantic similarity of verses selected from Chapter 12 across translations given in Table 5 showing original Sanskrit verses from the Bhagavad Gita (Prabhupada, 1972) in Devanagari and English transliteration.

Me in Me in Me, fix your mind in Me. You will live in Me. In Me alone, there is doubt that there is no doubt about it" does not make any sense and is also incorrect.

Chapter 12: Verse 13, GT-Swami is most similar in terms of its cosine value of semantic similarity. The translations of Easwaren, Gandhi and Swami are contextually significant. This verse originally indicates the temperament of a devotee who harbours no hate or ill will for any human being. The GT version, *"He is not hated by all living beings, friendly and compassionate"* sounds logical but does not hold contextual significance.

Chapter 12: Verse 15, GT-Swami is most similar in terms of its cosine value of semantic similarity. The GT version, *"He who is freed from all joy, anger, fear and anxiety, who is not afraid of the world and who is not afraid of this world"* is improper as it misses the meaning of the original verse which implies that the altruistic soul who is free from all the bonds of pleasure, fear, anger and anxiety neither disturbs the world nor is not disturbed by it.

Chapter 12: Verse 20, GT-Gandhi is most similar in terms of its cosine value of semantic similarity. The GT translation *"Those who worship this nectar of religious principles as described above are very dear to Me and are very dear to Me"*, though sounding logical, loses contextual significance in the last part, and features repetition (see Fig. 10).

5. Discussion

Among the verses selected for qualitative assessment with the assistance of a Sanskrit researcher, we found that only one verse (Table 3, Chapter 7 - Verse 9) was translated correctly, capturing the context and the foundations of Hindu philosophy. These were mistranslated in the rest of the verses which had contextual references or poetic elements. If we were to look closely at the singular verse translated accurately by Google Translate, we can see that the original Sanskrit Chapter 7: Verse 9 (Table 3, contains 9 distinct words that are bereft of any wordplay or poetic inferences. However, when we review the Sanskrit version in Chapter 12: Verse 8 (Table 5), due to the presence of words having the same roots, Google Translate is unable to identify the significance, where *"mayy eva manadhatsva mayi buddhi niveÅsaya"* is wrongly translated as *"Concentrate on Me in Me in Me, fix your mind in me"*.

The discrepancies in translation can be thus, attributed to the inability of Google Translate to understand the context of the root words. The same word in the Sanskrit language can have multiple meanings which have to be understood depending on the context of the statement. Most of the ancient Sanskrit epics such as Ramayana and Mahabharata, are written in the form of *shloka* (stanza) and embedded with references to past texts and events and allegories. Also, the verses from various

chapters are inextricably linked. This proves to be a major challenge in translation and can lead to erroneous results if the verses are translated independently without understanding the references. For instance, in the Bhagavad Gita, in the verses (Chapter 9: Verse 34 and Chapter 18: Verse 65), the original Sanskrit words are exactly the same in the first three parts of the shloka, only the fourth part is different as shown below in bold:

- Sanskrit Transliteration - Chapter 9: Verse 34: *"man-manā bhava mad-bhakto mad-yājī māṁ namaskuru mām evaiṣhyasi yuktvaivam ātmānaṁ mat-parāyaṇaḥ".*
- Google Translate - Chapter 9: Verse 34: *"**Be mindful of Me, be devoted to Me, live in Me, and bow down to Me** You will come to Me alone, thus uniting yourself and being devoted to Me".*

- Sanskrit Transliteration - Chapter 18: Verse 65: *"man-manā bhava mad-bhakto mad-yājī māṁ namaskuru mām evaiṣhyasi satyaṁ te pratijāne priyo 'si me".*
- Google Translate - Chapter 18: Verse 65: *"**Be mindful of Me, be devoted to Me, live in Me, and bow down to Me** You will come to Me I promise you truly you are dear to Me".*

If we were to analyse the Google Translate versions of both verses, they sound fairly similar and do not convey much about the contextual significance of the verses. In Chapter 9, Arjuna continues to be in a state of confusion as he listens intently to Krishna whereas in Chapter 18, Arjuna's doubts are completely resolved and these words hold a complete difference in both spiritual and psychological terms. The text of the Gita has been understood to hold significant psychotherapeutic potential and it has been recommended that its pragmatic use can improve both trust and communication (Bhatia et al., 2013).

In Chapter 17: Verse 26 (Table 4) Lord Krishna explains to Arjuna the meaning of *sat* (literally translated as truth) which is part of a triple formula – *'Om Tat Sat'* introduced in a previous verse of the same chapter (Chapter 17 Verse 25). This reference is lost in the Google translation altogether. This is a significant concept from the Bhagavad Gita which had a number of interpretations by prominent scholars since ancient times and has been prominent in *Vedanta* school of Hindu philosophy (Sharma, 1960; Anderson, 2012).

In Hindu philosophy, Om is the most sacred term referring to all that which cannot be defined and beyond (Bright, 1996). The Devanagari script views Om as sacred since it is beyond philosophy and definitions. Om is also a symbolic representation of the impersonal aspect of God, the Supreme one. Om represents all that was there before the birth of the universe; more precisely, before the birth of the multiverse, since Hinduism introduced the idea of the multiverse through its philosophy and mythology (Capra, 2010). Om refers to the formless Brahman and is the primordial sound that pervades creation (Phillips, 1986). Note that Brahman is defined as the ultimate reality in the universe (multiverse) (Capra, 2010) and is also one of the terms that cannot be translated to English easily as it changes meaning in different contexts (Chaudhuri, 1954), similar to dharma and karma. Brahman is the pervasive, eternal truth, and consciousness that does not change; however, it is the cause of all changes. Hence, Brahman can be seen as a philosophical paradox (Krishna, 2021). It can be argued that Brahman is the closest word to the concept of God in Abrahamic religions; however, God is known to be a creator, protector and observer; whereas Brahman has all these properties, but also remains part of the universe. In the Isha Upanishad (Easwaran, 2007; Greeff, 1998), this verse further defines the property of Brahman:

"Om
Purnamadah Purnamidam
Purnat Purnamudachyate
Purnasya Purnamadaya
Purnameva Vashishyate
Om Shanti, Shanti, Shanti."

which has been translated by Eknath Easwaren (Easwaran, 2007) as:

"Om
All this is full. All that is full
From fullness, fullness comes
When fullness is taken from fullness,
Fullness still remains.
Om Shanti, Shanti, Shanti.

Note that full has been translated as infinite, wholeness, complete, absolute, perfect, and reality by different translators of the Upanishads (Easwaran, 2007; Whitney, 1890; Mehta, 1970). Hence, the translation of the Upanishads poses similar challenges to the Bhagavad Gita. Om is a term that cannot be translated and remains, as it is, in prominent translations of Hindu texts.

In terms of sentiment analysis, we find that Google Translate expresses sentiments (Fig. 4) that vary highly when compared to expert translations. Google Translate over-expresses the "empathetic" sentiment and under-expresses sentiments such as "annoyed", "thankful" and "surprise". This shows that Google Translate has not been able to capture those sentiments as well as the expert translators. Hence, the Google Translate version of the Bhagavad Gita needs to be further improved so that it can be semantically similar to expert translators.

A major limitation of this study is that the given text is not a conventional text, i.e. Bhagavad Gita is a philosophical song summarizing major schools of Hindu philosophy, which can have a number of interpretations, and hence distinct schools were formed. For instance, *Advaita Vedanta* (non-dualism) (Anderson, 2012; Nelson, 1998) and *Dvaita Vedanta* (dualism) (Sharma, 1960; Widgery, 1942) Vedanta schools developed out of philosophical differences in interpretations of the Bhagavad Gita. We note that Advaita Vedanta became prominent from Adi Shankara's interpretation of Bhagavad Gita (Varma, 2018; Namboodiripad, 1989) in the 8th century, known as the *Sankara Bhashya* (Gambhirananda, 1984). These schools were formed when Sanskrit was a prominent language in studying Hindu philosophy, and the schools were formed not due to mistranslation but due to interpretation. Due to different schools of philosophy, there can be translation bias; i.e. a translator with Advaita Vedanta background may translate with biases towards their school of philosophy and Dvaita Vedanta translator may do the same. In terms of Google Translate, we note that such bias is not there, but then there are limitations that also create a bias. Advaita Vedanta has been the most prominent school of Hindu philosophy for the last thousand years with various texts of interpretations of the Bhagavad Gita and Vedas through scholars; hence, if these are used in the model training data, then the model will have philosophical biases. Hence, it would be interesting to check the translation ability of Google Translate in more conventional texts; however, these are limited since Sanskrit texts were composed more than two - three thousand years ago and most are in the form of verse (such as Mahabharata, Ramayana, Upanishads and Puranas). It would be reasonable to apply the framework to evaluate other languages, that are currently active with large numbers of speakers; such as French, Spanish, Russian, Hindi Punjabi, and Bengali.

6. Conclusion

We presented a framework for the evaluation of Google Translate using Sanskrit as an example language. In our framework, we used a combination of semantic and sentiment analysis for comparing expert translations of the Bhagavad Gita with Google Translate.

In terms of sentiment analysis, a major observation was that the sentiments *optimistic*, *pessimistic*, and *joking* were somewhat equally expressed in all four translations. We found that Google Translate over-expresses the *empathetic* sentiment and under-expresses sentiments such as *annoyed*, *thankful* and *surprise*. We found that Google Translate leads in terms of optimistic sentiments and Mahatma Gandhi leads in pessimistic sentiments. In semantic analysis, we found that Chapter 3 is semantically most similar; whereas Chapter 17 is semantically least similar when comparing the translations with Google Translate.

Generally, we found that Google Translate provided a low level of semantic and sentiment similarity when compared to translations by human experts. This indicates that a lot has to be done to improve Google Translate in this domain since we are dealing with philosophical and metaphorical concepts in the Bhagavad Gita and a low-resource language (Sanskrit) having a small number of native speakers. We further compared selected translations using a qualitative approach with the help of a Sanskrit translator. In the qualitative evaluation, we found that Google Translate is unsuitable for the translation of poetic Sanskrit words and phrases due to its inability to recognize contextual significance and imagery. The mistranslations are not surprising as the Bhagavad Gita is known as a difficult text to translate and interpret since it relies on contextual, philosophical, and historical information. Furthermore, although Sanskrit is a low-resource language, we note that it is an official language in India. Sanskrit is the main language for various ancient Hindu texts, and hence there has been a lot of focus on Sanskrit in academia. Therefore, the current study has a wide range of applications which includes the assessment of automatic translation of ancient and modern texts.

In future work, there is scope for using our proposed framework for the evaluation of Google Translate for other languages. As noted earlier, our current study used Sanskrit which is not much used as a conversational language and we evaluated Google Translate using the Bhagavad Gita which is a poem. Hence, in future work, we can evaluate other languages from India, particularly Hindi which has the third highest number of speakers in the world, after English and Mandarin. Apart from Hindi, our framework is useful for any language which has already been translated by experts that can be used for comparison with Google Translate.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Code and data

Github repository: https://github.com/sydney-machine-learning/Google-Sanskrit-translate-evaluation.

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