Semantic and Sentiment Analysis of Selected Bhagavad Gita Translations Using BERT-Based Language Framework

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ABSTRACT It is well known that translations of songs and poems not only break rhythm and rhyming patterns, but can also result in loss of semantic information. The Bhagavad Gita is an ancient Hindu philosophical text originally written in Sanskrit that features a conversation between Lord Krishna and Arjuna prior to the Mahabharata war. The Bhagavad Gita is also one of the key sacred texts in Hinduism and is known as the forefront of the Vedic corpus of Hinduism. In the last two centuries, there has been a lot of interest in Hindu philosophy from western scholars; hence, the Bhagavad Gita has been translated in a number of languages. However, there is not much work that validates the quality of the English translations. Recent progress of language models powered by deep learning has enabled not only translations but a better understanding of language and texts with semantic and sentiment analysis. Our work is motivated by the recent progress of language models powered by deep learning methods. In this paper, we present a framework that compares selected translations (from Sanskrit to English) of the Bhagavad Gita using semantic and sentiment analyses. We use hand-labelled sentiment dataset for tuning state-of-art deep learning-based language model known as *bidirectional encoder representations from transformers* (BERT). We provide sentiment and semantic analysis for selected chapters and verses across translations. Our results show that although the style and vocabulary in the respective translations vary widely, the sentiment analysis and semantic similarity shows that the message conveyed are mostly similar.

INDEX TERMS Language models, deep learning, sentiment analysis, semantic analysis, BERT, comparative religion.

I. INTRODUCTION

Comparative religion is a field that encompasses a systematic comparison of the doctrines and practices, philosophy, theology, and spiritual viewpoints of the world's religions [1]–[3]. The area of *philosophy of religion* [4], [5] encompasses the study of central themes and ideas in religions and the associated cultural traditions that relate to philosophical topics such as metaphysics, epistemology, and ethics. On the other hand, *religious philosophy* [6] is an area that encompasses philosophical topics but from the view of the religion of interest which is particularly driven by believers, such as Hindu philosophy, Christian theology, Jewish and Islamic philosophy. However, at times, both groups of scholars can

contribute to the subject. Hindu philosophy [7]–[9] features central themes of ethics [10], nature of consciousness [8], karma (duty and action) [11], [12], and the quest for understanding ultimate reality known as Brahman [9]. Hindu philosophy is also referred to as the Indian philosophy [13], [14]. The Upanishads are ancient texts of Hindu philosophy which have been the foundations of six major theistic schools, where *vedanta* [15] and *yoga* [16] have been the most prominent. Hindu philosophy has an intersection between philosophy of religion and religious philosophy which has been given a diverse study and examination by western scholars apart from Hindu philosophers [14], [17].

The Bhagavad Gita is considered as one of the main holy texts of Hinduism which is part of the Mahabharata which is one of the oldest and largest epics written in verse form [18]–[20]. The Bhagavad Gita, which translates as the song of

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God is also known as a text that summarizes and comprises the core of Hindu philosophy [14]. In the Mahabharata war, Arjuna is the lead archer with Lord Krishna as his chari-oteer representing the Pandava army who are at war with the Kaurava. Arjuna is facing some of his family members on the other side of the war and becomes confused whether he should go to war or renunciate and become a yogi. The Bhagavad Gita provides a discussion duty and ethics as a set of questions from Arjuna and answers by Lord Krishna. The philosophy of karma, known as karma yoga is attributed to the Bhagavad Gita [21]–[23]. The transmission of the Bhagavad Gita has been through oral tradition for thousands of years, from the event of the Mahabharata war in India, with recent estimates around 5100 years ago [24], [25]; however, the exact dates have been debated in the literature with some scholars dating it to around 2500 - 3500 years ago [26], [27]. We need to note that scholars believe that the Mahabharata was written in ancient Sanskrit where as the Bhagavad Gita has been written in modern Sanskrit; hence, some scholars argue that Bhagavad Gita was later inserted into the epic Mahabharata [20], [28]. The original text, which has been composed in Sanskrit, has been ever since translated into various languages. The Bhagavad Gita consists of 18 chapters which feature a series of questions and answers between Lord Krishna and Arjuna with a range of topics that includes the philosophy of Karma. The Mahabharata war lasted for 18 days and hence the organisation of the Gita is symbolic. The Bhagavad Gita is written in a poetic style so that it can be sung and remembered for generations given the absence of a writing system. Over the last few centuries, there has been a lot of effort in translation of the Bhagavad Gita. There has been a major focus on English translation and commentary by philosophers and scholars of comparative religion, partic-ularly from India, Europe and United States.

Religious linguistics refers to the study of language used in the domain of religion and primarily aims at identifying the structures and functions of religious language (lexicon, syntax, phonology, morphology, etc.). In principle, religious subject matters could encompass a variety of agents, states of affairs or properties, such as God, deities, angels, miracles, redemption, grace, holiness, sinfulness [29]. Recent research suggests that a register of religious language, such as prayer, induces certain psychological effects in the brain [30] which makes certain components of religious language a cogni-tive register. Analysis of religious texts has been prominent, as highlighted, and most translations of the Bhagavad Gita and related texts come with interpretations and commentary regarding philosophy and how the verses relate to issues at present [31]. The Bhagavad Gita has been predominantly used as a text and inspired interpretations from areas of self-help and management, psychology [32], economics [33], pol-itics [34] and leadership [35]. However, these commentaries dwell with the general message of the texts rather than seman-tic or syntactic analysis. Stein [36] extracted 14 multi-word expressions using local grammar and semantic classes from Bhagavad Gita capturing some central themes in the text.

Bawa *et al.* [37] provided a review on machine translation for English, Hindi and Sanskrit languages. Rajput *et al.* [38] performed a statistical analysis of the Bhagavad Gita text for its translations in four languages: English, French, Hindi and Sanskrit. These works, have focused on linguistic and sta-tistical measures which opens the road for machine learning and natural language processing for analysis of religious and philosophical texts.

Natural language processing (NLP) is an area of artificial intelligence that focuses on processing and modelling lan-guage [39]–[41]. NLP is typically implemented with lan-guage models where deep learning has been prominent for tasks such as topic modelling, language translation, speech recognition, semantic and sentiment analysis [40]. Sentiment analysis provides an understanding of human emotions and affective states [42]–[44] which has been prominent in understanding customer behaviour [45], health and medicine [46], stock market predictions [47], and modelling elec-tion outcomes [48], [49]. Deep learning methods such as long-short term memory (LSTM) network models have been prominently used as language models due to their capa-bility to model temporal sequences with long-term depen-dencies [50]. Attention based mechanism in LSTM mod-els have shown significant improvements [51], and further progress has been made using *Transformer* models which incorporate attention into encoder-decoder LSTM framework [52], [53]. The *bidirectional encoder representations from Transformer* (BERT) [54] model has become a prominent pre-trained language model with knowledge from a large data corpus. BERT features more than 300 million model parameters for language modeling tasks and has the poten-tial to provide good semantic and sentiment analysis. BERT employs masked language modeling (MLM) for pre-training and has been one of the most successful pre-trained models. In our earlier work, we used BERT-based framework for sen-timent analysis of COVID-19 related tweets during the rise of novel cases in India [55]. We also used BERT for modelling US 2020 presidential elections with sentiment analysis from tweets to predict state-wise winners [49]. Thus, BERT can be used for better understanding the difference using sentiment analysis amongst translations in philosophical texts such as the Bhagavad Gita.

The Upanishads are a set of Hindu philosophical and sacred texts of which some are related to the Bhagavad Gita in terms of topics and style. The Upanishads have been translated more than 150 times from 1783 to 1994, where western scholars make up a significant portion of translators and commentators [17]. This shows the impact and interest of Hindu texts in the west; hence, analysing the style and quality of the translations is essential. It is important to evaluate some of the key translations with the others in terms of sentiments and semantics. The Bhagavad Gita, has been written origi-nally in verse (as a song), and it is well known that trans-lating such literary works not only breaks rhyming patterns, but can also change the meaning and message behind the verses [56].

This paper is motivated by the recent progress of language models powered by deep learning models. We compare selected translations of the Bhagavad Gita by focusing on sentiment analysis and semantic similarity of the verses. We compare selected translations with a focus on translations directly from Sanskrit to English and one that uses an intermediate language (Gujarati). We use novel sentence embedding based on BERT which provides semantic analyses by encoding and representing the verses using sentence embedded vectors. In the case of sentiment analysis, the pre-trained BERT model is further tuned using a hand labelled Twitter-based training dataset that captures 10 sentiments. We visualise selected Bhagavad Gita chapter-wise and verse-wise sentiments across the selected translations.

The rest of the paper is organised as follows. In Section 2, we provide further details about background and historical development behind the composition of the Bhagavad Gita. Section 3 presents the methodology with details regarding data processing and model development. Section 4 presents the results that feature data analysis and model prediction. Section 5 provides a discussion and Section 6 concludes the paper.

II. BACKGROUND
A. HISTORICAL DEVELOPMENTS
The information in Hindu texts was passed through oral transmission for thousands of years before being written in Sanskrit [57]–[59]. Although most of the ancient Hindu texts (Vedas, Upanishads and Bhagavad Gita) used Sanskrit, there are some prominent texts that were written in Tamil such as the Tirukkuṟaḷ [60]. Knowledge about natural and astronomical events have been preserved through oral transitions [25] which are linked to the Indus valley civilisation (Harappan) with mature period dated 8000 - 9000 years BCE (before the common era) by recent studies [61]. There are studies that show that the earliest text of Hinduism, known as the Rig Veda, contains accounts of the Saraswati River [62] being active. Latest research shows that the Saraswati River started building sediments and drying 10,000 years ago [63]. The written history and dating of the composition of the texts are continuously being updated, since the transmission of knowledge was done orally for thousands of years before being written. There has also been a call to rename the Indus valley civilisation as the Saraswati civilisation and update the dating of the Vedic period.[1] A major challenge has been in translating Vedic (ancient) Sanskrit which is the language of the Rig Veda [64], [65]. The Bhagavad Gita is written in modern Sanskrit which has been easier to translate [66] when compared to the Rig Veda [67].

B. BHAGAVAD GITA
The Bhagavad Gita features a discourse on duty and karma between Arjuna and Lord Krishna at the battlefield of Kurukshetra. It describes an event at the beginning of the Mahabharata war where Arjuna, the lead archer of the land, has to fight his close family members for the rightful heir to the throne of Hastinapur [68] which is now modern day Delhi. Arjuna is the lead archer on the side of the Pandavas with Lord Krishna as his charioteer, who is also a close friend and relative. The Pandavas went on war with the Kauravas who were their close relatives (cousins) for right to the throne of Hastinapur and Indraprastha. Arjuna, after facing his relatives, friends and gurus on the opposing side of the battlefield gets deeply disturbed and emotional, and begins pondering about philosophy of life and essence of dharma (ethics). Arjuna makes a decision not to go to war and asks a series of questions to his charioteer and mentor, Lord Krishna who is known as the avatar (born as human) of Lord Vishnu [69], who in the western religious notion would be equivalent to the term God. Due to the complexity of the situation which Arjuna faces about duty and ethics, the set of questions from Arjuna and answers by Lord Krishna makes Bhagavad Gita the forefront of Hindu philosophy. Bhagavad Gita also is known as the central sacred text of Hinduism [70], [71].

C. THE SANSKRIT LANGUAGE
Sanskrit is a language known for the richness of its vocabulary and layered meanings which induces subtle differences when translated to other languages [72], [73]. Sanskrit is the language for the key Hindu texts such as the Bhagavad Gita, Ramayana, Upanishads, Vedas, and Mahabharata [74], [75]. There are a number of challenges in translating Sanskrit texts into other languages as discussed next. Firstly, Sanskrit is a language for research and scholarship and study of Hinduism; however, it has a limited number of speakers. Secondly, although the key Hindu mantras for major events are written in Sanskrit [76], majority of Hindus do not understand Sanskrit. On the bright side, Hindi is based on Sanskrit and there is significant vocabulary in Hindi from Sanskrit [77]. Finally, Sanskrit is a major branch of Indo-European [78] languages which have links to European languages such as Latin, German and English [79], [80]. Indian Invasion Theory (IIT) proposed that development of Sanskrit and Hindu (Vedic) texts in ancient India is from invasion/migration of Indo-Aryan tribes into India in pre-Vedic age [81]. IIT has been the forefront of colonialism and has been used as a way for British rulers to motivate their rule and supremacy in British India [82]. IIT aligned well with Eurocentric education system which did not give importance to ancient Indian and Hindu scholars such as Aryabhata who was instrumental in developing the Hindu decimal number system [83]–[85], which was branded as Arabic numerals [86]. IIT has been contested heavily [87], [88] with evidence from Harrapan excavations [61] due to inconsistent timelines about migration/invasion and lack of evidence given by IIT. Apart from this, the Rig Veda which is

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[1]Chronology of Indian civilisation is 'dubious', says IIT-Kharagpur calendar: https://indianexpress.com/article/cities/kolkata/chronology-of-indian-civilisation-is-dubious-says-iit-kharagpur-calendar-7690601/

the earliest Hindu text features hymns of Saraswati River [89] when it was flowing more than 10,000 years ago [63]. There is an opposing Out of India Theory (OIT) [90] that suggests that the evolution of Sanskrit and related languages moved from India to Europe and other parts of Asia through migrations.

Pānini who is known as the 'father of linguistics'' [91] was a revered philologist and grammarian in ancient India [92]. Pānini is known for his text Astādhyāyī [93] which provides a treatise on Sanskrit grammar with rules on linguistics, syntax and semantics covered in verse form. The Sanskrit language has over the decade gained a lot of interest in computational linguistics and computer science. There has been work done in understanding Sanskrit from the view of language models and natural language processing [94], [95], [95]. Briggs [94] argued that Sanskrit is the best language for modelling using artificial intelligence methods.

There are more than 300 English translations of the Bhagavad Gita in English. An earlier review provided a chronology of translations and commentaries mostly from western scholars from 1785 to 1980 [96]. The Bhagavad Gita has been translated in more than 100 languages.

III. METHODOLOGY

A. DATASETS: TRANSLATIONS OF THE BHAGAVAD GITA

We select prominent translations of the Bhagavad Gita that span different translation times-frames (decades) and focus on scholars from a Hindu background in order to avoid any translation biases [20]. Our framework for analysis of translations can be extended to other translations of the Bhagavad Gita, we merely select these texts as a proof-of-concept. We tried to use the older and the most popular translations, ensuring that the translations feature verse by verse translations. The translations typically contain an interpretation which have been discarded in our analysis.

The Bhagavad Gita consist of 18 chapters which features a series of questions and answers between Lord Krishna and Arjuna with a range of topics that includes the philosophy of Karma. The Mahabharata war lasted 18 days [100] and hence the organisation of the Gita is symbolic. In our work, we consider three prominent translations of Bhagavad Gita as the source of data for analysis. The translators' name, text name, and the year of publication are shown in the Table 1.

The English translation of the Bhagavad Gita published in 1946 by Mahadev Desai [97] was translated from Gujarati version based on the commentary known as ''Anasakti Yoga'' by Mahatma Gandhi [20]. It is based on talks given by Gandhi between February and November 1926 at the Satyagraha Ashram in Ahmedabad, India. This was the time when Gandhi had withdrawn from mass political activity and devoted much of his time and energy to translating Gita from Sanskrit to his native language Gujarati. As a result, he met with his followers daily, after morning prayer sessions, to discuss the Gita's contents and meaning as it unfolded before him. Mahatma Gandhi viewed the Bhagavad Gita not as a historical work, but one that describes the perpetual conflict that rages on in the hearts of the mankind under the guise of physical warfare. Hence, Gandhi's non-violent interpretation is in stark contrast with contemporary Indian freedom fighters, such as Lala Lajpat Rai, Aurobindo Ghose, Bal Gangadhar Tilak. These freedom fighters argued that it was the sacred duty of Indians to fight against the British colonial rule, just as Krishna had urged Arjuna to fulfill his sacred duty [101]. The translation by Mahatma Gandhi is accompanied by short commentaries in every chapter which are discarded in our analysis.

The Bhagavad Gita translation by Eknath Easwaran is a direct Sanskrit-English translation published in 1985. Easwaran's comprehensive introduction (55-page) places the Bhagavad Gita in its historical setting, and brings out the universality and timelessness of its teachings. It features chapter introductions to clarify key concepts and provides a context, and notes and a glossary to explain Sanskrit terms. Eknath Easwaran's commentary shows the Gita's relevance to the modern society and highlights key topics in ethics, humanism and spirituality. Note that the introduction and chapter commentaries have been discarded in our study. The Bhagavad Gita translation by Shri Purohit Swami [99] avoids the use of Sanskrit concepts that may be unfamiliar to English-speakers, for example translating the word 'yoga' as 'spirituality'. However, we note that 'yoga' has been translated as 'union' in prominent works. This is also a direct Sanskrit-English translation published much earlier than the previous ones (1935). Unlike Eknath Easwaran, Shri Purohit Swami does not present a commentary on the Bhagavad Gita, but offers direct translation of the text.

We also considered other prominent translations and commentaries, such as those by A. C. Bhaktivedanta Swami Prabhupada [102], Paramhansa Yogananda [103], Sarvepalli Radhakrishnan [104], and Swami Chinmayananda Saraswati [105]; however, due to limited scope of our study, we could not use them. These texts can be considered in future studies.

B. TEXT DATA EXTRACTION AND PROCESSING

In order to process the respective files given in printable document format (PDF), we converted them into text files. This conversion from PDF to text file gave us a raw dataset consisting of all the texts shown in Table 3. Next, preprocessing is done on the entire dataset, which included the following steps.

1) Removing unicode characters generated in the text files due to noise in the PDF files;
2) Removing verse numbering in the Bhagavad Gita;
3) Replacing the archaic words such as ''thy'' and ''thou'' with modern words for retaining semantic information;
4) Replacing different words used to refer to the respective protagonists, Krishna and Arjuna (Table 2);
5) Converting verses to a single line.
6) Removing commentary on the verses by the author.

TABLE 1. Details of the texts used for sentiment and semantic analysis.

| Texts	Translator	Year
The Gita according to Gandhi [97]	Mahatma Gandhi & Mahadev Desai	1946
The Bhagavad Gita [98]	Eknath Easwaran	1985
The Bhagavad Gita [99]	Shri Purohit Swami	1935

7) Removing repetitive and redundant sentences such as "End of the Commentary".

Table 2 shows the conversion of archaic words and aliases used for Arjuna and Krishna. In Mahatma Gandhi's translation, there are 136 occurrences of different words used to refer to Arjuna, some of them being - "Partha", "Kaunteya", "Bharata", "Mahabahu", etc. The words such as "Savyasachin", which literally means ambidextrous, have been replaced according to the context in which they appeared (in this case – Arjuna, because he could shoot arrows with both hands). Similar conversions have been made for different names of Krishna. In Shri Purohit Swami's translation, Krishna is more commonly referred to as the "lord" (101 occurrences). These word transformations are done to enable the language model to decipher the meaning and context from the verses easily. In the case of the translation by Eknath Easwaran, no archaic words were used and also different names were not used for Krishna and Arjuna; hence, Table 2 does not provide any information.

In natural language processing applications, there have been studies regarding removal of stop words which can help in removing low level information so that the model can focus on the high level representation [106]–[108]. Although it is typical for language models to remove stop words (e.g., "a," "and," "but," "how," "or," and "what"), in the case of sentiment analysis, it can eliminate information regarding the context of the sentiment [109]. Hence, we did not remove stop words for sentiment analysis. Table 3 presents examples of selected verses from the processed text by Mahatma Gandhi and Shri Purohit Swami after transforming words for preserving semantic information using information given in Table 2. Figure 1 presents the chapter-wise number of occurrences for the word conversions during text processing for the Bhagavad Gita translation by Mahatma Gandhi and Shri Purohit Swami.

C. SENTENCE EMBEDDING MODELS
Sentence BERT (S-BERT) [110] is a sentence embedding model which improves BERT model by reducing computational time to find similar pair of text using Siamese and triplet network structures to derive semantically meaningful sentence embeddings. Although BERT is one of the most successful pre-trained models, it neglects dependency among predicted tokens. Masked and permuted pre-training [111] (MPNet) model inherits the features of BERT and another improved model known as generalized autoregressive pre-training (XLNet) [112]. *MPNet-base* encodes sentences into high-dimensional embedding vectors that can be used for various natural language processing tasks. The model takes
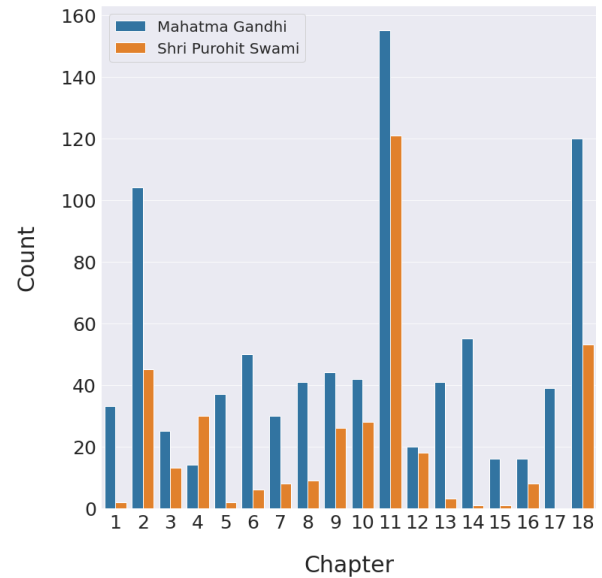
FIGURE 1. Number of archaic words transformed in translations by Mahatma Gandhi and Shri Purohit Swami.

a variable length English text as an input and gives 768-dimensional output vector. The input sentences of length greater than 384 tokens are truncated. MPNet uses masked and permuted language modeling to model the dependency among predicted tokens and see the position information of the full sentence. The model is also fine-tuned using a contrastive learning objective on a dataset of 1 billion sentence pairs[2] for generating the embeddings. Given a sentence from a pair of similar sentences, the model needs to predict the sentence with which it was originally paired from a set of randomly sampled sentences. The sentence embeddings are typically compared using cosine similarity.

KeyBERT [113] is a keyword extraction technique that leverages BERT embeddings to produce keywords that take into account the semantic aspects of the document. In this method, the input document is embedded using a pre-trained BERT model which embeds a chunk of text into a fixed-size vector. The keywords and expressions (n-grams) are extracted from the same document using *bag of words* techniques. Each keyword is then embedded into a fixed-size vector with the same model used to embed the document. As the keywords and the document are represented in the same embedding space, KeyBERT computes a cosine similarity between the keyword embeddings and the document embedding. Then,

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[2]https://huggingface.co/sentence-transformers/all-mpnet-base-v2

TABLE 2. Text processing using word conversion with same meaning.

Original Word	Transformed word	Mahatma Gandhi	Shri Purohit Swami	Eknath Easwaran
"thou"	"you"	134	118	-
thy	your	84	84	-
thee	you	60	58	-
partha	arjuna	38	0	-
art	are	26	20	-
shalt	shall	21	23	-
kaunteya	arjuna	21	0	-
bharata	arjuna	19	0	-
thyself	yourself	11	11	-
Hrishikesha	Krishna	7	0	-

TABLE 3. Processed text after transforming words for preserving semantic information from Mahatma Gandhi and Shri Purohit Swami.

Author	Original sentence	Transformed sentence
Mahatma Gandhi	1. If, O Janardana, thou holdest that the attitude of detachment is superior to action, then why, O Keshava, dost thou urge me to dreadful action?	If, O Krishna, you hold that the attitude of detachment is superior to action, then why, O Krishna, do you urge me to dreadful action?
Mahatma Gandhi	27. Whatever thou doest, whatever thou eatest, whatever thou offerest as sacrifice or gift, whatever austerity thou dost perform, O kaunteya, dedicate all to Me.	Whatever you do, whatever you eat, whatever you offer as sacrifice or gift, whatever austerity you do perform, O Arjuna, dedicate all to Me.
Shri Purohit Swami	7. Yet since with mortal eyes thou canst not see Me, lo! I give thee the Divine Sight. See now the glory of My Sovereignty."	Yet since with mortal eyes you can not see Me, lo! I give you the Divine Sight. See now the glory of My Sovereignty."
Shri Purohit Swami	3. Thou art the Primal God, the Ancient, the Supreme Abode of this universe, the Knower, the Knowledge and the Final Home. Thou fillest everything. Thy form is infinite.	You are the Primal God, the Ancient, the Supreme Abode of this universe, the Knower, the Knowledge and the Final Home. You fill everything. Your form is infinite.

the most similar keywords (with the highest cosine similarity score) are extracted. Furthermore, KeyBERT includes *maximum sum similarity* (MSS) and *maximal marginal relevance* (MMR) to introduce diversity in the resulting keywords. MMR considers the similarity of keywords/key-phrases with the document, along with the similarity of already selected keywords and key-phrases. This results in a selection of keywords that maximizes their within diversity with respect to the document. In our proposed framework, we use KeyBERT along with MMR for keyword extraction of all the chapters in different translations of the Bhagavad Gita.

D. FRAMEWORK

We present the framework that is used for sentiment and semantic analysis of the Bhagavad Gita. Our framework analyzes sentiment and semantic aspects of individual verses from the Bhagavad Gita and also derives insights about the differences in the themes discussed in the texts. As shown in Figure 2, we begin by converting the PDF files into text files and process them as mentioned earlier (Section III – B). We provide sentiment analysis via $BERT_{base}$ model by predicting sentiments of verses across the selected transla-

tions (texts) of the Bhagavad Gita. We employ multi-label sentiment classification where more than one sentiment can be classified at once, i.e., a verse can be both emphatic and optimistic as shown in Figure 2. Although sentiment analysis can be done with model prediction that gives a positive/negative polarity score, this would not reveal much information about the nature of the sentiment as the positive/negative score can be vague due to different expressions used in translations. Hence, we use the hand-labelled SenWave dataset [114] which features 11 different sentiments labelled by a group of 50 experts for 10,000 tweets worldwide during COVID-19 pandemic in 2020. The $BERT_{base}$ model is trained using the SenWave dataset [114] for a multi-label sentiment classification task.

Although sentiment analysis can provide an idea regarding the differences in the translations, it does not provide information about the difference in the semantics (meaning) across the translations. Hence, semantic analysis [115] is vital and accompanies sentiment analysis. In the framework, we provide further analysis of the sentiment predictions by comparing verse-by-verse and chapter-by-chapter statistics of the predicted sentiments across the respective translations. We also provide semantic analysis via sentence embedding
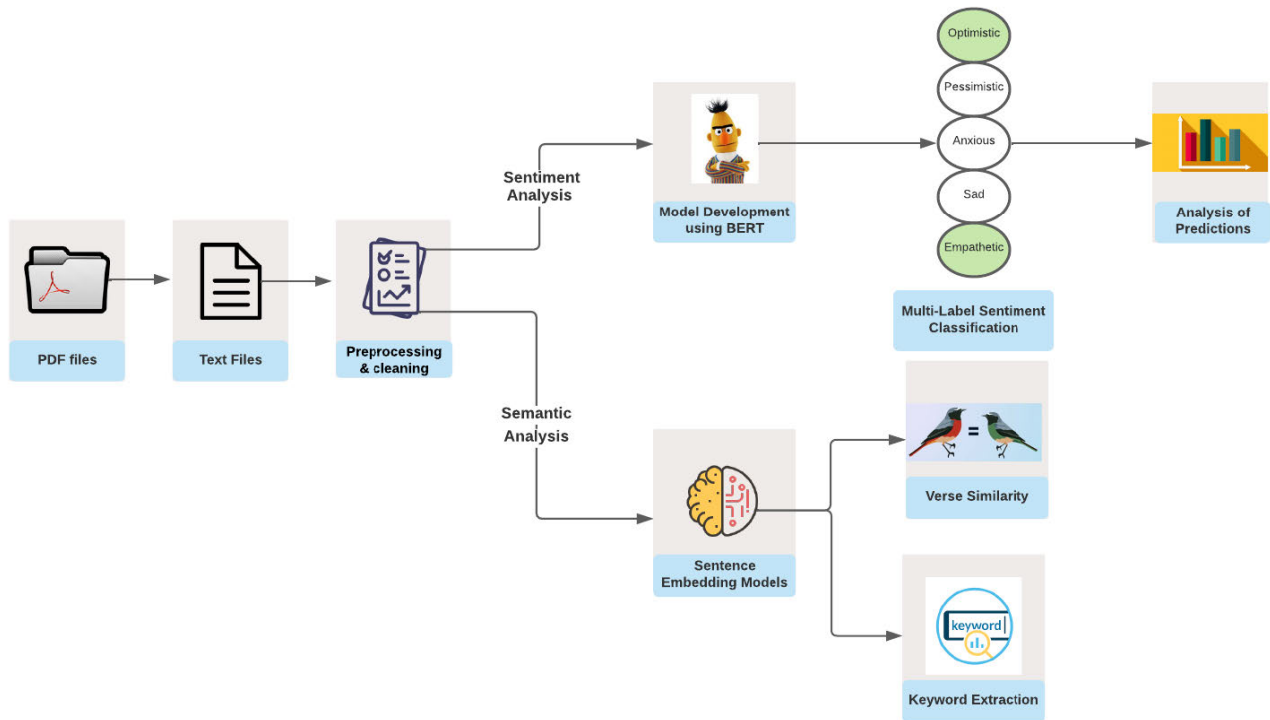
FIGURE 2. Framework for semantic similarity and sentiment analysis for selected translations of the Bhagavad Gita.

model (MPNet which is based on $BERT_{base}$) and verse-by-verse similarity and perform keyword extraction (based on MPNet-base) for further analysis of the translations as shown in Figure 2.

We use the MPNet-base [111] sentence embedding model to encode verses as it produces high quality embeddings. Since the embedding is generally in a higher dimension, we reduce the dimension of the encoded vectors to explore the clustering of data in different translations and chapters. We use the uniform manifold approximation and projection (UMAP) [116] algorithm for dimensionality reduction in order to visualise the high-dimensional vectors. We also extract keywords from the text using KeyBERT to analyze central themes. We note that related methods such as rapid automatic keyword extraction (RAKE) [117], yet another keyword extractor! (YAKE!) [118], and term frequency–inverse document frequency (TF-IDF) [119] can be used to extract keywords and key-phrases. However, they are based mostly on the statistical properties of a text rather than semantic similarity. Hence, we use KeyBERT as it takes into account the semantic aspects of the text. We filter out the top 10 keywords and sort them in order of their relevance to a given chapter.

E. MODEL TRAINING
We note that although the SenWave dataset is publicly available, permission is required from the authors for usage.

In order to ensure reproducibility of the results, and given the constraints, we do not provide the processed dataset. However, we provide trained models in our GitHub repository.[3] The Senwave dataset features 10,000 Tweets that were collected from March to May 2020 labelled with 10 different sentiments plus 1 label which refers to COVID-19 official report. We limit to 10 sentiments and remove the "official report" in data processing. A tweet can feature sentiments such as "optimistic", "pessimistic", "anxious", and "thankful". The multi-label sentiment classification task refers to the tweet that can be classified as "optimistic" and "anxious" at once. We train the $BERT_{base}$ model on Sen-Wave dataset by pre-processing the tweets using our previous work [55].

The pre-trained BERT-base uncased model is further tuned on the SenWave dataset [114] with training and test dataset created in a 90/10 % split on a dataset of 10,000 tweets using a batch size of 1 using 4 training epochs. We use the default hyper-parameters for the model and implement regularisation using a dropout [120] layer with dropout probability of 0.3 to avoid over-fitting. Finally, we add a linear activation layer with 10 outputs to predict 10 sentiments. Moreover, we use the adaptive moment estimation (Adam) gradient [121] optimizer for training with a learning rate of 1e-05, and binary

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[3]https://github.com/sydney-machine-learning/sentimentanalysis_bhagavadgita
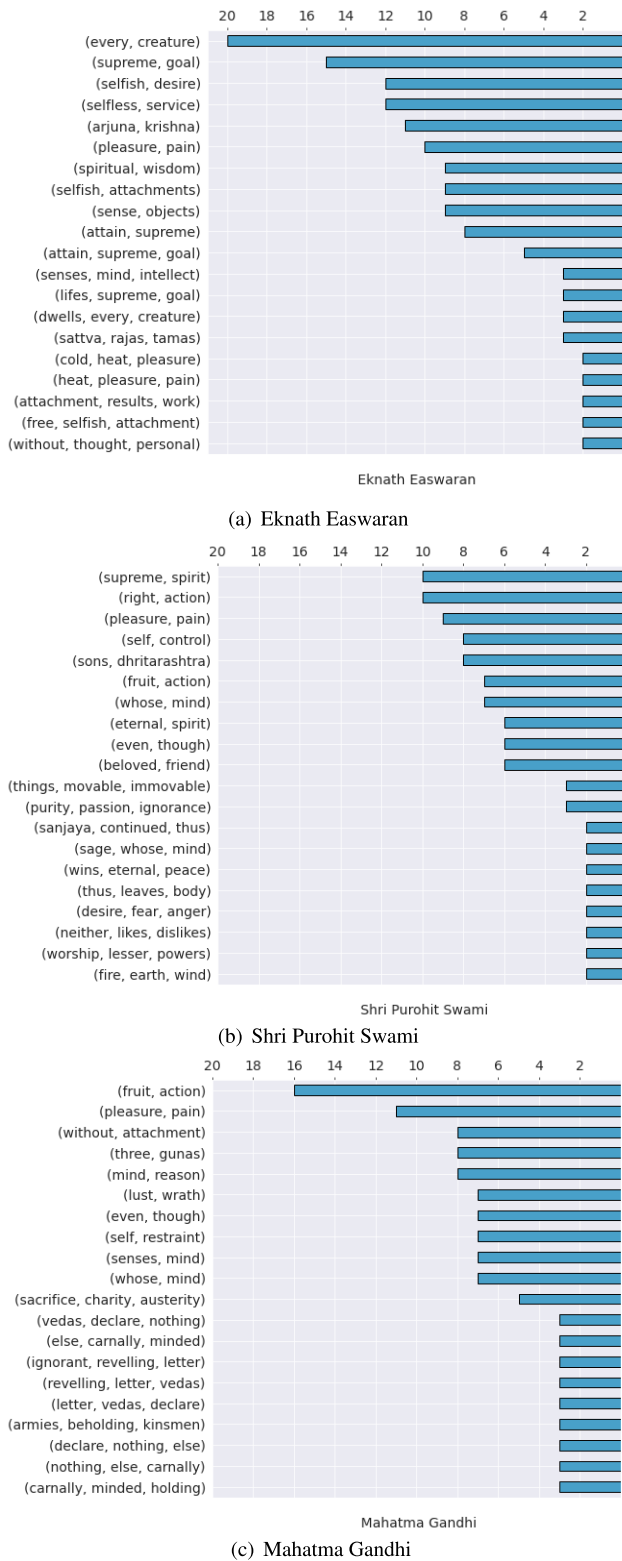
(a) Eknath Easwaran

(b) Shri Purohit Swami

(c) Mahatma Gandhi

FIGURE 3. Top 10 bigrams and trigrams from processed verses of all translations.
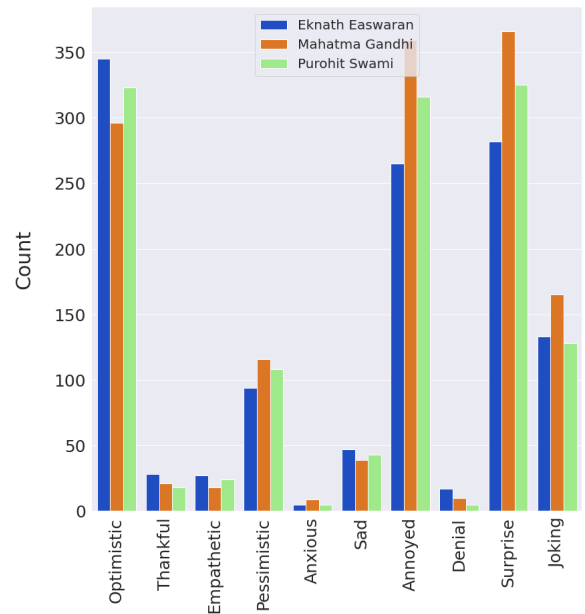
FIGURE 4. Text-wise sentiment analysis.

the MPNet-base model for extraction of keywords (using KeyBERT) from all chapters. However, given the constraint in the MPNet-base model that number of tokens should not exceed 384, it would not be possible to encode large chapters directly. Hence, we propose a method to overcome this limitation by breaking each chapter into paragraphs of 15 verses each. We include 3 verses from the previous paragraph into the current paragraph to retain some context and maintain continuity. For example, in the first paragraph, verses 1-15 are included, and in the second paragraph verses 13-27, then 25-39, and so on. We keep the top 20 keywords because keywords that have a lower similarity score in the original paragraph may be more relevant when the entire chapter is considered.

Next, we extract the keywords for all paragraphs i, with 20 candidate keywords of paragraph j, such that $i \neq j$. For each keyword, we add up its cosine similarity score for different paragraphs. Finally, we obtain the top 10 keywords having the highest cumulative scores. The key idea here is that if a term is a keyword in a certain paragraph, it also needs to be a keyword in other paragraphs for it to qualify as a keyword for the entire chapter. We use maximal marginal relevance (MMR) with a diversity value of 0.5 to prevent the selection of similar meaning keywords.

IV. RESULTS

A. DATA ANALYSIS

We first present results with basic data analysis for visualisation of the datasets. Figure 3 presents the bigrams and trigrams obtained for the respective translations of the Bhagavad Gita. We removed the stop words in order to obtain the bigrams and trigrams. Throughout the Bhagavad

cross entropy loss function for the multi-label classification task.

We encode verses using the MPNet-base model and compute the verse by verse semantic similarity. We also use
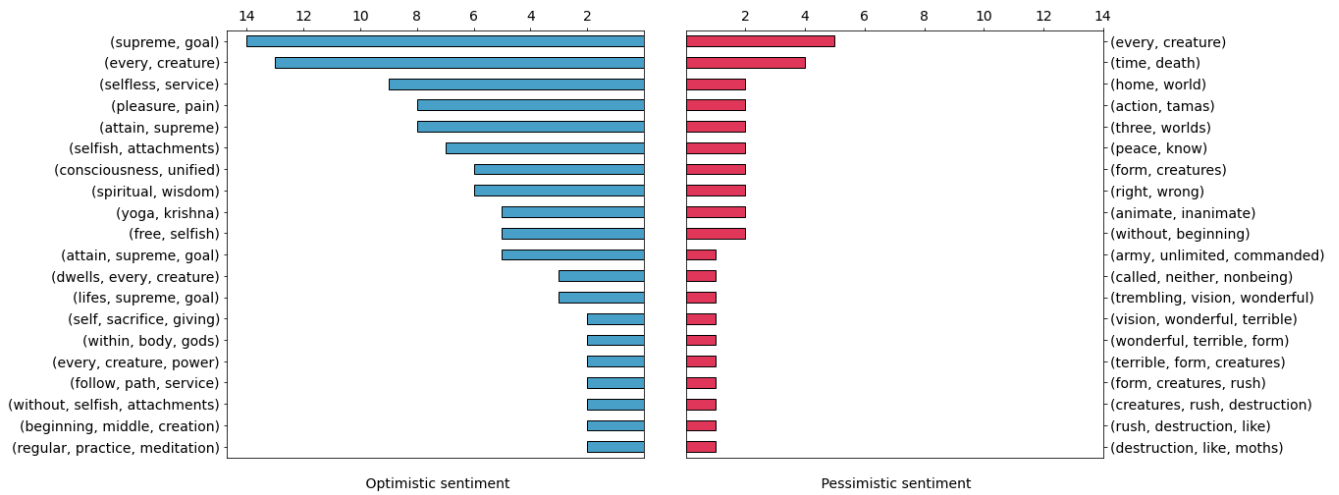
FIGURE 5. Top 10 optimistic and pessimistic bigrams and trigrams from processed verses of Eknath Easwaran's translation.
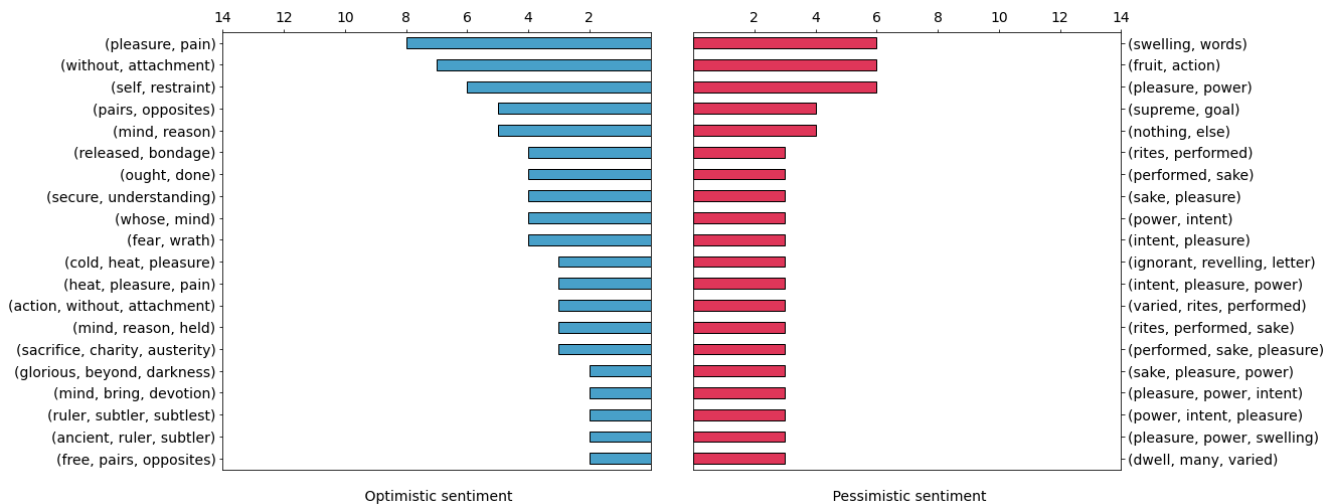

FIGURE 6. Top 10 optimistic and pessimistic bigrams and trigrams from processed verses of Mahatma Gandhi's translation.

Gita, the concept of three 'gunas' or attributes has been widely discussed. Dominance of the 'sattvic' attribute leads to liberation, that of 'rajasa' attribute leads to rebirth as humans and 'tamas' means moving to a lower form of life. Hence, the bigram 'three gunas' has been aptly extracted in Gandhi's version (Figure 3(c)). Also, the three major human attributes (gunas) i.e. sattva, rajas, tamas in Easwaran's translation roughly translate to the attributes purity, passion and ignorance as described in Shri Purohit Swami's translation (Figure 3(b)).

We observe that the bigram, *pleasure and pain* appears in all translations. This gives the message the a person who is fit for liberation is unaffected by worldly (material) desires and at complete peace with themselves, unaffected by either pleasure or pain. Since the bigrams and trigrams merely count the occurrence of a set of words, the central themes that are emphasised will become evident afterwards. While all

three texts discuss the idea of 'supreme spirit' or the *Atman*; however, the path taken to realize it differs. Eknath Easwaran stresses the importance of *selfless service* devoid of *selfish attachments* and *desires* (Figure 3). Shri Purohit Swami advocates the path of *right* (righteous) *action* by observing *self control*. Interestingly, Chapter 3 of Eknath Easwaran's translation is titled 'Selfless Service' while Shri Swami Purohit has titled it as 'Karma Yoga - The Path of Action'. Mahatma Gandhi observes that the mind would have to be completely *self restrained* to be able to renounce the *attachment to fruits of action*. The essence of Mahatma Gandhi's interpretation is beautifully captured in verse 47 of Chapter 2 - *"Action alone is thy province, never the fruits thereof; let not thy motive be the fruit of action, nor shouldst thou desire to avoid action."*

Furthermore, we notice that the top three bigrams and trigrams (Figure 3) across the three different translations are almost entirely different. It seems that the different translators
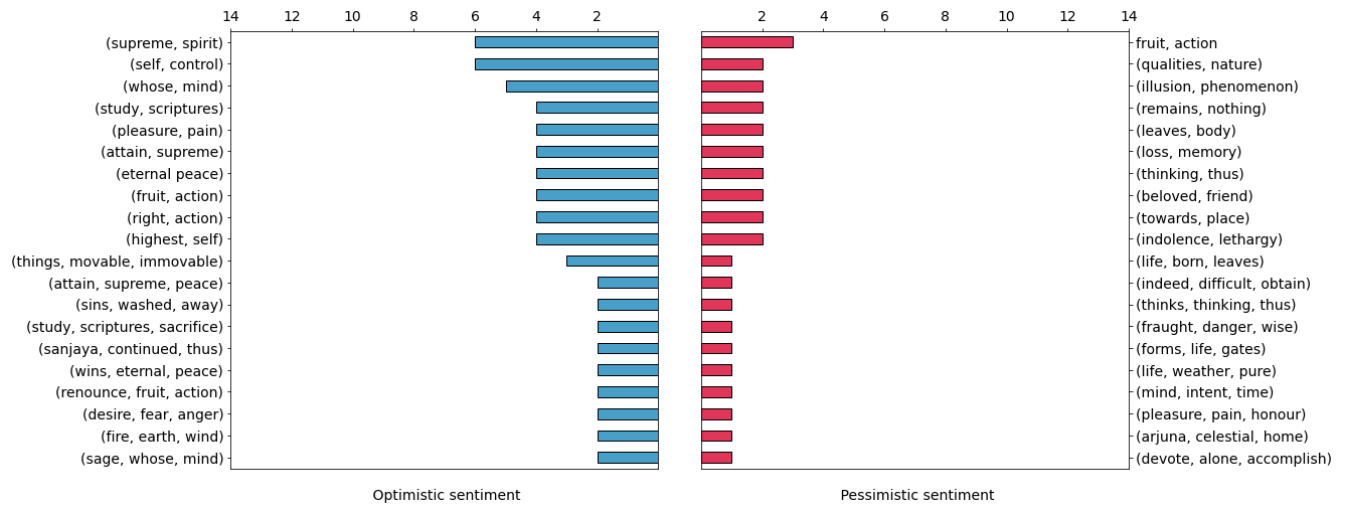
FIGURE 7. Top 10 optimistic and pessimistic Bi-grams and Tri-grams from processed verses for Shri Swami Purohit's translation.

have used different words to refer to similar concepts, for example, Eknath Easwaran's translation features [every, creature] and [supreme, goal] as top bigrams whereas Shri Purohit Swami's translation gives [supreme, spirit] and [right, action]. Moreover, Mahatama Gandhi's translation features [fruit, action] and [pleasure, pain] which is also present in Eknath Easwaran's translation. Hence, a word by word comparison using bigrams and trigrams shows a major difference in the respective translations.

Table 4 lists all the chapter titles of the three translations. In Mahatma Gandhi's translation, chapters are referred to as 'discourses'. We note the difference in the way the different translators interpreted the title of the respective chapters. Eknath Easwaran, for example, translated Chapter 2 heading as "Self-Realization" while Shri Purohit Swami translated it as "The Philosophy of Discrimination".

B. SENTIMENT ANALYSIS
Next, we use the BERT model for verse-by-verse sentiment analysis of the respective Bhagavad Gita translations. We first present the bigrams and the trigrams of the top ten optimistic and pessimistic sentiments for the entire text for the respective translations.

The sentiment analysis shows that [pleasure, pain] is an optimistic bigram in all three translations (Figure 5, Figure 6, Figure 7). However, this has been used in the context that one should have complete control over one's mind, which is one of the central themes in the Bhagavad Gita. According to the Bhagavad Gita, the mind should not be clouded by either pleasure or pain, by heat or cold, or by other worldly influences (Chapter 2, verse 15). Only such a person is fit for immortality (moksha) to escape the cycle of birth and death (Chapter 2, verse 15). Lord Krishna uses the contradicting concepts of pleasure and pain to demonstrate this theme about the human condition [122] in order to convince Arjuna to pick his bow up and rise above worldly emotions.

Moreover, in terms of leading optimistic sentiments predicted by the model, according to the bigrams - we find [supreme, goal] and [every, creature] and the leading optimistic sentiment bigrams for the Eknath Easwaran's translation (Figure 5), whereas Shri Purohit Swami's translation gives [supreme, spirit] and [self, control] (Figure 7). Mahatma Gandhi's translation gives [pleasure, pain] and [without, attachment] (Figure 6). We notice that [pleasure, pain] is listed in the top five optimistic bigrams across the respective translation which shows that although the wording used in the translations are different, the sentiments they express are similar. Interestingly, we notice that [every, creature] (Figure 5) and [fruit, action] (Figure 7) is listed in both pessimistic and optimistic sentiments in the respective translations. A major reason could be the context in which these terms appear in the respective verses in the text.

We next present the chapter-wise sentiments for the respective translations as shown in Figures 8 and 9. Figure 4 presents the sentiments for the entire text where we notice that sentiments such as "denial", "anxious", "thankful" and "empathetic" are the least expressed sentiments while "annoyed", "optimistic" and "surprised" are the most expressed across the three texts. In terms of chapter-wise analysis, we find that there is a major difference in the predicted sentiments "optimistic", "pessimistic" and "surprise" in most cases shown in Figures 8 and 9. While Eknath Easwaran's translation leads in all positive sentiments - "optimistic", "thankful" and "empathetic", Mahatma Gandhi's translation has the highest number of "pessimistic", "annoyed", "anxious" and "surprise" sentiments. It is worthwhile to look into the text and review the exact verses and the predicted sentiments. We select Chapter 6 (Figure 8 - Panel f) and show the verses and their predicted sentiments which have a stark difference among different translations in Table 5. The words used, grammar and language style, and the meaning associated with the verse greatly differs across

(a) Chapter 1: The War Within

(b) Chapter 2: Self-Realization

(c) Chapter 3: Selfless Service

(d) Chapter 4: Wisdom in Action

(e) Chapter 5: Renounce and Rejoice

(f) Chapter 6: The Practice of Meditation

(g) Chapter 7: Wisdom and Realization

(h) Chapter 8: The Eternal Godhead

(i) Chapter 9: The Royal Path
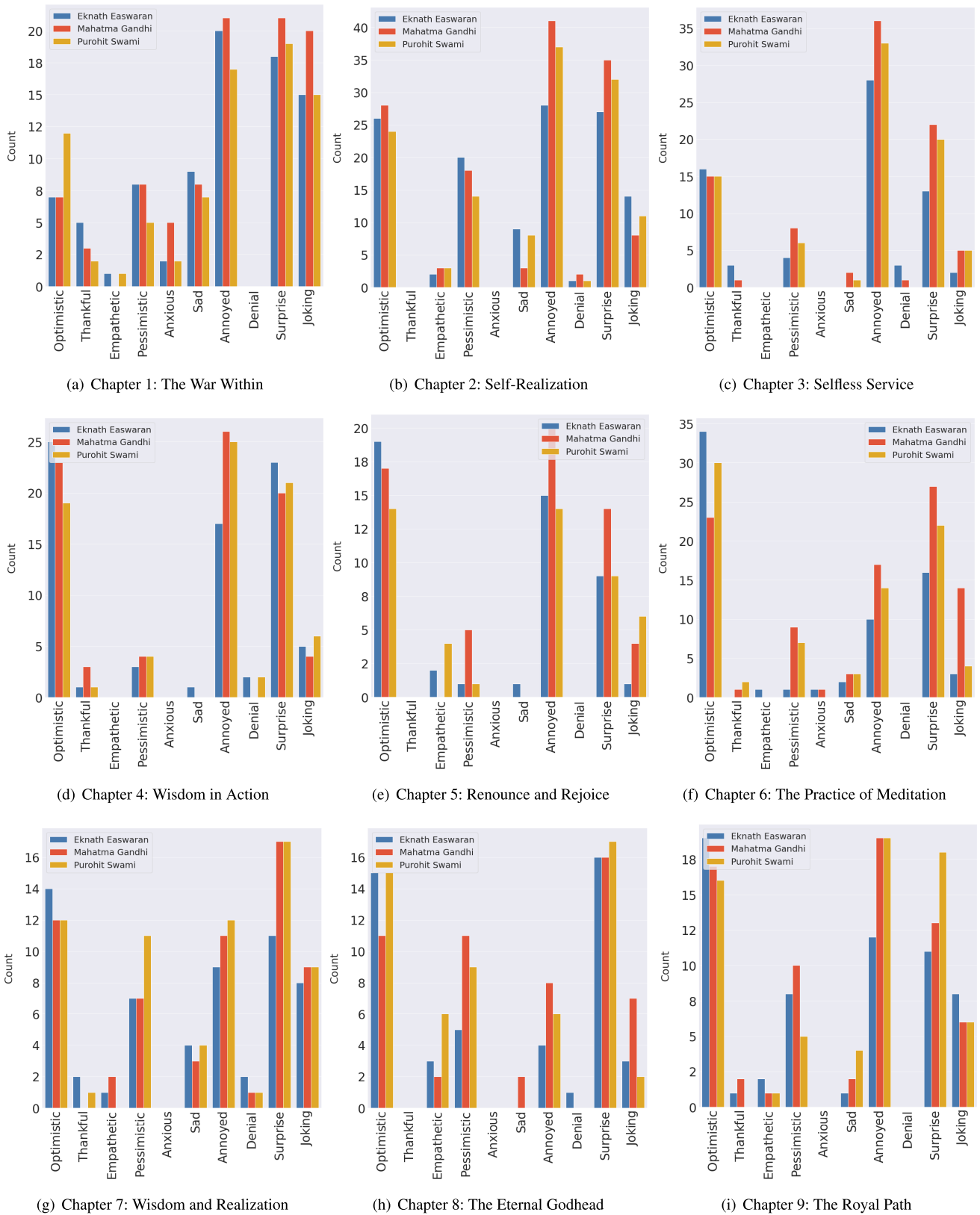
FIGURE 8. Chapter-wise sentiment analysis (Chapters 1 - 9).

(a) Chapter 10: Divine Splendor

(b) Chapter 11: The Cosmic Vision

(c) Chapter 12: The Way of Love

(d) Chapter 13: The Field and the Knower

(e) Chapter 14: The Forces of Evolution

(f) Chapter 15: The Supreme Self

(g) Chapter 16: Two Paths

(h) Chapter 17: The Power of Faith

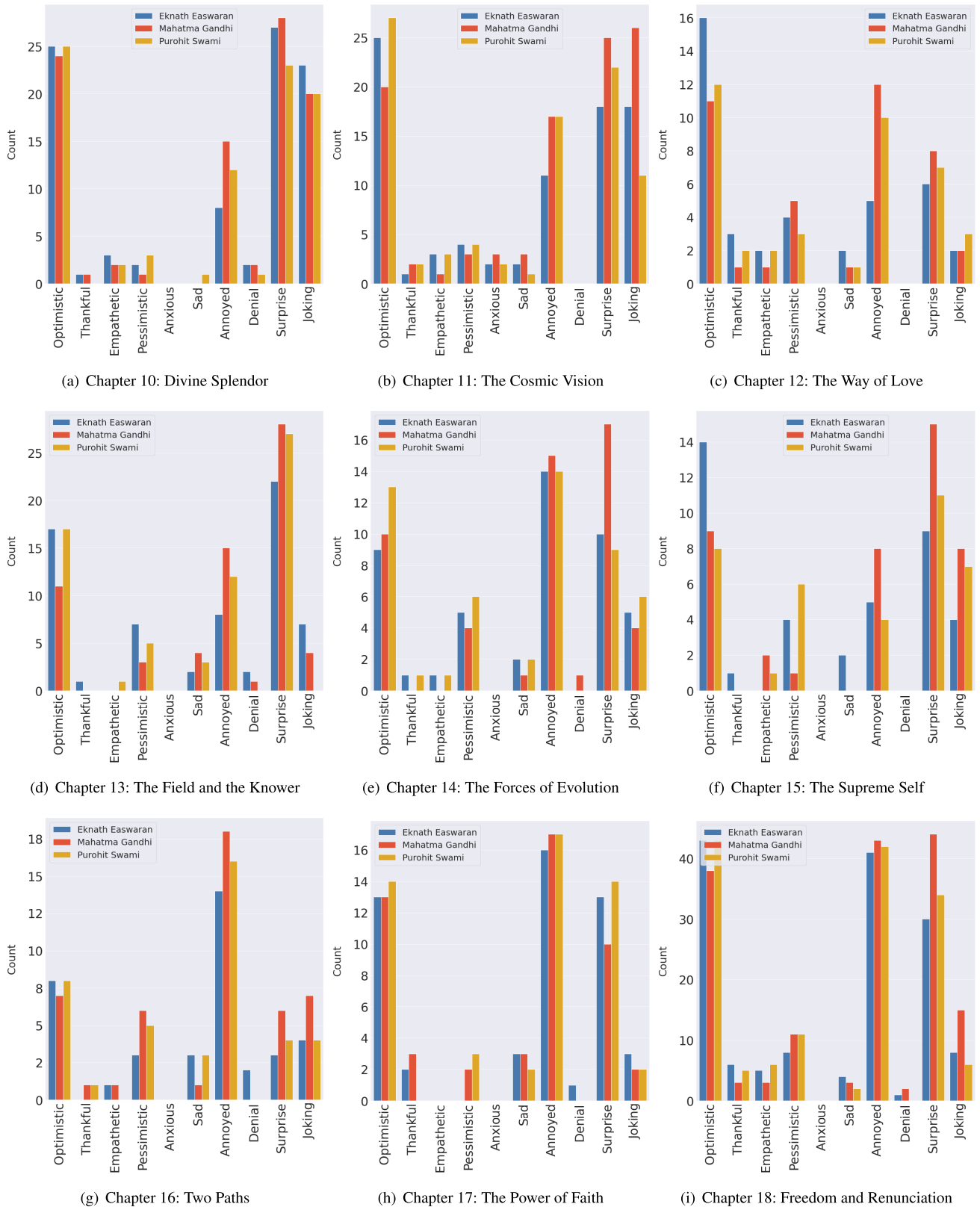(i) Chapter 18: Freedom and Renunciation

FIGURE 9. Chapter-wise sentiment analysis (Chapters 10 - 18).

TABLE 4. Names of chapters in the Bhagavad Gita as given in the different translations.

Chapter No.	Eknath Easwaran	Shri Swami Purohit	Mahatma Gandhi
1	The War Within	The Despondency of Arjuna	-
2	Self-Realization	The Philosophy of Discrimination	-
3	Selfless Service	Karma-Yoga - The Path of Action	-
4	Wisdom in Action	Dnyana-Yoga - The Path of Wisdom	-
5	Renounce and Rejoice	The Renunciation of Action	-
6	The Practice of Meditation	Self-Control	-
7	Wisdom from Realization	Knowledge and Experience	-
8	The Eternal Godhead	Life Everlasting	-
9	The Royal Path	The Science of Sciences and the Mystery of Mysteries	-
10	Divine Splendor	The Divine Manifestations	-
11	The Cosmic Vision	The Cosmic Vision	-
12	The Way of Love	Bhakti-Yoga - The Path of Love	-
13	The Field and the Knower	Spirit and Matter	-
14	The Forces of Evolution	The Three Qualities	-
15	The Supreme Self	The Lord-God	-
16	Two Paths	Divine and Demonic Civilization	-
17	The Power of Faith	The Threefold Faith	-
18	Freedom and Renunciation	The Spirit of Renunciation	-

TABLE 5. Some of the least similar verses in Chapter 6 according to predicted sentiments.
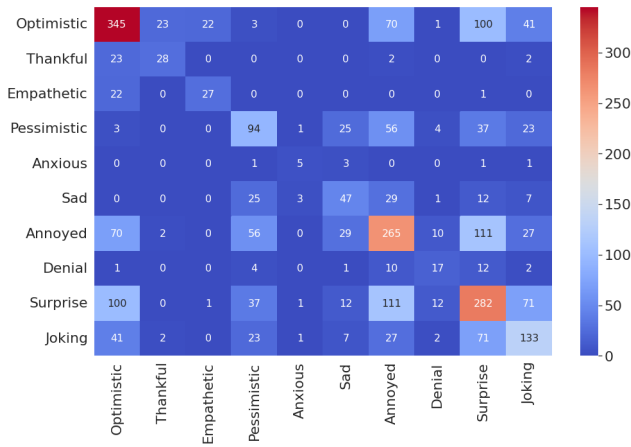
	Eknath Easwaran	Mahatma Gandhi	Shri Purohit Swami
Verse 2	Therefore, Arjuna, you should understand that renunciation and the performance of selfless service are the same. Those who cannot renounce attachment to the results of their work are far from the path.	What is called sannyasa, know you to be yoga, O Arjuna; for none can become a yogin who has not renounced selfish purpose.	O Arjuna! Renunciation is in fact what is called Right Action. No one can become spiritual who has not renounced all desire.
Predicted Sentiment	Annoyed, Surprise	Annoyed, Joking	Annoyed
Verse 5	Reshape yourself through the power of your will; never let yourself be degraded by self-will. The will is the only friend of the Self, and the will is the only enemy of the Self.	By one's Self should one raise oneself, and not allow oneself to fall; for soul (Self) alone is the friend of self, and Self alone is self's foe.	Let him seek liberation by the help of his Highest Self, and let him never disgrace his own Self. For that Self is his only friend; yet it may also be his enemy.
Predicted Sentiment	Optimistic, Annoyed	Pessimistic, Surprise	Optimistic, Annoyed
Verse 20	In the still mind, in the depths of meditation, the Self reveals itself. Beholding the Self by means of the Self, an aspirant knows the joy and peace of complete fulfillment.	Where thought curbed by the practice of yoga completely ceases, where a man sits content within himself, soul having seen soul;	There, where the whole nature is seen in the light of the Self, where the man abides within his Self and is satisfied there, its functions restrained by its union with the Divine, the mind finds rest.
Predicted Sentiments	Optimistic	Pessimistic, Sad, Surprise	Optimistic, Surprise
Verse 32	ARJUNA: O Krishna, the stillness of divine union which you describe is beyond my comprehension. How can the mind, which is so restless, attain lasting peace?	I do not see, O Krishna, how this yoga, based on the equal-mindedness that You have expounded to me, can steadily endure, because of fickleness (of the mind).	Arjuna said: I do not see how I can attain this state of equanimity which You has revealed, owing to the restlessness of my mind.
Predicted Sentiments	Surprise	Pessimistic, Annoyed	Surprise

the different translators as shown in Table 5 along with the underlying sentiment. If we consider verse 2, we find that the given sentiments are entirely different for the different translations. This is due to the way the verse is presented to our BERT-based language model. In the case of translation by Mahatama Gandhi, the verse could be perceived as joking. Eknath Easwaran presents that same verse in a tone that is showing annoyed and surprised sentiments while Shri Purohit Swami presents it in a tone that is annoyed. We need to highlight that similar to the sentiment analysis based on tweets, the proposed model does not consider the context of the overall chapter and hence this could be a limitation. We provide rest of the sentiment predictions in our GitHub repository.[4]
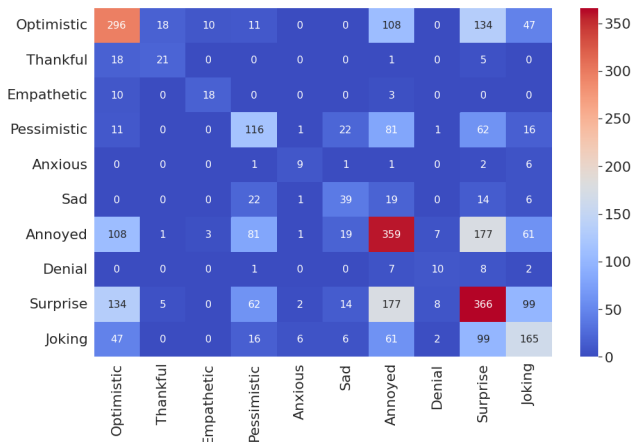
Figure 10 shows the heatmap with number of occurrence of a given sentiment in relation to the rest of the sentiments of all the verses in the respective translations. We notice that "annoyed", "optimistic" and "surprise" are the key sentiments across all the respective translations. In relation to rest of the sentiments, we find that the combination of "optimistic and annoyed", "optimistic and surprise", and "optimistic and joking" are the leading combinations.

We need to measure the similarity and diversity of the sentiments expressed with verse-by-verse comparison across the different translations. Table 6 shows the Jaccard similarity score computed on the predicted sentiments for three pairs of texts for selected chapters. The score is highest for Mahatma Gandhi and Shri Purohit Swami's versions which indicates they had the highest overlap of the predicted sentiments.
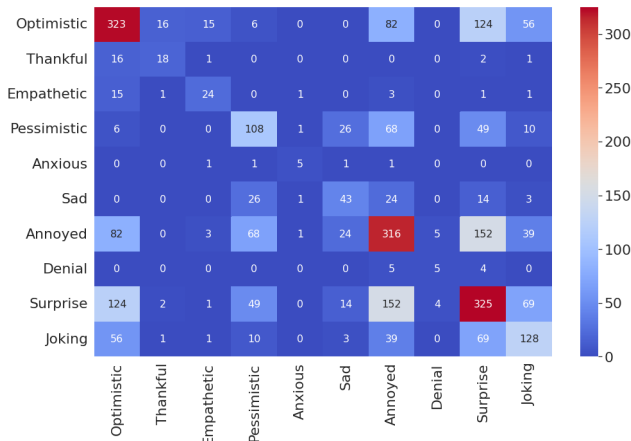
[4]https://git.io/J9GcU

(a) Eknath Easwaran

(b) Mahatma Gandhi

(c) Shri Purohit Swami

FIGURE 10. Heatmap showing number of occurrence of a given sentiment in relation to the rest of the sentiments of all the verses in the respective translations.

TABLE 6. Sentiment analysis of selected pairs of translations with Jaccard similarity score for predicted sentiments for select chapters. We provide the mean of the scores at the bottom (*).

	Easwaran-Gandhi	Purohit-Easwaran	Gandhi-Purohit
Chapter 3	0.604	0.506	0.684
Chapter 5	0.568	0.520	0.614
Chapter 7	0.559	0.486	0.574
Chapter 8	0.547	0.503	0.568
Chapter 9	0.501	0.486	0.565
Chapter 10	0.523	0.507	0.562
Chapter 11	0.507	0.488	0.527
Chapter 12	0.500	0.483	0.518
Chapter 15	0.494	0.490	0.516
Chapter 16	0.500	0.495	0.527
Chapter 17	0.510	0.501	0.536
*	0.526	0.497	0.563

verse cosine similarity score for the translations grouped by the chapter. We provide the mean and standard deviation of the score for the respective verses in each chapter. We observe that Chapter 17 is semantically least similar and Chapter 10 is most similar. Further, in the pair-wise comparison, Mahatma Gandhi and Shri Purohit Swami's translation are most similar to each other. It is important to note that these two translations also have the highest Jaccard similarity score for the predicted sentiments. We present some of the semantically least similar verses in Table 8. In Chapter 5 – Verse 5, Eknath Easwaran interprets the goals of knowledge and service to be the same, Mahatma Gandhi sees schools of Sankhya and Yoga philosophy as one, and Shri Purohit Swami interprets wisdom (Jnana) and right action (Dharma) as one. In this case, Mahatma Gandhi's verse is least similar to the other two (Score 1 and Score 2 are both lower than Score 3), primarily because it uses the Sanskrit terms of Sankhya and Yoga. Whenever, a particular translation uses a Sanskrit term, it obtains a lower cosine similarity score with respect to the other two as BERT-based models have been primarily trained on a large corpus of English texts. In Chapter 16 – Verse 4, we observe that there is a difference in the devilish qualities being discussed. Some of the qualities unique to each text are: cruelty (Eknath Easwaran), pretentiousness, coarseness (Mahatma Gandhi) and pride, insolence (Shri Purohit Swami). The difference in choice of words may be due to the different eras in which these translations were created, leading to the use of words prevalent at that point of time. Next, we present semantically most similar verses in Table 9. In Chapter 3 – Verse 4, we observe that although the choice of words are different, the meaning conveyed is similar. We find that the BERT-based language model assigns a high similarity score to all the three pairs. In Chapter 9 – Verse 18, the choice of words used by Mahatma Gandhi and Shri Purohit Swami is almost identical and hence, we obtain a high similarity score (Score 2).

Furthermore, we review the semantic score by presenting the actual verses from the translated versions of a selected

C. SEMANTIC ANALYSIS

Next, we provide analysis of the translation using semantic analysis of verse-by-verse comparison of the text. We encode the verses using the MPNet-base model and report the cosine similarity score for every chapter. Table 7 shows the verse by
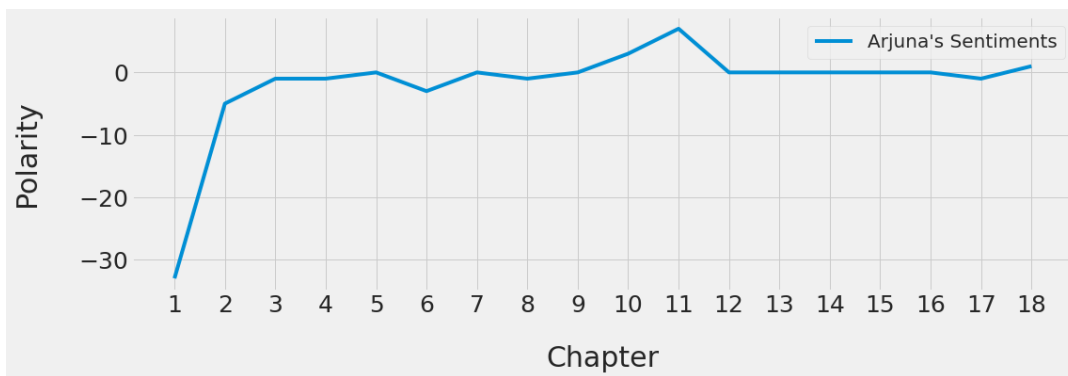
FIGURE 11. Arjuna's sentiments over time (chapters) in the translation by Eknath Easwaran.
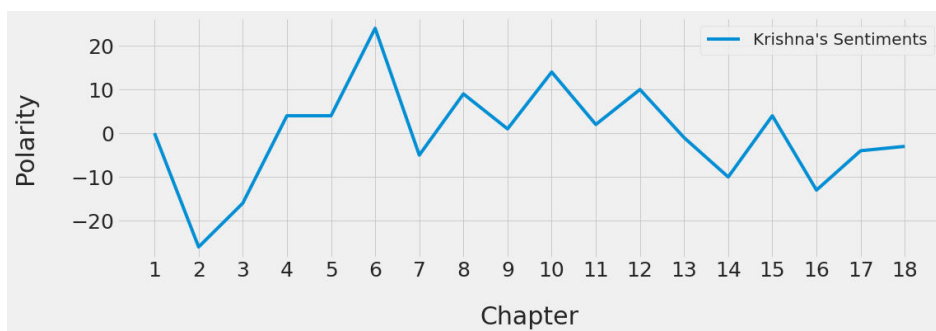

FIGURE 12. Lord Krishna's sentiments over time (chapters) in the translation by Eknath Easwaran.

chapter. We choose Chapter 12 since this chapter has one of the least verses, it is easier for us to include it in the paper. We publish the scores for the rest of the chapters in our GitHub repository.[5] In Table 10, we present all the verses taken from Chapter 12 with the cosine similarity score. We also present the mean and the standard deviation of the scores to provide an indication about the overall semantic similarity of the verses for the chapter for the comparison of selected translations.

We visualise the encoded verses in two dimensions using UMAP in Figure 13. We present the visualizations for one in every three chapters. We do not intend to find separate clusters for each translation as it is evident from Table 7 that the verses from each translation are semantically very similar to each other. However, we do find some interesting clusters which represent a sequence of events or consecutive verses in the text. For example, in Figure 13(a), the distinct clusters represent separate events. In Chapter 1, these include verses describing Sanjaya's description of battlefield to Dhritarashtra, Arjuna moving his chariot to the center of the battlefield, Arjuna expressing his grief to Krishna. In Chapter 4 (Figure 13(b)), we observe 3 clusters. The left-most cluster includes verses describing different forms of sacrifice, the bottom-most cluster comprises verses where Lord Krishna emphasises renunciation of oneself from fruits of action, and

the third cluster includes the conversation between Krishna and Arjuna from the first ten verses of the chapter. In Chapter 10 (Figure 13(d)), the lower cluster comprises the verses in which Lord Krishna describes his divine attributes to Arjuna, and the upper cluster features the rest of the conversation between Krishna and Arjuna in the chapter (primarily first 20 verses).

Furthermore, the keywords in the text/chapter play a vital role in semantic similarity. It is important to note that most keywords aptly signify the themes of the chapters. This helps us to quickly assess how different authors differ in their interpretation of key concepts. Table 11 shows the keywords obtained for all the chapters for the respective translations. In order to get a better perspective, we need to review the keywords from a selected chapter. Table 12 shows the keywords from Chapter 12 and their associated scores obtained using KeyBert.

Table 12 shows the keywords extracted from Chapter 12. This chapter starts with Arjuna asking Lord Krishna who are the better practitioners of yoga: those who love him dearly or those who seek the eternal reality. Lord Krishna responds that worshipping the eternal reality (Brahman) [9], [123] is extremely difficult for the humans. So, he suggests Arjuna to meditate and be devoted to him while engaging in selfless action (karma yoga). We note again that Lord Krishna is the avatar of Lord Vishnu (supreme consciousness) who is equivalent to the Abrahamic notion of God. A steady and

[5]https://git.io/JSyPB

stable state of mind can only be achieved by humans with the practice of meditation. It is pertinent to note the KeyBERT has extracted "meditate" as one of the top 10 keywords in Shri Purohit Swami's translation. Lord Krishna further says that the devotees who focus their mind with unflinching devotion are very dear to him (Chapter 12 – Verse 20). 'Devotion' and 'devotee' marks another central theme (topic) that has been correctly extracted, which also is the top keyword in all three translations. Furthermore, words such as "eternal", "unchanging", "omnipresent" are used to refer to the Atman (self/qualia). Arjuna and Krishna, though not themes, appear extensively in the chapter and therefore, they have been also extracted. We report the cumulative score where we have added the cosine similarity scores of the keywords in batches of 15 verses each (Table 12).

In order to provide further visualisation of the keywords and how they are related to each other, we use dimension reduction and plot the first two components of the latent vectors. We use uniform manifold approximation and projection (UMAP) [116] for dimension reduction. We obtained the UMAP embeddings by encoding top 10 keywords from all chapters using the MPNet sentence embedding model. The keywords which appeared in more than one chapter were removed. In these visualisations, we are primarily interested in analyzing clusters of data as UMAP algorithm is good at preserving the local structure by grouping neighboring data points together. Figure 14 presents the visualisation (scatter plot) of UMAP embedding. The cluster of keywords that provide important semantic information, with respect to their use in the Bhagavad Gita, are shaded in yellow. In Eknath Easwaran's translation, (Figure 14(a)) the words associated to the impending battle such "archers", "chariots", "war", "armies", "battle" form a cluster. Also, "roared", "death" and "killed" are close to this cluster in the embedding space. The keywords in the philosophy of giving away (the central theme in Chapter 5 – Renounce and Rejoice) also form a cluster. These include "sacrifice" (and "sacrifices"), "renounce", "renouncing", "renunciation", "abstaining", "surrendering", all of which have a similar underlying meaning. One of the central themes in Easwaran's translation - *selfless service* is captured by words such as "self-realization", "selflessly" ("selfless"), "realize" which cluster together. However, "selfish", "selfishly" also are a part of this cluster though they convey the opposite meaning. The terms "eternal", "immutable", "changeless" and "immortality" which are closely associated with qualia (Atman) appear as a cluster. The keywords representing the protagonists and associates in the Bhagavad Gita ("Krishna", "Arjuna", "Duryodhana", "Dhritarashtra") and their qualities such as "sattva", "dharma", "tyaga", "rajas" and "tamas" form a cluster in the upper portion of the embedding space.

In Mahatma Gandhi's translation (Figure 14(b)), "rajas, tamas" (bth undesirable qualities) a re very close to each other. Furthermore, most of the prominent personalities representing the righteous side of the war - "Krishna", "Arjuna", "Bhima" (Arjuna's brother),

"Pandu" (Arjuna's father), "Subhadra" (Arjuna's wife) and some of their qualities and attributes such as "tyagi", "yogi", "sattva", "rajas", "tamas" form a cluster. Moreover, "Ashvattha" [124] which is a sacred fig tree for Hindus is very close to the keyword "tree". The words related to the Atman (qualia) - "omnipresent", "transcending", "unchanging", "imperishable", "everlasting" "immovable" form a cluster near the bottom of the plot. The entities involved in or pertaining to the impending war of Kurukshetra - "bowmen", "vestments", "trumpets", "multitude" (referring to huge number of armed men on both sides), "mortals", "sons" are also found to cluster together. Finally, "lord", "devotion", "devotee", "worship", "reverence" also form a cluster. In Shri Purohit Swami's translation, Figure 14(c), the attributes of soul (as described in the Bhagavad Gita) form a cluster. These attributes that include - "divinity", "mysticism", "spirit", "power", "consciousness", "philosophy", "wisdom", "knowledge" form a cluster with "souls". Sacrifice is another key theme in Shri Purohit Swami's translation. In our visualization, "sacrifice", "relinquishment", "renunciation", and "vow" cluster together. The idea of the eternity of the soul is captured by the words - "omniscient", "omnipresent", "immovable", "changeless", "eternal". While the eternity of soul is a widely discussed theme in the Bhagavad Gita, so is the idea of rebirth. "Progenitors", "reborn", "reincarnation", "births", "creation", "nature", "mankind" are the keywords closely related to this idea that cluster together. We have not shown all the keywords due to limited space. It is interesting to note that in the respective UMAP embeddings, the points representing Arjuna and Lord Krishna are always closest to each other. Please note that the bigger sizes of the words "krishna", "yoga" and "sacrifice" do not imply any semantic importance (Figure 14(a), Figure 14(b), and Figure 14(c)).

V. FURTHER ANALYSIS AND DISCUSSION

We note that the Bhagavad Gita captures the conversation between Arjuna and Lord Krishna which takes place in the middle of the Kurushetra battlefield just before the war. The conversation is merely a few hours long and over the course of the Bhagavad Gita, Arjuna goes from being extremely distressed to a more calm and lucid state aware of his responsibilities. We wish to explore if the verses in which Arjuna has spoken can capture the variations of the sentiments expressed. Therefore, we provide an analysis where we calculate a sentiment polarity score in the range $[-1, 1]$ based on grouping the optimistic and pessimistic sentiments. In order to quantify the polarity of predicted sentiments, we assign a sentiment polarity score based on set of verses in each chapter by the respective speakers (Lord Krishna and Arjuna). We assign the sentiments such as "optimistic", "thankful" and "empathetic" a score of $+1$, and further assign "pessimistic", "anxious", "sad", "annoyed", and "denial" a score of -1. Finally, we assign "joking" and "surprise", a score of 0 since they can have positive or negative connotation. It should be noted that Arjuna does

TABLE 7. Semantic analysis using cosine similarity for selected chapters from selected pairs of the translations. Note that the mean is given with standard deviation (in brackets) for all the verses in the respective chapters at the bottom (*).

	Easwaran vs Gandhi	Purohit vs Easwaran	Gandhi vs Purohit
Chapter 3	0.627 (0.133)	0.608 (0.146)	0.694 (0.114)
Chapter 5	0.629 (0.129)	0.637 (0.105)	0.628 (0.122)
Chapter 7	0.698 (0.144)	0.668 (0.147)	0.691 (0.148)
Chapter 8	0.662 (0.123)	0.650 (0.081)	0.673 (0.124)
Chapter 9	0.681 (0.126)	0.686 (0.109)	0.731 (0.094)
Chapter 10	0.759 (0.096)	0.747 (0.113)	0.733 (0.123)
Chapter 11	0.705 (0.109)	0.731 (0.101)	0.721 (0.110)
Chapter 12	0.609 (0.120)	0.633 (0.097)	0.724 (0.096)
Chapter 15	0.686 (0.116)	0.675 (0.110)	0.657 (0.067)
Chapter 16	0.662 (0.096)	0.667 (0.100)	0.691 (0.116)
Chapter 17	0.654 (0.111)	0.591 (0.132)	0.642 (0.132)
*	0.670 (0.119)	0.663 (0.113)	0.689 (0.113)

TABLE 8. Semantically least similar verses. The cosine similarity (score) is given with the following combinations. Note that the comparisons are defined by Eknath Easwaran vs Mahatma Gandhi (Score 1), Mahatma Gandhi vs Shri Purohit Swami (Score 2), and Shri Purohit Swami vs Eknath Easwaran (Score 3).

Chapter	Verse	Eknath Easwaran	Mahatma Gandhi	Shri Purohit Swami	Score 1	Score 2	Score 3
5	5	The goal of knowledge and the goal of service are the same; those who fail to see this are blind.	The goal that the sankhyas attain is also reached by the yogins. He sees truly who sees both sankhya and yoga as one.	The level which is reached by wisdom is attained through right action as well. He who perceives that the two are one, knows the truth.	0.295	0.338	0.517
9	22	Those who worship me and meditate on me constantly, without any other thought I will provide for all their needs.	As for those who worship Me, thinking on Me alone and nothing else, ever attached to Me, I bear the burden of getting them what they need.	But if a man will meditate on Me and Me alone, and will worship Me always and everywhere, I will take upon Myself the fulfillment of his aspiration, and I will safeguard whatsoever he shall attain.	0.571	0.527	0.528
15	11	Those who strive resolutely on the path of yoga see the Self within. The thoughtless, who strive imperfectly, do not.	Yogins who strive see Him seated in themselves; the witless ones who have not cleansed themselves to see Him not, even though they strive.	The saints with great effort find Him within themselves; but not the unintelligent, who in spite of every effort cannot control their minds.	0.450	0.629	0.367
16	4	Other qualities, Arjuna, make a person more and more inhuman: hypocrisy, arrogance, conceit, anger, cruelty, ignorance.	Pretentiousness, arrogance, self-conceit, wrath, coarseness, ignorance—these are to be found in one born with the devilish heritage.	Hypocrisy, pride, insolence, cruelty, ignorance belong to him who is born of the godless qualities.	0.447	0.586	0.520
17	18	Disciplines practiced in order to gain respect, honor, or admiration are rajasic; they are undependable and transitory in their effects.	Austerity which is practiced with an eye to gain praise, honour and homage and for ostentation is said to be rajasa; it is fleeting and unstable.	Austerity coupled with hypocrisy or performed for the sake of self-glorification, popularity or vanity, comes from Passion, and its result is always doubtful and temporary.	0.440	0.740	0.212

TABLE 9. Semantically most similar verses. The cosine similarity (score) is given with the following combinations. Note that the comparisons are defined by Eknath Easwaran vs Mahatma Gandhi (Score 1), Mahatma Gandhi vs Shri Purohit Swami (Score 2), and Shri Purohit Swami vs Eknath Easwaran (Score 3).

Chapter	Verse	Eknath Easwaran	Mahatma Gandhi	Shri Purohit Swami	Score 1	Score 2	Score 3
3	4	One who shirks action does not attain freedom; no one can gain perfection by abstaining from work.	Never does man enjoy freedom from action by not undertaking action, nor does he attain that freedom by mere renunciation of action.	No man can attain freedom from activity by refraining from action; nor can he reach perfection by merely refusing to act.	0.753	0.879	0.837
7	9	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 sweet fragrance in earth; the brilliance in fire; the life in all beings; and the austerity in ascetics.	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.	0.909	0.917	0.856
9	18	I am the goal of life, the Lord and support of all, the inner witness, the abode of all. I am the only refuge, the one true friend; I am the beginning, the staying, and the end of creation; I am the womb and the eternal seed.	I am the Goal, the Sustainer, the Lord, the Witness, the Abode, the Refuge, the Friend; the Origin, the End the Preservation, the Treasure house, the Imperishable Seed.	I am the Goal, the Sustainer, the Lord, the Witness, the Home, the Shelter, the Lover and the Origin; I am Life and Death; I am the Fountain and the Seed Imperishable.	0.839	0.907	0.871
12	18	That devotee who looks upon friend and foe with equal regard, who is not buoyed up by praise nor cast down by blame, alike in heat and cold, pleasure and pain, free from selfish attachments,	Who is same to foe and friend, who regards alike respect and disrespect, cold and heat, pleasure and pain, who is free from attachment;	He to whom friend and foe are alike, who welcomes equally honour and dishonour, heat and cold, pleasure and pain, who is enamoured of nothing,	0.827	0.885	0.820

(a) Chapter 1

(b) Chapter 4

(c) Chapter 7

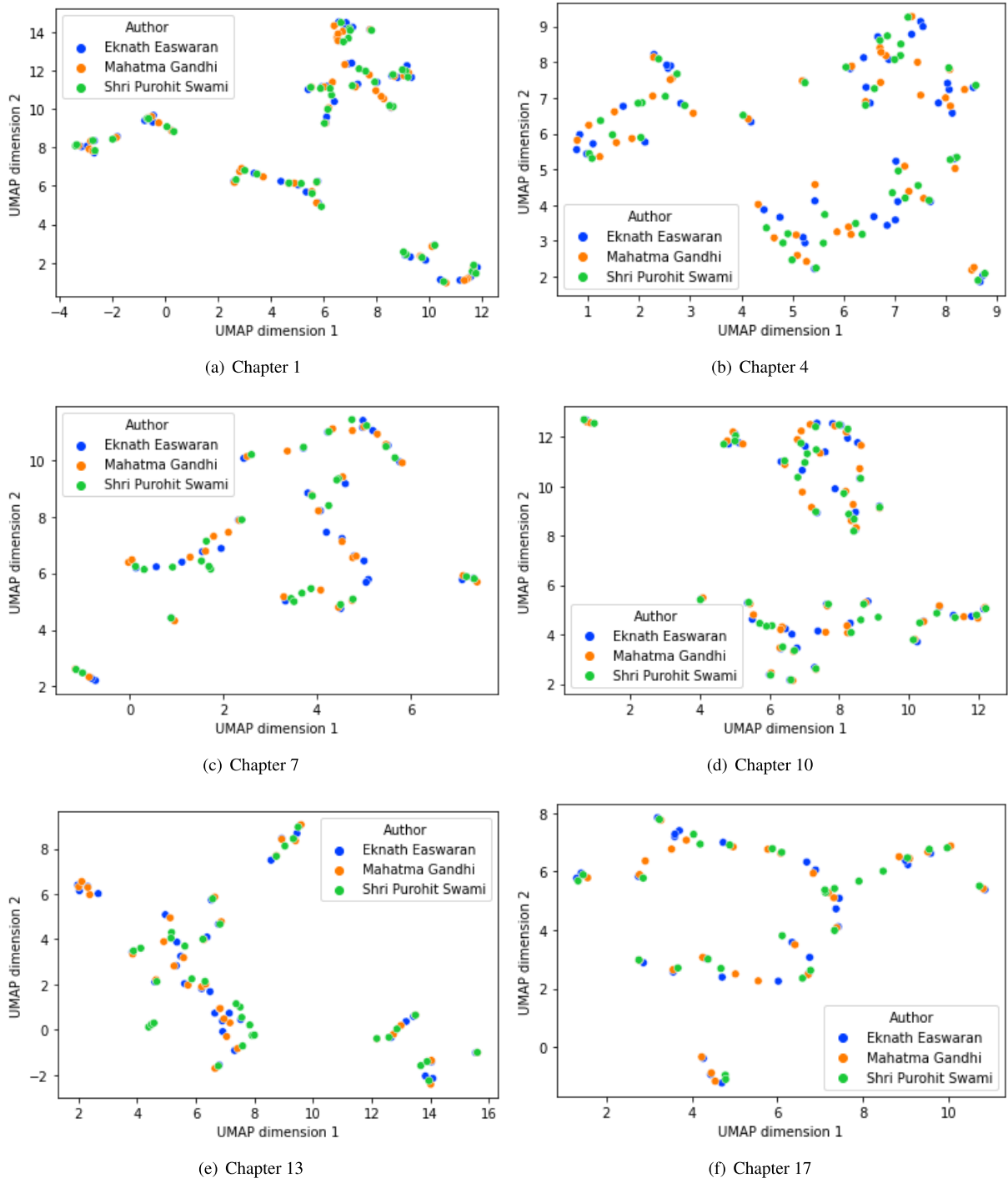(d) Chapter 10

(e) Chapter 13

(f) Chapter 17

FIGURE 13. Chapter-wise UMAP embedding visualization.

not speak in certain chapters (7, 9, 13, 15, 16) and hence, the polarity score is zero. We show the chapter-wise polarity score for Eknath Easwaran's translation in Figure 11 for Arjuna where we observe that Chapter 1 has the maximum negative sentiment over time (chapters). This is because in the beginning of the Bhagavad Gita, Arjuna is distraught and refuses to fight the war on seeing his family and friends on

the opposite side. Moreover, we notice the polarity increases towards positive sentiments from Chapter 2 and then there is a bump in Chapter 11. This is because in Chapter 11, Arjuna is overwhelmed by Lord Krishna's *universal form* (viraat roopa) and considers himself fortunate to have witnessed it, hence the maximum positive sentiments come from this chapter. Similarly, we have shown the variation of Lord Krishna's

TABLE 10. Semantic similarity of verses from Chapter 12. The cosine similarity (score) is given with the following combinations. Note that the comparisons are defined by Eknath Easwaran vs Mahatma Gandhi (Score 1), Mahatma Gandhi vs Shri Purohit Swami (Score 2), and Shri Purohit Swami vs Eknath Easwaran (Score 3). We provide the mean and standard deviation (in brackets) of the scores at the bottom (*).

Verse	Eknath Easwaran	Mahatma Gandhi	Shri Purohit Swami	Score 1	Score 2	Score 3
1	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?	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 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?	0.414	0.589	0.573
2	KRISHNA: Those who set their hearts on me and worship me with unfailing devotion and faith are more established in yoga.	Those I regard as the best yogins who, riveting their minds on Me, ever attached, worship Me, with the highest faith.	Lord Shri Krishna replied: Those who keep their minds fixed on Me, who worship Me always with unwavering faith and concentration; these are the very best.	0.490	0.575	0.663
3	As for those who seek the transcendental Reality, without name, without form, contemplating the Unmanifested, beyond the reach of thought and of feeling,	But those who worship the Imperishable, the indefinable, the Unmanifest, the Omnipresent, the Unthinkable, the Rock-seated, the Immovable, the Unchanging,	Those who worship Me as the Indestructible, the Undefinable, the Omnipresent, the Unthinkable, the Primeval, the Immutable and the Eternal;	0.579	0.826	0.488
4	with their senses subdued and mind serene and striving for the good of all beings, they too will verily come unto me.	Keeping the whole host of senses in complete control, looking on all with an impartial eye, engrossed in the welfare of all beings—these come indeed to Me.	Subduing their senses, viewing all conditions of life with the same eye, and working for the welfare of all beings, assuredly they come to Me.	0.533	0.619	0.742
5	Yet hazardous and slow is the path to the Unrevealed, difficult for physical creatures to tread.	Greater is the travail of those whose mind is fixed on the Unmanifest; for it is hard for embodied mortals to gain the Unmanifest—Goal.	But they who thus fix their attention on the Absolute and Impersonal encounter greater hardships, for it is difficult for those who possess a body to realise Me as without one.	0.430	0.622	0.426
6	But they for whom I am the supreme goal, who do all work renouncing self for me and meditate on me with single-hearted devotion,	But those who casting all their actions on Me, making Me their all in all, worship Me with the meditation of undivided devotion,	Verily, those who surrender their actions to Me, who muse on Me, worship Me and meditate on Me alone, with no thought save of Me,	0.776	0.799	0.725
7	these I will swiftly rescue from the fragments cycle of birth and death, for their consciousness has entered into me.	Of such, whose thoughts are centered on Me, O Arjuna, I become before long the Deliverer from the ocean of this world of death.	O Arjuna! I rescue them from the ocean of life and death, for their minds are fixed on Me.	0.546	0.752	0.560
8	Still your mind in me, still your intellect in me, and without doubt you will be united with me forever.	On Me set your mind, on Me rest your conviction; thus without doubt shall you remain only in Me hereafter.	Then let your mind cling only to Me, let your intellect abide in Me; and without doubt you shall live hereafter in Me alone.	0.632	0.788	0.669
9	If you cannot still your mind in me, learn to do so through the regular practice of meditation.	If you can not set your mind steadily on Me, then by the method of constant practice seek to win Me, O Arjuna.	But if you can not fix your mind firmly on Me, then, My beloved friend, try to do so by constant practice.	0.583	0.622	0.655
10	If you lack the will for such self-discipline, engage yourself in my work, for selfless service can lead you at last to complete fulfillment.	If you are also unequal to this method of constant practice, concentrate on service for Me; even thus serving Me you shall attain perfection.	And if you are not strong enough to practise concentration, then devote yourself to My service, do all yours acts for My sake, and you shall still attain the goal.	0.637	0.746	0.664
11	If you are unable to do even this, surrender yourself to me, disciplining yourself and renouncing the results of all your actions.	If you are unable even to do this, then dedicating all to Me, with mind controlled, abandon the fruit of action.	And if you are too weak even for this, then seek refuge in union with Me, and with perfect self-control renounce the fruit of your action.	0.749	0.646	0.682
12	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.	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.	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.	0.673	0.854	0.681
13	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,	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;	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,	0.558	0.811	0.507
14	patient, contented, self-controlled, firm in faith, with all their heart and all their mind given to me with such as these I am in love.	Who is ever content, gifted with yoga, self-restrained, of firm conviction, who has dedicated his mind and reason to Me—that devotee (bhakta) of Mine is dear to Me.	Always contented, self-centred, self-controlled, resolute, with mind and reason dedicated to Me, such a devotee of Mine is My beloved.	0.495	0.646	0.768
15	Not agitating the world or by it agitated, they stand above the sway of elation, competition, and fear: that one is my beloved.	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.	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.	0.567	0.758	0.621
16	They are detached, pure, efficient, impartial, never anxious, selfless in all their undertakings; they are my devotees, very dear to me.	Who expects nothing, who is pure, resourceful, unconcerned, untroubled, who indulges in no undertakings, —that devotee of Mine is dear to Me.	He who expects nothing, who is pure, watchful, indifferent, unruffled, and who renounces all initiative, such a one is My beloved.	0.684	0.847	0.569
17	That one is dear to me who runs not after the pleasant or away from the painful, grieves not, lusts not, but lets things come and go as they happen.	Who rejoices not, neither frets nor grieves, who covets not, who abandons both good and ill—that devotee of Mine is dear to Me.	He who is beyond joy and hate, who neither laments nor desires, to whom good and evil fortunes are the same, such a one is My beloved.	0.628	0.678	0.597
18	That devotee who looks upon friend and foe with equal regard, who is not buoyed up by praise nor cast down by blame, alike in heat and cold, pleasure and pain, free from selfish attachments,	Who is same to foe and friend, who regards alike respect and disrespect, cold and heat, pleasure and pain, who is free from attachment;	He to whom friend and foe are alike, who welcomes equally honour and dishonour, heat and cold, pleasure and pain, who is enamoured of nothing,	0.827	0.885	0.885
19	the same in honor and dishonor, quiet, ever full, in harmony everywhere, firm in faith such a one is dear to me.	Who weighs in equal scale blame and praise, who is silent, content with whatever his lot, who owns no home, who is of steady mind,— that devotee of Mine is dear to Me.	Who is indifferent to praise and censure, who enjoys silence, who is contented with every fate, who has no fixed abode, who is steadfast in mind, and filled with devotion, such a one is My beloved.	0.541	0.732	0.583
20	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.	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.	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."	0.840	0.684	0.664
*				0.609 (0.120)	0.724 (0.096)	0.633 (0.097)

sentiments in Figure 12, where he begins with a neutral sentiment polarity and then becomes negative in Chapter 2, and positive afterwards till Chapter 13. Moving on, his sentiments fluctuates and also becomes close to neutral as the time progresses.

In Table 5, verse 2 validates our earlier observation of the differences in central themes (selfless service - Eknath Easwaran, right action - Shri Purohit Swami). It is important to note that the BERT model has been trained on a dataset of tweets which featured sarcastic comments

TABLE 11. Keywords for all chapters.

Chapter	Eknath Easwaran	Mahatma Gandhi	Shree Purohit Swami
1	arjuna, krishna, battle, dharma, brahmins dhritarashtra, war, devadutta, bhishma, bhima	arjuna, maharatha, battle, devadatta, armies, sanjaya, bhima, kripa, yudhishthira, war	arjuna, dharmaraja, maharaja, battle, dhritarashtra, devadatta, war, duryodhana, sanjaya, kripa
2	arjuna, sorrow, souls, immortality, krishna, death, arise, reverence, despair, disciple	arjuna, anguish, krishna, sorrowing, reverence, arise, heartedness, compassion, endure, slain	arjuna, equanimity, anguish, krishna, reverence, compassion, endure, terror, disciple, battle
3	arjuna, devotion, wisdom, selfless, selflessly, krishna, knowledge, inaction, desires, brahman	arjuna, krishna, sacrifice, inaction, detachment, renunciation, desires, pervading, yoga, prakriti	arjuna, wisdom, sacrifice, meditates, inaction, krishna, meditate, worship, refraining, honour
4	teachings, arjuna, dharma, krishna, yoga, eternal, devotee, sages, changeless, surrendering	arjuna, yoga, wrath, sages, devotee, essence, changeless, succession, learnt, varnas	arjuna, reincarnate, wisdom, krishna, worship, materialism, devotee, changeless, ancestors, births
5	selfless, wisdom, renunciation, arjuna, krishna, judgment, desires, sannyasa, duality, selfishly	renunciation, yoga, soul, sankhyas, virtue, actions, peace, karmayoga, attain, ascetic	meditating, wisdom, renunciation, krishna, arjuna, praise, divine, sin, purification, perceives
6	meditation, yoga, selfrealization, arjuna, selfless, attains, energy, abiding, refrain, renounce	yoga, yogi, arjuna, oneself, contentment, nirvana, purification, spirit, motionless, sannyasin	spirituality, meditation, krishna, arjuna, celibacy, purification, renounces, virtuous, vow, sage
7	arjuna, devotion, krishna, spiritual, prakriti, eternal, universe, yoga,nature,realize	arjuna,vedas,transcending,yoga, jiva, essence,evil,universe,manliness,mystery	arjuna,krishna,godless,spiritual, righteousness, eternal,scriptures,beings,natures,unto
8	brahman,arjuna,devotion, krishna, eternal, souls, adhiyajna, death, existence, realize	brahman, arjuna, vedas, adhyatma, devotion, death,embodied,abode,yogi,departs	arjuna,devotion,consciousness, eternity,souls, divinity,krishna,meditate,scriptures,omniscient
9	devotion, krishna, arjuna, eternal, souls, divine, behold, vijnana, wisdom, existence	arjuna,dharma, transcendent, prakriti, doctrine, souls, homage, multitude, condemn, lord	devotion, arjuna, krishna, godless,mysticism,souls, multitude,immovable,beings,universe
10	krishna, arjuna,brahman,devotion,sages, creation,divine,manifestations,wisdom,equanimity	arjuna,brahman,devotion,gods, beings, discernment,yoga,everlasting,contentment, inward	krishna,arjuna,devotion, godless,wisdom, eternal,mankind,holiest,progenitors,contentment
11	arjuna,krishna,creation,behold,infinite, celestial,perceive,yoga,exalted,sages	arjuna,krishna,gods,behold, universe, multitudes,vasus,yoga,vestments,imperishable	arjuna,krishna,omnipresent, universe,behold, celestial,embraced,radiance,powers,petal
13	devotion,brahman,krishna,buddhi,spiritual, immortality, wisdom, arjuna, sages, arise	brahman, consciousness, devotion, arjuna, uprightness, body, aphoristic, aversion, immovable, pretentiousness	devotion, wisdom, vitality, perception, krishna, omniscient, nature, arjuna, matter, renunciation
14	krishna, arjuna, tamas, indolence, transcends, reborn, wisdom,death,rajas,wombs	arjuna,tamas,sages,creation, prakriti, attains,heedlessness,sattva,beings,restlessness	purity,indolence,krishna, divinity,sinless, infatuation,spirit,reborn,eternal,knowledge
15	krishna,eternal,scriptures,wisdom, essence, immutable,ashvattha,sages,tree,universe	vedanta,ashvattha,eternal, souls,perceive, tree,ramified,abode,inward,ancient	eternal,creation,krishna, scriptures,wisdom, perceive,celestial,regeneration,nourishment,tree
16	krishna,arjuna,demonic,scriptures, purity, god,renunciation,qualities,hypocrisy,shall	arjuna,sacrifice,purity, souls,wrath,spiritedness, devilish,aversion,pretentiousness,god	godless,krishna,wrath, scriptures,harmlessness, modesty,shall,destroy,delusion,hypocritical
17	tamasic,krishna,sacrifices,worship,arjuna, scriptures,disregard,rajas, hypocrisy,sattva	worship,krishna, yakshas, arjuna,forsake, shastra,sattva,rajas,pretentiousness,unholy	sacrifice,purity,krishna, arjuna,scriptures, nourishing,aryans,vigour,unclean,covet
18	arjuna,discipline,sacrifice,renunciation, sannyasa, discomfort,divine,tyaga,selfish,meaning	arjuna,sacrifice,renunciation, doctrine,undertakes, tyagi,abandon,embodied,actions,wise	arjuna,benevolence,sacrifice, renunciation,philosophy, relinquishment,desire,renounce,forgoing,act

TABLE 12. Keywords extracted from Chapter 12 for the respective translations.

Eknath Easwaran	Score	Mahatma Gandhi	Score	Shri Purohit Swami	Score
devotion	1.83	devotion	2.17	devotee	1.54
arjuna	1.61	arjuna	1.54	worship	1.51
krishna	1.52	omnipresent	1.20	krishna	1.33
yoga	1.31	yoga	1.16	arjuna	1.29
selfless	1.29	mortals	1.00	eternal	1.10
eternal	1.22	embodied	0.98	meditate	0.99
serene	1.10	lord	0.93	renunciation	0.90
renouncing	0.89	unchanging	0.92	verily	0.76
beings	0.86	attain	0.87	realise	0.70
established	0.66	steadily	0.73	attention	0.60

and jokes. Hence, the Senwave dataset contains the label - "joking". However, in the Bhagavad Gita, this sentiment is not apt and therefore, some verses may have been classified as "joking" inaccurately. Please note that we have shown the pre-processed verses here as they have been used for sentiment prediction and not the original verses.

In the heatmaps (Figure 10), we observe that verses labelled as 'joking' have a significant overlap with "optimistic", "annoyed" and "surprise". We could have removed

the joking label from the training data as we know that the Bhagavad Gita does not contain jokes, but it is interesting to know that due to the translation style, humour was detected in the way certain questions were asked and answered. We present some verses in Table 13 that were classified as "joking". We note that these were not jokes but verses that can be considered humorous, which is based on the way experts have hand-labelled tweets during COVID-19 outbreak in 2020. We can note this as a major limitation since we are using hand labelled sentiments from social media as
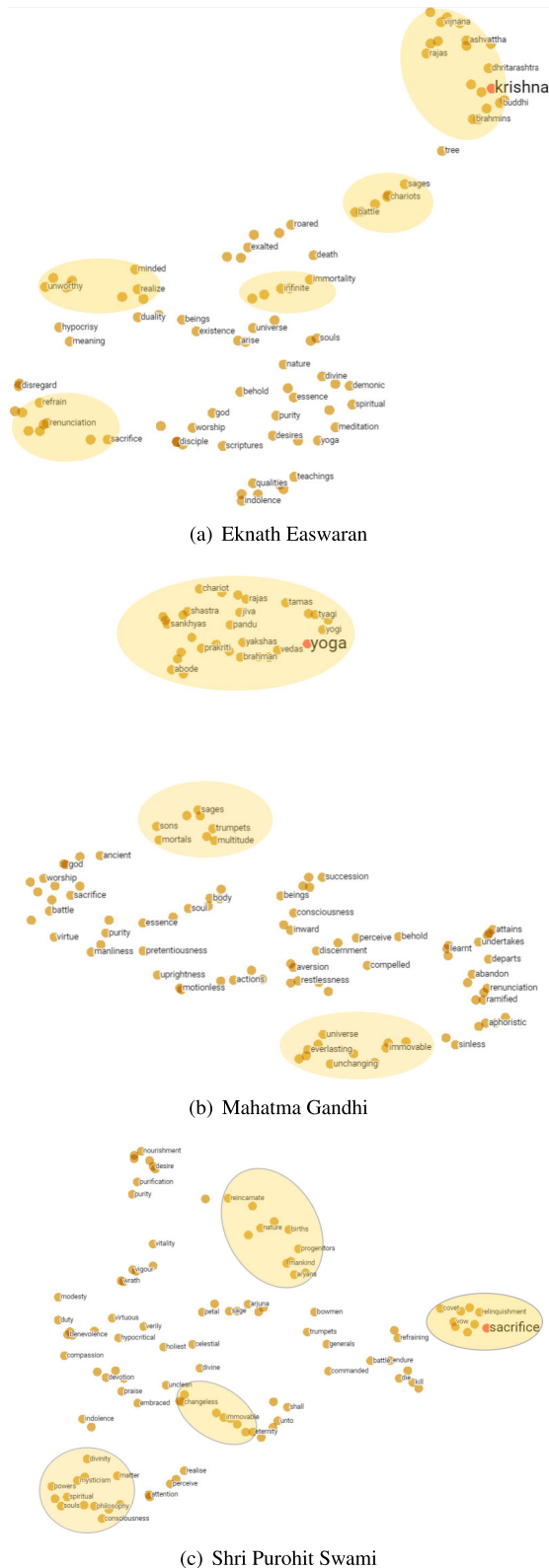
(a) Eknath Easwaran

(b) Mahatma Gandhi

(c) Shri Purohit Swami

FIGURE 14. Visualisation of UMAP embedding of keywords from the respective translations.

training data and applying it to a entirely different area - philosophy and religion.

We have two major limitations of the proposed framework. The first major limitation is in terms of the model and the training data, since the model is based on pre-trained BERT model which is generic and cannot capture the essence of Hindu philosophy. We note that there are specific Sanskrit terms that are difficult to translate. There are a number of BERT specific models, for different domains such as Med-BERT for medicine [125] and Legal-BERT for law [126]. In the case of philosophy, we do not have any pre-trained model for masked language modelling. Our application is unique, and hence a BERT-based on western philosophy will not suffice. We would need a pre-trained BERT model for Hindu philosophy in order to capture the essence and specific words such as *Brahman, avatar, karma, bhagwan, Vishnu, maya, viraat roopa, and dharma*. Once the key terms are recognised, pre-processing of the respective texts will not be crude where we simply change the words to English without considering the context. We need to note that the English language is heavily influenced by the concept of God in Abrahamic religions (Christianity, Judian and Islam); hence, the term God has a specific meaning which is in contrast to equivalent concepts such as Brahman or Vishnu. The Abrahmic notion of God refers to the creator who is not part of the universe [127], but can control the universe and controls the mortals (humans) with rewards and punishment. The Hindu definition of God is entirely different [128], where the creator and the creation are seen as the same. Hindu philosophy views the creation featuring two major aspects; i.e., consciousness (Purusha) which is depicted by the male Gods such as Brahma and nature and matter; nature (Prakrati) which is depicted by their consorts, the Goddesses such as Saraswati, Parvati and Laxmi.

We note that in Chapter 2 of the Bhagavad Gita, there are fifteen predicates used to define the Atman which in some philosophical traditions such as the Advaita Vedanta is seen same as the Paramatman (supreme Atman) and also Brahman (ultimate reality). The descriptions of Atman are given by the terms avinasin (non-perishable), avyaya (non-changeable), anasin (non-destructible), aprameya (non-measurable), aja, (non-born) nitya (eternal), sasvata (constant), sarvagata (omnipresent), sthanu (steadfast) acale (non-movable), sanatana (everlasting) avyakta (non-manifest), acintya (nonconceivable), avikarya (non-variable), and avadhya (non-violable). These definitions of the supreme reality are also found in the Upanishads [129]. These include, tat tvam asi (thou art that) - Chandogya Upanishad - 6.8.7 aham brahmāsmi (I am Brahman) - Brihadaranyaka Upanishad 1.4.10 which build the foundation of Advaita Vedanta [130].

Hinduism is often labelled as polytheist, but in principle it is a form of pantheism [131] which is a philosophical system based on the notion that reality is identical with divinity, i.e., the creator and creation are the same. Apart from this, Hindu philosophy also caters for schools of atheism, such as Carvaka philosophy [132]; and non-theism, such as Buddhism and Jainism. These schools and definitions make it difficult to translate Sanskrit words to English since they

TABLE 13. Selected verses with 'joking' as the predicted sentiment.

Chapter			Eknath Easwaran	Mahatma Gandhi	Shri Purohit Swami
5	Verse 23		But those who overcome the impulses of lust and anger which arise in the body are made whole and live in joy.	The man who is able even here on earth, before he is released from the body, to hold out against the floodtide of lust and wrath,—he is a yogi, he is happy.	He who, before he leaves his body, learns to surmount the promptings of desire and anger is a saint and is happy.
	Predicted Sentiment		Joking, Optimistic	Joking, Optimistic	Joking, Optimistic
11	Verse 14		Filled with amazement, his hair standing on end in ecstasy, he bowed before the Lord with joined palms and spoke these words.	Then Arjuna, wonderstruck and thrilled in every fibre of his being, bowed low his head before the Lord, addressing Him thus with folded hands. Arjuna Said:	Thereupon Arjuna, dumb with awe, his hair on end, his head bowed, his hands clasped in salutation, addressed the Lord thus:
	Predicted Sentiment		Joking	Joking, Surprise	Joking, Surprise
11	Verse 27		All are rushing into your awful jaws; I see some of them crushed by your teeth.	Are hastening into the fearful jaws of Your terrible mouths. Some indeed, caught between Your teeth, are seen, their heads being crushed to atoms.	I see them all rushing headlong into Your mouths, with terrible tusks, horrible to behold. Some are mangled between your jaws, with their heads crushed to atoms.
	Predicted Sentiments		Joking	Joking, Anxious, Annoyed	Joking

have historical development of the terms with philosophical annotations. For examples, Vishnu means "preserver", "vastness" and Brahma "refers to "the creator" and Shiva can refer to "the auspicious one" and depending on the content, various different names are used. For instance, Natraja refers to the dancing Shiva - widely known as the cosmological dancer [133]. Rudra often refers to the personality of Shiva in anger. Moreover, certain Sanskrit terms with similar wordings can have entirely different meaning, e. Bhram (illusion), Brahma (creator), Brahman (ultimate reality), Brahmand (universe), and Brahmin (priest or academic caste/profession).

Apart from the context and the difference in the philosophical system, we note that the challenge of translating the Bhagavad Gita is not only that it is written in an ancient language which is not a conversational language nowadays, but also that it is written as a poem (as a song). The term 'gita' translates to 'song' and Bhagavad Gita translates to 'song of the divine'. The Bhagavad Gita has been written as a song so that it can be remembered and sung and this is how it has been transmitting through oral tradition. It is well known that translating poetry and songs leads to losing rhyming patterns and at times meaning, since certain metaphors and expressions are constrained to specific languages, cultural traditions and time-frames [134], [135]. Moreover, certain verses in the Gita can have multiple layers of meaning since they are written in the form of poetry and feature literary devices such as metaphors [136]. Hence, translating such texts is very challenging, due to language and style of the ancient Hindu writers also known as Rishi's [137], [138]. Note there are certain prominent translations, such as the 'Bhagavadgita' by Sir Edwin Arnold that give a poetic interpretation [139] but do not distinguish the different verses. A recent translation by Badhe [140] maintained the verses with rhythm and rhyming patterns so that it does not lose the essence of the song-verse style from the original Sanskrit version. Future work can be done by analysis of sentiment and semantic similarity of translations that maintain rhythm and rhyme.

VI. CONCLUSION AND FUTURE WORK
We presented a framework for comparing translations of the Bhagavad Gita using sentiment and semantic analysis. In terms of the comparison of the translations with statistical measures (such as bigrams and trigrams), we found major differences in the translations. Due to the nature of the Sanskrit language and the fact that the Bhagavad Gita is a song with rhythm and rhyme, it is not surprising that different translators used different vocabulary to describe the same concepts. Moreover, we note the vast difference in the dates of the translations (1935, 1946, and 1985); hence it is natural to find a major change in vocabulary and expressions. Moreover, we also found that two of the earlier translators (Mahatma Gandhi and Shri Purohit Swami) used archaic words which were pre-processed to modern vocabulary so that it is easier for modelling. In the translation by Eknath Easwaran, we did not find any archaic words. Furthermore, the translators also used different names for Arjuna and Lord Krishna, which we also pre-processed. Hence, the language and vocabulary across the different translations vastly differ.

In the sentiment analysis, we find that although the language and vocabulary has been vastly different, the BERT-based language model has been able to recognise the sentiments well which have been mostly similar given the different chapters of the respective translations. The sentiments such as optimistic, annoyed and surprised have been the most expressed while the model also considered a significant number of verses as joking. It is also interesting to find how the sentiment polarity changes for Arjuna and Lord Krishna over time, as the conversation deepens where Arjuna is pessimistic towards the beginning and then becomes optimistic with knowledge of Hindu philosophy and Karma Yoga imparted by Lord Krishna. Apart from the knowledge given by the philosophy of karma and dharma, the polarity of the sentiments expressed which changed over time could be a reason why the Bhagavad Gita is seen as a book of psychology, management and conflict resolution. The sentiments expressed by Krishna shows that with philosophical knowledge of dharma and

mentor-ship, a troubled mind can get clarity for making the right decisions in times of conflict.

The results from the semantic analysis also showed that the meaning conveyed across the different translations were similar although different language and vocabulary were used. Further, the keywords extracted from the different translations also showed similar terms, although in different order of importance.

Future work can focus in using Sanskrit expert translators to review the sentiments presented by the framework for the different translators. Moreover, we can also apply the framework to translations of the Bhagavad Gita that retain rhythm and rhyme. The same framework can be used to analyse the translations of other texts, these include the Upanishads and also translations of texts in other domains from different languages.

DATA AND CODE
Python-based open source code and data can be found here.[6]

AUTHOR CONTRIBUTIONS STATEMENT
Rohitash Chandra devised the project with the main conceptual ideas and experiments and contributed to overall writing, literature review and discussion of results. Venkatesh Kulkarni provided implementation and experimentation and further contributed in results visualization and analysis.

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