

Natural language processing for philosophy of religion: Analysis of translations, sentiments and topics in religious texts

Rohitash Chandra

School of Mathematics and Statistics
UNSW Sydney

Seminar: LaTrobe University



Overview

- Language modelling with deep learning
- Hindu texts (Bhagavad Gita and Upanishads)
- Sentiment Analysis - Bhagavad Gita
- Topic Modelling - Bhagavad Gita and Upanishads
- Google Translate and Post-evaluation of language models
- Future plans

Sentiment Analysis

- Sentiment analysis is part of natural language processing, text analysis, computational linguistics, and biometrics.
- Sentiment analysis typically use language models to identify, extract, quantify, and study affective states (emotions).
- Sentiment analysis is used for marketing and advertising, analysing customer reviews and surveys, social media analysis, and applied to various domains including medicine and public health.

Topic Modelling

- Topic modelling is used for discovering abstract "topics" that occur in a collection of documents or text corpus.
- Topic modelling used text-mining tool for discovery of hidden semantic structures in a text body.
- A document typically concerns multiple topics in different proportions; hence, it is a challenge for naturally language processing algorithms and models given ambiguity in expressions (Twitter and social media) .
- Topic modelling is useful in social media analysis, understanding public behaviour during events such as elections. It has been useful for marketing and advertising.

Recurrent Neural Networks

At times, we only need to look at recent information to perform the present task, such as a language model trying to predict the next word based on the previous ones. In such cases, where the gap between the relevant information and the place that it's needed is small, recurrent neural networks (RNNs) can learn to use past information.

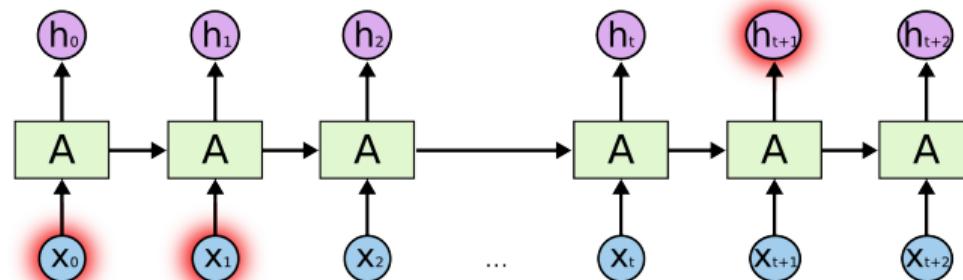


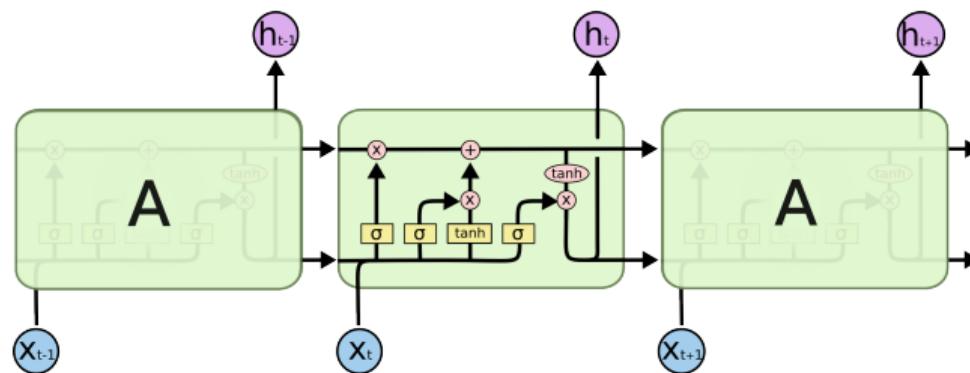
Figure: Vanishing gradient problem - long term dependencies ¹

¹Source: <https://colah.github.io/posts/2015-08-Understanding-LSTMs/>

LSTM

There are also cases where we need more context where the gap between the relevant information and the point where it is needed to become very large. As that gap grows, RNNs have difficulty to learn to connect the information. The problem is known as the vanishing gradient problem where RNNs have difficulty to learn long term dependencies in sequences.

Long short-term memory (LSTM) networks address the vanishing gradient problem with memory cells.



LSTM

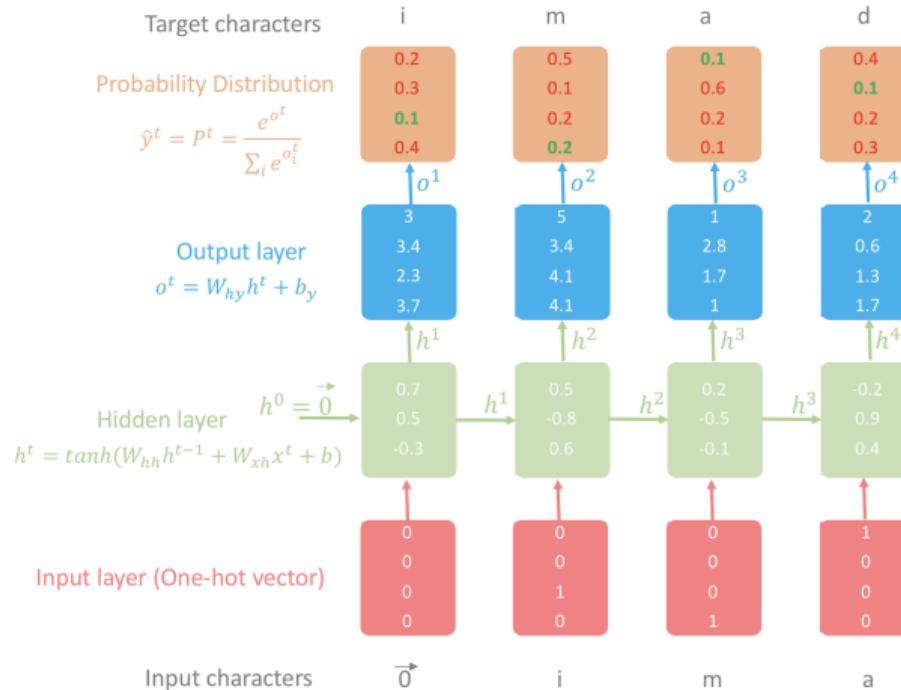


Figure: LSTM for Language modelling ³

Transformers

- A transformer is an extended LSTM model that adopts the mechanism of attention which mimics cognitive attention to enhance important parts of the data while fading the rest.
- Transformers also use an encoder-decoder architecture and have mostly been used for NLP tasks such as translation and text summarising.
- In comparison to conventional RNNs, transformers do not require data to be processed in a sequential order since the attention operation provides context for any position in the input sequence.

Transformers

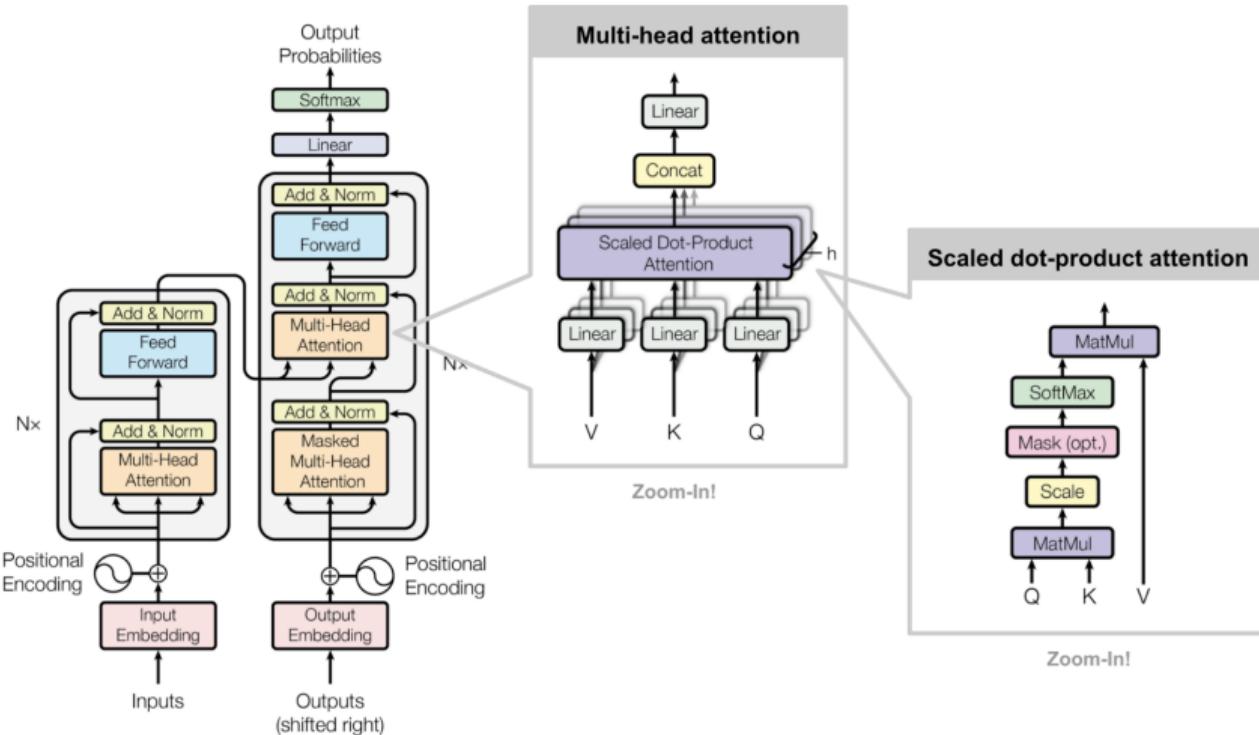


Figure: Transformers - specialised LSTM networks with attention mechanism.

BERT

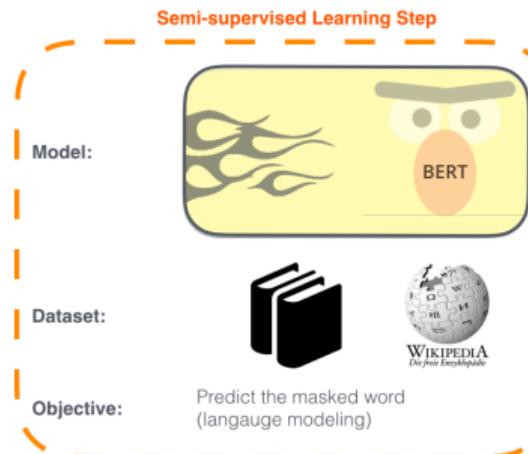
Developed by Google, bidirectional encoder representations from Transformers (BERT) is pre-trained on a large corpus for language tasks.

- The original BERT has two models: 1.) BERT-base features 12 encoders with 12 bidirectional self-attention heads, and 2.) BERT-large features 24 encoders with 16 bidirectional self-attention heads.
- These are pre-trained from unlabeled data extracted from a corpus with 800 million words and English Wikipedia with 2,500 million words, respectively.
- Word2vec and GloVe are content-free models that generate a single word embedding representation for each word, whereas BERT takes into account the context for each occurrence of a given word which makes BERT one of the best language models.

BERT

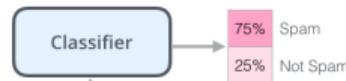
1 - Semi-supervised training on large amounts of text (books, wikipedia..etc).

The model is trained on a certain task that enables it to grasp patterns in language. By the end of the training process, BERT has language-processing abilities capable of empowering many models we later need to build and train in a supervised way.



2 - Supervised training on a specific task with a labeled dataset.

Supervised Learning Step



Email message	Class
Buy these pills	Spam
Win cash prizes	Spam
Dear Mr. Atreides, please find attached...	Not Spam

Figure: BERT for Language modelling ⁴

⁴Source: <https://jalammar.github.io/illustrated-bert/>

Analysis of Hindu texts



Analysis of translations: Bhagavad Gita

- 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 seen as a holy text by Hindus which serves as the forefront of the Vedic corpus of Hinduism.
- In the last two centuries, there have been a lot of interest in Hindu philosophy by western scholars and 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 and compares them.

Analysis of Hindu texts



Figure: Bhagavad Gita - Viraat Roop of Lord Krishna

Translations of the Bhagavad Gita

- Recent progress of language models powered by deep learning has enabled not only translations but 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.
- We compare selected translations (mostly from Sanskrit to English) of the Bhagavad Gita using semantic and sentiment analyses.

Texts	Translator	Year
The Gita according to Gandhi ⁸³	Mahatma Gandhi & Mahadev Desai	1946
The Bhagavad Gita ⁸⁴	Eknath Easwaran	1985
The Bhagavad Gita ⁸⁵	Shri Purohit Swami	1935

Analysis of translations: Bhagavad Gita

Bhagavad Gita: Chapter 3 - verse 37-39

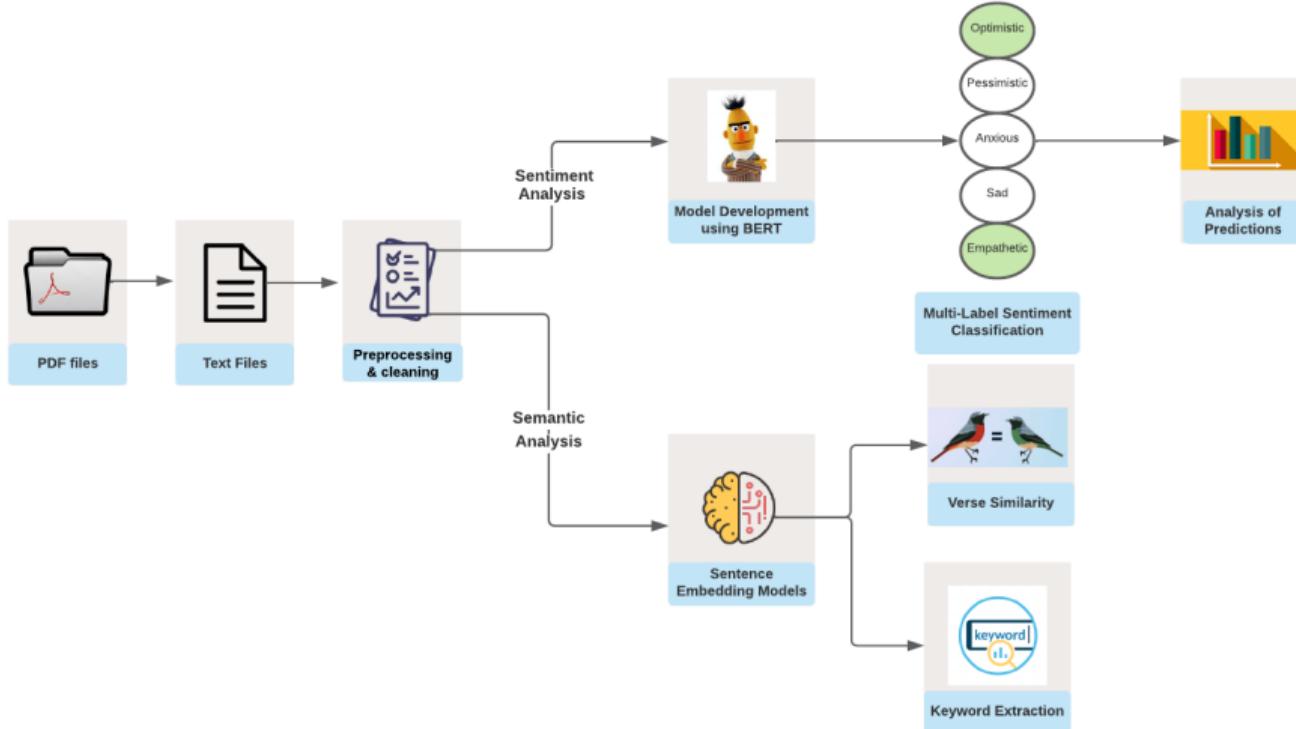
- "37. It is desire, it is aversion, born of passion. Desire consumes and corrupts everything. It is man's greatest enemy. 38. As fire is shrouded in smoke, a mirror by dust and a child by the womb, so is the universe enveloped in desire. It works through the senses, the mind and the reason; and with their help destroys wisdom and confounds the soul. 39. Therefore, O Arjuna, first control thy senses and then slay desire, for it is full of sin, and is the destroyer of knowledge and of wisdom.
" - Sri Purohit Swami
- "37. It is Lust, it is Wrath, born of the guna—Rajas. It is the arch-devourer, the arch-sinner. Know this to be man's enemy here. 38. As fire is obscured by smoke, a mirror by dirt, and the embryo by the amnion, so is knowledge obscured by this. 39. Knowledge is obscured, O Kaunteya, by this eternal enemy of the wise man, in the form of Lust, the insatiable fire." - Mahatma Gandhi

Analysis of translations: Bhagavad Gita

Bhagavad Gita: Chapter 6 - verse 36

- "It is not possible to attain Self-Realisation if a man does not know how to control himself; but for him who, striving by proper means, learns such control, it is possible." - Sri Purohit Swami
- "Without self-restraint, yoga, I hold, is difficult to attain; but the self-governed soul can attain it by proper means, if he strives for it." - Mahatma Gandhi

Analysis of translations: Bhagavad Gita



Analysis of translations: Bhagavad Gita

Original sentence	Transformed sentence
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?
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.
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."
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.

Figure: Text pre-processing

Analysis of translations: Bhagavad Gita

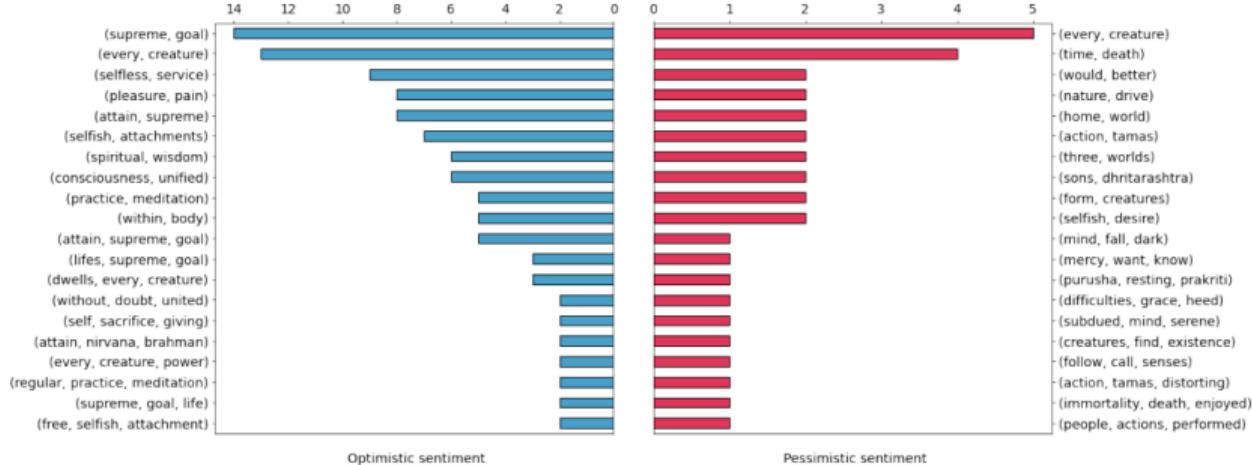


Figure: Top 10 optimistic and pessimistic Bi-grams and Tri-grams from processed verses for Eknath Easwaran's translation

Analysis of translations: Bhagavad Gita

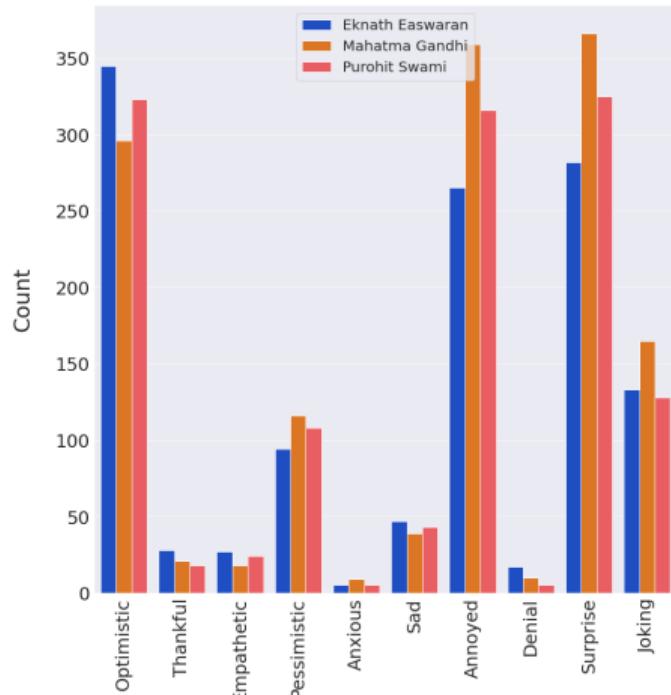
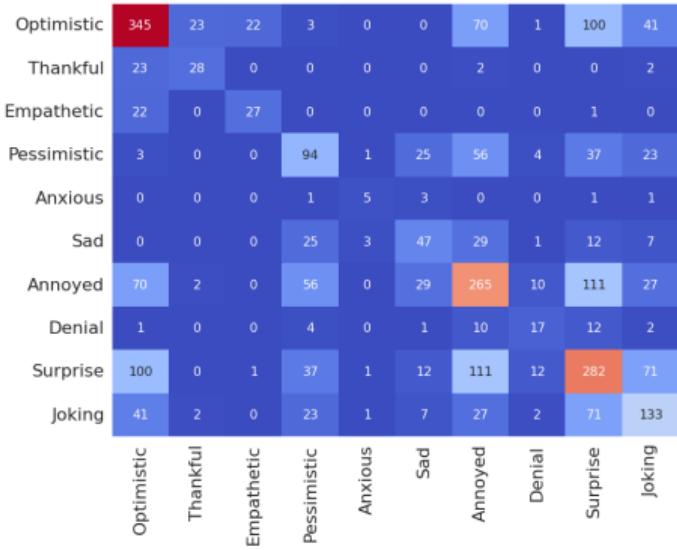
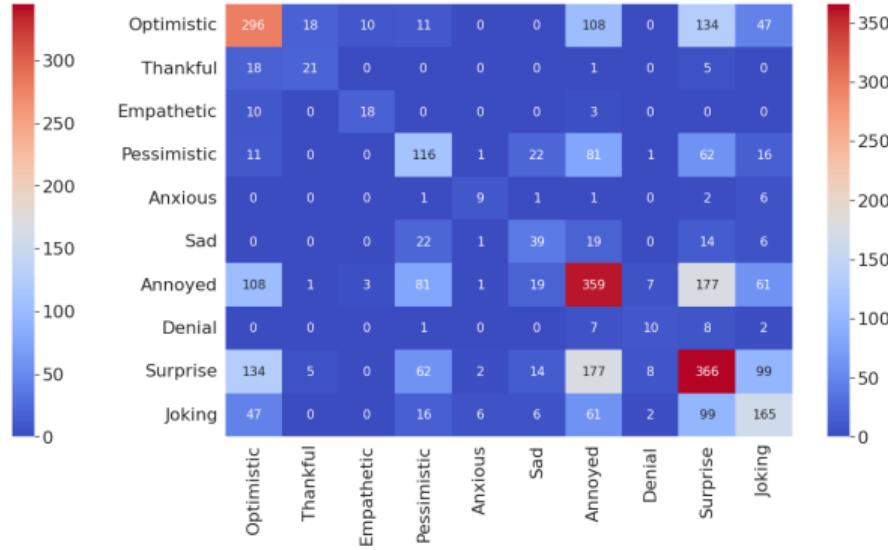


Figure: Text-wise sentiment analysis.

Analysis of translations: Bhagavad Gita



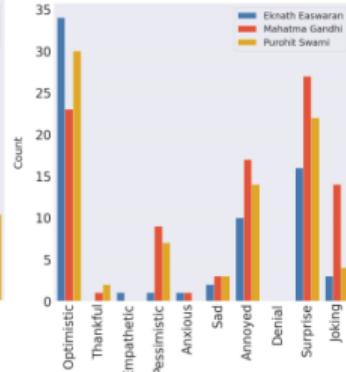
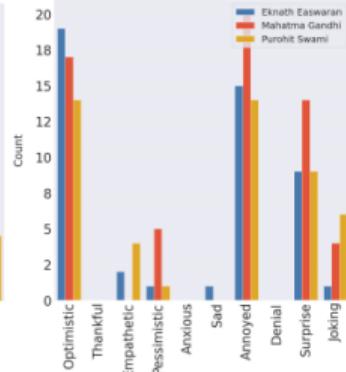
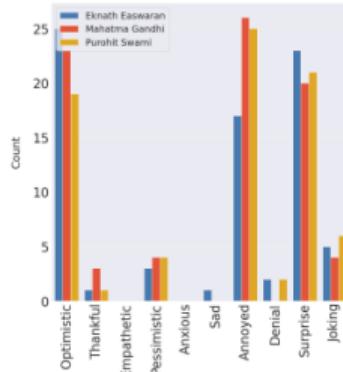
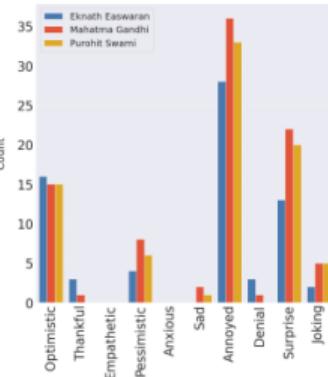
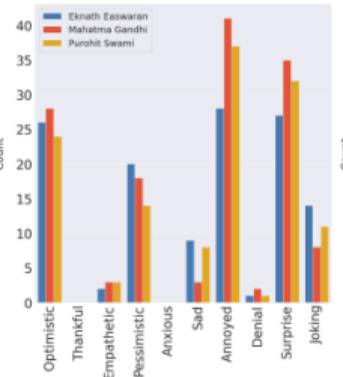
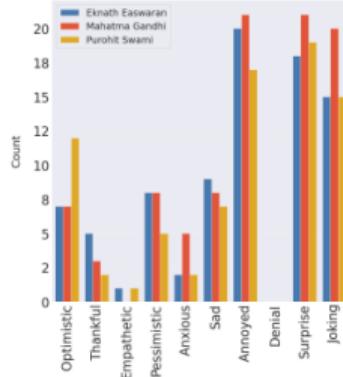
(a) Eknath Easwaran



(b) Mahatma Gandhi

Figure: 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.

Analysis of translations: Bhagavad Gita



Analysis of translations: Bhagavad Gita

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

Table: Selected verses with 'joking' as the predicted sentiment.



Analysis of translations: Bhagavad Gita

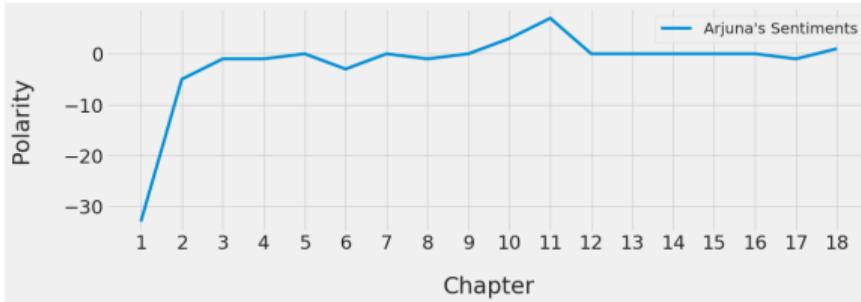


Figure: Arjuna's sentiments over time (chapters).

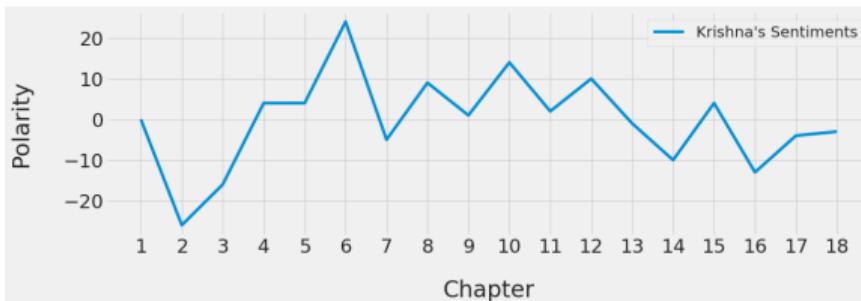


Figure: Lord Krishna's sentiments over time (chapters).

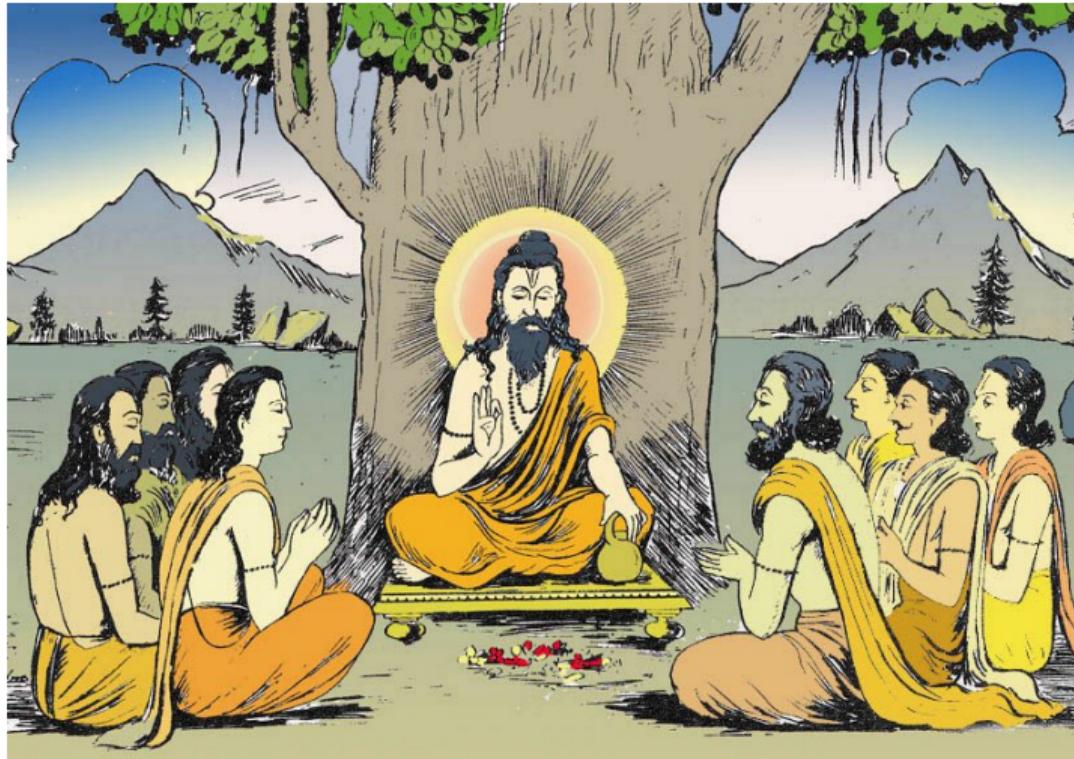
Analysis of translations: Bhagavad Gita: Conclusions

- 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.

Analysis of translations: Bhagavad Gita

- 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.
- 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.

Topic Modelling: Bhagavad Gita and Upanishads



Topic Modelling: Bhagavad Gita and Upanishads

- A distinct feature of Hindu religious and philosophical text is that they come from a library of texts rather than single source.
- The Upanishads is known as one of the oldest philosophical texts in the world that forms the foundation of Hindu philosophy.
- The Bhagavad Gita is core text of Hindu philosophy and is known as a text that summarises the key philosophies of the Upanishads with major focus on the philosophy of karma.
- These texts have been translated into a number of languages and there exists studies about themes and topics that are prominent; however, there is not much study of topic modelling using language models which are powered by deep learning.
- We use advanced language produces such as BERT to provide topic modelling of the key texts of the Upanishads and the Bhagavad Gita.

Quotes on the Upanishads

- "I go into the Upanishads to ask questions." - Niels Bohr
- "There is no kind of framework within which we can find consciousness in the plural; this is simply something we construct because of the temporal plurality of individuals, but it is a false construction....The only solution to this conflict insofar as any is available to us at all lies in the ancient wisdom of the Upanishad." - Erwin Schrödinger
- "As we study the philosophy of the Upanishads, the impression grows on us that the attainment of this path is not exactly the simplest of tasks. Our Western superciliousness in the face of these Indian insights is a mark of our barbarian nature, which has not the remotest inkling of their extraordinary depth and astonishing psychological accuracy." - Carl Jung

Selected verses from the Upanishads

- "What is the cause of the cosmos? Is it Brahman? From where do we come? By what live? Where shall we find peace at last? What power governs the duality of pleasure and pain by which we are driven?" - Svetasvatara Upanishad
- "You are what your deep, driving desire is. As your desire is, so is your will. As your will is, so is your deed. As your deed is, so is your destiny." - Brihadaranyaka Upanishad
- "Knowledge is two-fold, higher and lower. The study of the Vedas, linguistics, Rituals, astronomy, and all the arts can be called lower knowledge. The higher is that which lead to Self-realization." - Mundaka Upanishad

Topic Modelling: Bhagavad Gita and Upanishads

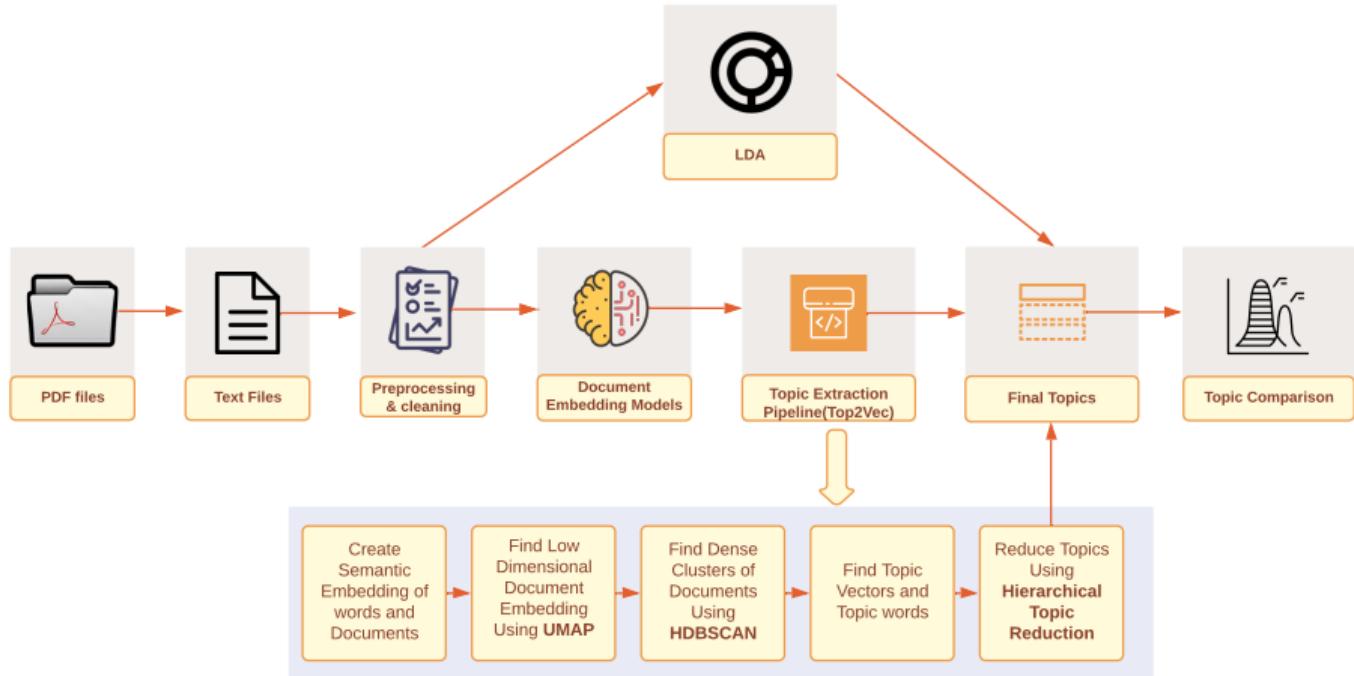


Figure: Framework

Topic Modelling: Bhagavad Gita and Upanishads

Texts	Translator	Year
The Bhagavad Gita	Eknath Easwaran	1985
The Upanishads	Eknath Easwaran	1987
The Ten Principal Upanishads	Shri Purohit Swami & W.B. Yeats	1938
108 Upanishads	The International Gita Publication	-

Table: Details of the texts used for topic modelling.

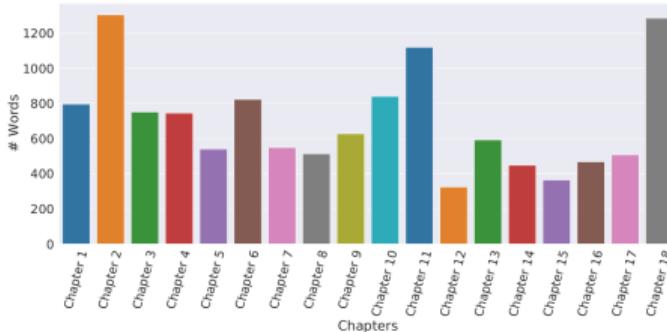
Corpus	# Documents	# Words	Avg # words	# Verses
The Upanishads(Eknath Easwaran)	862	40737	47.26	708
The Bhagavad Gita(Eknath Easwaran)	700	20299	27.50	700
Ten principal Upanishads	1267	27492	21.70	1267
108 Upanishads	6191	405559	65.50	6191

Table: Dataset Statistics

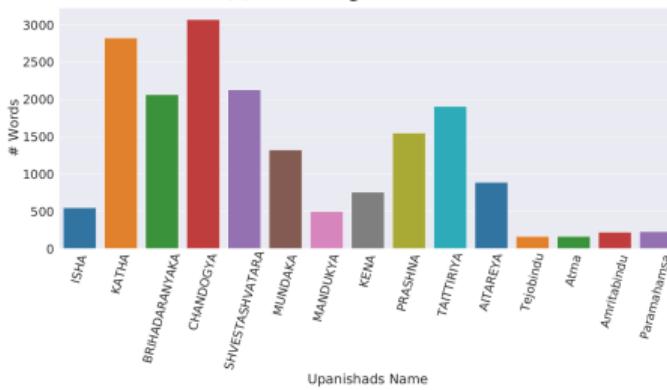
Original Documents	Transformed Documents
II-5(a). What winds up empirical life is (its) appearance as unreal.	what winds up empirical life is its appearance as unreal.
"What discipline is required to know, \u2018this is a pot, except the adequacy of the means of right \u2019 \n knowledge ?"	"what discipline is required to know this is a pot except the adequacy of the means of right knowledge."
Lord, have we not prophesied in thy name? and in thy name have cast out \n devils? and in thy name done many wonderful works?	Lord have we not prophesied in your name and in your name have cast out devils and in your name done many wonderful works.

Table: Processed text after removing special characters and transforming archaic words into modern English.

Topic Modelling: Bhagavad Gita and Upanishads



(a) The Bhagavad Gita



(b) The Upanishads

Topic Modelling: Bhagavad Gita and Upanishads

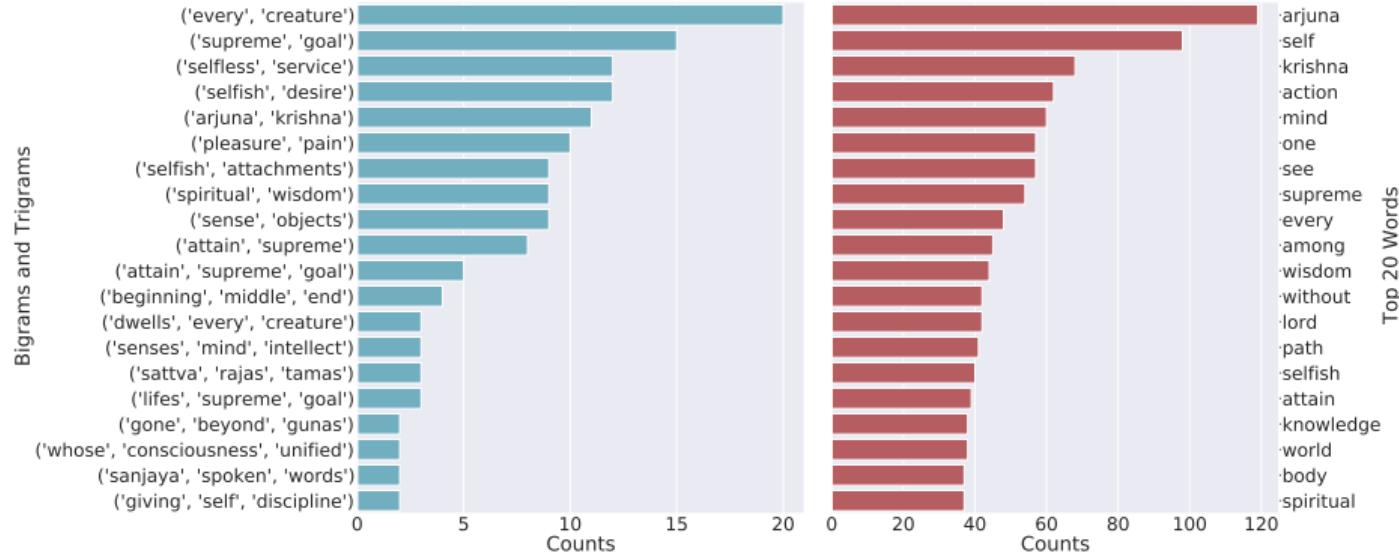


Figure: Visualisation of top 20 words, and top 10 bigrams and trigrams for the Bhagavad Gita.

Topic Modelling: Bhagavad Gita and Upanishads

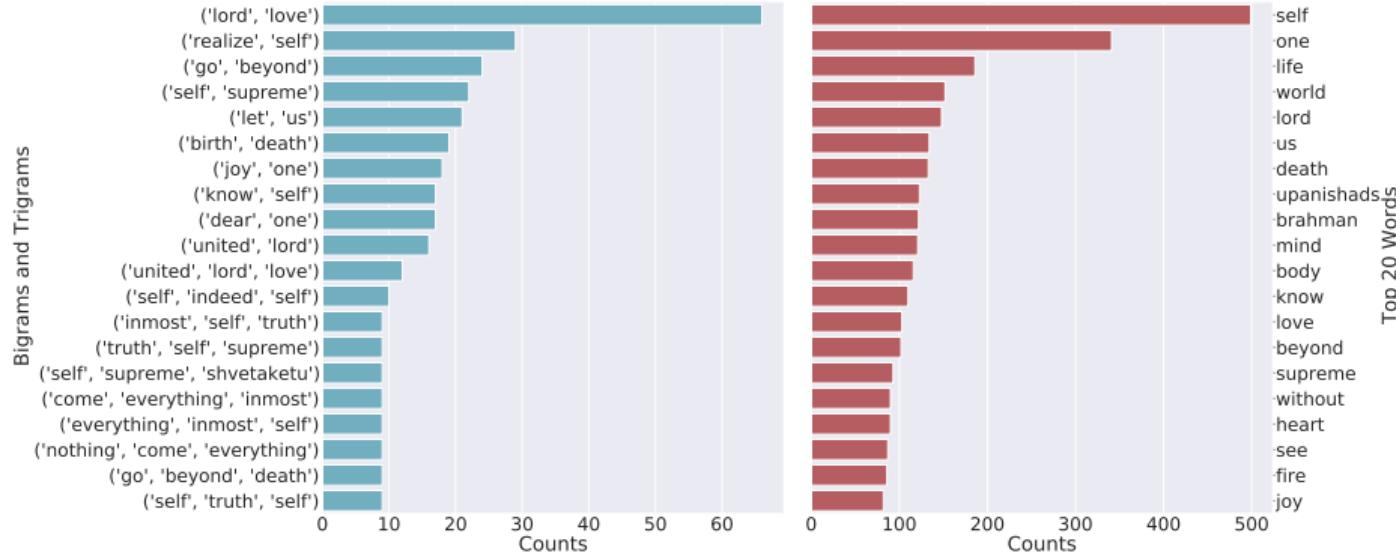


Figure: Leading bigrams and trigrams for the Bhagavad Gita and Upanishads by Eknath Easwaran.

Topic Modelling: Bhagavad Gita and Upanishads

We use the *topic coherence normalized pointwise mutual information*(NPMI) (TC-NPMI) is a metric used to fine-tune and evaluate different models on different corpus. The NPMI for a pair of words (w_i, w_j) from the top N (set to 50) words of a given topic ia given as:

$$\text{NPMI}(w_i, w_j) = \left(\frac{\log \frac{P(w_i, w_j) + \epsilon}{P(w_i) \cdot P(w_j)}}{-\log(P(w_i, w_j) + \epsilon)} \right) \quad (1)$$

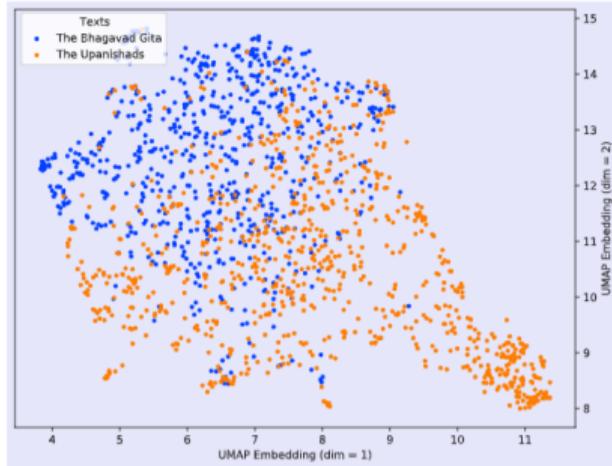
where, the joint probability $P(w_i, w_j)$, i.e the probability of the single word $P(w_i)$ is calculated by the Boolean sliding window approach (window length of s set to the default value of 110).

Topic Modelling: Bhagavad Gita and Upanishads

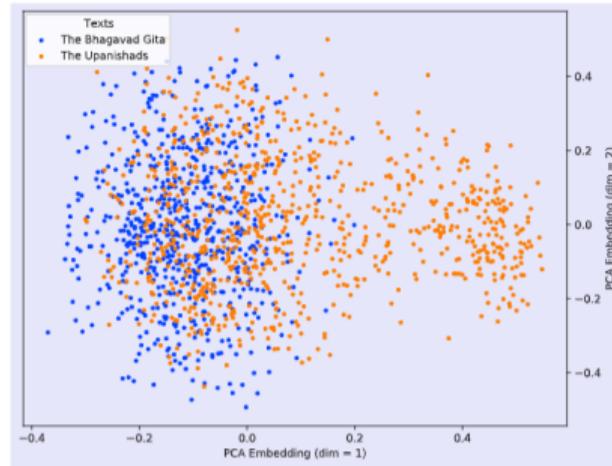
Model	Datasets							
	Bhagavad Gita		The Upanishads		Ten Principal Upanishads		108 Upanishads	
	# Topics	TC-NPMI	# Topics	TC-NPMI	# Topics	TC-NPMI	# Topics	TC-NPMI
SBERT-UMAP-HDBSCAN	14	0.70	18	0.67	28	0.70	115	0.63
SBERT-UMAP-KMeans	14	0.72	18	0.69	28	0.73	115	0.66
USE-UMAP-HDBSCAN	14	0.73	18	0.67	32	0.73	125	0.64
USE-UMAP-KMeans	14	0.73	18	0.69	32	0.71	125	0.67
LDA	20	0.32	20	0.29	24	0.31	140	0.39

Table: Value of topic coherence metric (TC-NPMI) for different Corpus

Topic Modelling: Bhagavad Gita and Upanishads



(a) UMAP Embeddings



(b) PCA Embeddings

Figure: Comparison of dimensionality reduction and visualisation by PCA and UMAP for the combined semantic space of the Bhagavad Gita (Eknath Easwaran) and the Upanishads (Eknath Easwaran). Note that the PCA has 4.4 % explained variance ratio for dim = 1 and 3.7 % for dim = 2, taken from total of 500 dimensions in original data.

Topic Modelling: Bhagavad Gita and Upanishads

Topics of Gita	Gita Topic ID	Most Similar topics in Upanishads	Upanishads Topic ID	Similarity Score
krishna,jayadratha,shraddha,ahamkara, arjuna,ikshvaku,sankhya,ashvattha,kusha,vishnu	topic-1	sage,wisdom,devotee,sages,vishnu,mahabharata, devotees,samashrava,hindu,mahavakyas,theravada	topic-1	0.76
selfless,selflessly,selfish,selfishly,desires, unkindness,desire,suffering,greed,themselves	topic-2	desires,happiness,eternal,selfless,beings,spiritual, existence,spirituality,desire,joy,eternity,buddhism	topic-11	0.76
worships,worship,devotion,devotees,eternal, myself,beings,eternity,spiritually,spiritual	topic-3	eternal,divine,deity,eternity,lords,lord,everlasting, devotional,omnipotent,gods,beings,soul,beloved	topic-3	0.75
meditation,meditate,spiritually,spiritual, yoga,minds,asceticism,spirit,nirvana,wisdom	topic-4	meditation,meditating,meditates,meditate,meditated, minds,mind,spiritually,interiorize,enlightenment,spiritual	topic-5	0.90
immortality,death,mortality,immortal,deathless, eternity,eternal,dying,mortal,dead,mortals	topic-5	immortality,death,immortal,mortality,deathless, mortal,dying,mortals,eternity,deathlessness,eternal	topic-6	0.86
gods,eternal,universe,beings,eternity,heavens, celestial,immortality,heavenly,divine,god	topic-6	celestial,sun,heavens,earth,earthly,heaven,heavenly, luminous,sunrise,sky,universe,illuminated,light,illumine	topic-8	0.80
brahman,wisdom,devotees,brahma, devotee,teachings,sages,worships,divine,devote	topic-7	sage,wisdom,devotee,sages,vishnu,mahabharata,devotees, samashrava,hindu,mahavakyas,theravada,hindus,buddhi	topic-1	0.74
existence,universe,beings,eternal,nonexistence, immortality,creatures,eternity,creature,cosmos	topic-8	universe,omnipotent,eternal,cosmos,eternity,beings,cosmic, immortal,gods,celestial,deity,beyondness,god,heavens	topic-7	0.73
ignorance,ignorant,wisdom,delusions,darkness, delusion,evils,intellects,eternal,asceticism	topic-9	meditation,meditating,meditates,meditate,meditated, minds,mind,spiritually,interiorize,enlightenment,spiritual	topic-5	0.67
Mean Similarity Score(AvgSim)				0.73

Table: Topics of the Bhagavad Gita(Eknath Easwaran) with most similar topics from the Upanishads(Eknath Easwaran)

Topic Modelling: Bhagavad Gita and Upanishads

In previous slide Table, we can observe that topic 4 of the Bhagavad Gita and topic-5 of the Upanishads have a similarity of 90%, this can be seen from the topics also they are representing the similar themes that are related to the ideas of meditation, yoga and spirituality.

Similarly, we observe that topic-5 of Gita have a similarity score of 86%, when compared with topic-6 of the Upanishads. Here, we can also observe that both topics encapsulate similar ideas of death, mortality and immortality.

Topic Modelling: Bhagavad Gita and Upanishads

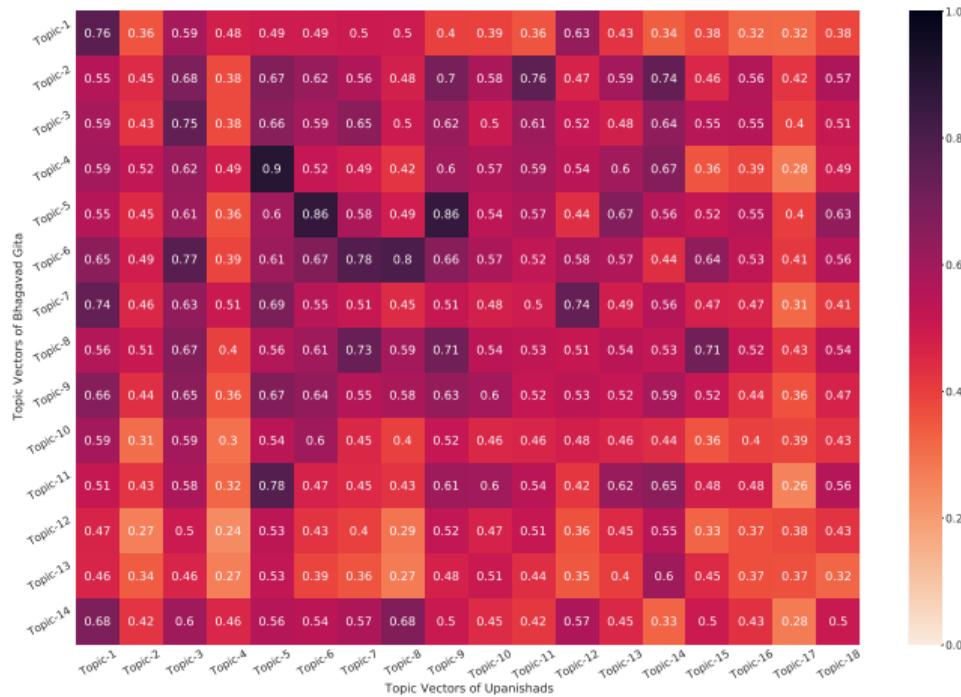


Figure: Heatmap showing the similarity between different topics of Bhagavad Gita and Upanishads (Eknath Easwaran) from (SBERT-UMAP-HDBSCAN).

Topic Modelling: Bhagavad Gita and Upanishads

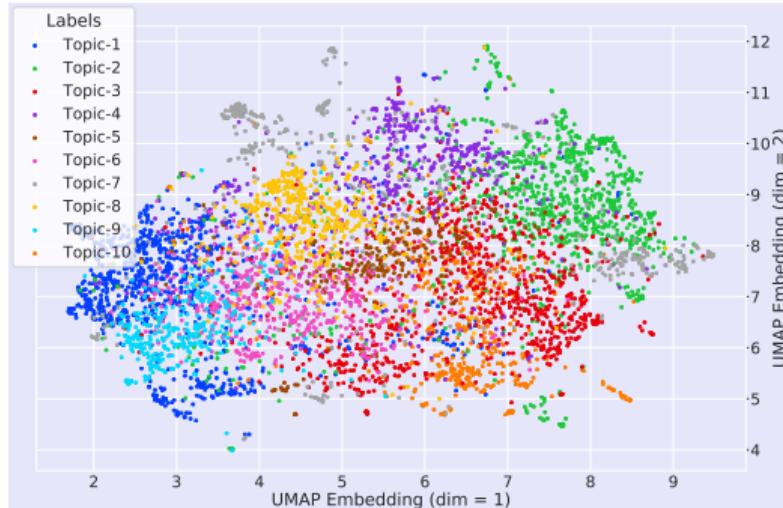


Figure: Visualisation of different topics of 108 Upanishads

We observe that the certain topics are separated by a large distance in UMAP embedding ($\text{dim} = 1$); these include Topic 1, Topic 2 and Topic 3 which imply that their themes do not have overlapping or common features.

Topic Modelling: Bhagavad Gita and Upanishads

- Our results show very high similarity between the topics of these two texts with the mean cosine similarity of 73%.
- We find that out of the fourteen topics extracted from the Bhagavad Gita, nine of them have a cosine similarity of more than 70% with the topics of the Upanishads.
- We also find that topics generated by the BERT-based models show very high topic coherence score when compared to the conventional models. Our best-performing model gives a coherence score of 73% on the Bhagavad Gita and 69% on the Upanishads.
- The visualization of the low-dimensional embeddings of these texts shows very clear overlapping themes among their topics adding another level of validation to our results.

Post-evaluation: Man vs Machine - qualitative study with survey

- We review the predictions from the AI-based language framework using a qualitative assessment.
- We provide results taken from a survey where the same verses will be given to a group of people who were asked to discriminate the respective sentiments for selected chapters of the Bhagavad Gita.
- We provide a verse-by-verse comparison and analysis of the predictions from the AI-language model.
- Pending ethics approval - hope to begin survey and visit Midam Charitable Trust Pondicherry in December.

Evaluation of Google Translate

≡ Google Translate

Text Documents Websites

Detect Language Hindi Sanskrit English ▾ ↔ English Spanish Arabic ▾

श्रीमद्भगवद्गीता × Srimad Bhagavad Gita ☆

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16 / 5,000 सं ▾

Send feedback

Figure: Google Translate for Sanskrit

Limitations and Challenges

- Interpretation of poetry - songs translated from ancient languages.
- Limitation of language models for modelling Indian languages - Hindi and Sanskrit.
- The validity of topic coherence score for this application needs to be further validated by human experts through qualitative research methods.
- Collaboration with humanities - lack of funding for humanities research in Australia.
- Recognition of inter-disciplinary humanities research by scientific journals.
- Being misrepresented as a priest or theologian when studying philosophy of religion.

Current and Future Work

- Sentiment and Semantic Analysis of Translations in the Bible: Sermon of Mount - Ongoing
- Metaphor detection in religious texts (Bhagavad Gita and Sermon of Mount - Bible) - Ongoing
- Hindu-BERT: pre-trained model for Hindu philosophy (planned)
- Evaluation by Sanskrit experts (planned)
- Topic modelling in evolution of ancient poetry and songs (planned)
- Humour detection ancient religious texts - poetry and songs (planned)
- Political biasness in media reporting (planned).

Team: AI for Philosophy of Religion



(a) Mukul Ranjan (b) Venkatesh Kulkarni (c) Mahek Vora (d) Tom Blau (e) Vansh Kachhwal (f) Abhishek Tiwari (g) Ashu Solo (h) Sushrut Badhe
(IIT Guwahati) (IIT Guwahati) (IIT Guwahati) (CSIRO) (IIT Delhi) (IIT Madras) (IIT (Canada) Madras)
(Midam Ch. Trust)

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Software and Data Availability

- Please note all projects have open software and data published via Github.
- <https://github.com/sydney-machine-learning>