Question Answering System Task

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1 Solution

The chosen index contains embeddings of the questions, questions, and answers from the training split in a pickle format. Since the dataset is comparatively small, the performance of index-only search still gave good performance with no noticeable latency. This was confirmed by comparing the search times using linear search using numpy and Faiss index search. Answers are also stored in the index to enable fast inference and to avoid parsing the JSON training data during the inference.

1.1 Encoder

To encode the questions, Sentence-BERT [2] (all-MiniLM-L6-v2) is used since the model is fast, compact and has accuracy comparable to larger models in sentence embedding performance benchmarks. For the FreebaseQA [1] dataset, the chosen model performed better than heavier models such as all-mpnet-base-v2, and all-MiniLM-L12-v2 on test split precision. Also, this model enabled fast inference through API even when used with the CPU.

1.2 Similarity metric

[2] proposes Sentence-BERT to derive semantically meaningful sentence embeddings that can be compared using **cosine similarity**. Also, cosine similarity is used in the objective function to train the Sentence-BERT. Hence, cosine similarity is chosen as the similarity metric to compare representations in the implementation.

1.3 Optimal similarity threshold search

Since the FreebaseQA dataset has no true negatives, traditional metrics cannot be used directly to calculate the optimal similarity threshold. The following approaches are implemented to calculate the optimal threshold that satisfies the requirements. Code for threshold search can also be found in my Kaggle notebook here.

- A **grid search** for threshold values from 0.5 to 1.0 with 0.05 increments was performed on the dev split. Based on this experiment, the best similarity threshold was 0.70 which yielded a precision of 0.554 on the dev split.
- To calculate the optimal value of the threshold, the **Receiver Operating Characteristic (ROC) Curve** is plotted to choose the threshold that maximizes the True Positive Rate while minimizing the False Positive rate. Based on Youden's J statistic [3], the optimal threshold was calculated as 0.72 using the dev split.

Since the precision value is very sensitive to the similarity threshold, a threshold value of 0.75 is also tried in addition to the calculated 0.72 and the evaluation of the system on test split is as follows:

Threshold	Precision (First 100)	Precision	Answer Constraint Satisfied (1/3rd)
0.72	0.56	0.625	Yes
0.75	0.605	0.672	Yes

Table 1: Precision values and answer constraints for different threshold values.

2 Limitations

- The current approach loads all embeddings into memory, and performs the cosine similarity search which is not feasible for large datasets.
- Using the pickle format for serialization can be inefficient and slow for large data structures.

3 Future work

- Specialized libraries like Faiss or Annoy can be used for efficient similarity search, which can handle large data more efficiently.
- Efficient serialization formats like HDF5 or databases designed for large-scale data storage can be implemented.

References

[1] K. Jiang, D. Wu, and H. Jiang. Freebaseqa: A new factoid qa data set matching trivia-style question-answer pairs with freebase. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, pages 318–323, 2019.

[2] N. Reimers and I. Gurevych. Sentence-bert: Sentence embeddings using siamese bert-networks. *arXiv preprint arXiv:1908.10084*, 2019.

[3] W. J. Youden. Index for rating diagnostic tests. *Cancer*, 3(1):32–35, 1950.