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[`is_training_available()`](../../docs/package_reference/util.html#sentence_transformers.util.is_training_available)

*

[`mine_hard_negatives()`](../../docs/package_reference/util.html#sentence_transformers.util.mine_hard_negatives)

*

[`normalize_embeddings()`](../../docs/package_reference/util.html#sentence_transformers.util.normalize_embeddings)

*

[`paraphrase_mining()`](../../docs/package_reference/util.html#sentence_transformers.util.paraphrase_mining)

*

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*

[`truncate_embeddings()`](../../docs/package_reference/util.html#sentence_transformers.util.truncate_embeddings)

*

* [Model

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*

[`export_dynamic_quantized_onnx_model()`](../../docs/package_reference/util.html#sentence_transformers.backend.export_dynamic_quantized_onnx_model)

*

[`export_optimized_onnx_model()`](../../docs/package_reference/util.html#sentence_transformers.backend.export_optimized_onnx_model)

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* [cos_sim()](../../docs/package_reference/util.html#sentence_transformers.util.cos_sim)

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* MS MARCO

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* * *

MS MARCO

[MS MARCO Passage Ranking](https://github.com/microsoft/MSMARCO-Passage-Ranking) is a large dataset to train models for information retrieval. It consists of about 500k real search queries from Bing search engine with the relevant text passage that answers the query.

This page shows how to **train** Sentence Transformer models on this dataset so that it can be used for searching text passages given queries (key words, phrases or questions).

If you are interested in how to use these models, see [Application - Retrieve & Re-Rank](../applications/retrieve_rerank/README.html).

There are **pre-trained models** available, which you can directly use without the need of training your own models. For more information, see: [Pretrained Models > MSMARCO Passage Models](../docs/sentence_transformer/pretrained_models.html#msmarco-passage-models).

Bi-Encoder¶

For retrieval of suitable documents from a large collection, we have to use a Sentence Transformer (a.k.a. bi-encoder) model. The documents are independently encoded into fixed-sized embeddings. A query is embedded into the same vector space. Relevant documents can then be found by using cosine similarity or dot-product.

![[BiEncoder]](<https://raw.githubusercontent.com/UKPLab/sentence-transformers/master/docs/img/BiEncoder.png>)

This page describes two strategies to **train an bi-encoder** on the MS MARCO dataset:

MultipleNegativesRankingLoss¶

Training code: `train_bi-encoder_mnrl.py` (https://github.com/UKPLab/sentence-transformers/tree/master/examples/training/ms_marco/train_bi-encoder_mnrl.py)

When we use

```
[`MultipleNegativesRankingLoss`](../../docs/package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MultipleNegativesRankingLoss  
"sentence_transformers.losses.MultipleNegativesRankingLoss"), we provide  
triplets: `(query, positive_passage, negative_passage)` where  
`positive_passage` is the relevant passage to the query and `negative_passage`
```

is a non-relevant passage to the query. We compute the embeddings for all queries, positive passages, and negative passages in the corpus and then optimize the following objective: The `(query, positive_passage)` pair must be close in the vector space, while `(query, negative_passage)` should be distant in vector space.

To further improve the training, we use **in-batch negatives** :

![[MultipleNegativesRankingLoss]](<https://raw.githubusercontent.com/UKPLab/sentence-transformers/master/docs/img/MultipleNegativeRankingLoss.png>)

We embed all `queries`, `positive_passages`, and `negative_passages` into the vector space. The matching `(query_i, positive_passage_i)` should be close, while there should be a large distance between a `query` and all other (positive/negative) passages from all other triplets in a batch. For a batch size of 64, we compare a query against $64+64=128$ passages, from which only one passage should be close and the 127 others should be distant in vector space.

One way to **improve training** is to choose really good negatives, also known as **hard negative** : The negative should look really similar to the positive passage, but it should not be relevant to the query.

We find these hard negatives in the following way: We use existing retrieval systems (e.g. lexical search and other bi-encoder retrieval systems), and for each query we find the most relevant passages. We then use a powerful [cross-encoder/ms-marco-MiniLM-L-6-v2](<https://huggingface.co/cross-encoder/ms-marco-MiniLM-L-6-v2>) [Cross-Encoder](../applications/cross-encoder/README.html)

to score the found `(query, passage)` pairs. We provide scores for 160 million such pairs in our [MS MARCO Mined Triplet dataset collection](https://huggingface.co/collections/sentence-transformers/ms-marco-mined-triplets-6644d6f1ff58c5103fe65f23).

For

```
[`MultipleNegativesRankingLoss`](../../docs/package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MultipleNegativesRankingLoss
```

"sentence_transformers.losses.MultipleNegativesRankingLoss"), we must ensure

that in the triplet `(query, positive_passage, negative_passage)` that the

`negative_passage` is indeed not relevant for the query. The MS MARCO dataset

is sadly **highly redundant**, and even though that there is on average only

one passage marked as relevant for a query, it actually contains many passages

that humans would consider as relevant. We must ensure that these passages are

not passed as negatives: We do this by ensuring a certain threshold in

the CrossEncoder scores between the relevant passages and the mined hard

negative. By default, we set a threshold of 3: If the `(query,

positive_passage)` gets a score of 9 from the CrossEncoder, then we will only

consider negatives with a score below 6 from the CrossEncoder. This threshold

ensures that we actually use negatives in our triplets.

You can find this data by traversing to any of the datasets in the [MS MARCO

Mined Triplet dataset collection](https://huggingface.co/collections/sentence-

transformers/ms-marco-mined-triplets-6644d6f1ff58c5103fe65f23) and using the

`triplet-hard` subset. Across all datasets, this refers to 175.7 million

triplets. The original data can be found

[here](https://huggingface.co/datasets/sentence-transformers/msmarco-hard-

negatives). Load some of it using:

```
from datasets import load_dataset

train_dataset = load_dataset("sentence-transformers/msmarco-co-condenser-margin-mse-sym-mnrl-mean-v1",
                              "triplet-hard", split="train")

# Dataset({
#   features: ['query', 'positive', 'negative'],
#   num_rows: 11662655
# })

print(train_dataset[0])

# {'query': 'what are the liberal arts?', 'positive': 'liberal arts. 1. the academic course of instruction
at a college intended to provide general knowledge and comprising the arts, humanities, natural
sciences, and social sciences, as opposed to professional or technical subjects.', 'negative': "Rather
than preparing students for a specific career, liberal arts programs focus on cultural literacy and
hone communication and analytical skills. They often cover various disciplines, ranging from the
humanities to social sciences. 1 Program Levels in Liberal Arts: Associate degree, Bachelor's
degree, Master's degree."}
```

MarginMSEif•

**Training code:[train_bi-encoder_margin-
mse.py](<https://github.com/UKPLab/sentence->

transformers/tree/master/examples/training/ms_marco/train_bi-encoder_margin-
mse.py)**

[`MarginMSELoss`](../../docs/package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MarginMSELoss

"`sentence_transformers.losses.MarginMSELoss`") is based on the paper of

[Hofstätter et al](https://arxiv.org/abs/2010.02666). Like when training with

[`MultipleNegativesRankingLoss`](../../docs/package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MultipleNegativesRankingLoss

"`sentence_transformers.losses.MultipleNegativesRankingLoss`"), we can use

triplets: `(query, passage1, passage2)`. However, in contrast to

[`MultipleNegativesRankingLoss`](../../docs/package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MultipleNegativesRankingLoss

"`sentence_transformers.losses.MultipleNegativesRankingLoss`"), `passage1` and `passage2` do not have to be strictly positive/negative, both can be relevant or not relevant for a given query.

We then compute the [`Cross-Encoder`](../../applications/cross-encoder/README.html) score for `(query, passage1)` and `(query, passage2)`. We provide scores for 160 million such pairs in our [`msmarco-hard-negatives dataset`](https://huggingface.co/datasets/sentence-transformers/msmarco-hard-negatives). We then compute the distance: `CE_distance = CEScore(query, passage1) - CEScore(query, passage2)`.

For our Sentence Transformer (e.g. bi-encoder) training, we encode `query`, `passage1`, and `passage2` into embeddings and then measure the dot-product between `(query, passage1)` and `(query, passage2)`. Again, we measure the

distance: `BE_distance = DotScore(query, passage1) - DotScore(query, passage2)`

We then want to ensure that the distance predicted by the bi-encoder is close to the distance predicted by the cross-encoder, i.e., we optimize the mean-squared error (MSE) between `CE_distance` and `BE_distance`.

An **advantage** of

`MarginMSELoss` (https://docs.package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MarginMSELoss)

"`sentence_transformers.losses.MarginMSELoss`") compared to

`MultipleNegativesRankingLoss` (https://docs.package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MultipleNegativesRankingLoss)

"`sentence_transformers.losses.MultipleNegativesRankingLoss`") is that we

don't require a `positive` and `negative` passage. As mentioned before,

MS MARCO is redundant and many passages contain the same or similar content.

With

`MarginMSELoss` (https://docs.package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MarginMSELoss)

"`sentence_transformers.losses.MarginMSELoss`"), we can train on two relevant

passages without issues: In that case, the `CE_distance` will be smaller and

we expect that our bi-encoder also puts both passages closer in the vector space.

And **disadvantage** of

`MarginMSELoss` (https://docs.package_reference/sentence_transformer/losses.html#sentence_transformers.losses.MarginMSELoss)

"sentence_transformers.losses.MarginMSELoss") is the slower training time: We

need way more epochs to get good results. In

[`MultipleNegativesRankingLoss`](../../docs/package_reference/sentence_transformer/losses.html

#sentence_transformers.losses.MultipleNegativesRankingLoss

"sentence_transformers.losses.MultipleNegativesRankingLoss"), with a batch

size of 64, we compare one query against 128 passages. With

[`MarginMSELoss`](../../docs/package_reference/sentence_transformer/losses.html#sentence_tra

nsformers.losses.MarginMSELoss

"sentence_transformers.losses.MarginMSELoss"), we compare a query only against

two passages.

[Previous](../quora_duplicate_questions/README.html "Quora Duplicate

Questions") [Next](../matryoshka/README.html "Matryoshka Embeddings")

* * *

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