

SimCSE: Simple Contrastive Learning of Sentence Embeddings

Model : sup-simcse-bert-base-uncased

Contents

Training Data Description :	2
Preprocessing Step :	2
Embed Encoding Step :	2
Method 1 : Using built in Function Resize :	3
Finding :	3
Method 2 : Using PCA algorithm :	4
Finding :	4
Method 3 : Using SVD Truncate algorithm :	5
Finding :	5
Method 4 : Using Neural Networks (Auto Encoder)	6
Finding :	6
Appendix.....	7
Resize.....	7
PCA.....	9
First Attempt.....	9
Second Attempt.....	10
SVD Truncate.....	11
AutoEncoder.....	12

Training Data Description :

The training data will have 3 main data :

- The Original Phrases. (alias as 0 in the label result)
- The rewritten phrases that have the approximately similar meaning. (alias as 1 in the label result)
- The rewritten phrases that have negative meaning. (alias as 2 in the label result)

For example :

Original Phrase : Of course he did

Rewritten Phrase : he did

Negative Rewritten Phrase : of course not

=> There will be 3 similarity result types :

- + Similarity of Original and Rewritten
- + Similarity of Rewritten and Negative Rewritten
- + Similarity of Original and Negative Rewritten

Preprocessing Step :

Data will be randomly retrieved from the training data of the model with a sample size of 500 for each phrase type.

There are 3 main phrase types based on the length of the phrase : Small Phrases that have less than 10 words , Medium Phrases that length from 10 words to 20 words and Long Phrases that have more than 20 words.

Embed Encoding Step :

Each phrase will be converted to an output vector using the model encoder. And the output vector will have 768Ds in default.

Task : Reduce Dimension Output from 768 D to 64 D

Method 1 : Using built in Function Resize :

Finding :

Resize function does not have a significant impact on the similarity after reducing dimension, either improving or worsening the similarity from 2 to 10 percent depending on the original 768D similarity.

By using the Resize function : See results in the appendix

- Small Phrases
 - + Similarity for small phrase reduction will likely be unchanged , or marginally improve (less than 2 %) if the original phrase and the rewritten phrase firstly have a high similarity (more than 80 percent).
 - + Those that have similarity less than 80 percent will experience a significant decrease (approximately 10 %)
 - + Those that have similarity less than 50 percent between the original and the rewritten may experience an increase in similarity after Reduce Dimension
- Medium Phrases
 - + Similarity after medium phrase dimension reduction is on par with small phrase dimension reduction
- Long Phrases
 - + Similarity after Long phrase dimension reduction has a positive impact for likely all cases.

Summary Statistics : Difference between before and after Reduce Dimension (RD) when using Resize

Average difference : **2%** similarity **gained** after RD

Min difference in Similarity : **11%** similarity **reduced** after RD

Max difference in Similarity : **20%** similarity **gained** after RD

Median difference in Similarity : **0%** similarity changed.

⇒ Median is lower than Mean => **Resize likely to have its performance better than average performance , which is 0% similarity changed after Reduce Dimension.**

Method 2 : Using PCA algorithm :

Finding :

(See detail results in Appendix)

Using PCA to reduce dimension the vector output will destroy the similarity for all cases. Therefore it is unable to apply.

- First Attempt : PCA based on the sub dataset (sample size 500)

Results are very terrible for all cases

- Second Attempt : PCA based on the entire dataset (sample size 275601)

Results are still very terrible for all cases

=> Hence, PCA is inapplicable

Summary Statistic: Difference between before and after Reduce Dimension when using PCA

Average difference : 86% similarity reduce after RD

Min difference in Similarity : 126% similarity reduce after RD

Max difference in Similarity : 35% similarity reduce

Median difference in Similarity : 89% similarity reduce.

Median is higher than Mean => **PCA likely to have its performance worse than average performance, which will further decrease the similarity after Reduce Dimension**

Method 3 : Using SVD Truncate algorithm :

Finding :

(See detail results in Appendix)

Although using SVD Truncate has a slightly better result compared to PCA, technically, using SVD Truncate to reduce dimension is on par with Using PCA to reduce dimension because they all have a negative impact to the vector output due to volatile change in similarity. Therefore, they are unable to apply.

However, there are some major difference compared to PCA :

- For short phrases, PCA works better than SVD Truncate to Reduce Dimension
- For medium and long phrases , SVD has better results.

Summary Statistic: Difference between before and after Reduce Dimension when using SVD Truncate

Average difference : 74% similarity reduce after RD

Min difference in Similarity : 128% similarity reduce after RD

Max difference in Similarity : 37% similarity reduce

Median difference in Similarity : 74% similarity reduce.

Median is equal to Mean => **SVD likely to have its performance similar to its average performance, which decrease the similarity after Reduce Dimension**

Method 4 : Using Neural Networks (Auto Encoder)

Finding :

(See detail results in Appendix)

Auto Encoder has the best results, even better than Resize because it not only keep the similarity unchanged after Reducing Dimension but also has a more stable performance.

Summary Statistic: Difference between before and after Reduce Dimension when using SVD Truncate

Average difference : 1% similarity reduce after RD

Min difference in Similarity : 14% similarity reduce after RD

Max difference in Similarity : 16% similarity gained

Median difference in Similarity : 0% similarity changed.

Median is lower than Mean => **Auto Encoder likely to have its performance better than its average performance, which keeps the similarity likely unchanged after Reducing Dimension.**

Appendix

Resize

Small Phrase < 10 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.9160471559	0.1764839739	0.2462169528	0.92329669	0.1083822176	0.1668673903
2	0.8164205551	0.05298232287	0.01546010748	0.8825424314	0.1401336938	0.1165760309
3	0.8838492036	0.2996256948	0.4103116393	0.7902023196	0.05900786445	0.2597800493
4	0.7730103731	0.4844681919	0.7666797638	0.7429532409	0.4516728818	0.742392242
5	0.9323086143	0.6656961441	0.747535944	0.938426137	0.6667433381	0.7240594625
6	0.8748320341	0.4984515011	0.5966677666	0.8607755899	0.4167440236	0.5325911045
7	0.7181403637	0.8140470982	0.6593587995	0.6967712045	0.8624010086	0.5919571519
8	0.490291208	0.7228000164	0.3860903382	0.5887284875	0.3895608485	0.744543016
9	0.8167100549	-0.039435938	0.04679647833	0.8388754129	0.03074777313	0.1887014061
10	0.7370314598	0.4896235168	0.4910527766	0.7962059975	0.338625133	0.4011682272

Medium Phrase > 10 words and < 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.6418862343	0.4563589096	0.2478127778	0.7547147274	0.5142351985	0.2786907256
2	0.6744619608	0.2787923515	0.1635418534	0.6261547208	0.2531001568	0.2058434337
3	0.6605906487	0.5971212387	0.5179123878	0.611382544	0.603639245	0.4909999669
4	0.8276210427	0.6100082397	0.7180603147	0.8025061488	0.5492473245	0.6776707768
5	0.7827811837	0.8341248035	0.8695409894	0.7548390031	0.8472266197	0.8560105562
6	0.9269535542	0.4673035741	0.5310392976	0.9224339724	0.5231744051	0.6260664463
7	0.8887920976	0.4692143202	0.3659130335	0.8738236427	0.421423465	0.298076272
8	0.8855964541	0.6240269542	0.5844043493	0.9010452628	0.6661293507	0.6199396253
9	0.4355341792	0.5148645043	0.5522639155	0.5246419907	0.4783340096	0.3751327991
10	0.9803878665	0.7015968561	0.6760758162	0.9873874784	0.6964432597	0.6806049943

Long Phrase > 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.8716976643	0.6181213856	0.5945637822	0.8650340438	0.6167147756	0.5785084963
2	0.6759517193	0.7087241411	0.5493679047	0.7100947499	0.6854230762	0.5201151967
3	0.7379953861	0.5444076657	0.4238884449	0.778970778	0.501192987	0.4018721282
4	0.8688520789	0.4085522294	0.3191720247	0.8903583884	0.3173321486	0.2399447858
5	0.778693378	0.3891911805	0.2666461766	0.834842205	0.4960215688	0.3655577302
6	0.7122676373	0.4245236516	0.4544761181	0.7611706853	0.4700272679	0.4631889164
7	0.6167194843	0.3989822268	0.2336193323	0.6126019955	0.4016983807	0.3285750449
8	0.851046145	0.5450409055	0.5009057522	0.832744956	0.3707433343	0.3728858829
9	0.6696338654	0.6029624343	0.4716639519	0.6267873049	0.6502290964	0.4736689329
10	0.6020120382	0.06102094054	0.3899568319	0.5394722819	0.2366923392	0.4977438748

PCA

First Attempt

Small Phrase < 10 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.9160471559	0.1764839739	0.2462169528	0.5980114539	-0.04502142087	0.1361744161
2	0.8164205551	0.05298232287	0.01546010748	0.4875681714	0.04526376034	0.170233977
3	0.8838492036	0.2996256948	0.4103116393	0.001548241044	0.05519235501	0.02091254532
4	0.7730103731	0.4844681919	0.7666797638	0.139989344	0.1148508857	0.05076380031
5	0.9323086143	0.6656961441	0.747535944	0.1503208218	-0.01514583847	-0.03439669048

Medium Phrase > 10 words and < 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.6418862343	0.4563589096	0.2478127778	0.2134056508	0.5615493023	-0.04020514544
2	0.6744619608	0.2787923515	0.1635418534	0.02793748571	-0.01142838633	-0.1304833049
3	0.6605906487	0.5971212387	0.5179123878	-0.1706082596	-0.0552670626	0.003380761369
4	0.8276210427	0.6100082397	0.7180603147	0.09005561276	-0.1194708234	-0.05242274975
5	0.7827811837	0.8341248035	0.8695409894	0.2749139741	0.2103524422	0.0813552166

Long Phrase > 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.8716976643	0.6181213856	0.5945637822	-0.1587079456	-0.1999685939	0.05821631658
2	0.6759517193	0.7087241411	0.5493679047	-0.04213284832	0.01500218681	0.08856857527
3	0.7379953861	0.5444076657	0.4238884449	0.02208728489	-0.2971252686	0.1992067738
4	0.8688520789	0.4085522294	0.3191720247	0.07950443291	-0.1126479301	-0.2103905098
5	0.778693378	0.3891911805	0.2666461766	0.09262621203	-0.008572783349	0.06640055702

Second Attempt

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64
1	0.8164205551	0.05298232287	0.01546010748	-0.09615293831
2	0.8838492036	0.2996256948	0.4103116393	0.3322187974
3	0.8716976643	0.6181213856	0.5945637822	-0.2801058204
4	0.6167194843	0.3989822268	0.2336193323	-0.05227715773

SVD Truncate

Small Phrase < 10 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.916047156	0.176483974	0.246216953	-0.255475581	0.053442221	0.159104362
2	0.816420555	0.052982323	0.015460107	0.373114496	-0.297671437	-0.034044128
3	0.883849204	0.299625695	0.410311639	0.231980115	0.014913138	0.419170529
4	0.773010373	0.484468192	0.766679764	0.180964991	-0.058226164	0.007683913
5	0.932308614	0.665696144	0.747535944	0.007683913	0.007683913	-0.035091612

Medium Phrase > 10 words and < 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.641886234	0.45635891	0.247812778	0.316219866	0.080544129	0.191139877
2	0.674461961	0.278792351	0.163541853	0.309711605	0.433814943	0.381631732
3	0.660590649	0.597121239	0.517912388	-0.009609533	-0.004967357	0.038627908
4	0.827621043	0.61000824	0.718060315	0.297636658	-0.155196935	-0.058227401
5	0.782781184	0.834124804	0.869540989	0.201219976	0.1296134	0.070707977

Long Phrase > 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64	1_2_Similarity_64	0_2_Similarity_64
1	0.871697664	0.618121386	0.594563782	0.039438989	-0.078512661	0.040853973
2	0.675951719	0.708724141	0.549367905	0.294644207	0.372868538	0.182040051
3	0.737995386	0.544407666	0.423888445	0.463370293	0.217038557	0.268955708
4	0.868852079	0.408552229	0.319172025	0.063819401	-0.293331623	-0.293331623
5	0.778693378	0.38919118	0.266646177	0.358659238	-0.22314477	-0.091892138

AutoEncoder

Small Phrase < 10 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64
1	0.9160471559	0.1764839739	0.2462169528	0.9254652262
2	0.8164205551	0.05298232287	0.01546010748	0.7481586337
3	0.8838492036	0.2996256948	0.4103116393	0.9039180875
4	0.7730103731	0.4844681919	0.7666797638	0.7690733671
5	0.9323086143	0.6656961441	0.747535944	0.9065493345
6	0.8748320341	0.4984515011	0.5966677666	0.8761385679
7	0.7181403637	0.8140470982	0.6593587995	0.7389985323
8	0.490291208	0.7228000164	0.3860903382	0.4216069281
9	0.8167100549	-0.039435938	0.04679647833	0.8100810647
10	0.7370314598	0.4896235168	0.4910527766	0.7165603042

Medium Phrase > 10 words and < 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64
1	0.6418862343	0.4563589096	0.2478127778	0.5905750394
2	0.6744619608	0.2787923515	0.1635418534	0.6687065363
3	0.6605906487	0.5971212387	0.5179123878	0.6893504858
4	0.8276210427	0.6100082397	0.7180603147	0.7890355587
5	0.7827811837	0.8341248035	0.8695409894	0.8108150959
6	0.9269535542	0.4673035741	0.5310392976	0.9425581694
7	0.8887920976	0.4692143202	0.3659130335	0.9297263622
8	0.8855964541	0.6240269542	0.5844043493	0.9081563354
9	0.4355341792	0.5148645043	0.5522639155	0.5040022731
10	0.9803878665	0.7015968561	0.6760758162	0.9846978188

Long Phrase > 20 words Similarity results :

TestNo	0_1_Similarity_768	1_2_Similarity_768	0_2_Similarity_768	0_1_Similarity_64
1	0.8716976643	0.6181213856	0.5945637822	0.9253243208
2	0.6759517193	0.7087241411	0.5493679047	0.608058989
3	0.7379953861	0.5444076657	0.4238884449	0.796811223
4	0.8688520789	0.4085522294	0.3191720247	0.884740293
5	0.778693378	0.3891911805	0.2666461766	0.724983573
6	0.7122676373	0.4245236516	0.4544761181	0.6933592558
7	0.6167194843	0.3989822268	0.2336193323	0.6193163991
8	0.851046145	0.5450409055	0.5009057522	0.8756940961
9	0.6696338654	0.6029624343	0.4716639519	0.5975826979
10	0.6020120382	0.06102094054	0.3899568319	0.5746639371