

# Information Retrieval

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Assignment 5

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## Scoring and the Vector Space Model

- I) The index contains 18,353 terms and has a size of 2.71 Megabyte.
- II) At the end of this document, we include a subset of the index that contains only the query terms. The term “in” is missing, though, since it is recognized as a stop word and, thus, removed during index construction and query evaluation. Notably, many of the terms have a tfidf-value of *zero*. This is because they occur in *every* document of the corpus, which causes the idf-value and, thereby, the product to be zero.
- III)
  - **Simple tf-idf:**

We iterate over the entries in the index and build a **SearchResult** object for every document that contains at least one query term. Afterwards, we calculate the accumulated score for each of these search results by *summing up* the tf-idf values of the matched terms.
  - **Cosine Similarity:**

We regard each document as a vector and calculate the respective magnitude while iterating over the entries in the index. In the same loop we, again, build a **SearchResult** object for every document that contains at least one query term and store the tf-idf values of the matching terms. Then, we iterate over these search results and determine their final scores by calculating the dot product between query and document and dividing it by the magnitude.
  - **Term Proximity:**

For term proximity we want to put special emphasis on documents, where query terms occur next to each other. In order to do that we were looking for all sets of query terms that can be found near each other. We called the number of words within which query terms were found near each other “window” and only allowed windows not greater than 10 words. Note that each

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query term occurrence itself is already a hit, if another query term is within reach of 10 words, that pair is counted as another hit, too, and so on. Our method was to iterate through a list of all occurrences of query terms in the document and to find and calculate all possible sets of query terms that don't exceed the maximum window size. In order to achieve that, we iterated over the search results of each document: (i.e. all occurrences of the query terms) and formed pairs consisting of the term position and an index representing the contents of the term. We then constructed an ordered arraylist out of the pairs, which allowed us iterate over the list only once and to calculate all sets of query terms larger than 2 out of the previous results. When we found the query term sets, we scored them according to a formula that normalized the window size and increased the importance of many query terms within a window:  $\text{number of query terms} / \text{window size} * 1.5^{\text{number of query terms}}$ . We then added all scores together for each document.

IV) The following tables show the search results for each query and each ranking method. For an explanation why so many documents receive the score 0.0, please see below.

(a) “summer night”

• **Simple tf-idf:**

Rank	Book	Id	Score
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

• **Cosine Similarity:**

Rank	Book	Score
1	annaKarenina.txt	0 0.0
2	threeMenInABoat.txt	7 0.0
3	prideAndprejudice.txt	6 0.0
4	portraitOfALady2.txt	5 0.0
5	portraitOfALady1.txt	4 0.0
6	mobyDick.txt	3 0.0
7	janeEyre.txt	2 0.0
8	emma.txt	1 0.0

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- **Term Proximity:**

Rank	Book	Score	
1	janeEyre.txt	2	370.5
2	mobyDick.txt	3	269.0
3	annaKarenina.txt	0	235.0625
4	threeMenInABoat.txt	7	130.5
5	emma.txt	1	102.0
6	prideAndprejudice.txt	6	81.0
7	portraitOfALady2.txt	5	60.0
8	portraitOfALady1.txt	4	40.5

(b) “great expectation”

- **Simple tf-idf:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Cosine Similarity:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Term Proximity:**

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Rank	Book	Score	
1	annaKarenina.txt	0	557.25
2	emma.txt	1	535.95
3	mobyDick.txt	3	482.14286
4	portraitOfALady1.txt	4	450.0
5	prideAndprejudice.txt	6	381.0
6	portraitOfALady2.txt	5	364.2
7	janeEyre.txt	2	308.79286
8	threeMenInABoat.txt	7	124.5

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(c) “mystic conversation”

- **Simple tf-idf:**

Rank	Book	Score	
1	mobyDick.txt	3	0.30377
2	janeEyre.txt	2	0.16255
3	threeMenInABoat.txt	7	0.16255
4	portraitOfALady2.txt	5	0.16255
5	portraitOfALady1.txt	4	0.12494
6	annaKarenina.txt	0	0.12494
7	emma.txt	1	0.0
8	prideAndprejudice.txt	6	0.0

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- **Cosine Similarity:**

Rank	Book	Score	
1	portraitOfALady2.txt	5	7.8E-4
2	portraitOfALady1.txt	4	5.0E-4
3	mobyDick.txt	3	4.9E-4
4	threeMenInABoat.txt	7	4.6E-4
5	janeEyre.txt	2	4.0E-4
6	annaKarenina.txt	0	2.5E-4
7	prideAndprejudice.txt	6	0.0
8	emma.txt	1	0.0

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- **Term Proximity:**

Rank	Book	Score	
1	annaKarenina.txt	0	375.0
2	prideAndprejudice.txt	6	106.5
3	janeEyre.txt	2	85.5
4	emma.txt	1	72.0
5	portraitOfALady1.txt	4	56.925
6	mobyDick.txt	3	55.5
7	portraitOfALady2.txt	5	45.0
8	threeMenInABoat.txt	7	19.5

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(d) “sentimental reasons”

- **Simple tf-idf:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Cosine Similarity:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Term Proximity:**

Rank	Book	Score	
1	portraitOfALady2.txt	5	151.5
2	mobyDick.txt	3	144.0
3	prideAndprejudice.txt	6	141.0
4	annaKarenina.txt	0	138.0
5	portraitOfALady1.txt	4	130.5
6	emma.txt	1	130.5
7	janeEyre.txt	2	96.75
8	threeMenInABoat.txt	7	15.0

(e) “fall in love”

- **Simple tf-idf:**

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Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Cosine Similarity:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Term Proximity:**

Rank	Book	Score	
1	annaKarenina.txt	0	1002.08036
2	janeEyre.txt	2	373.5
3	emma.txt	1	289.6875
4	portraitOfALady2.txt	5	198.75
5	prideAndprejudice.txt	6	198.0
6	portraitOfALady1.txt	4	159.5
7	mobyDick.txt	3	123.0
8	threeMenInABoat.txt	7	76.5

(f) “sister mother father”

- **Simple tf-idf:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

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- **Cosine Similarity:**

Rank	Book	Score	
1	annaKarenina.txt	0	0.0
2	threeMenInABoat.txt	7	0.0
3	prideAndprejudice.txt	6	0.0
4	portraitOfALady2.txt	5	0.0
5	portraitOfALady1.txt	4	0.0
6	mobyDick.txt	3	0.0
7	janeEyre.txt	2	0.0
8	emma.txt	1	0.0

- **Term Proximity:**

Rank	Book	Score	
1	prideAndprejudice.txt	6	884.74107
2	annaKarenina.txt	0	844.73571
3	emma.txt	1	519.78571
4	portraitOfALady1.txt	4	426.08571
5	janeEyre.txt	2	314.58036
6	portraitOfALady2.txt	5	197.625
7	mobyDick.txt	3	94.95
8	threeMenInABoat.txt	7	51.9



V) The following table shows the pair-wise comparison of the books. The Cosine Similarity is symmetric.

	Emma	Jane Eyre	Moby Dick	Portrait of a Lady 1	Portrait of a Lady 2	Pride and Prejudice	Three Men in a Boat
Anna Karenina	0.00284	0.00408	0.00339	0.00444	0.00528	0.00296	0.00169
Emma	-	0.00398	0.00131	0.00171	0.00163	0.00667	0.00219
Jane Eyre	-	-	0.00356	0.00391	0.00412	0.00262	0.00257
Moby Dick	-	-	-	0.00245	0.00294	0.00196	0.00374
Portrait of a Lady 1	-	-	-	-	0.05252	0.00292	0.00142
Portrait of a Lady 2	-	-	-	-	-	0.00325	0.00131
Three Men in a Boat	-	-	-	-	-	-	0.00106

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VI) Unfortunately, many documents that contain (at least some of) the query terms receive nevertheless a score of *zero*, because the query terms are very general. That is, many query terms occur in all documents of the corpus and, thus, have an idf-value of zero. The ranking methods “Simple tf-idf” and “Cosine Similarity” are based on the tf-idf values and calculate, consequently, the score 0.0.

One possibility to counteract this behavior would be to add 1 to the denominator when calculating the idf:  $idf_t = \log(\frac{|corpus|}{1+df_t})$ . Then, terms that occur in *all* documents and have a *high* frequency would receive a very low, negative score. Terms that occur in *all* documents but not as often would receive a negative score that is closer to zero. One could argue that this behavior represents “relevance” of these general terms reasonably well.

However, if we implemented this alternative, we would only shift the problem from terms that occur in *all* documents to terms that occur in *all but one* documents. Terms that occur in all but one documents would always receive the tf-idf value 0.0, regardless of how often they appear in the respective document.

Our implementation of a “Term Proximity” ranker has a disadvantage, too. While it does not rely on the tf-idf values, it strongly favors long documents over short ones.

In conclusion we find that a search engine should base the ranking of search results not only on tf-idf values but rather incorporate many more signals. The authority of a Web page, represented by its PageRank, is one such example signal.

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## Appendix

**convers** → 0:0.0:5680, 631, 4073, 676, 3071, 3148, 71, 1025, 14, 16, 182, 1129, 9, 1604, 1154, 68, 19, 217, 220, 23, 509, 335, 3374, 648, 2783, 1572, 2375, 284, 254, 3300, 537, 1989, 2234, 85, 1722, 491, 2397, 1593, 8220, 134, 44, 39, 109, 77, 37, 103, 345, 57, 10, 439, 459, 310, 952, 223, 310, 2010, 7325, 5811, 1016, 497, 5978, 4158, 63, 424, 1194, 622, 840, 14, 776, 3645, 8216, 1325, 802, 2443, 4165, 773, 4, 23, 3494, 44, 924, 77, 7264, 20, 6430, 367, 3062, 2177, 60, 4457, 2899, 1420, 237, 26, 245, 175, 10, 2054, 26, 1761, 190, 8148, 9764, 1973, 440, 16, 234, 747, 14, 12, 67, 296, 168, 193, 168, 7, 485, 194, 94, 1083, 348, 53, 977, 309, 1712, 1888, 768, 2822, 3032, 8543, 663, 1396, 20, 160, 5975, 434, 5147, 1671, 34, 6044, 3264, 14155, 2144, 4128, 2874, 115, 42, 38, 721, 6023, 148, 859, 329, 15, 6694, 847, 449, 173, 3766, 17, 144, 52, 24, 33, 45, 67, 2981, 1677, 1532, 121, 2011, 1231, 432, 2450, 999, 2, 53, 4, 22, 172, 662, 311, 401, 3251, 277, 2559, 1012, 1069, 1150, 834, 768, 334, 3048, 1790, 2717, 81, 841, 141, 224, 136, 826, 422, 479, 816, 325, 639, 197, 1094, 2271, 54, 1084, 68, 314, 250, 1, 10, 27, 604, 5919, 176, 2130, 188, 3288, 58, 1085, 2195, 924, 3866, 747, 3123, 3495, 2045, 64, 80, 2099, 300, 25, 1758, 2504, 6506, 532, 258, 767, 780, 165, 384, 720, 1415, 242  
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**expect** → 0:0.0:4643, 1540, 1468, 938, 10455, 772, 1000, 4411, 1900, 1303, 3035, 2963, 226, 607, 5155, 4869, 3286, 727, 3290, 2936, 8739, 5150, 134, 8710, 2656, 794, 17, 2702, 1833, 3059, 1452, 2786, 203, 7083, 134, 2810, 3558, 5466, 1854, 429, 3828, 3534, 1547, 3478, 1755, 2519, 614, 3323, 589, 292, 550, 356, 30, 2501, 1526, 32, 4740, 11261, 1621, 1716, 2402, 2595, 2459, 428, 1444, 9099, 256, 809, 167, 2041, 825, 2588, 81, 2227, 8155, 1086, 231, 107, 360, 726, 1387, 749, 1677, 26, 2228, 2548, 544, 588, 1214, 1723, 1635, 604, 2531, 147, 290, 13, 38, 27, 304, 121, 89, 4315, 205, 1514, 4599, 497, 581, 2350, 115, 2294, 3944, 3736, 999, 2226, 5044, 620, 3925, 2289, 97, 8412, 422, 23, 349, 4658, 695, 1512, 4177, 1144, 10575, 3210, 823, 160, 56, 40, 766, 850, 1141, 1052, 442, 2678, 574, 15176, 2456, 1317, 5490, 18, 4414, 1598, 3593, 2269, 773, 1540, 1746, 1798, 8599, 622, 4594, 908, 4    1:0.0:7256, 2158, 37, 6, 1547, 1178, 3318, 198, 236, 2437, 2172, 101, 3508, 3313, 121, 750, 1363, 5, 1632, 6572, 1208, 497, 1106, 3946, 2465, 3975, 606, 567, 302, 5207, 1726, 71, 2264, 1155, 133, 1102, 434, 1808, 408, 25, 3578, 5040, 1323, 1664, 1716, 1603, 1821, 1684, 455, 13, 641, 850, 1935, 3346, 4369, 1752, 1425, 119, 1035, 1299, 63, 14, 400, 1718, 2656, 631, 1539, 452, 3093, 5323, 497, 1345, 1045, 521, 394, 5368, 1717, 6782, 74, 2344, 5580, 1295, 2, 4730, 277, 2537, 100, 1722, 526, 2614, 404, 1140    1:0.0:8404, 4310, 7022, 756, 1954, 1492, 12751, 787, 1132, 1024, 549, 371, 1886, 1014, 165, 2168, 3605, 4796, 3214, 267, 696, 3942, 323, 1496, 68, 427, 1679, 168, 479, 4465, 413, 2454, 4994, 1310, 2762, 1777, 1934, 7264, 2415, 798, 2455, 7269, 2091, 5165, 7663, 1074, 1833, 4621, 6166, 406, 262, 448, 838, 3012, 6572, 835, 1533, 791, 32, 1303, 4591, 1010, 283, 324, 2256, 2481, 666, 2565, 12, 779, 321, 2009, 1813, 315, 144, 4180, 475, 4127, 2087, 926, 58, 651, 1198, 1088    1:0.0:40691, 6869, 65154, 12, 240, 117, 3133, 103, 64, 17291, 10424, 64026, 7369    1:0.0:2280, 7589, 423, 1107, 1142, 2831, 3449, 2560, 14, 2078, 1629, 1342, 523, 940, 1789, 498, 1276, 2441, 810, 2425, 612, 308, 1056, 1827, 2349, 3334, 2010, 1205, 1276, 517, 5148, 1239, 3762, 1825, 822, 613, 5862, 1673, 5446, 8042, 5, 11, 15826, 33, 263, 3171, 4104, 273, 5964, 569, 1222, 1187, 1104, 662, 14    1:0.0:2943, 1729, 2320, 478, 541, 138, 805, 21, 1156, 861, 84, 1630, 327, 762, 158, 2921, 390, 409, 4568, 705, 1909, 6369, 18, 877, 68, 385, 3267, 3577, 6105, 373, 3677, 430, 3533, 32, 411, 1612, 4551, 1611, 929, 4164, 1270, 793, 653, 278, 8, 16, 2582, 220, 4816, 109, 86, 190, 4058, 10106, 3085, 299, 654, 598, 1688, 2496, 4108, 7877    1:0.0:1445, 1522, 512, 4205, 642, 3637, 2469, 796, 2223, 577, 864, 836, 714, 5937, 1775, 1109, 81, 1343, 6592, 2153, 589, 2494, 668, 1853, 1091, 667, 754, 1048, 1137, 354, 118, 231, 1584, 1102, 238, 778, 1440, 1050,

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**sentiment** → 0:0.0:9283, 47358, 14334, 52249, 62530, 39541, 1212, 56, 26019, 24186, 42477     1:0.0:7312, 8415, 190, 5305, 1567, 13554, 1058, 5190, 4201, 19215, 19833, 1889, 2192, 193, 13891, 29094, 789, 9669, 602 1:0.0:1666, 7551, 3179, 1182, 7155, 10119, 26962, 7598, 395, 6168, 4222, 122, 1289, 16141, 2417, 16681, 32961, 951, 1645, 7281, 1088, 13791, 396 1:0.0:46523, 11060, 5867, 4536, 93353     1:0.0:8458, 4561, 5841, 9292, 1615, 19727, 696, 3259, 9029, 15085, 2848, 8642, 3167, 1255, 7698, 11291 1:0.0:6154, 13290, 11, 5343, 1804, 2014, 5762, 2719, 9759, 3405, 3168, 3617, 12397, 13550, 32014, 1256     1:0.0:8297, 21480, 29528, 1816, 125, 385, 1045, 7244, 7705, 9291, 10123, 5716, 2506, 6306, 1422, 2634, 1805     1:0.0:25632, 41600

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**summer**  $\rightarrow$  0:0.0:67890, 952, 31, 1023, 6711, 6, 4101, 3376, 4068, 459, 17, 9350, 5807, 1064, 16, 494, 204, 5010, 3322, 346, 85, 20, 1237, 2364, 3632, 4063, 3305, 1937, 12065, 5745, 3888, 11899, 928, 46229, 31579, 33, 24, 53, 193, 6655, 3211, 5267, 8925, 12657, 2857, 14356, 21321, 1668, 3849, 13293, 1299, 17424    1:0.0:5863, 1777, 19, 7302, 5, 3601, 1392, 31406, 17288, 40, 2798, 5180, 13593, 137, 27, 1960, 6607, 888, 10068, 5176, 2949, 5452, 17507    1:0.0:831, 30910, 7314, 6080, 4804, 10401, 7393, 32484, 2793, 3129, 8102, 9339, 9906, 590, 593, 3386, 28834, 9917, 3513    1:0.0:1214, 6130, 13, 9293, 91, 10721, 18615, 5, 15092, 2678, 56381, 32003, 8, 20467, 13146, 4903, 15520, 7604    1:0.0:6770, 37, 14449, 65382, 4596, 16164, 6455, 2538, 2547    1:0.0:3217, 3582, 1803, 12752, 2288, 5481, 50976, 1495, 2740, 5261 1:0.0:22672, 20388, 5301, 2586, 6960, 5254, 94, 3131, 2051, 44, 32, 2703, 3438, 3, 922, 1136, 6263, 1298, 26785    1:0.0:3691, 10810, 1701, 303, 7414, 14180, 1968, 4082, 630, 10549, 9950