

## **CMPE 493 INFORMATION RETRIEVAL ASSIGNMENT 1 : BOOLEAN SEARCH ENGINE**

In this assignment we built a boolean search engine. Inverted index was used as the search dictionary. AND, OR and NOT operators for singular words are usable in the system.

### **Index\_building module is working with:**

```
python3 index_build.py ./reuters21578/ ./stopwords.txt
```

### **As the index is built, Query\_processing module is working with:**

```
python3 query_process.py
```

Assignment consists of 3 main steps:

- 1- Data Preprocessing
- 2- Inverted Index Building
- 3- Query Processing and Boolean Search

### **1- Data Preprocessing**

Reuters data was read via a HTML file processing library, BeautifulSoup. As the documents are read, they are trimmed from punctuations according to the string.punctuation list and cleaned from stop words specified by the user. Latin-1 encoding was used for the documents. Multiprocessing which creates a process for each document was used to speed up the data reading at data preprocessing step.

### **2- Inverted Index Building**

In this step the index of files which is linked as doc to words in doc is transformed into word to docs containing the word.

For the inverted index, I used built-in dictionary in which keys represent words while values are basic list structures for postings list. I preferred dictionary (hashmap structure in python) for inverted index because it uses a hash function to link key and values and it provides an  $O(1)$  time complexity to store and retrieve a particular object. [1] I preferred a basic array structure for postings list as it has  $O(1)$  complexity for adding new elements. It has  $O(n)$  complexity for searching items but as the postings lists of words are not large, I thought it won't create a problem during query search. [2]

### 3- Query Processing

At the last step of the assignment, a query processing and a boolean search engine connected to the inverted index built in the first step is implemented. Conjunction, disjunction and negation operations for singular words are open to use.

```
Last login: Thu Nov 18 21:48:08 on ttys000
maral@192 ~ % cd /Users/maral/Desktop/Assignment1
maral@192 Assignment1 % python3 index_build.py ./reuters21578/ ./stopwords.txt
- Index is created in 4.194551944732666 seconds -
maral@192 Assignment1 % █
```

**Figure 1 (Inverted index building operation takes 4.19 seconds)**

Creating an inverted index takes 4.19 seconds.

```
Last login: Thu Nov 18 21:48:08 on ttys000
maral@192 ~ % cd /Users/maral/Desktop/Assignment1
maral@192 Assignment1 % python3 index_build.py ./reuters21578/ ./stopwords.txt
- Index is created in 4.194551944732666 seconds -
maral@192 Assignment1 % python3 query_process.py
Index is successfully loaded!
Please enter a query (You can use AND OR NOT operators). Enter E to exit.
Please enter a query(''E'' for exit):price AND oil
price AND oil
price AND oil is found at:
[127, 144, 191, 194, 213, 236, 246, 263, 357, 471, 489, 502, 543, 597, 829, 834, 843, 873, 885, 952, 1026, 1349, 1370, 1387, 1711, 1848, 18
75, 1909, 1990, 2045, 2061, 2068, 2074, 2121, 2132, 2228, 2251, 2383, 2696, 2775, 2828, 2833, 2975, 2998, 3024, 3065, 3174, 3181, 3189, 324
9, 3303, 3342, 3389, 3430, 3452, 3455, 3490, 3535, 3563, 3571, 3593, 3798, 3869, 3985, 4005, 4017, 4035, 4061, 4174, 4214, 4232, 4453, 4474
, 4481, 4546, 4564, 4576, 4584, 4634, 4662, 4679, 4713, 4744, 4835, 4878, 5037, 5061, 5145, 5167, 5179, 5184, 5244, 5255, 5268, 5270, 5273,
5318, 5323, 5389, 5559, 5631, 5761, 5769, 5787, 5851, 5936, 6023, 6086, 6121, 6177, 6201, 6208, 6371, 6413, 6656, 6876, 6954, 6994, 6996,
7174, 7200, 7408, 7639, 7643, 7731, 7937, 8015, 8041, 8095, 8131, 8134, 8173, 8209, 8210, 8478, 8606, 8615, 8630, 8820, 8960, 8964, 9031, 9
077, 9149, 9156, 9213, 9392, 9436, 9462, 9485, 9639, 9650, 9691, 9706, 9732, 9733, 9761, 9763, 9799, 9853, 9933, 9947, 10015, 10078, 10080,
10091, 10168, 10190, 10192, 10228, 10261, 10275, 10291, 10306, 10330, 10348, 10385, 10567, 10605, 10649, 10693, 10703, 10845, 10873, 10975
, 11083, 11118, 11172, 11177, 11213, 11224, 11232, 11236, 11241, 11273, 11350, 11455, 11711, 11723, 11753, 11768, 11778, 11781, 11880, 1188
2, 11949, 12013, 12050, 12111, 12277, 12279, 12281, 12608, 12647, 12670, 12680, 12791, 12799, 13115, 13236, 13265, 13276, 13281, 13290, 136
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829, 15875, 15939, 16116, 16130, 16195, 16215, 16268, 16270, 16483, 16589, 16607, 16649, 16939, 16956, 16991, 17015, 17018, 17101, 17102, 1
7131, 17161, 17173, 17177, 17254, 17289, 17291, 17294, 17329, 17359, 17385, 17386, 17389, 17405, 17408, 17409, 17416, 17419, 17429, 17446,
17478, 17519, 17759, 17812, 17816, 17892, 17913, 17929, 17963, 18085, 18193, 18200, 18367, 18378, 18393, 18403, 18420, 18422, 18432, 18448,
18464, 18621, 18689, 18738, 18744, 18746, 18754, 18765, 18773, 18776, 18795, 18810, 18840, 19051, 19059, 19069, 19082, 19083, 19128, 19193
, 19285, 19291, 19397, 19490, 19497, 19499, 19509, 19534, 19551, 19556, 19559, 19588, 19662, 19832, 19867, 19927, 19998, 20030, 20095, 2035
2, 20389, 20420, 20666, 20709, 20721, 20919, 20936, 21067, 21076, 21131, 21152, 21486]
Please enter a query(''E'' for exit):█
```

**Figure 2 (A Conjunction Operation for ‘price AND oil’)**

```
Please enter a query(''E'' for exit):petroleum OR oil OR gas
petroleum OR oil OR gas
petroleum OR oil OR gas is found at:
[68, 84, 91, 140, 145, 176, 277, 304, 370, 372, 507, 542, 544, 570, 622, 708, 739, 799, 837, 862, 918, 927, 963, 1024, 1066, 1084, 1297, 13
01, 1316, 1335, 1343, 1379, 1387, 1456, 1466, 1501, 1520, 1558, 1619, 1650, 1658, 1661, 1703, 1709, 1711, 1751, 1756, 1824, 1856, 1891, 190
6, 1948, 2007, 2045, 2061, 2303, 2394, 2415, 2477, 2479, 2480, 2483, 2511, 2515, 2522, 2528, 2685, 2737, 2738, 2745, 2758, 2789, 2818, 2833
, 2835, 2897, 2923, 2927, 2998, 3015, 3024, 3080, 3145, 3169, 3174, 3210, 3249, 3252, 3264, 3310, 3344, 3490, 3505, 3592, 3714, 3736, 3747,
3752, 3758, 3763, 3779, 3787, 3798, 3840, 3843, 3846, 3864, 3872, 3925, 3980, 4016, 4017, 4027, 4049, 4162, 4209, 4232, 4290, 4317, 4340,
4353, 4467, 4475, 4507, 4510, 4553, 4566, 4569, 4590, 4600, 4601, 4604, 4661, 4730, 4734, 4755, 4834, 4835, 4908, 4930, 4936, 4951, 4962, 4
963, 4981, 5037, 5044, 5061, 5150, 5187, 5210, 5236, 5295, 5342, 5425, 5440, 5472, 5538, 5544, 5552, 5675, 5739, 5755, 5776, 5793, 5796, 58
28, 5848, 5936, 5949, 5965, 6001, 6087, 6111, 6119, 6121, 6133, 6145, 6162, 6163, 6166, 6169, 6177, 6219, 6256, 6271, 6286, 6301, 6322, 642
5, 6560, 6606, 6656, 6660, 6685, 6688, 6692, 6712, 6722, 6740, 6742, 6746, 6760, 6836, 6876, 6888, 6905, 6954, 7067, 7097, 7150, 7156, 7174
, 7200, 7287, 7291, 7307, 7397, 7408, 7423, 7462, 7529, 7548, 7611, 7639, 7663, 7671, 7702, 7740, 7742, 7790, 7831, 7896, 7952, 7972, 8014,
8032, 8033, 8039, 8041, 8050, 8051, 8055, 8062, 8069, 8100, 8108, 8131, 8149, 8190, 8209, 8210, 8237, 8423, 8465, 8478, 8530, 8570, 8600,
8615, 8630, 8765, 8780, 8815, 8820, 8824, 8920, 9077, 9100, 9112, 9185, 9275, 9279, 9328, 9352, 9354, 9381, 9392, 9402, 9436, 9445, 9462, 9
485, 9545, 9547, 9549, 9583, 9639, 9645, 9650, 9778, 9912, 9915, 9952, 10011, 10038, 10078, 10106, 10123, 10190, 10200, 10228, 10261, 10268
, 10291, 10317, 10371, 10375, 10521, 10567, 10670, 10703, 10718, 10795, 10812, 10831, 10846, 10847, 11002, 11044, 11053, 11056, 11089, 1109
3, 11111, 11118, 11134, 11145, 11171, 11177, 11213, 11231, 11232, 11236, 11350, 11393, 11406, 11466, 11522, 11533, 11632, 11674, 11711, 117
17, 11724, 11760, 11898, 11943, 11950, 12029, 12031, 12060, 12123, 12149, 12173, 12181, 12193, 12209, 12277, 12279, 12313, 12344, 12345, 12
378, 12513, 12521, 12531, 12536, 12578, 12606, 12611, 12636, 12680, 12686, 12691, 12700, 12728, 12818, 12822, 12851, 12939, 12953, 12977, 1
3035, 13102, 13115, 13127, 13181, 13200, 13256, 13265, 13266, 13280, 13350, 13623, 13634, 13702, 13753, 13993, 14679, 14749, 14755, 14829,
14891, 14894, 14900, 15004, 15071, 15238, 15250, 15322, 15325, 15366, 15396, 15416, 15613, 15639, 15733, 15759, 15760, 15814, 16007, 16116,
16130, 16155, 16166, 16176, 16212, 16215, 16238, 16270, 16323, 16438, 16463, 16483, 16499, 16581, 16589, 16593, 16597, 16604, 16636, 16680
, 16742, 16789, 16833, 16894, 16916, 16918, 16961, 16966, 17079, 17080, 17093, 17096, 17100, 17101, 17108, 17125, 17135, 17153, 17161, 1717
0, 17173, 17199, 17225, 17327, 17329, 17353, 17354, 17355, 17357, 17361, 17369, 17405, 17408, 17409, 17410, 17415, 17416, 17422, 17430, 174
33, 17446, 17463, 17469, 17472, 17492, 17515, 17516, 17544, 17547, 17554, 17605, 17611, 17653, 17669, 17675, 17693, 17708, 17735, 17749, 17
878, 17911, 17913, 17927, 18137, 18138, 18193, 18217, 18253, 18305, 18325, 18367, 18401, 18405, 18480, 18567, 18579, 18651, 18739, 18760, 1
8774, 18782, 18784, 18785, 18857, 18891, 18896, 18903, 18917, 18932, 18993, 19078, 19082, 19083, 19110, 19175, 19200, 19271, 19333, 19350,
19370, 19471, 19472, 19492, 19601, 19664, 19699, 19852, 19874, 20093, 20352, 20360, 20392, 20464, 20517, 20578, 20590, 20653, 20666, 20669,
20697, 20749, 20774, 20869, 20935, 20936, 21417, 21486, 21519, 21536, 21541, 21568]
Please enter a query(''E'' for exit):█
```

**Figure 3 (A disjunction operation for ‘petroleum OR oil OR gas’)**

Maral Dicle MARAL

18.11.2021

price AND oil NOT vegetable  
price AND oil NOT vegetable is found at:  
[4, 5, 18, 15, 16, 22, 45, 97, 184, 115, 123, 127, 144, 148, 176, 179, 181, 191, 194, 204, 209, 217, 230, 232, 236, 240, 246, 258, 259, 263, 267, 278, 302, 305, 311, 325, 335, 347, 357, 362, 367, 372, 377, 388, 381, 424, 425, 432, 454, 478, 485, 489, 502, 515, 527, 548, 597, 631, 640, 635, 651, 648, 672, 768, 775, 829, 834, 843, 842, 873, 874, 875, 8  
84, 885, 912, 919, 929, 952, 954, 960, 967, 977, 982, 989, 1012, 1018, 1026, 1036, 1055, 1057, 1081, 1106, 1147, 1151, 1153, 1154, 1159, 1194, 1212, 1242, 1292, 1303, 1312, 1349, 13  
61, 1365, 1369, 1370, 1371, 1377, 1380, 1387, 1388, 1402, 1405, 1424, 1439, 1473, 1491, 1513, 1519, 1539, 1560, 1578, 1598, 1634, 1662, 1674, 1675, 1685, 1694, 1701, 1711, 1729, 173  
5, 1738, 1744, 1761, 1766, 1777, 1813, 1836, 1838, 1864, 1875, 1880, 1882, 1886, 1889, 1893, 1895, 1897, 1909, 1926, 1934, 1942, 1958, 1965, 1978, 1990, 1996, 2001, 2045, 2056  
2059, 2061, 2068, 2072, 2074, 2080, 2094, 2097, 2108, 2121, 2132, 2160, 2161, 2185, 2206, 2214, 2215, 2223, 2228, 2243, 2251, 2257, 2271, 2278, 2297, 2303, 2354, 2370, 2375, 2383,  
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2783, 2792, 2812, 2828, 2833, 2846, 2847, 2879, 2907, 2922, 2924, 2932, 2934, 2945, 2965, 2975, 2979, 2982, 2998, 3013, 3024, 3038, 3045, 3062, 3063, 3065, 3071, 3077, 3079, 3089, 3  
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2, 3724, 3727, 3748, 3758, 3761, 3789, 3793, 3798, 3809, 3892, 3923, 3945, 3953, 3956, 3965, 3965, 3985, 3987, 3997, 4005, 4007, 4017, 4052, 4057, 4061, 4066, 4072, 4099, 4102, 4108, 4122  
, 4127, 4145, 4174, 4191, 4204, 4212, 4214, 4221, 4223, 4232, 4262, 4267, 4270, 4283, 4291, 4303, 4312, 4326, 4350, 4354, 4356, 4369, 4373, 4382, 4392, 4405, 4407, 4443, 4453, 4456,  
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4683, 4704, 4713, 4714, 4741, 4744, 4748, 4753, 4772, 4787, 4800, 4824, 4830, 4835, 4839, 4846, 4847, 4864, 4866, 4878, 4893, 4895, 4912, 4941, 4943, 4944, 4966, 4988, 5011, 5020, 5  
037, 5061, 5109, 5134, 5135, 5139, 5145, 5167, 5179, 5184, 5213, 5214, 5225, 5229, 5231, 5244, 5255, 5249, 5255, 5258, 5268, 5270, 5273, 5283, 5299, 5301, 5311, 5318, 5323, 5335, 53  
40, 5345, 5350, 5379, 5382, 5389, 5411, 5424, 5465, 5471, 5480, 5486, 5513, 5515, 5529, 5548, 5559, 5567, 5587, 5596, 5598, 5628, 5631, 5641, 5643, 5668, 5702, 5711, 5726, 5761, 576  
9, 5787, 5788, 5792, 5812, 5813, 5839, 5851, 5865, 5873, 5874, 5882, 5888, 5889, 5890, 5916, 5935, 5936, 5948, 5965, 5988, 5997, 6023, 6056, 6085, 6086, 6091, 6097, 6112, 6121, 6124  
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1, 9897, 9922, 9926, 9947, 9953, 9954, 9977, 10015, 10017, 10025, 10034, 10036, 10044, 10055, 10059, 10078, 10088, 10082, 10085, 10091, 10103, 10116, 10148, 10168, 10187, 10190, 101  
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13121, 13124, 13130, 13157, 13172, 13208, 13216, 13220, 13232, 13234, 13236, 13251, 13258, 13261, 13263, 13265, 13276, 13281, 13285, 13287, 13290, 13314, 13320, 13331, 13378, 13434  
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4, 13865, 13886, 13895, 13900, 13947, 13966, 14001, 14005, 14008, 14081, 14149, 14164, 14183, 14199, 14212, 14280, 14307, 14310, 14358, 14390, 14397, 14398, 14454, 14476, 14486, 144  
99, 14515, 14520, 14558, 14574, 14588, 14619, 14635, 14638, 14639, 14649, 14656, 14668, 14670, 14675, 14685, 14687, 14691, 14708, 14718, 14724, 14749, 14797, 14805, 14833, 14838, 14  
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, 15875, 15885, 15887, 15894, 15905, 15915, 15924, 15939, 15940, 15952, 15973, 16017, 16019, 16096, 16103, 16110, 16113, 16116, 16119, 16128, 16130, 16132, 16147, 16149, 1616  
4, 16170, 16180, 16183, 16194, 16195, 16203, 16211, 16215, 16216, 16236, 16237, 16238, 16241, 16268, 16270, 16271, 16289, 16307, 16313, 16320, 16355, 16381, 16398, 16409, 16415, 164  
35, 16436, 16443, 16445, 16479, 16483, 16494, 16501, 16510, 16512, 16513, 16524, 16558, 16562, 16572, 16589, 16596, 16607, 16618, 16649, 16681, 16727, 16734, 16740, 16768, 16772, 16  
777, 16781, 16783, 16831, 16844, 16847, 16851, 16854, 16870, 16930, 16940, 16950, 16956, 16974, 16982, 16991, 17000, 17015, 17018, 17021, 17022, 17027, 17037, 17095, 17101, 171  
7102, 17128, 17131, 17132, 17145, 17154, 17161, 17173, 17177, 17183, 17184, 17187, 17193, 17198, 17203, 17212, 17239, 17244, 17252, 17254, 17289, 17291, 17294, 17301, 17322, 17329,  
17332, 17336, 17341, 17347, 17356, 17359, 17366, 17370, 17385, 17386, 17395, 17397, 17400, 17405, 17407, 17408, 17409, 17410, 17413, 17416, 17418, 17419, 17423, 17426, 17429, 17434,

Figure 4 ( A Conjunction and Negation operation for ‘price AND oil NOT vegetable’)

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Please enter a query('E' for exit):petroleum OR oil NOT price  
petroleum OR oil NOT price is found at:  
[2, 140, 156, 211, 237, 273, 349, 370, 391, 918, 927, 939, 988, 1004, 1098, 1306, 1335, 1343, 1456, 1463, 1558, 1616, 1660, 1825, 1856, 1874, 1878, 1948, 2159, 2187, 2210, 2221, 223  
1, 2262, 2394, 2435, 2495, 2820, 2834, 2838, 2923, 2973, 3003, 3015, 3048, 3210, 3310, 3332, 3364, 3906, 3980, 3995, 4039, 4129, 4201, 4315, 4367, 4454, 4503, 4510, 4577, 4600, 4604  
, 4742, 4834, 4936, 4948, 5035, 5116, 5118, 5119, 5156, 5163, 5203, 5295, 5330, 5485, 5538, 5541, 5544, 5552, 5558, 5578, 5609, 5675, 5712, 5789, 5796, 5985, 6000, 6125, 6163, 6166,  
6193, 6301, 6306, 6317, 6436, 6573, 6578, 6722, 6836, 6878, 6893, 7003, 7004, 7067, 7150, 7287, 7355, 7397, 7416, 7423, 7461, 7529, 7611, 7613, 7618, 7854, 7889, 7904, 7931, 8089,  
8100, 8117, 8140, 8238, 8264, 8286, 8331, 8335, 8339, 8567, 8598, 8610, 8623, 8627, 8756, 8854, 8877, 8882, 8905, 8971, 8995, 9008, 9127, 9155, 9204, 9206, 9253, 9260, 9275, 9279, 9  
478, 9634, 9736, 9742, 9858, 9872, 9908, 9913, 10106, 10123, 10133, 10146, 10147, 10158, 10170, 10225, 10268, 10272, 10284, 10292, 10317, 10375, 10395, 10406, 10448, 10581, 10  
624, 10627, 10750, 10816, 10860, 10947, 11007, 11025, 11062, 11145, 11149, 11168, 11171, 11270, 11305, 11325, 11351, 11406, 11465, 11491, 11522, 11533, 11559, 11600, 11635, 11636, 1  
1705, 11872, 11892, 12151, 12154, 12209, 12282, 12313, 12345, 12369, 12392, 12691, 12707, 12717, 12739, 12755, 12775, 12803, 12865, 12935, 12940, 12988, 13008, 13025, 13061, 13102,  
13184, 13200, 13611, 13633, 14279, 14506, 14544, 14611, 14698, 14732, 15238, 15296, 15344, 15349, 15351, 15366, 15599, 15812, 15824, 15909, 15931, 16005, 16055, 16056, 16112, 16155,  
16166, 16169, 16176, 16314, 16414, 16475, 16532, 16577, 16613, 16636, 16640, 16646, 16658, 16655, 16680, 16702, 16739, 16742, 16807, 16833, 16948, 16960, 16979, 16996, 17000, 17003  
, 17012, 17020, 17040, 17079, 17082, 17093, 17100, 17200, 17225, 17236, 17290, 17327, 17333, 17355, 17369, 17427, 17431, 17433, 17473, 17510, 17515, 17611, 17653, 17682, 17813, 1786  
8, 17878, 17886, 17958, 17968, 17983, 18146, 18201, 18234, 18325, 18332, 18381, 18398, 18410, 18408, 18567, 18573, 18657, 18723, 18728, 18966, 18975, 19207, 19492, 19505, 19810, 198  
52, 19869, 20004, 20007, 20081, 20088, 20093, 20270, 20406, 20464, 20669, 20685, 20740, 20788, 20870, 21249, 21260, 21293, 21405, 21541]  
Please enter a query('E' for exit):

Figure 5 (Disjunction and Negation operation for ‘petroleum OR oil NOT price’)

## REFERENCES

- [1]"Built-in Types — Python 3.10.0 documentation", *Docs.python.org*, 2021. [Online]. Available: <https://docs.python.org/3/library/stdtypes.html#typesmapping>. [Accessed: 18- Nov- 2021].
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