

Information Retrieval

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Gabriele Ferrario - 817518 - g.ferrario@campus.unimib.it

Riccardo Pozzi - 807857 - r.pozzi@campus.unimib.it

Personalized Search Engine for microblog

Introduction

The goal of this project is to define a search engine that enables user profiling and allows users to perform both standard searches as well as advanced and personalized ones.

Starting from data obtained from the social network Twitter.com¹ it has been possible to create users' profiles starting from their personal tweets by extracting their main interests thanks to the Tf-idf metric from both the words and the hashtags they frequently use.

The implemented search engine allows the user to search for news tweets containing specific keywords or hashtags or a combination of both, providing additional advanced query modes.

¹ "Twitter." <https://twitter.com/>.

Indeed eventual errors in keywords, such as typographical ones, have been considered by the implementation of an approximate or fuzzy search mode, which is available to the user along with the synonyms expansion mode which, thanks to WordNet², is able to enrich the original query so that it matches synonyms too.

Furthermore, once an user is logged in, search results are refined according to his/her personal interests extracted as mentioned above.

Dataset

Dataset is composed by tweets directly collected from Twitter.com using the official Twitter API through tweepy³ python library.

All of them have been saved directly into Elasticsearch⁴ and they've been organized in two different indices: "usertweets" and "retrievalbase" which contain respectively tweets from users for profiling purposes and the ones that will be the targets of the search engine.

About users' profiles: six twitter accounts of english speaking people were considered; three among politicians:

- Barack Obama @BarackObama
- Boris Johnson @BorisJohnson
- Joe Biden @JoeBiden

and three among sportsmen:

- LeBron James @KingJames
- Raheem Sterling @sterling7
- Kevin Durant @KDTrey5.

All of these tweets have been then analyzed to obtain a profile for each user which is

² George A. Miller (1995). WordNet: A Lexical Database for English. Communications of the ACM Vol. 38, No. 11: 39-41.

Christiane Fellbaum (1998, ed.) WordNet: An Electronic Lexical Database. Cambridge, MA: MIT Press.

³ "Tweepy." <https://www.tweepy.org/>.

⁴ "Elastic." <https://www.elastic.co/>.

represented as a document inside the Elasticsearch index “users”.

About the retrieval base instead, several tweets were gathered from the following newspaper profiles:

- Wall Street Journal @WSJ
- BBC News (World) @BBCWorld
- BBC Sport @BBCSport
- New York Times @nytimes
- USA TODAY @USATODAY
- FOX Sports @FOXSports

and then saved into the “retrievalbase” Elasticsearch index.

Totally the number of collected tweets is 36.893; 17.551 of which are users’ tweets and the remaining 19342 represent the retrieval base instead.

Each of them is provided in JSON format and includes several attributes such as “id”, “full_text” and “user” as shown in *Figure 1*.

```
{
  "created_at": "Fri Jan 22 19:00:48 +0000 2021",
  "id": 1352692708448595968,
  "full_text": "Hank Aaron was one of the best baseball players ...",
  "truncated": false,
  "entities": {
    "hashtags": [
      {
        "text": "doyourjob"
      }
    ]
  },
  "user": {
    "id": 813286,
    "name": "Barack Obama",
    "screen_name": "BarackObama",
    "location": "Washington, DC",
    "description": "Dad, husband, President, citizen.",
    "profile_background_image_url_https": "https://a.twimg.com/b.png",
  },
  "lang": "en",
  ...
}
```

}

Figure 1: Example of Tweet where the most significant fields are indicated

The project's focus has been directed especially to “full_text” which represents the body of the tweet and to the hashtags present in the tweet. On average “full_text” contains 26 words, while regarding hashtags only one tweet out of four contains a hashtag.

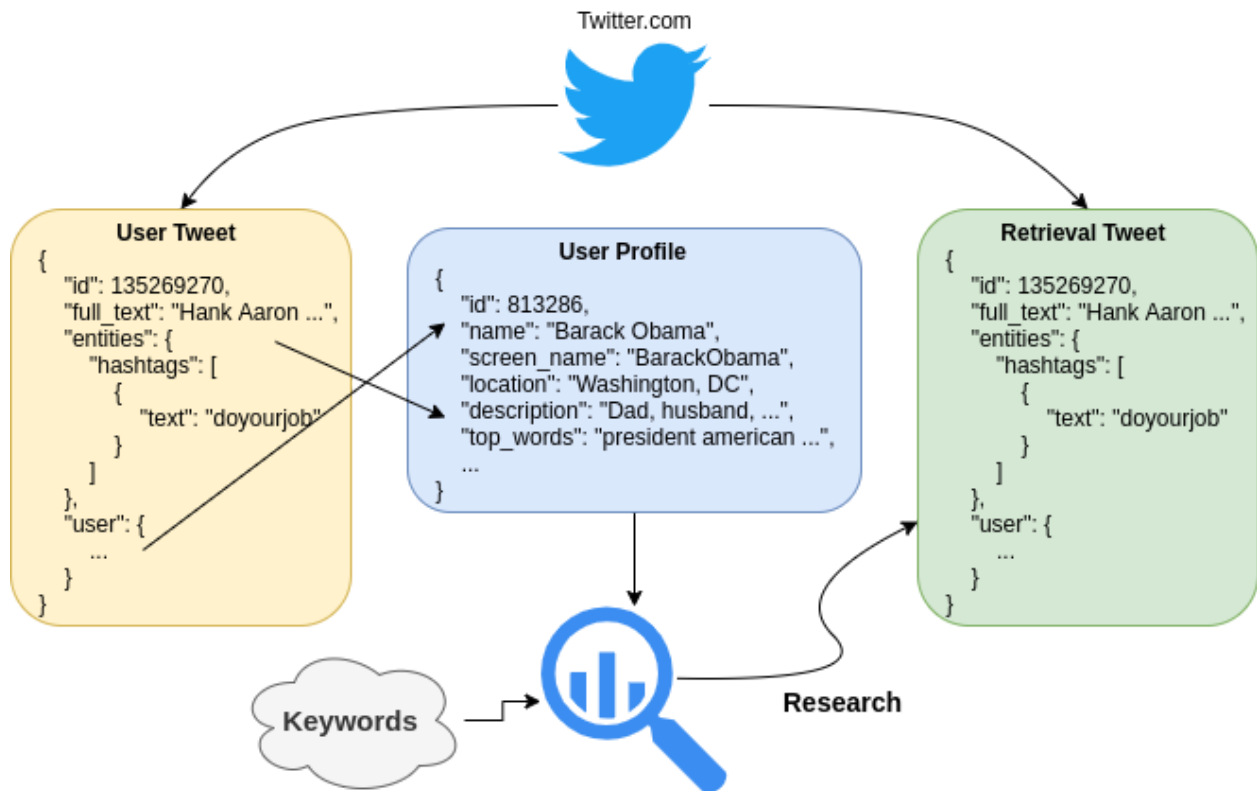


Figure 2: Data flow and data structure

Search Engine

The proposed search engine is based on Elasticsearch where the entire content of each tweet has been saved but only the necessary fields have been indexed; index mapping has been set to “static” and all the unneeded fields have been disabled while a correct mapping has been specified for the crucial ones.

“Full_text” is treated as text while hashtags as both keyword and text to allow exact search (keyword) as well as to take advantage of the text analyzer, which for instance enables case insensitive searches.

The chosen default analyzer for text fields is the built-in “english” featuring the following operations.

- standard tokenizer: tokenises using white spaces, hyphens and other characters
- english_possessive_stemmer: remove possessives (‘s)
- lowercase folding
- english_stop: removes stop words
- English_stemmer (Porter stemmer)

Another analyzer has been defined to enrich query with synonyms, called “english_synonym”, starting from the built-in “english” and adding a “synonym_graph” filter configured to use WordNet synonyms and positioned right after the lowercase folding. It has been used at search time only in order to allow the choice of whether to consider synonyms or not and at the same time avoiding to create bigger indices because of synonyms. The only acceptable downside is that by the fact the synonym expansion is issued at query time a little more computational effort is required.

```
original: "Hank Aaron was one of the best baseball players"
english: "hank aaron on best basebal player"
english_synonym: "aaron henri hank loui aaron aaron 1 i ac singl uniti
matchless nonpareil on peerless unmatched unmatched unriv unrival an
unitari on onli topper c charl outdo outflank trump scoop better best h
best herbert best basebal game player"
```

Figure 3: an example showing output from english and english_synonym analyzers

User profiles are represented as documents inside the “users” index which contain basic information such as name, description and frequently used emojis along with more valuable ones like “top words” and “top hashtags”, respectively the top 30 most important words and the top 10 hashtags. This importance comes from Tf-idf score which outperformed the simpler approach based on the number of occurrences of each word: each user has been considered as a document containing all his tweets’ full_text and hashtags; full_texts have been then preprocessed through these steps:

- Lowercase folding
- Punctuation removal
- Hashtags removal (they’re treated separately)
- Removal of words composed by two or less characters, numbers, stop words, http links
- Emoji removal (they’re removed from full_text and then treated separately)
- Stemming (Porter stemmer: the same as the stemmer used when indexing)

After that Tf-idf value has been calculated for each word excluding the 5% most frequent ones considered as corpus-specific stop words.

The following example shows how Tf-idf improved the most relevant Barack Obama’s words by removing common used ones like “change”, “make” and “get”:

Top occurrences: "presid obama make chang american vote today year work get time peopl climat help live senat whitehous watch one day job leader need fight take america countri health read new"

Tf-idf: "obama presid american climat senat ofa whitehous leader economi garland america potu plan court state add obamafound congress nation suprem address elect organ gun econom worker equal joe Biden weekli afford"

Figure 4: comparison of the extr most important words by number of occurrences and by Tf-idf

The search operation is performed against the “retrievalbase” index and it allows personalized search based on the user profile as well as different kinds of search modes which will be described in details in the next section.

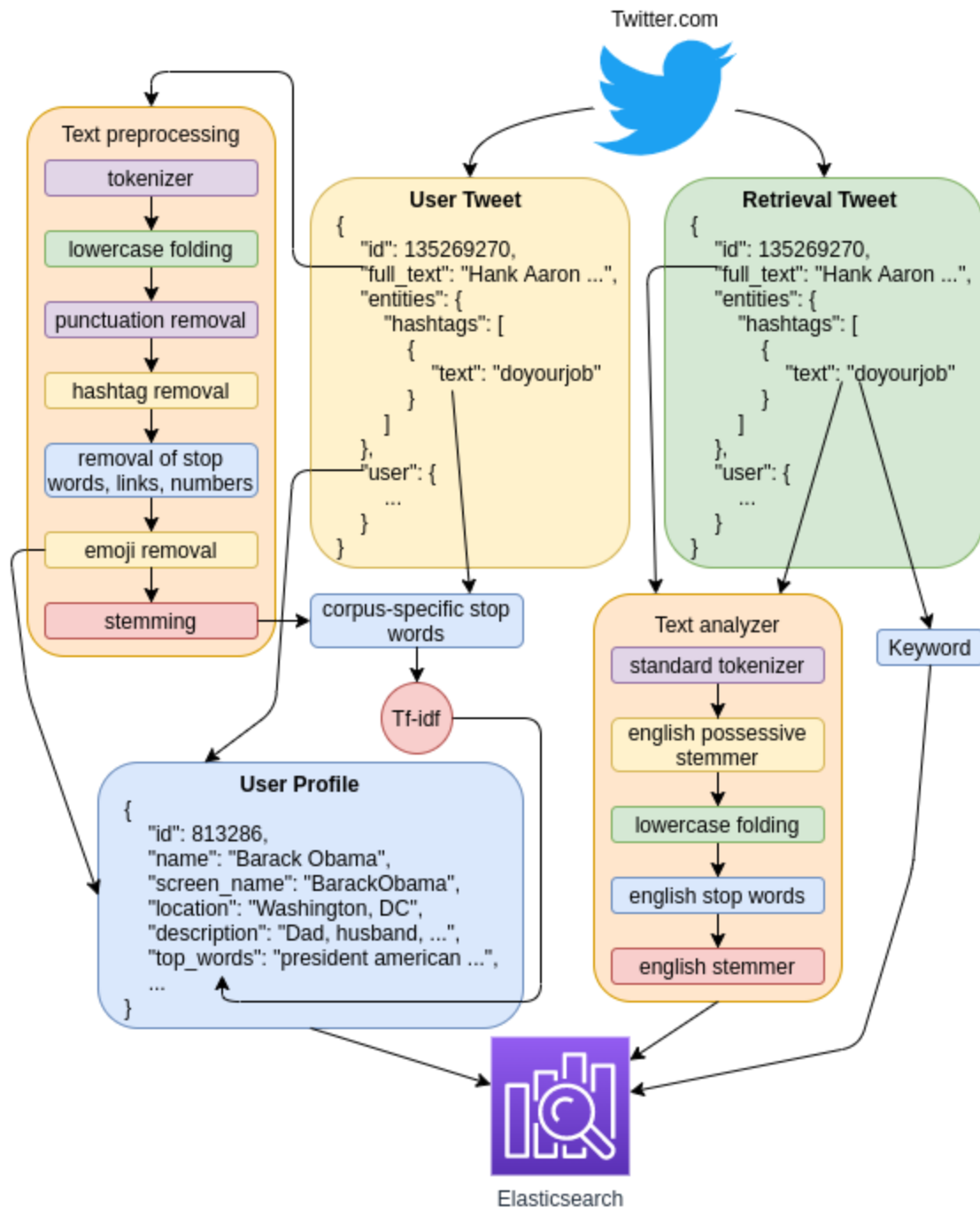


Figure 5: Diagram showing indexing flow on the right and profiling flow on the left.

Demonstration plan

The implemented search engine is available to the user through a simple React⁵ based frontend user interface which directly access Elasticsearch APIs.

Two main search modes have been defined: a basic and an advanced one.

The basic one explicitly provides two input fields: one for querying the corpus or `full_text` of the tweet and another one for querying tweet's hashtags; combined use of both inputs is allowed, producing a conjunctive query (logical and) of the inputs in order to retrieve all and only the tweets matching both the corpus query and the hashtags one.

Under the hood multiple queries are issued inside an elasticsearch “must” (logical and) containing two “should” (logical or):

- A full text (match) query against `corpus/full_text` field in the first should
- Another full text (match) query against hashtags in the second should, which allows case insensitive matches and takes advantage of other steps done by the english analyzer such as stemming
- An exact (term) query against hashtags in the second should to privilege exact matches

Then more complex search features against the “`full_text`” can be added to the first should by toggling the corresponding switches:

- A fuzzy query with “fuzziness” set to “AUTO” allowing approximate results useful for example in case of typographical errors
- A synonym enhanced query which using the “`english_synonym`” analyzer is able to match keywords synonyms

⁵ "React." <https://reactjs.org/>.

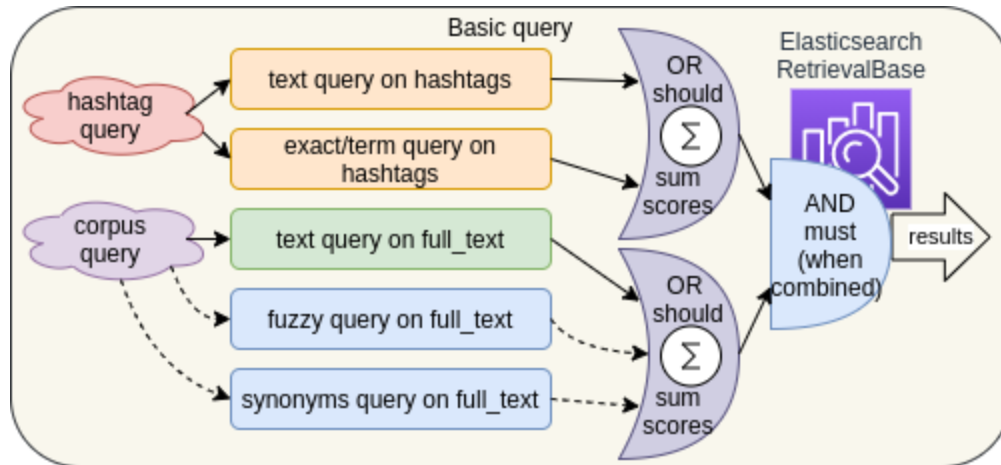


Figure 6: Basic query implementation schema.

This way better matches are privileged since what matches the first corpus query matches the additional queries too resulting in a score boost. Synonyms query has been further de-boosted because by increasing the number of words in the query it could influence too much the final scores with the risk of privileging a result containing multiple synonyms over an exact match.

The following figures show the results received from different examples of basic queries.

☐
☐
☐
☐

Advanced

Fuzzy

Synonyms

sport

Hashtags

SEARCH

Showing Top 10 results of 277.






	@FOXSports FOX Sports	Sat Jan 09 02:04:09 +0000 2021	Score: 6.106031
RT @FOXSportsPR: FOX Sports welcomes gambling analyst @spshoot, the latest contributor to the new FOX Sports app and https://t.co/Klrd4lcvD...			
	@FOXSports FOX Sports	Thu Oct 22 15:12:04 +0000 2020	Score: 6.106031
This week on the People's Sports Podcast, @TheWilderThings brings in special guest @rachelbonnetta to discuss the most tortured fanbases in sports. https://t.co/pCQqCXsFL2			
	@FOXSports FOX Sports	Thu Sep 03 00:19:08 +0000 2020	Score: 6.106031
RT @goodsportsinc: Our partnership with @FOXSports continues to help #RestorePlay through FOX Sports Films' new doc, "TUA". Sports equipmen...			
	@FOXSports FOX Sports	Wed Sep 09 16:25:04 +0000 2020	Score: 6.0347023
"Thursday is the ultimate nirvana for sports fans as the NFL, NBA, MLB, NHL - plus MLS, tennis and college football - are all in action." FOX Sports Insider @MrogersFOX breaks down the approaching super sports equinox 📺 https://t.co/959DUuzzBZ			
	@FOXSports FOX Sports	Thu Jan 07 21:03:29 +0000 2021	Score: 6.017045
RT @FOXSportsPR: FOX Sports welcomes @RJ_Young - college football analyst for the new FOX Sports app and https://t.co/Klrd4lcvD0 . Catch hi...			

Figure 7: Basic query with corpus only.

Figure 7 shows a corpus only query where it's clearly observable the advantages given by the english text analyzer: the research is case insensitive thanks to lowercase step and plurals are found too thanks to stemming.

☐
Advanced

☐
Fuzzy

☐
Synonyms

Corpus

Covid19

SEARCH

Showing Top 10 results of 5.






	@nytimes The New York Times	Wed Jan 13 04:50:04 +0000 2021	Score: 12.910793
RT @carolrosenberg: Just in: Guantanamo has received its first shipment of #Covid19 vaccines, inoculated the first 100 prison staff members...			
	@USATODAY USA TODAY	Sat Jan 30 13:33:45 +0000 2021	Score: 5.87547
RT @JillDLawrence: By @suzyscribe: #COVID19 could devastate the homeless. How will America pick up the pieces? https://t.co/iqLjE5jMXi via...			
	@USATODAY USA TODAY	Tue Jan 12 18:13:08 +0000 2021	Score: 5.87547
RT @JillDLawrence: By supply chain experts @TinglongDai and @Yadav_supplychn: Why holding second doses of #COVID19 vaccines in reserve is...			
	@USATODAY USA TODAY	Sat Jan 02 19:38:18 +0000 2021	Score: 5.87547
RT @JillDLawrence: By @jerushahruth and @inlayterms: 2020 was the 'apocalypse' that must continue in 2021 to correct what #COVID19 has reve...			
	@BBCWorld BBC News (World)	Thu Dec 03 21:45:17 +0000 2020	Score: 4.5421534
RT @BBCRosAtkins: The UK is clear that #COVID19 vaccines will not be mandatory. But after it approved the #Pfizer vaccine, we know there's...			

Figure 8: Basic query with hashtags only.

Figure 8 shows a hashtags only query where it's possible to note the effect of the two queries against hashtags. Indeed the exact match "Covid19" has about double the score of case insensitive matches as "COVID19" is matched by both hashtag subqueries.

☐

Advanced

☐

Fuzzy

☐

Synonyms

SEARCH

Showing Top 10 results of 2.



	<div>@BBCWorld</div> <div>BBC News (World)</div>	<div>Fri Jan 22 18:16:38 +0000</div> <div>2021</div>	<div>Score:</div> <div>16.318089</div>
<div>Piers Morgan tells BBC's #Americast podcast that Donald Trump was duped by a prankster who called him on Air Force One https://t.co/0praCOUijW</div>			
	<div>@BBCWorld</div> <div>BBC News (World)</div>	<div>Fri Jan 22 08:35:00 +0000</div> <div>2021</div>	<div>Score:</div> <div>14.137117</div>
<div>'An impersonator got through to the president on Air Force One and had a conversation. Trump thought he was talking to me.' @piersmorgan tells #Americast how a prankster fooled the former US president 🎧 Listen to the full interview on BBC Sounds https://t.co/a7QKUsJZgJ</div>			

Figure 9: Basic query combining corpus and hashtags.

Figure 9 shows a query which combines corpus and hashtags obtaining only tweets matching both.

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Showing Top 10 results of 667.






	@BBCWorld BBC News (World)	Mon Jan 18 06:51:58 +0000 2021	Score: 21.235157
BBC India Sportswoman of the Year contest returns https://t.co/rCQy53Cw5J			
	@USATODAY USA TODAY	Tue Jan 12 09:06:00 +0000 2021	Score: 9.228238
The three cities were selected because they are gateways to outdoor recreation, which travelers have flocked to during the COVID-19 pandemic , an Allegiant spokeswoman said. https://t.co/oHxbFLFC36			
	@nytimes The New York Times	Mon Jan 04 21:23:03 +0000 2021	Score: 6.094429
de Blasio and Cuomo have long had a difficult relationship. "Threatening to revoke the privilege of vaccination from the city's public hospital system is punitive and unnecessary," a spokeswoman for the mayor said. https://t.co/telNJet2LY			
	@nytimes The New York Times	Fri Jan 15 22:00:04 +0000 2021	Score: 5.67128
President-elect Joe Biden is dropping the Trump administration's "Operation Warp Speed" name for the federal vaccine effort. There is an "urgent need to address failures of the Trump team approach to vaccine distribution," Biden's spokeswoman tweeted. https://t.co/HNrUPTvVtU			
	@WSJ The Wall Street Journal	Wed Jan 20 15:30:10 +0000 2021	Score: 5.5745173
In the final hours of President Trump's term, China's official news agency declared good riddance on Twitter and a Chinese foreign ministry spokeswoman derided the departing U.S. Secretary of State, Mike Pompeo, as a source of entertainment for China. https://t.co/WfGHDG5FOh			

Figure 10: Fuzzy query.

Figure 10 is an example of a fuzzy query in which the keyword “pandemic” contains a typographical error. Nevertheless fuzziness allows the user to retrieve tweets matching “pandemic”, and although no tweet matches completely the entire given query it’s important to note the score of the first result which is over the double of the other results. This is due to the fact that it matches not only the fuzzy query but also the simpler full text one therefore the two queries scores are summed up.

☐
☐
☐
☒

Advanced

Fuzzy


Synonyms

revolution

Hashtags

SEARCH

Showing Top 10 results of 5.



@BBCWorld

BBC News (World)


Fri Jan 22 09:14:36 +0000

2021

Score:

16.657713

How Covid-19 turbocharged the QR **revolution** <https://t.co/L8KPiAjEkP>



@WSJ

The Wall Street Journal


Fri Jan 15 01:00:08 +0000

2021

Score:

12.638686

James Simons, who helped lead a quantitative **revolution** that has swept the world of finance, is stepping back from his Renaissance hedge fund <https://t.co/LhLvOZHJ4a>



@USATODAY

USA TODAY


Wed Jan 27 02:36:00 +0000

2021

Score:

11.697896

The two men, who were off-duty at the time, were photographed inside the Capitol in front of a statue of John Stark — a major general in the Continental Army during the American **Revolution**. <https://t.co/CNUSK54bhG>



@USATODAY

USA TODAY


Sun Jan 24 22:00:01 +0000

2021

Score:

4.902943

On Sunday, the New York Yankees made another move to shore up their starting **rotation**. <https://t.co/SBf0VpiE3G>



@BBCWorld

BBC News (World)

Thu Nov 26 16:50:37 +0000

2020

Score:

4.483319

RT @BBCBusiness: Dating coach Sami Wunder recommends "**rotational** dating", which she practised herself, refusing to be exclusive until she w...

Figure 11: Synonym query

Figure 11 shows an example of a synonym enhanced query. The search for “revolution” related tweets brought back some tweets talking about rotations. Important is to note the difference in score between tweets about “revolution” (exact match) and the ones about “rotation” (synonym match).

The advanced query offers the user a single search bar which queries tweet's corpus or full_text field. Some tests were done to both search against full_text and hashtags using the same input query but, since hashtags are part of the full_text field, results matching hashtags were double boosted. The simpler query against full_text only proved to be more effective.

Furthermore the big difference with the basic query is that the user's profile, if logged in, is considered by the advanced query.

About the implementation, the input query has been privileged over the user profile so that results must mandatorily match the input query and user profile query is then used to boost matches closer to the user's personal interests.

Technically the input query is an elasticsearch “must” (results have to match the must) containing a “should” with a simple full text query against the corpus and eventually additional queries for fuzziness and synonyms expansion.

The profile query is instead a “should” with two queries:

- one that searches for user's profile top words in the full_text using the simplest “whitespace” analyzer which only divides the query in tokens as top words are already preprocessed
- and one which searches for the user's top hashtags in the hashtags field using text analyzer thus allowing case insensitive matches for instance.

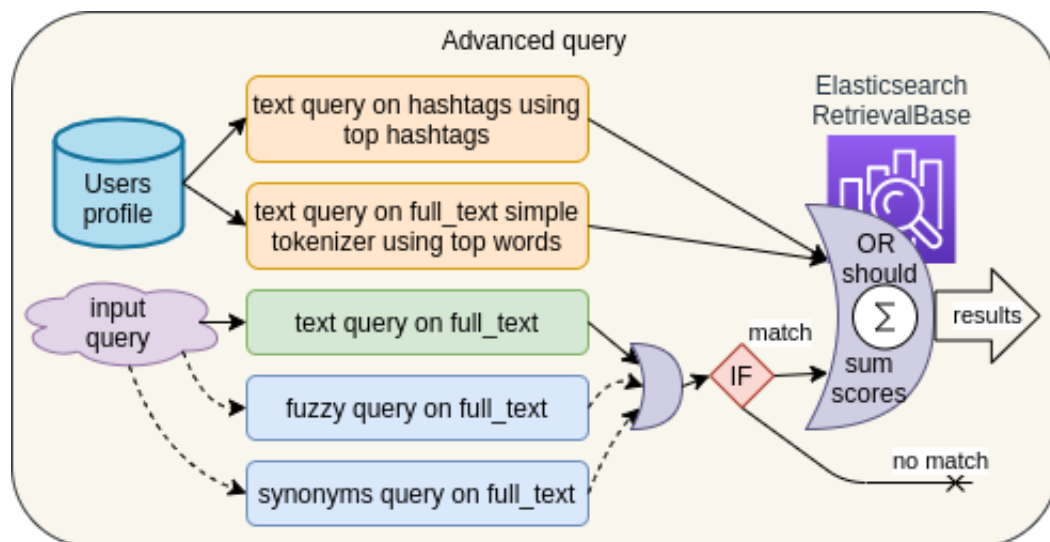


Figure 12: Advanced query implementation schema.

Additionally the possibility to “take a look” at what tweets are the closest to the user profile has been provided: in advanced query mode when a user is logged in and the input query is empty the search action shows results completely based on the user profile.

Follow some figures showing examples of the advanced query whose results are personalized according to the logged user.

The screenshot displays a search interface for a user named Joe Biden (@JoeBiden). On the left, there are toggle switches for 'Advanced' (checked), 'Fuzzy', and 'Synonyms'. The search bar contains the text 'europe' and a 'SEARCH' button. Below the search bar, it says 'Showing Top 10 results of 60.' The results are listed in a table-like format with columns for source, date, and score. The results are as follows:

Source	Date	Score
@WSJ The Wall Street Journal	Thu Jan 21 07:30:04 +0000 2021	18.51463
@WSJ The Wall Street Journal	Tue Dec 29 00:30:08 +0000 2020	15.171036
@WSJ The Wall Street Journal	Wed Jan 20 10:45:04 +0000 2021	13.084202
@BBCWorld BBC News (World)	Wed Dec 02 00:47:06 +0000 2020	13.029762
@nytimes The New York Times	Wed Jan 27 20:50:04 +0000 2021	13.029762
@BBCWorld BBC News (World)	Thu Nov 19 20:09:27 +0000 2020	12.900693


Each result includes a snippet of text with highlighted keywords. For example, the first result from @WSJ mentions 'Europe's economy' and 'fail'. The right sidebar shows the user's profile information, including location (Wilmington, DE), description, and a list of top words and hashtags related to the search results.

Figure 13: Joe Biden Personalized search for “europe”.

Figure 13 shows Joe Biden’s personalized results obtained by searching for “europe” and it’s possible to detect at least three different topics that are economy, crisis and pandemic which are somehow connected and the relationship between EU and US.

☒ Advanced
☐ Fuzzy
☐ Synonyms

SEARCH



Boris Johnson

@BorisJohnson

Location:

United Kingdom

Description:

Prime Minister of the United Kingdom and @Conservatives leader. Member of Parliament for Uxbridge and South Ruislip.

Top words:

borisjohnson brexit 10downingstreet nh conserv britain fantast minist govern corbyn 31st coronaviru invest parliament british octob polic vaccin viru nation foreignoffic priorit referendum trade prime jeremi crime plan foreign tackl

Top hashtags:

#getbrexitdone #coronavirus #stayaalert #leaveoct31 #voteconservative #stayhomesavelives #backboris #peoplespmqs #teamuk #endwildlifecrime

Top emoji:

👍 🇬🇧 🇪🇺 🇬🇧 🇪🇺 🇬🇧 🇪🇺 🇬🇧 🇪🇺

LOGOUT

Showing Top 10 results of 60.



@BBCWorld

BBC News (World)

Thu Dec 24 15:39:43 +0000 2020

Score: 18.01986

RT @BBCNews: "This is I believe a good deal for the whole of Europe" UK Prime Minister Boris Johnson says it won't be a bad thing for the...



@BBCWorld

BBC News (World)

Thu Dec 24 07:41:39 +0000 2020

Score: 17.09504

RT @BBCBreakfast: A statement on a UK/EU Brexit trade deal could be made this morning. From Brussels Europe Correspondent Gavin Lee explain...



@BBCWorld

BBC News (World)

Fri Jan 22 14:44:03 +0000 2021

Score: 14.684998

Coronavirus vaccine delays halt Pfizer jabs in parts of Europe https://t.co/KF5IOSi2SK



@nytimes

The New York Times

Sat Jan 30 19:00:05 +0000 2021

Score: 14.541023

The EU abruptly reversed an attempt to block Covid-19 vaccines from being shipped across the Irish border into Britain, the latest stumble in Europe's faltering vaccine rollout. https://t.co/T6WANKNvpW



@nytimes

The New York Times

Wed Jan 27 20:50:04 +0000 2021

Score: 14.324509

Europe's coronavirus vaccination woes have snowballed into a full-blown crisis. https://t.co/UvXj0Rvti2



@WSJ

The Wall Street Journal

Thu Jan 28 17:45:05 +0000 2021

Score: 11.796459

AstraZeneca's vaccine shouldn't be given to people over the age of 64 due to a lack of data about its efficacy in this group, advisers to the German government warned on Thursday, further complicating Europe's stalled Covid-19

Figure 14: Boris Johnson Personalized search for "europe".

Figure 14 proposes the exact same search of Biden but impersonating Boris Johnson, whose personalized results can be summarized into the topics: Brexit and relationship between EU and UK and pandemic with a really strong focus given to the vaccines.

Advanced

Fuzzy

Synonyms

SEARCH

@WSJ

The Wall Street Journal

Wed Dec 30 19:30:04 +0000 2020

Score: 15.908474

A Republican **senator** said he would object to the results of the **election** when **Congress** holds a joint session next week to certify Joe Biden as the **winner**, a move that would force a vote to affirm **states'** tallies but has no chance of overturning the outcome <https://t.co/hq20Ixe6pR>

@nytimes

The New York Times

Tue Jan 05 18:30:14 +0000 2021

Score: 13.649254

Vice **President** Mike Pence will play a delicate role on Wednesday when **Congress** convenes to ratify **President-elect** Joe Biden's victory. It is akin to the presenter opening the Academy Award envelope and reading the **winner**, with no say in who it is. <https://t.co/PXZPSPU1a9>

@BBCWorld

BBC News (World)

Sat Jan 16 13:03:50 +0000 2021

Score: 13.410328

RT @BBCBreaking: Long-time **leader** Yoweri Museveni declared **winner** of Uganda's presidential **election** amid vote-rigging allegations <https://t.co/...>

@USATODAY

USA TODAY

Mon Jan 04 14:29:48 +0000 2021

Score: 13.4013

Georgia's Secretary of **State** Brad Raffensperger said it would be "appropriate" for the Fulton County district attorney to investigate **President** Trump's request that he "find" enough votes to make him the **winner** of the **state's** presidential **election**. <https://t.co/4g8wEjaFtG>

@USATODAY

USA TODAY

Thu Jan 07 12:04:00 +0000 2021

Score: 12.999912

Congress declared Joe Biden the **winner** of the 2020 presidential **election** victory early Thursday morning, reconvening a joint session after rioters who support **President** Donald Trump stormed the U.S. Capitol Wednesday. <https://t.co/eLTlNuU0f0>

Barack Obama

@BarackObama

Location:
Washington, DC

Description:
Dad, husband, President, citizen.

Top words:
obama presid
american climat
senat ofa
whitehous leader
economi garland
america potu plan
add court state
obamafound
congress suprem
nation address
elect organ gun
econom worker
equal joe Biden
weekli afford

Top hashtags:
#actonclimate
#doyourjob #sotu
#getcovered
#obamacare
#iranddeal #scotus
#leadontrade
#leadonleave
#loveislove

Top emoji:
👍 👎 🇺🇸 🇩🇪 🇬🇧 🇮🇹 🇯🇵 🇰🇷 🇸🇪 🇻🇪 🇿🇼 🇦🇪 🇦🇷 🇦🇹 🇦🇺 🇧🇪 🇧🇬 🇧🇷 🇧🇻 🇧🇾 🇧🇿 🇨🇦 🇨🇩 🇨🇰 🇨🇮 🇨🇯 🇨🇰 🇨🇮 🇨🇯 🇨🇰 🇨🇮 🇨🇯

LOGOUT

Figure 16: Barack Obama Personalized search for “winner”.

Figure 16 proposes again the exact same query of Sterling but this time issued by Barack Obama, whose personalized results strongly deviate from Sterling’s ones: it’s easy to understand that “winner” for Obama takes a strong political meaning, in fact all the top 5 tweets talk about politics.