

R tools for accessing research literature for text mining

Scott Chamberlain^{*,a}

^a*rOpenSci, Museum of Paleontology, University of California, Berkeley, CA, USA*

Abstract

Text mining is a powerful method for answering research questions. However, getting texts to extract information can be a daunting and complicated task. The primary reason for this is the diversity of publisher technologies. There are thousands of different publishers, each with their own licenses, URL patterns, access options, and more. Layered on top of that is the varied access each user has based on their institutional affiliation. Here, I introduce a suite of software packages in the R programming language for fetching texts. The tapestry of different publishers, access levels, and other factors requires a patchwork of approaches for getting texts to users. The flagship R package called `fulltext` attempts to simplify search and retrieval of texts for text mining by serving as an interface to the varied and complex publishers. The `fulltext` package, along with many others, make acquiring texts easier than ever, facilitating answering research questions with text mining.

*Corresponding author

Email address: `myrmecocystus(at)gmail.com` (Scott Chamberlain)

5 Introduction

There's more than 100 million research articles published (Crossref API: <https://github.com/CrossRef/rest-api-doc>), representing an enormous amount of knowledge. In addition to simply reading these articles, the articles contain a vast trove of information of interest to researchers for machine aided questions (Kong & Gerstein, 2018; Usai et al., 2018). For example, many researchers are interested in statistical outcomes of articles that can be extracted from numeric results: P-values, effect sizes, means, and more. In addition, researchers are often interested in words in articles, their use through time, and the contexts they are found in.

Text mining is the broad term associated with pulling information out of articles. Given the importance of text mining, good text mining tools are needed to make it easier for researchers to do. Graphical user interface (GUI) based text mining tools are available (e.g., Ba & Bossy, 2016; Cañada et al., 2017; Muñoz, Kissling & Loon, 2019) and some research papers have used them (Chaix et al., 2019), but given the urgent recent call to action for more reproducible research (Open Science Collaboration, 2015; Camerer et al., 2016, 2018), we must move away from GUI based tools as fast as possible. A number of examples of programmatic tools can be found in the literature. For example, Sinclair et al. (2016) present a tool in Python called seqenv for the domain specific task of linking sequences to environments through text mining.

Most recent text mining papers do not use programmatic approaches, highlighting the need for more programmatic text mining tools, and increased discussion of those tools to increase awareness. For example, many papers search Web of Science using their web interface, and downloading papers manually (Ding, Li & Fan, 2018; McCallen et al., 2019). Many of these papers doing GUI based searching and paper downloads are using R or Python downstream for analysis; replacing GUI based data acquisition with programmatic approaches will improve research.

The R programming language is free of cost, and is used widely throughout many academic fields; tools in R for text mining are of particular importance because they can be adopted by academics rapidly.

Here, I present an overview of text mining tools in the R programming language, not for text mining analysis, but rather those tools for searching for, acquiring, and extracting parts of texts (e.g., title, abstract, authors). Most of the packages presented here are part of the rOpenSci suite (<https://ropensci.org/>).

34 **Digital articles: technical aspects**

35 Those articles that are digital (which in theory includes all articles) can be split into two groups:
36 machine readable and non-machine readable.

37 The machine readable articles are those in XML¹, JSON², or plain text format. The former two, XML
38 and JSON, are the best machine readable types because they are structured data³, whereas plain text
39 has no structure - it's simply a set of characters with line breaks and spaces in between.

40 Of the non-machine readable types, the most notable is the Portable Document Format (PDF)⁴. These
41 can be broken out into two groups: text based PDFs and scanned PDFs (images of text). The former
42 are converted from digital versions of various kinds (MS Word, OpenOffice, LaTeX, markdown, etc.),
43 while the latter are created by scanning print articles to a PDF format. Text-based PDFs are much
44 better for text mining purposes as plain text can be extracted easily in R with [pdftools](#), a binding to
45 [libpoppler](#). However, with scanned PDFs, text must be extracted using Optimal Character Recognition
46 (OCR; see R package [tesseract](#)), which isn't always a clean solution, especially compared to true text
47 based PDFs.

48 The reality in scholarly publishing is all publishers, if they provide any access to their articles, only
49 provide PDF format. Very few publishers, with some quite large (Elsevier, Pensoft, PLOS), provide
50 XML format. Although most publishers most likely have the XML behind each of their articles, they for
51 some indefensible reason do not share it - making text mining more difficult. Some provide plain text
52 (Elsevier). I only know of one publisher that provides full text as JSON (PLOS). Thus, text mining, in
53 most cases, will require extracting text from PDFs.

54 **Digital articles: the access landscape**

55 Acces to full-text is the holy grail in text mining. Some use cases can get by with article metadata
56 (authors, title, etc.), some with abstracts, but many use cases require full-text.

57 The landscape of access to full-text is extremely hetergeous, with the majority of variation along the
58 publisher axis. The major hurdle is paywalls. The majority of articles are published by the big three

¹<https://www.w3.org/TR/xml/>

²<https://tools.ietf.org/html/rfc7159>

³https://en.wikipedia.org/wiki/Data_model

⁴<https://en.wikipedia.org/wiki/PDF>

59 publishers - Wiley, Springer, Elsevier - and the majority of their articles are behind paywalls.

60 A promising sign is an increasing number of open access articles, yet open access articles represent a
61 small percent of all articles: an estimate in 2018 said that 28% of the scholarly literature was open
62 access (Piwowar et al., 2018).

63 With respect to paywalled articles, access varies by institution, depending on each institution's publisher
64 contracts. MORE ABOUT THIS ...

65 Some may not realize access to articles varies with IP address so that access from campus vs. from
66 home (if not on a VPN) will drastically differ. Sometimes a VPN is required, and this can provide a
67 significant technical hurdle to users attempting to do text mining work.

68 One final hurdle in text mining comes unsurprisingly from Elsevier. They use so-called "fences" for
69 programmatic access. That is, even if a person trying to get an article programmatically their institution
70 has access to and they have access to, and they are on the correct IP address, they may still not get
71 access to an Elsevier article. Elsevier puts in place these fences and only if you contact their technical
72 team directly can you get these fences removed, and only then on a per institution basis.

73 I can not end this section without mentioning SciHub. This is a last resort option for many probably
74 (or possibly first, depending on your level of access), providing access to full text of articles that are
75 normally paywalled. No tools in this manuscript provide access to SciHub.

76 **The discovery problem**

77 A text mining project starts with a question. From that question, researchers then attempt to acquire
78 scholarly articles for text mining. Finding appropriate articles is not altogether straight-forward.

79 Some of the discovery difficulty relates to the fact that there are so many places to search for articles;
80 a non-exhaustive list: Google Scholar, Microsoft Academic Research, Scopus, ScienceDirect, Web of
81 Science, Pubmed/Entrez, Europe PMC, Directory of Open Access Journals, Open Knowledge Maps,
82 CORE, Fatcat, and more. It's probably difficult to know where the best place is to search. Some of
83 these are paywalled (e.g., Web of Science), and some are not.

84 The most important aspect about any source for article search with respect to reproducible research is
85 being able to use the data source programmatically. Of those listed above, the following can be used
86 programmatically: Microsoft Academic Research, Scopus, ScienceDirect, Pubmed/Entrez, Europe PMC,

87 and Directory of Open Access Journals. All of these are included in the R package [fulltext](#), discussed
88 further below.

89 On top of the vast array of different data sources is the varied ways that search is implemented in each
90 source. Most sources are probably using Solr or Elasticsearch under the hood, though we can't know
91 this for sure as most do not make their software infrastructure public knowledge. Nonetheless, data
92 sources differ in how search works from the user perspective. For example, some provide wild card/fuzzy
93 search (i.e., 'appl*' includes results for 'apple', 'application', etc.) and some do not. Some sources
94 are searching full text of articles, while others only search metadata (i.e., title, authors, abstract). In
95 addition, each source has a different set of metadata/full text available. In brief, the same search against
96 different sources produces different results. Some text mining research articles perform the same search
97 against many different sources (refs), while others choose just one source.

98 **Data sources**

99 There is increasing open access scientific literature content available online. However, only a small
100 proportion of scientific journals provide access to their full text; whereas, most publishers provide open
101 access to their metadata only (most often through Crossref; Table 1). The following is a synopsis of the
102 major data sources and associated R tools.

103 Table 1. Sources of scientific literature, their content type provided via web services, whether rOpenSci
 104 has an R packages for the service, and where to find the API documentation.

| Data Provider | Content Type | rOpenSci Package | Documentation |
|-----------------------------------|----------------------|-------------------|--------------------|
| Crossref | Metadata | rcrossref/crminer | 5 |
| DataCite | Metadata | rdatacite | 6 |
| Biodiversity Heritage Library | Full text/Metadata | rbhl | 7 |
| Public Library of Science (PLOS) | Full text/altmetrics | rplos | 8 |
| Scopus (Elsevier) | Full text/Metadata | fulltext | 9 |
| arXiv | Full text/Metadata | aRxiv | 10 |
| Biomed Central (via Springer) | Full text/Metadata | fulltext | 11 |
| bioRxiv | Full text/Metadata | fulltext | 12 |
| PMC/Pubmed (via Entrez) | Full text/Metadata | rentrez | 13 |
| Europe PMC | Full text/Metadata | europepmc | 14 |
| Microsoft Academic Search | Metadata | microdemic | 15 |
| Directory of Open Access Journals | Metadata | jaod | 16 |
| JSTOR Data for Research | Full text | jstor | 17 |
| ORCID | Metadata | rorcid | 18 |
| Wikimedia's Citoid | Citations | rcitoid | 19 |
| Open Citation Corpus | Citations | citecorp | 20 |

⁵<https://api.crossref.org>

⁶<https://support.datacite.org/docs/api>

⁷<http://bit.ly/KYQ1Rd>

⁸<http://api.plos.org/solr>

⁹<http://bit.ly/J9S616>

¹⁰<https://arxiv.org/help/api/index>

¹¹<https://dev.springer.com/>

¹²<http://www.biorxiv.org/>

¹³<https://www.ncbi.nlm.nih.gov/books/NBK25500>

¹⁴<https://azure.microsoft.com/en-us/services/cognitive-services>

¹⁵<https://dev.labs.cognitive.microsoft.com/docs/services/56332331778daf02acc0a50b/operations/>

¹⁶<https://doi.org/10.2196/2013.10.10>

¹⁷<https://www.jstor.org/df/>

¹⁸<https://pub.orcid.org/>

¹⁹https://en.wikipedia.org/api/rest_v1/#/Citation/getCitation

²⁰<http://opencitations.net/>

| Data Provider | Content Type | rOpenSci Package | Documentation |
|---------------|------------------------|------------------|--------------------|
| Fatcat | Metadata | none | 21 |
| SHERPA/RoMEO | Journal Level Metadata | rromeo | 22 |
| CORE | Full text/Metadata | rcoreoa | 23 |
| Dissemin | Metadata | dissemr | 24 |

Crossref and Datacite

Crossref is a non-profit that creates (or “mints”) Digital Object Identifiers (DOIs). In addition, they maintain metadata associated with each DOI. The metadata ranges from simple (including author, title, dates, DOI, type, publisher) to including number of citations to the article, as well as references in the article, and even abstracts. At the time of writing they hold 100 million DOIs.

One can search by DOI or search citation data to get citations. In addition, Crossref has a text mining opt-in program for publishers. The result of this is that some publishers provide URLs for full text content of their articles. The majority of these links are pay-walled, while some are open access. Using any of the various tools for working with Crossref data, you can filter your search to get only articles with full text links, and further to get only articles with full text links that are open access.

The main interfaces for Crossref in R are [rcrossref](#) and [crminer](#). [rcrossref](#) is a complete client for the public facing Crossref web services including metadata, whereas [crminer](#) focuses only on retrieving full text of articles. Similar interfaces to [rcrossref](#) are available in Ruby ([serrano](#)) and Python ([habanero](#)). Datacite is similar to Crossref, but focuses on datasets instead of articles. The main interface for Datacite in R is [rdatacite](#).

Biodiversity Heritage Library

The Biodiversity Heritage Library (BHL) houses scans of biodiversity books, and provides web interfaces and APIs to query and fetch those data. They also provide text of the scanned pages. The main R interace to BHL is through [rbhl](#).

²¹<https://fatcat.wiki/>

²²<https://www.sherpa.ac.uk/romeo/apimanual.php?la=en&flDnum=%7C&mode=simple>

²³<https://core.ac.uk/>

²⁴<https://dissemin.readthedocs.io/en/latest/api.html>

124 *Public Library of Science*

125 The Public Library of Science (PLOS) is one of the largest open access only publishers. They as of this
126 writing have published 2.1 million articles. One of the strong advantages of PLOS is that they provide
127 an API to their Solr instance, which is a very flexible way to search their articles. The main R interface
128 to PLOS is through [rplos](#).

129 *Elsevier/Scopus*

130 Elsevier is one of the largest publishers. Most of their articles are not open access. However, they have a
131 number of advantages if you have access to their articles: they are one of the few publishers to provide
132 machine readable XML (many publishers do have XML versions of articles, but do not provide it); they
133 are one of the few (two) publishers part of Crossref's text and data mining program. The packages
134 [fulltext](#) and [crminer](#) can be used to access Elsevier articles through Crossref's TDM program. There's
135 an interface to Scopus article search within [fulltext](#).

136 *arXiv/bioRxiv*

137 arXiv and bioRxiv are preprint publishers, the former in existence for many years, and the latter new
138 on the scene. You can access articles from these publishers through [fulltext](#). arXiv does provide a web
139 API that we hook into; bioRxiv does not, but we can get you articles nonetheless.

140 *Pubmed/PMC/Europe PMC*

141 Pubmed/PMC is a corpus/website of NIH funded research in the United States; while Europe PMC is
142 an equivalent for the European Union. You can access articles from Pubmed/PMC through [fulltext](#),
143 and for Europe PMC through [europepmc](#).

144 *Microsoft Academic Research*

145 Microsoft Academic Research (MAR) is a search engine for research articles. You can use their GUI
146 web interface to search, and they provide APIs for programmatic access. The R interface for MAR is
147 [microdemic](#); and [fulltext](#) hooks into [microdemic](#) as well for article search and abstract retrieval.

148 *Directory of Open Access Journals*

149 Directory of Open Access Journals (DOAJ) maintains data on open access journals, as well as some
150 portion of the articles in those journals. Thus, you can search for journals as well as articles with DOAJ.
151 The R interface for DOAJ is [jaod](#).

152 *JSTOR*

153 JSTOR's Data for Research program gives institutions with access to JSTOR, access to full text of
154 articles within JSTOR. There is no way however to make the interaction with JSTOR completely
155 programmatic, thus making reproducible research very difficult. Nonetheless, there is an R package
156 ([jstor](#)) for using data from JSTOR's Data for Research.

157 *ORCID*

158 ORCID (<https://orcid.org/>) is an organization keeping track of identifiers and metadata for researchers
159 around the world. Individuals can optionally maintain metadata on their scholarly works connected to
160 their account with ORCID. Thus, across all of ORCID, a significant cache of metadata is accruing on
161 scholarly works, their funding amounts, collaborators, etc., useful for bibliometrics research and more.
162 The R interface for ORCID is [rorcid](#).

163 *Citoid/Open Citation Corpus*

164 The Open Citation Corpus (<http://opencitations.net/>) holds records of which articles cite which other
165 articles, allowing for all important research on the scholarly web of citation. Citation data has been
166 very closely guarded until recently, but the largest publishers are still not contributing to the Open
167 Citation Corpus. The R interface to the Open Citation Corpus is [rcitoid](#).

168 *Fatcat*

169 Fatcat is a project from Ben Newbold of the Internet Archive Labs. It is a “versioned, publicly-editable
170 catalog of research publications: journal articles, conference proceedings, pre-prints, blog posts”. Fatcat
171 is currently does not have an R client, but is used inside of the [fulltext](#) package.

172 *SHERPA/RoMEO*

173 SHERPA/RoMEO (<http://sherpa.mimas.ac.uk/romeo/index.php>) aggregates and analyses publisher
174 open access policies and provides summaries of self-archiving permissions and conditions of rights given
175 to authors. The `[rromeo]` is an R interface to SHERPA/RoMEO.

176 *CORE*

177 CORE (<https://core.ac.uk/>) touts itself as the world's largest collection of open access research articles,
178 providing metadata on journals and articles, as well as access to the full text of articles. The `rcoreoa` R
179 package interfaces with the CORE API.

180 *Dissemin*

181 Dissemin (<https://dissem.in/>) detects papers behind pay-walls and invites authors to upload them
182 to an open repository. Dissemin provides metadata including links to open versions of articles. The
183 `[dissemr]` R package interfaces with the Dissemin API.

184 **fulltext: a toolset for text mining in R**

185 `fulltext` is a general purpose R package for the data part of text mining: search for articles, get links to
186 articles, get article abstracts, and fetch full text of articles. The `fulltext` package is always adding
187 additional data sources as time allows (See Table 1). Starting from searching for articles, the outputs of
188 search can be fed into a function to get links to those articles, or to get abstracts for those articles, or
189 to fetch their full text. The following is a breakdown of the major distinct parts of `fulltext`.

190 *Search*

191 `ft_search()` provides search access to nine different data sources (PLOS, BMC, Crossref, Entrez, arXiv,
192 bioRxiv, Europe PMC, Scopus, Microsoft Academic), creating a mostly unified interface to all data
193 sources. The parts of each data source that are common are for the most part factored out into the
194 parameters of the `ft_search()` function: query term(s), pagination (number of results, result number
195 to start at). In addition, we allow the user to pass on data source specific options to refine the search
196 per data source.

197 With `ft_search()`, you can query any combination of the nine data sources at once. The returned
198 object is a list, with access to results of each data source by its name (e.g., `$plos`, or `$crossref`). For
199 each data source, the returned object does vary because the returned data from each data source widely
200 varies; for the most part `data.frame`'s are returned. For those data sources not queried, their slot is
201 empty.

202 One important aspect of the research result we highlight is the licenses in the returned data for each
203 data source.

```
x <- ft_search(query = 'ecology', from = c("plos", "crossref"))
```

204 The results for this PLOS search have all CC-BY licenses

```
x$plos
#> Query: [ecology]
#> Records found, returned: [47257, 10]
#> License: [CC-BY]
#>
#> id
#> 1 10.1371/journal.pone.0001248
#> 2 10.1371/journal.pone.0059813
#> 3 10.1371/journal.pone.0080763
#> 4 10.1371/journal.pone.0155019
#> 5 10.1371/journal.pone.0175014
#> 6 10.1371/journal.pone.0150648
#> 7 10.1371/journal.pone.0208370
#> 8 10.1371/journal.pcbi.1003594
#> 9 10.1371/journal.pone.0102437
#> 10 10.1371/journal.pone.0166559
```

205 Whereas the results for this Crossref search have mixed licenses

```
x$crossref
#> Query: [ecology]
#> Records found, returned: [164657, 10]
```

```
#> License: [variable, see individual records]
#>   archive          container.title    created deposited
#> 1 Portico          Ecology 2006-05-03 2018-08-04
#> 2 Portico          Ecology 2006-05-03 2018-08-04
#> 3      NA          Ecology 2006-05-03 2018-08-04
#> 4      NA          Ecology 2006-05-03 2018-08-04
#> 5      NA          Ecology 2006-05-03 2018-08-04
#> 6      NA          Ecology 2006-05-03 2018-08-04
#> 7      NA          Ecology 2006-05-09 2018-08-01
#> 8 Portico          Ecology 2017-04-26 2019-03-08
#> 9      NA Trends in Ecology & Evolution 2002-07-25 2017-06-14
#> 10     NA Journal of Industrial Ecology 2014-11-21 2017-06-23
#> Variables not shown: published.print (chr), published.online (chr), doi
#>      (chr), indexed (chr), issn (chr), issue (chr), issued (chr), member
#>      (chr), page (chr), prefix (chr), publisher (chr), reference.count
#>      (chr), score (chr), source (chr), title (chr), type (chr), url (chr),
#>      volume (chr), author (list), link (list), license (list), subject
#>      (chr), alternative.id (chr), subtitle (chr), reference (list)
```

206 You can dig into the license field for each article, with URLs holding information on each license

```
vapply(x$crossref$data$license, function(w) w$URL[1], "")
#> [1] "http://doi.wiley.com/10.1002/tdm_license_1.1"
#> [2] "http://doi.wiley.com/10.1002/tdm_license_1.1"
#> [3] "http://doi.wiley.com/10.1002/tdm_license_1"
#> [4] "http://doi.wiley.com/10.1002/tdm_license_1.1"
#> [5] "http://doi.wiley.com/10.1002/tdm_license_1"
#> [6] "http://doi.wiley.com/10.1002/tdm_license_1"
#> [7] "http://doi.wiley.com/10.1002/tdm_license_1"
#> [8] "http://doi.wiley.com/10.1002/tdm_license_1.1"
#> [9] "http://www.elsevier.com/tdm/userlicense/1.0/"
#> [10] "http://doi.wiley.com/10.1002/tdm_license_1.1"
```

207 *Links*

208 `ft_links()` provides two pathways to get links (URLs) for articles, with a choice of four different data
209 sources (PLOS, BMC, Crossref, Entrez). First, you can use `ft_search()`, then pass the output of that
210 function to `ft_links()`.

```
out <- ft_search(query = "ecology", from = "entrez")
ft_links(out)
#> <fulltext links>
#> [Found] 6
#> [IDs] ID_30964001 ID_30962485 ID_30962432 ID_30952928 ID_30674747
#>      ID_30674743 ...
```

211 Second, you can pass DOIs directly to `ft_links()`. Both end up at the same point, links for each
212 article, if they could be found for the user selected data source.

```
# FIXME
ft_links(out$entrez$data$doi)
```

213 The biggest caveat with `ft_links()` is that we can't guarantee that the links will work. Link rot is one
214 way in which the links may not work: link rot is when the URL does not point to the original content
215 anymore, or fails altogether. Additionally, with Crossref, publishers can deposit URLs for articles, but
216 they make change the URLs at some later date but not update the URLs with Crossref.

217 *Abstracts*

218 `ft_abstract()` provides access to article abstracts from four different data sources (PLOS, Scopus,
219 Microsoft Academic Research, Crossref). The only way to use the function is to pass article identifiers,
220 which are for the most DOIs.

221 The advantage of abstracts over full text is that abstracts can often be retrieved even for paywalled
222 articles. That is, you can have much broader coverage of the articles you're targeting relative to full
223 text.

224 If you are after abstracts, and you are already getting or already have full text, and if the articles are in
225 XML format, then you can use [pubchunks](#) to extract out the abstracts.

226 *Fetch full text*

227 `ft_get()` fetches full text of articles from many different data sources. From the DOIs that are passed
228 in to the function, we detect the publisher, and there are specific plugins for certain publishers: AAAS,
229 American Institute of Physics, American Society of Clinical Oncology, American Society for Microbiology,
230 arXiv, bioRxiv, BiomedCentral, Copernicus, Crossref, Elife, Elsevier, Pubmed/PMC via NCBI's Entrez,
231 Frontiers, IEEE, Informa, Instituto de Investigaciones Filologicas, American Medical Association,
232 Microbiology Society, PeerJ, Pensoft, PLOS, PNAS, Royal Society of Chemistry, ScienceDirect, Scientific
233 Societies, and Wiley.

234 If there's no built-in plugin for the publisher already, we use the FTDOI API (<https://ftdoi.org>) to try
235 to get the link for the full text of the article. If the FTDOI API doesn't bear fruit, we search Crossref
236 for a link to the full text. If Crossref doesn't have any full text links, we give up.

237 Since users can go through a lot of article requests, we cache successfully downloaded articles, and keep
238 that knowledge consistent across R sessions; all subsequent requests for the same article just use the
239 cached version. Additionally, all errors in `ft_get()` are collected in a tidy data.frame in the output of
240 the function to help the user quickly determine what went wrong.

241 **How to text mine from R: Three case studies**

242 *Case study 1: Citation mining*

243 In this example, xxxx

244 *Load libraries*

```
library("rcrossref")
library("rplos")
library("rorcid")
library("rcitoid")
library("citecorp")
```

245 *rcrossref*

246 Using `rcrossref` for Crossref data:

```

x <- cr_works(query="NSF")
head(x$data)
#> # A tibble: 6 x 32
#>   alternative.id container.title created deposited published.print doi
#>   <chr>           <chr>           <chr>   <chr>     <chr>           <chr>
#> 1 S106352031630~ Applied and Co~ 2016-0~ 2019-02-~ 2018-03       10.1~
#> 2 <NA>           Biogeosciences~ 2017-0~ 2017-07-~ <NA>         10.5~
#> 3 <NA>           Global Biogeoc~ 2018-0~ 2019-01-~ 2018-10       10.1~
#> 4 <NA>           IEEE Communica~ 2016-1~ 2017-12-~ 2017          10.1~
#> 5 S002178241400~ Journal de Mat~ 2014-0~ 2018-10-~ 2014-10       10.1~
#> 6 123            Light: Science~ 2019-0~ 2019-01-~ 2019-12       10.1~
#> # ... with 26 more variables: indexed <chr>, issn <chr>, issue <chr>,
#> #   issued <chr>, member <chr>, page <chr>, prefix <chr>, publisher <chr>,
#> #   reference.count <chr>, score <chr>, ...

```

247 Case study 2: Abstract mining

248 Sometimes you just need abstracts for your research question. The benefit of only needing abstracts,
 249 and not need full text, is that there's many more articles that will have abstracts available than have
 250 their full text available.

251 As an example, let's say you xxxx

```
library("fulltext")
```

252 *xxxxx*

253 Using fulltext:

```

res <- ft_search("ecology", from = "crossref",
  crossrefopts = list(filter = c(has_abstract = TRUE)))
ids <- res$crossref$data$doi
out <- ft_abstract(x = ids, from = "crossref")
abstracts <- vapply(out$crossref, "[[", "", "abstract")

```

254 Using `quanteda`, read the abstracts into a corpus

```
library("quanteda")
corp <- corpus(abstracts)
docvars(corp) <- ids
```

255 Get a summary of the abstracts

```
summary(corp)
#> Corpus consisting of 10 documents:
#>
#>   Text Types Tokens Sentences          V1
#> text1    143    262         10 10.2458/v22i1.21112
#> text2    117    244          6 10.2458/v17i1.21696
#> text3     75    118          4 10.2458/v25i1.23119
#> text4      5      8          1 10.2458/v1i1.21154
#> text5    105    171          7 10.1155/2011/868426
#> text6    112    181          6 10.1155/2012/273413
#> text7    117    240          8 10.5194/we-13-91-2013
#> text8    140    245          9 10.5194/we-13-95-2013
#> text9    107    202          7 10.1155/2014/198707
#> text10   118    224          6 10.5402/2011/897578
#>
#> Source: /Users/sckott/github/ropensci/textmine/use-cases/* on x86_64 by sckott
#> Created: Thu Apr 11 11:20:19 2019
#> Notes:
```

256 Use the `kwic()` function to see a word in context across the abstracts

```
kwic(corp, pattern = "ecology")
#>
#> [text1, 33] knowledge production within critical political / ecology /
#> [text1, 50] in scientific articles on dryland / ecology /
```


#> [text1, 204] to equilibrium models in range / ecology /

#> [text1, 246] communal areas.Keywords: Critical political / ecology /

#> [text1, 255] , scientific models, rangeland / ecology /

#> [text2, 5] < jats:p> Political / ecology /

#> [text2, 23] manifestations of political economy and / ecology /

#> [text2, 45] I try to extend political / ecology /

#> [text2, 149] , in dialogue with political / ecology /

#> [text2, 177] people and resources that political / ecology /

#> [text2, 229] indigeneity scholars.Key words: political / ecology /

#> [text3, 71] an analysis from a political / ecology /

#> [text3, 114] system, supermarkets, political / ecology /

#> [text6, 134] was observed when allopatry and / ecology /

#> [text7, 167] ecosystem should be considered for / ecology /

#> [text7, 185] the" four-color issue of / ecology /

#> [text7, 201] step toward advancing knowledge in / ecology /

#> [text9, 195] or for theoretical studies integrating / ecology /

#>

#> . This article is a

#> , and investigates the functions

#> , and the fence-line photographs

#> , fence-line photography, scientific

#> , Southern Africa</

#> has expanded in multiple new

#> in the" problem"

#> to engage with ethnic studies

#> approaches to better understand the

#> focuses on cannot be adequately

#> , coloniality, Maidu,

#> standpoint allows a different interpretation

#> </ jats:p>

#> act together, leading to

```
#> "? Here, I
#> ", and propose that
#> and conservation biology. In
#> and biogeography.</
```

257 *Case study 3: Full text mining*

258 In this example, xxxx

```
library("fulltext")
# library("crminer")
```

259 *Search for articles*

260 Search for the term *ecology* in PLOS journals.

```
(res1 <- ft_search(query = 'ecology', from = 'plos'))
#> Query:
#> [ecology]
#> Found:
#> [PLOS: 47272; BMC: 0; Crossref: 0; Entrez: 0; arxiv: 0; biorxiv: 0; Europe PMC: 0; Scopus:
#> Returned:
#> [PLOS: 10; BMC: 0; Crossref: 0; Entrez: 0; arxiv: 0; biorxiv: 0; Europe PMC: 0; Scopus: 0; .
```

261 Each publisher/search-engine has a slot with metadata and data

```
res1$plos
#> Query: [ecology]
#> Records found, returned: [47272, 10]
#> License: [CC-BY]
#>
#> id
#> 1 10.1371/journal.pone.0001248
#> 2 10.1371/journal.pone.0059813
#> 3 10.1371/journal.pone.0080763
```

```
#> 4 10.1371/journal.pone.0155019
#> 5 10.1371/journal.pone.0175014
#> 6 10.1371/journal.pone.0150648
#> 7 10.1371/journal.pone.0208370
#> 8 10.1371/journal.pcbi.1003594
#> 9 10.1371/journal.pone.0102437
#> 10 10.1371/journal.pone.0166559
```

262 *Get full text*

263 Using the results from `ft_search()` we can grab full text of some articles

```
(out <- ft_get(res1))
#> <fulltext text>
#> [Docs] 10
#> [Source] ext - /Users/sckott/Library/Caches/R/fulltext
#> [IDs] 10.1371/journal.pone.0001248 10.1371/journal.pone.0059813
#>      10.1371/journal.pone.0080763 10.1371/journal.pone.0155019
#>      10.1371/journal.pone.0175014 10.1371/journal.pone.0150648
#>      10.1371/journal.pone.0208370 10.1371/journal.pcbi.1003594
#>      10.1371/journal.pone.0102437 10.1371/journal.pone.0166559 ...
```

264 *Extract text from pdfs*

265 Ideally for text mining you have access to XML or other text based formats. However, sometimes you
 266 only have access to PDFs. In this case you want to extract text from PDFs. `fulltext` can help with
 267 that.

268 You can extract from any pdf from a file path, like:

```
path <- system.file("examples", "example1.pdf", package = "fulltext")
ft_extract(path)
#> <document>/Library/Frameworks/R.framework/Versions/3.5/Resources/library/fulltext/examples/ex
#> Title: Suffering and mental health among older people living in nursing homes---a mixed-met
```

```
#> Producer: pdfTeX-1.40.10
#> Creation date: 2015-07-17
```

269 *Extract text chunks*

270 Requires the [pubchunks](#) library. Here, we'll search for some PLOS articles, then get their full text, then
 271 extract various parts of each article with `pub_chunks()`.

```
library("pubchunks")
res <- ft_search(query = "ecology", from = "plos", limit = 3)
x <- ft_get(res)
x %>% ft_collect() %>% pub_chunks(c("doi", "history")) %>% pub_tabularize()

#> $plos
#> $plos$`10.1371/journal.pone.0001248`
#>
#> doi history.received history.accepted
#> 1 10.1371/journal.pone.0001248      2007-07-02      2007-11-06
#> .publisher
#> 1      plos
#>
#> $plos$`10.1371/journal.pone.0059813`
#>
#> doi history.received history.accepted
#> 1 10.1371/journal.pone.0059813      2012-09-16      2013-02-19
#> .publisher
#> 1      plos
#>
#> $plos$`10.1371/journal.pone.0080763`
#>
#> doi history.received history.accepted
#> 1 10.1371/journal.pone.0080763      2013-08-15      2013-10-16
#> .publisher
#> 1      plos
```

272 **Future directions**

273 Text mining will always be a complex task given all the layers involved: often temporal time-span of
274 research questions; varied permissions among researchers and their articles they're trying to access;
275 varied approaches to getting full text (xml vs pdf vs plain text); and more.

276 Programmatic text mining is a first step towards making text mining easier. The R ecosystem is an
277 especially good place to do text mining because there are many packages for text mining analysis, and
278 endless packages for any required statistical analyses. In addition, rOpenSci and others are building
279 up a set of packages in R for searching for and acquiring full text programatically to help make the
280 research workflow as reproducible as possible.

281 Future work for `fulltext` includes:

- 282 1. Adding more publisher plugins
- 283 2. Fine tuned user control over publishers
- 284 3. Improve VPN/proxy controls
- 285 4. Incorporate more search engines to help resolve URLs for fulltext versions
- 286 5. Improve documentation

287 With respect to what publishers can do to make text mining easier, publishers should:

- 288 1. provide XML if they have it
- 289 2. not change URL patterns so often, or at all
- 290 3. maintain consistent URL patterns among journals, years, etc.
- 291 4. keep their Crossref metadata up to date
- 292 5. open up their citation data

293 **Acknowledgments**

294 XXXX

295 Data Accessibility

296 All scripts and data used in this paper can be found in the permanent data archive Zenodo under
297 the digital object identifier (DOI). This DOI corresponds to a snapshot of the GitHub repository at
298 <https://github.com/ropensci/textmine>. Software can be found at <https://github.com/ropensci/xxx>,
299 xxxx, all under MIT licenses.

300 References

- 301 Ba M., Bossy R. 2016. Interoperability of corpus processing work-flow engines: The case of alvisnlp/ml
302 in openminted. In: *Proceedings of the workshop on cross-platform text mining and natural language*
303 *processing interoperability (interop 2016) at Irec.* 15–18.
- 304 Camerer CF., Dreber A., Forsell E., Ho T-H., Huber J., Johannesson M., Kirchler M., Almenberg
305 J., Altmejd A., Chan T., Heikensten E., Holzmeister F., Imai T., Isaksson S., Nave G., Pfeiffer T.,
306 Razen M., Wu H. 2016. Evaluating replicability of laboratory experiments in economics. *Science*
307 351:1433–1436.
- 308 Camerer CF., Dreber A., Holzmeister F., Ho T-H., Huber J., Johannesson M., Kirchler M., Nave G.,
309 Nosek BA., Pfeiffer T., Altmejd A., Buttrick N., Chan T., Chen Y., Forsell E., Gampa A., Heikensten
310 E., Hummer L., Imai T., Isaksson S., Manfredi D., Rose J., Wagenmakers E-J., Wu H. 2018. Evaluating
311 the replicability of social science experiments in nature and science between 2010 and 2015. *Nature*
312 *Human Behaviour* 2:637–644.
- 313 Cañada A., Capella-Gutierrez S., Rabal O., Oyarzabal J., Valencia A., Krallinger M. 2017. LimTox: A
314 web tool for applied text mining of adverse event and toxicity associations of compounds, drugs and
315 genes. *Nucleic Acids Research* 45:W484–W489.
- 316 Chaix E., Deléger L., Bossy R., Nédellec C. 2019. Text mining tools for extracting information about
317 microbial biodiversity in food. *Food Microbiology* 81:63–75.
- 318 Ding Z., Li Z., Fan C. 2018. Building energy savings: Analysis of research trends based on text mining.
319 *Automation in Construction* 96:398–410.
- 320 Kong X., Gerstein MB. 2018. Text mining systems biology: Turning the microscope back on the
321 observer. *Current Opinion in Systems Biology* 11:117–122.

322 McCallen E., Knott J., Nunez-Mir G., Taylor B., Jo I., Fei S. 2019. Trends in ecology: Shifts in ecological
323 research themes over the past four decades. *Frontiers in Ecology and the Environment* 17:109–116.

324 Muñoz G., Kissling WD., Loon EE van. 2019. Biodiversity observations miner: A web application to
325 unlock primary biodiversity data from published literature. *Biodiversity Data Journal* 7.

326 Open Science Collaboration. 2015. Estimating the reproducibility of psychological science. *Science*
327 349:aac4716–aac4716.

328 Piwowar H., Priem J., Larivière V., Alperin JP., Matthias L., Norlander B., Farley A., West J., Haustein
329 S. 2018. The state of OA: A large-scale analysis of the prevalence and impact of open access articles.
330 *PeerJ* 6:e4375.

331 Sinclair L., Ijaz UZ., Jensen LJ., Coolen MJ., Gubry-Rangin C., Chroňáková A., Oulas A., Pavloudi C.,
332 Schnetzer J., Weimann A., Ijaz A., Eiler A., Quince C., Pafilis E. 2016. **Seqenv**: Linking sequences to
333 environments through text mining. *PeerJ* 4:e2690.

334 Usai A., Pironti M., Mital M., Mejri CA. 2018. Knowledge discovery out of text data: A systematic
335 review via text mining. *Journal of Knowledge Management* 22:1471–1488.