Title

Online Interactive Platform for COVID-19 Literature Visual Analytics: Platform Development Study

Journal

Journal of Medical Internet Research, 23(7)

ISSN

1438-8871

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Publication Date

2021

DOI

10.2196/26995

Peer reviewed

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Submitted to: Journal of Medical Internet Research
on: January 06, 2021

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Abstract

Background: The rate of publication of COVID-19 literature is astonishing and the research is extremely varied. Innovative tools are needed to aid researchers to find patterns in this vast amount of literature to identify subsets of interest in an automated fashion.

Objective: We present a new online software resource with a friendly user interface that allow users to query and interact with visual representations of relationships between publications.

Methods: We publicly released an application called PLATIPUS (Publication Literature Analysis and Text Interaction Platform for User Studies) that allows researchers to search, filter, and sort literature supplied by COVIDScholar. This tool contains standard filtering capabilities based on authors, journals, high-level categories, and various research-specific details via natural language processing. At the center of the software is a visual interface that offers a variety of representations of data-driven clusters that dynamically update from a researcher's query.

Results: PLATIPUS is publicly available online and currently links to over 116,000 publications. This application has the potential to transform how COVID-19 researchers utilize public literature to enable their research.

Conclusions: The PLATIPUS application provides the end-user with a variety of ways to search and filter over one hundred thousand COVID-19 publications. Clinical Trial: N/A

(JMIR Preprints 06/01/2021:26995)
DOI: https://doi.org/10.2196/preprints.26995

Original Manuscript

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Abstract

Background: The rate of publication of COVID-19 literature is astonishing and the research is extremely varied. Innovative tools are needed to aid researchers to find patterns in this vast amount of literature to identify subsets of interest in an automated fashion.
Objective: We present a new online software resource with a friendly user interface that allow users to query and interact with visual representations of relationships between publications.
Methods: We publicly released an application called PLATIPUS (Publication Literature Analysis and Text Interaction Platform for User Studies) that allows researchers to interact with literature supplied by COVIDScholar via a visual analytics platform. This tool contains standard filtering capabilities based on authors, journals, high-level categories, and various research-specific details via natural language processing and dozens of customizable visualizations that dynamically update from a researcher's query.
Results: PLATIPUS is available at https://vcs.pnnl.gov/ and currently links to over hundreds of thousands of publications and still growing. This application has the potential to transform how COVID-19 researchers utilize public literature to enable their research.
Conclusions: The PLATIPUS application provides the end-user with a variety of ways to search, filter and visualize over one hundred thousand COVID-19 publications.

Keywords: COVID-19, literature evaluation, software, visual analytics

Introduction

COVID-19 has generated a multitude of challenges for scientific and medical researchers, but one of the unexpected challenges was the pace at which scientific literature emerged. In addition, to the continually growing body of research that includes many thousands of publications in a single week, there is also related research on other coronaviruses or co-morbidities of interest [1, 2].

Computational researchers have been working diligently to assemble this information into minable collections, such as CORD-19 [3], CovidScholar [4, 5], and LitCovid [6, 7]. These datasets are of high value but have limited interaction capabilities. Currently, the primary approach for the scientific community to work with these extremely large corpuses of literature has been through data science-based solutions via search engines and tools that categorize data into facets, which works well for very targeted queries [8, 9].

With the onslaught of publications being released to help combat COVID-19, there are multiple solutions for searching for information within COVID publications. Examples include CDC's COVID-19 PubMed Search Alert [10], where the user can specify certain criteria and when a new publication gets released that matches the user's conditions, the user gets notified. PubMed Search Alert does not provide any support for viewing or searching currently available publications. CDC also has the PubMed Clinical Queries[11] which allows search by keywords and filter by category, but there are no visualization capabilities and returns a simple list of publications. Data-driven visualizations derived from the contents and metadata of these publications can help guide researchers by distilling down the number of publications into a manageable amount while preserving the theme of the query. A newly released tool CoronaCentral [12] offers and improved interface with some visualizations to make searches simpler through a detailed categorization scheme, as well as offering some basic graphics of data summaries based on these categories. Lastly, the CovidScholar database also helps users with parsing the data via specific tagging classifications as well as offering a visualization of word embeddings of subsets of papers [4, 5]. However, advanced visual analytics of this expanding corpus requires new data science and software solutions. We present a novel platform PLATIPUS (Publication Literature Analysis and Text Interaction Platform for User Studies), which builds on the comprehensive CovidScholar dataset and uses visual analytics to give basic and medical researchers a more user-friendly approach to explore their queries of interest. PLATIPUS is publicly available at https://vcs.pnnl.gov/explorer.

Methods

Data

The literature presented in PLATIPUS is collected from original publishers in collaboration with the COVIDScholar project at UC Berkeley/Lawrence Berkeley National Laboratory [13]. Articles in COVIDScholar are sourced by a system of dedicated web scrapers, document parsers, databases, and machine learning models that process papers and metadata into a standardized format that is amenable for text mining. The data in COVIDScholar includes a culmination of 19 sources, presented in Table 1, and consists of academic preprints, peer-reviewed research papers, book chapters, patents, clinical trial descriptions, and datasets, all of which have been made openly available by the original publishers to advance COVID-19 research. COVIDScholar updates their data multiple times per day and PLATIPUS queries the COVIDScholar database and re-ingests new articles once a day.

Table 1. Main sources of data in COVIDScholar collection

Document Type	Sources
preprints and non peer-reviewed articles	medRxiv, bioRxiv, Preprints.org, PsyArXiv, Social Science Research Network,

	SocArXiv, ChemRxiv, Preprints.org, National Bureau of Economic Research
peer-reviewed journal articles	Elsevier, PubMed, CORD-19, Dimensions,
book chapters	CORD-19
patents	The Lens
clinical trials	Dimensions
datasets	Dimensions

Text Analytics

PLATIPUS utilizes a tool called Automated Analytics and Integration of Data (AAID) to assist in the data ingestion and advanced analytic processing of the COVIDScholar dataset. AAID uses multiple algorithms to identify key sources of information while taking into account how the meaning of words change based on the context[14]. AAID utilizes natural language processing methodologies, specifically entity recognition, machine learning, and human-in-the-loop to augment the data with additional queryable tags [15]. In PLATIPUS, this means augmenting the COVIDScholar dataset with tags such as locations, organizations, diseases, diagnostics/analysis, countermeasures, species, and additional context. AAID utilizes NiFi data ingestion and processing pipeline which contains a variety of natural language processing methods, such as time-weighted penalized logistic regression models, recursive regex, binary bag of words models, and recurrent neural network models, which is described in detail in Supplemental Figure S1. The vectorization of the text is based on a bag-of-words approach. For the clustering visualizations a k-means default method is used. The analytic capabilities of the AAID pipeline continue to grow to utilize transformer deep learning classifiers as well as implementing methods to identify anomalies and abnormal characteristics[16].

As of May 2021 there are 159,797 articles that are parsed into various filters. At the top level are 1) Authors (n=564,845), 2) Categories (n=7), 3) Context (n=41), 4) Countermeasures (n=28) , 5) Diagnostics/Assay (n=19) 6) Disease (n=265), 7) Journal (n=11,412), 8) Locations (n=365), 9) Tags (n=7), 10) Species (n=76), and 11) Chemicals (n=175). Authors are associated with the publications and therefore there are hundreds. For selection purposes, the authors are sorted in order from the most to least prevalent. There are presently seven core categories (Treatment, Prevention, Mechanism, Diagnosis, Epidemic Forecasting, Transmission, and Case Report). Under Context there are 41 groupings associated with the primary context of the article (e.g., Disease Severity or Transmission Event). Countermeasures are approaches taken against the disease (e.g., Treatment, Vaccine, Awareness Campaign). The Diagnostics/Assay groupings contain the platforms associated with the article, such as transcriptomics, x-rays, etc. Disease is again a broad category where the most prevalent is a categorization of human or animal disease, but other specific associated syndrome or special notes are captured here. Journal, similar to author, is a large group of the virtual location of the publication online. Location is a physical location at which the research or case study is conducted for publication, which are extracted using resources from the National Geospatial-Intelligence Agency (NGA) and United States Geological Survey (USGS) [17, 18]. Lastly, there are 76 species, the most prevalent being human, rodents and swine, and 175 chemicals captured that are associated with the manuscripts.

Application Development

PLATIPUS is built on top of the SERBERUS application, which is an end-to-end software solution that rapidly builds visual analytic web applications (Figure 1). Powered by the Scalable Reasoning System (SRS)[19] on the back-end, a flexible user interface toolkit on the front-end, and drawing from expertise from a user experience and design team, this system is designed for custom solutions that can be readily constructed to support data exploration, discovery, and understanding.

The PLATIPUS application provides the end-user with a variety of ways to search and filter over one hundred thousand COVID-19 publications. Since PLATIPUS is built on top of SRS and Slykit, PLATIPUS will continue to evolve and grow with new visualizations and features as SRS and Slykit advances. As of May 2021, PLATIPUS allows the user to filter on locations, categories, authors, organization, disease, diagnostics/analysis, countermeasures, species, and additional context as well as a timeline. The visualizations that are currently available are: Circle Pack, Cluster Pack, Donut Graphs, Edge-based Graph, Line Chart, Matrix, Metrics, Paracord, Table, Text Clusters, Treemap, and Timeline described in Table 2. The first 10 of these visualizations are at the center of the dashboard and can be assembled based on user choice (one, two, three, etc.) all in the view. The timeline visualization is maintained across the top of the user-interface. At any time during the filtering and searching process, the user can access a high-level overview of an individual publication which includes the abstract, information about the authors, tags/categories, and the journal where it was published as well as directly link to the full publication. Once the user filters down to a subset of publications of interest, they can export the list of publications as a Comma-Separated Values (CSV) file.

Table 2. PLATIPUS core visualizations

Visualization	Description
Circle Pack	Relative sized circles of various metadata fields that supports up to three levels (i.e., Categories →Disease→Locations)
Cluster Graph	Primary properties are clustered into nodes, which area resized based on connection count.
Donut Graphs	Data separated based on various properties in a donut circle view where sizes within the donut are relative to frequency.
Edge-based Graph	Primary property is connected via nodes from a defined link property, which can be filtered based on the number of connections.
Line Chart	Multiline chart customized to property selected, data binning, color, and aggregation.
Matrix	A two-dimensional grid that shows the aggregations between two properties.
Metrics	High level summary of the data selected
Paracord	Links properties to find connection between metadata, especially useful to find single unique connections.
Table	Read-only table format to sort and limit the items being viewed.
Text Clusters	Groups keywords to place documents into common clusters.
Timeline	Bar graph to display metadata over time.
Treemap	Recursive drill-down into sub-groups from a primary group.

Results

The application allows the user to search by keyword, filter by various tags, select a time range, as well as visualize the tags and other document properties on innovative graphs and visualizations. Figure 2 shows the home screen of PLATIPUS, which is showing the test clustering view of the full set of COVID-related publication literature. PLATIPUS is broken into multiple panels; 1) the search bar on top center, 2) timeline for filtering articles by date in the center, 3) filters associated with the annotated data (e.g, authors, journals, etc.) on the left, 4) visualization panel (9 total options) in the bottom center, and 5) the article panel (right).

One of the key features of PLATIPUS is the numerous approaches that can be taken to visualize the data. Figure 3 highlights one alternatives to the text cluster in Figure 2 (custom circle pack) and how each visualization can be modified to show the specific information of interest to the user. The custom circle pack is driven from the filters on the left-hand side and allow quick views of the overall distribution of this information. For example, for all the COVID-19 related articles in PLATIPUS, we see the majority fall into four core categories: Diagnosis, Treatment, Prevention, and Mechanism. .

To further explore the functionality of the PLATIPUS application, we demonstrate an example via a case study. There has been significant evaluation of co-morbidities, such as diabetes, on the prognostic response of patients with COVID-19 [20-23]. In this case study, the search of the term “diabetes” in PLATIPUS returns 2,769 articles from the originating 159,797, as of May 2021 (Figure 4A). However, this number is too many for a researcher to search through manually. Often the researcher performing the search will select the first few to read in more detail by perusing abstracts or other down-select criteria. This method is still an option within PLATIPUS as the articles and abstracts are displayed on the right-hand side of the application. A benefit of PLATIPUS is the additional clustering visualization of articles that goes beyond the standard sorting function available in most publication search engines. By evaluating the clusters located in the center of the application (Figure 4A), a researcher interested in the putative receptor ACE2 can see this is a key cluster in the visualization. Selecting this cluster reduces the literature from 2,769 to 159 articles. PLATIPUS then allows the researcher to observe clusters of articles within this new refined query (Figure 4B). The researcher can either narrow down further this way or as an alternative can filter articles within the defined facets using a variety of methods (Custom Circle Pack shown in Figure 4C). Within this refined search, the user can view any of the publications via the reading pane. By choosing preview, a publication will open to allow researchers to view the full abstract and associated metadata and link to the full text, if available, as seen in Figure 5 [24]. Alternatively, on the left side of Figure 4A there are predefined filters, which include subsets such as “Diagnostics” or “Disease” as an alternate approach to filtering the data. The researcher can also export the metadata from selected document(s) as a CSV for review in the future.

The diabetes example is a visual analytics exploration of a relatively open question, but PLATIPUS also supports direct medical queries using the valuable tagging that is supplied via the AAID pipeline associated with the CovidScholar data. For example, as seen in Figure 6, we apply two filters to find literature that can help with the diagnosis of ”Multisystem Inflammatory Syndrome” and “Diagnosis”. Multisystem Inflammatory Syndrome is a new clinical condition due to a cytokine storm associated with COVID-19 that causes inflammation and organ failure [25] . In PLATIPUS the first filter selected is ‘Multisystem Inflammatory Syndrome”, which reduces the dataset to 177 manuscripts. This is further refined into a small set based on the selection of ”Diagnosis”, which reduces to 33 articles, visible on the left-hand side of Figure 6. The visualizations in this case are tailored to give context of the type of chemical information that is identified from the paper, which

may give further insight into how to down-select. The TreeMap allows the researcher to see the 33 are categorized of this specific query based on the information. Evaluating the 33 articles is quickly points to an environmental component of Multisystem Inflammatory Syndrome [26-29].

Discussion

Principal Results

The primary manner the scientific community interacts with scientific literature has, up until recently, not changed in decades. COVID-19 has brought to the forefront of research the challenge of mining literature versus identification of potential articles of interest to a user by key word searches. To date, PLATIPUS performs text analytics, clusters, and visualizes nearly 160,000 articles related to COVID-19 and automatically updates as new documents are added to COVIDScholar. The application uses state-of-the-art natural language processing (AAID) to provide insight and unique ways to filter and understand the data. PLATIPUS aims to decrease time spent looking through pages of articles by providing the user with multiple ways to search, filter, and view the data. The PLATIPUS application focuses on taking the large amount of literature related to COVID-19 and displaying keywords, categories, and other metadata to allow a user to quickly find relevant information captured by COVIDScholar.

Limitations

PLATIPUS was designed to assist in searching a multitude of COVID-19 publications efficiently so the user can either find their answer using the visualizations, searching, and drill-down capabilities or find a document that will assist in their search. Therefore, PLATIPUS does not support saving views or searches as it was designed to be a visual analytics search engine and visual table of contents. Additional limitations includes the suggestion of the ‘optimal’ visualization based on a query. PLATIPUS allows the users to toggle through visualizations and select those which are of the most utility. Additions to PLATIPUS in the future may be a more guided visualization experience based on the size and complexity of the literature returned from a query. Lastly, as of March 2021, PLATIPUS does not support finding similar articles to a single selection, but we expect this feature will be available in the future.

Acknowledgements

Research was supported by the Department of Energy (DOE) Office of Science through the National Virtual Biotechnology Laboratory, a consortium of DOE national laboratories focused on response to COVID-19, with funding provided by the Coronavirus CARES Act to the COVID-19 Testing R&D Project. The software was developed at the Pacific Northwest National Laboratory operated by Battelle under contract DE-AC05-76RLO01830. COVIDScholar, an AI-powered rapid data gathering, analysis, and dissemination tool, was developed at Berkeley National Laboratory. Work at the Lawrence Berkeley National Laboratory was supported by the Laboratory Directed Research and Development Program of Lawrence Berkeley National Laboratory under U.S. Department of Energy Contract No. DE-AC02-05CH11231.

Conflicts of Interest

None declared

Abbreviations

AAID: Automated Analytics and Integration of Data
CSV: Comma-Separated Values
PLATIPUS: Publication Literature Analysis and Text Interaction Platform for User Studies)

SRS: Scalable Reasoning System

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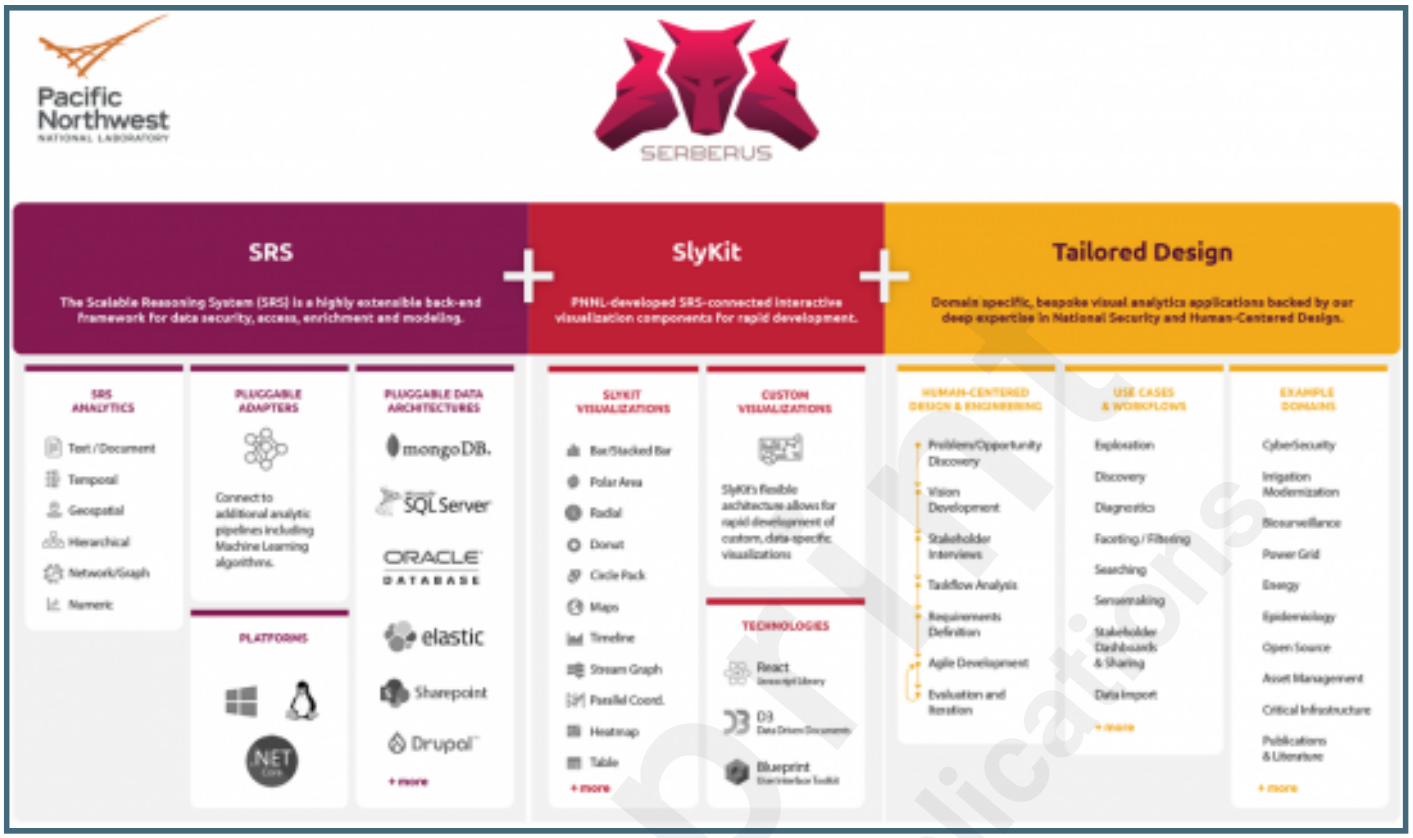
Supplementary Files

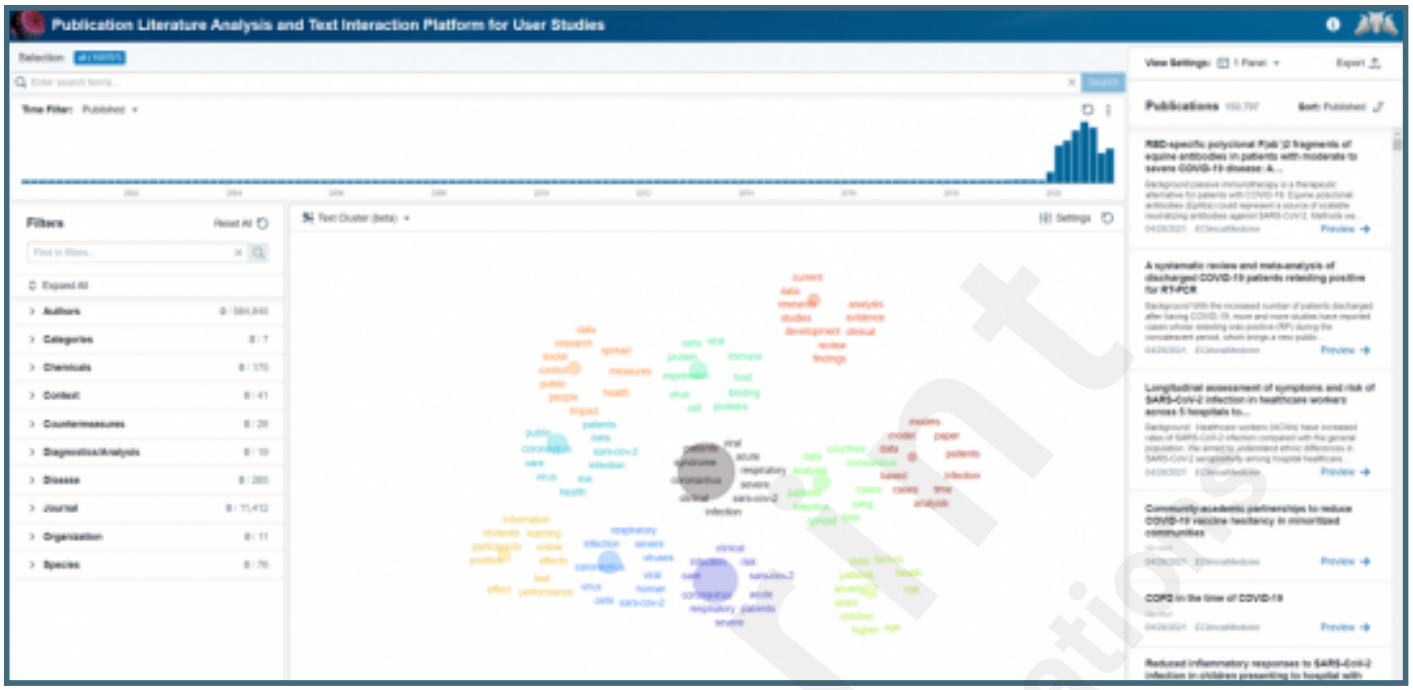
Untitled.
URL: http://asset.jmir.pub/assets/43839f790360263c490c7e97b413ae2f.pdf

Figures

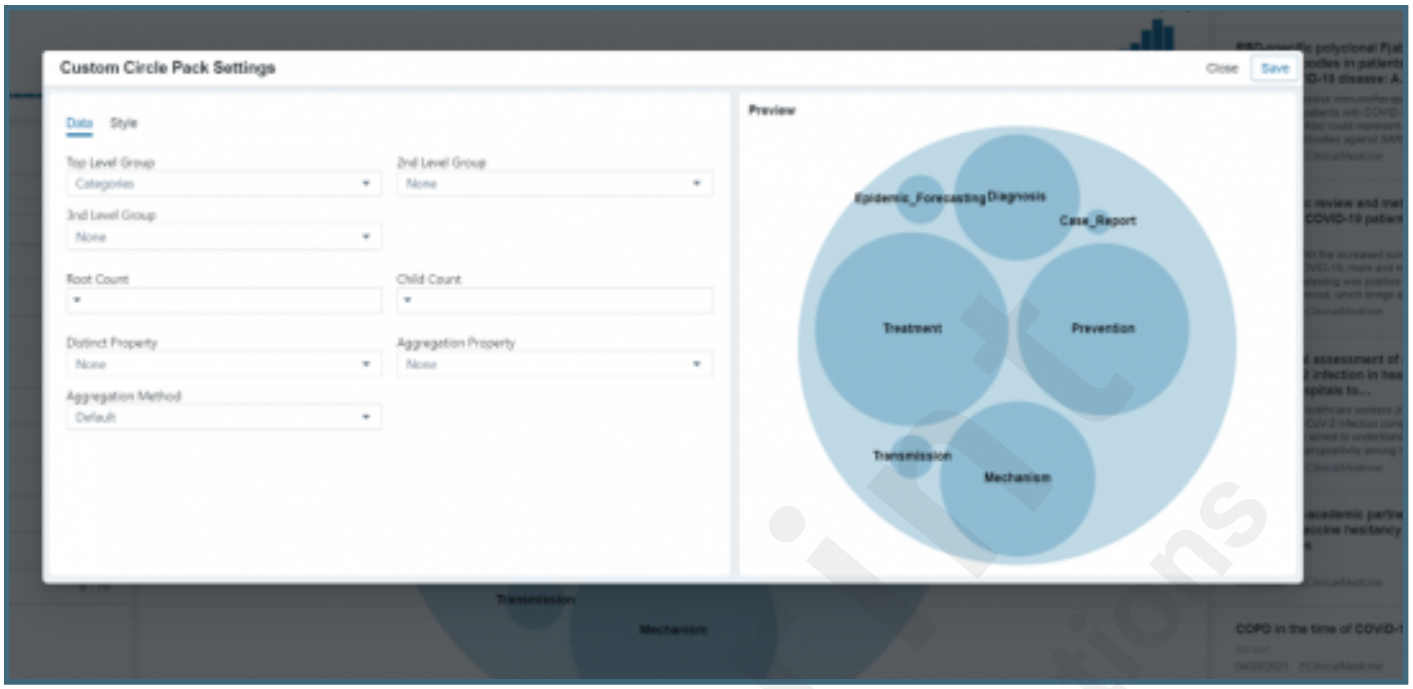
Description of the SERBERUS application full capability components.



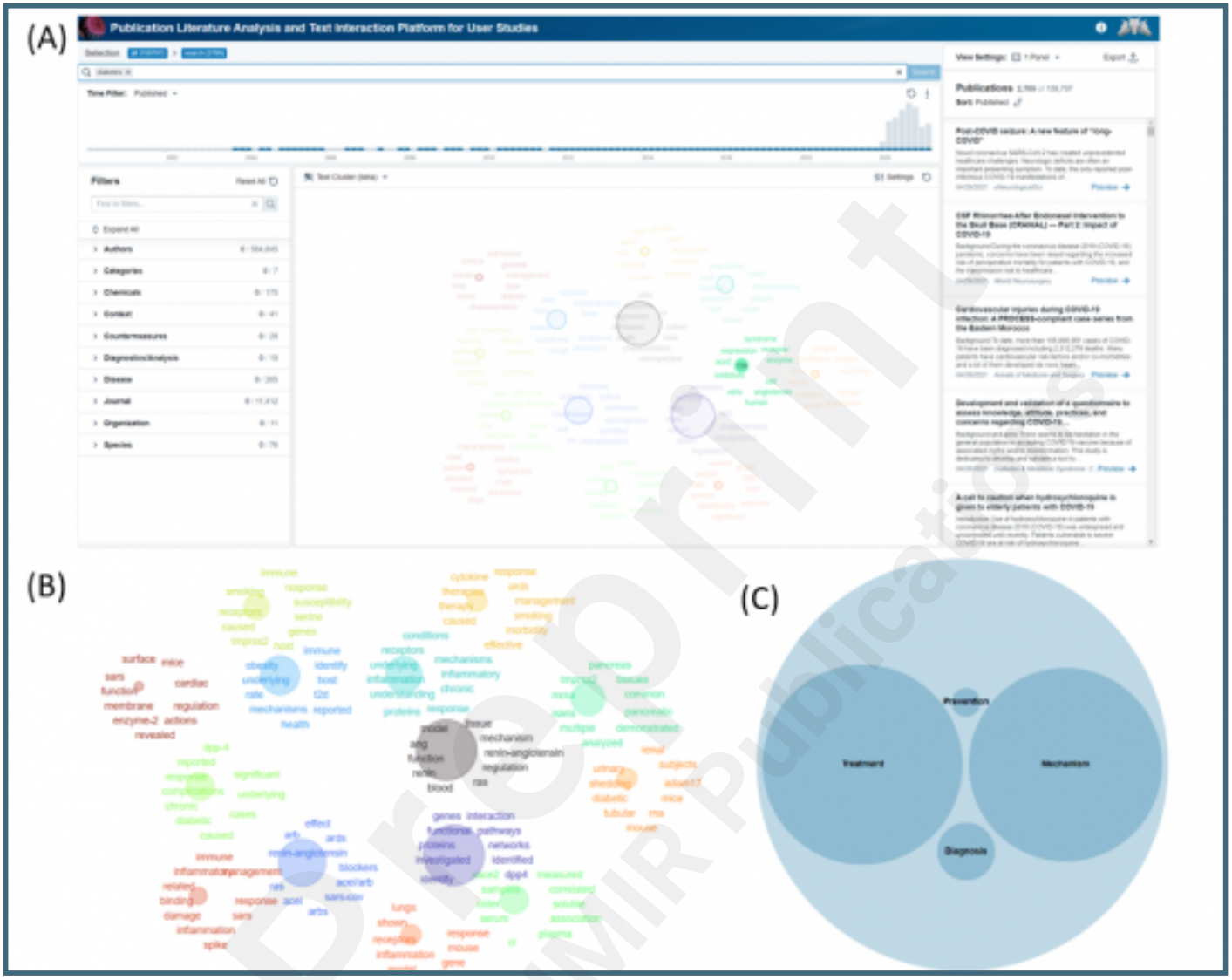
Screenshot of the primary PLATIPUS application page from which the user begins queries and visual interactive activities.



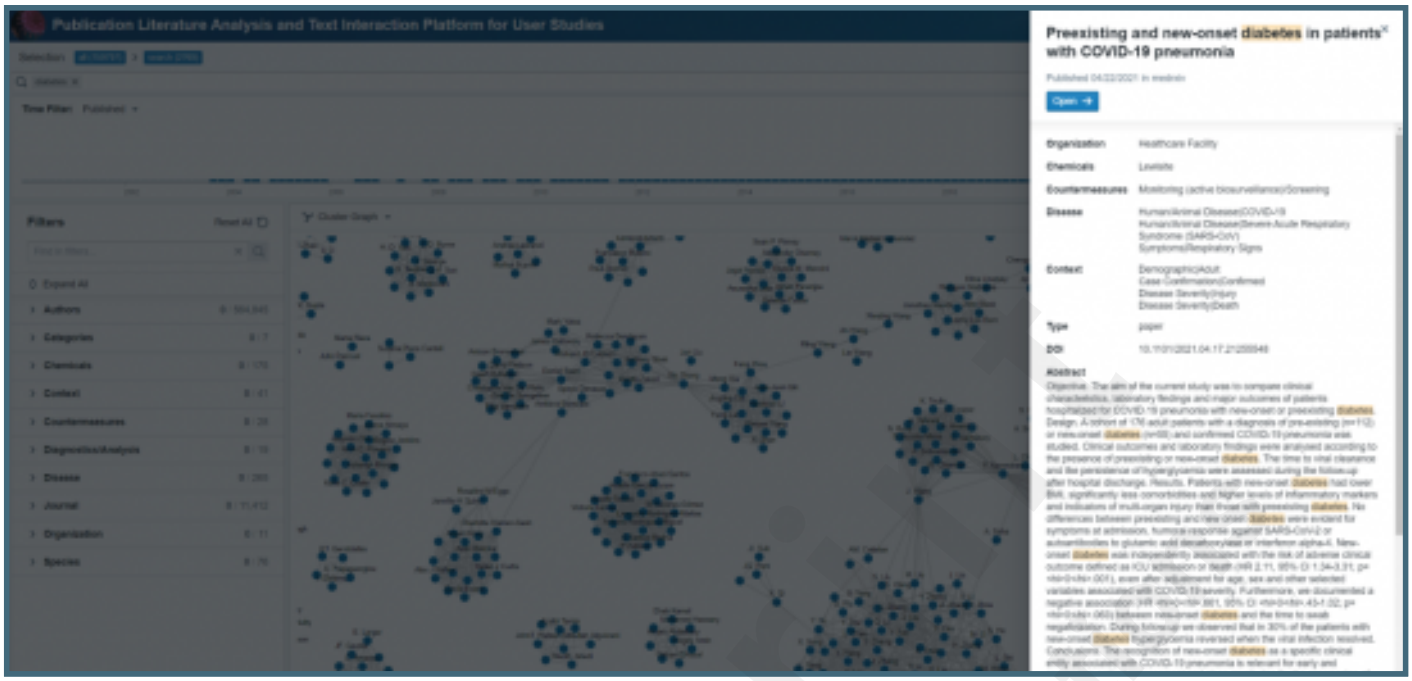
Example of the visualization customization component.



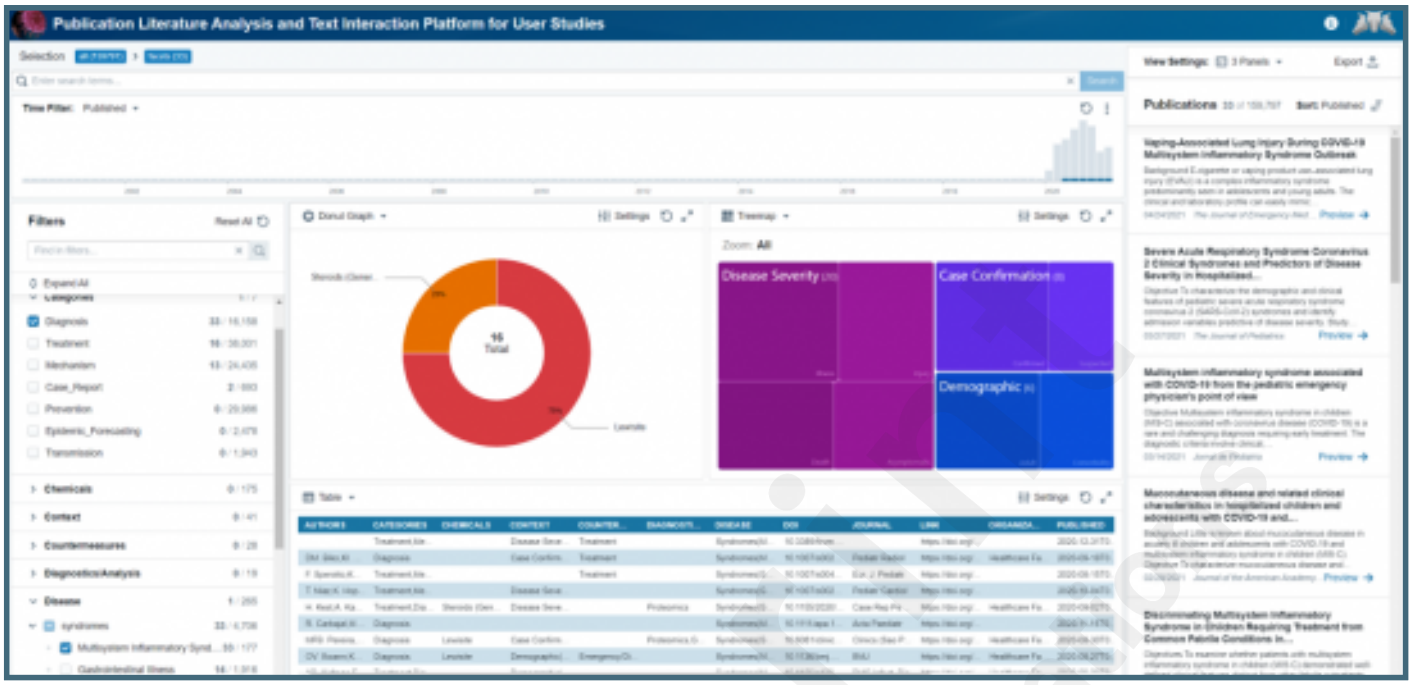
(A) View and selection based on a search for the term “diabetes” where a cluster associated with ACE2 is identified; with (B) and (C) as alternate visualization of the results after selection of the cluster including ACE2.



High-level view of a paper which includes information about the coronavirus and diabetes.



View and selection based on tagging capability drilling into tags of Multisystem Inflammatory Syndrome and Diagnosis.



TOC/Feature image for homepages

PLATIPUS.