VOSviewer Manual

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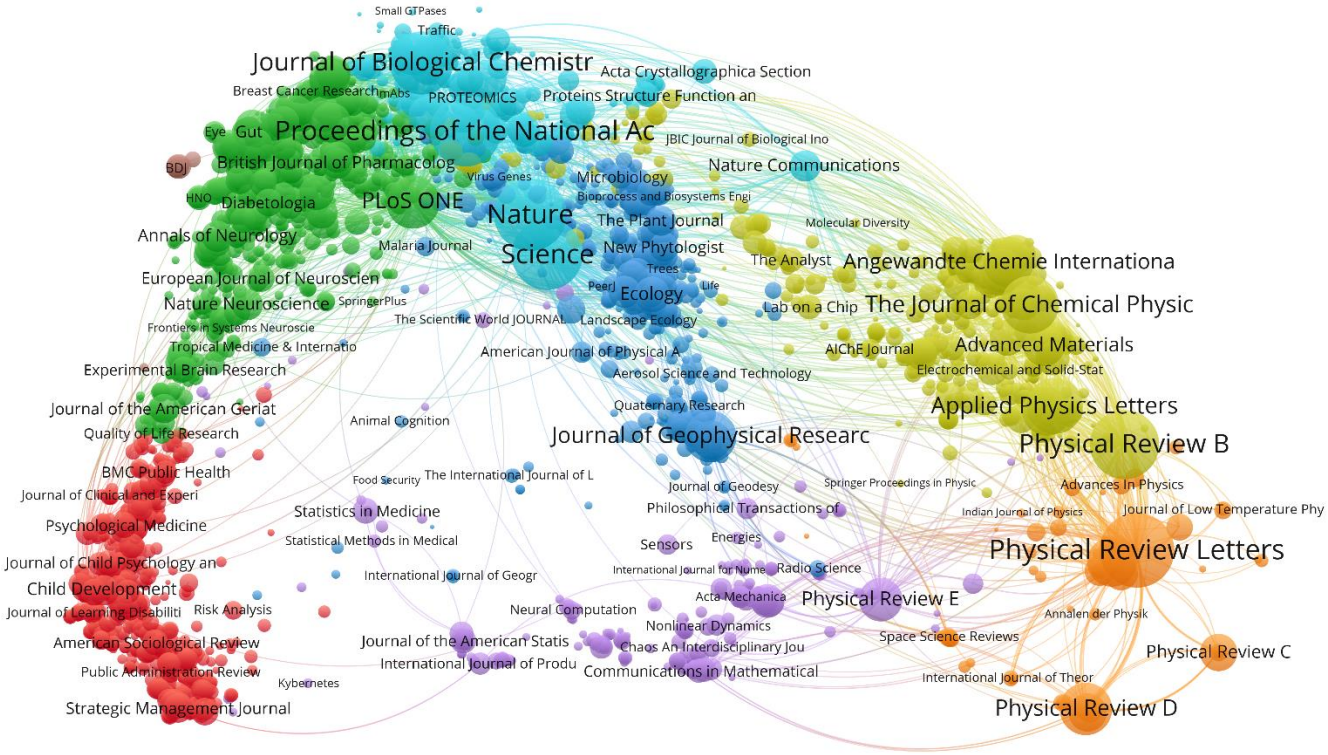

Manual for VOSviewer version 1.6.20

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1 Introduction

VOSviewer is a software tool for creating maps based on network data and for visualizing and exploring these maps. The functionality of VOSviewer can be summarized as follows:

- *Creating maps based on network data*. A map can be created based on a network that is already available, but it is also possible to first construct a network. VOSviewer can be used to construct networks of scientific publications, scientific journals, researchers, research organizations, countries, keywords, or terms. Items in these networks can be connected by co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation links. To construct a network, bibliographic database files (i.e., Web of Science, Scopus, Dimensions, Lens, and PubMed files) and reference manager files (i.e., RIS, EndNote, and RefWorks files) can be provided as input to VOSviewer. Alternatively, VOSviewer can download data through an API (i.e., OpenAlex API, Crossref API, Europe PMC API, and several others).
- *Visualizing and exploring maps*. VOSviewer provides three visualizations of a map: The network visualization, the overlay visualization, and the density visualization. Zooming and scrolling functionality allows a map to be explored in full detail, which is essential when working with large maps containing thousands of items.

Although VOSviewer is intended primarily for analyzing bibliometric networks, it can in fact be used to create, visualize, and explore maps based on any type of network data.

VOSviewer has been developed in the Java programming language. Because Java is platform-independent, VOSviewer runs on most hardware and operating system platforms. VOSviewer can be downloaded from www.vosviewer.com. It can be used freely for any purpose.

This manual pertains to version 1.6.20 of VOSviewer. The manual is organized as follows. We first introduce some terminology in Chapter 2. We then discuss the user interface of VOSviewer in Chapter 3, and we explain the file types used by VOSviewer in Chapter 4. Finally, we consider a number of advanced topics in Chapter 5.

For additional information about VOSviewer, we refer to a paper that we have written (Van Eck & Waltman, 2010). This paper provides a general introduction to VOSviewer. It also discusses in considerable detail the technical implementation of

specific elements of the software. Similar information, including a step-by-step tutorial, can also be found in a more recent book chapter (Van Eck & Waltman, 2014).

2 Terminology

When working with VOSviewer, it is important to understand the terminology used by the software. We now introduce this terminology.

Maps created, visualized, and explored using VOSviewer include items. *Items* are the objects of interest. Items may for example be publications, researchers, or terms. A map normally includes only one type of item. It is for example uncommon to have a map that includes both publications and terms. Between any pair of items there can be a link. A *link* is a connection or a relation between two items. Examples of links are bibliographic coupling links between publications, co-authorship links between researchers, and co-occurrence links between terms. A map normally includes only one type of link. Also, between any pair of items, there can be no more than one link. Each link has a *strength*, represented by a positive numerical value. The higher this value, the stronger the link. The strength of a link may for example indicate the number of cited references two publications have in common (in the case of bibliographic coupling links), the number of publications two researchers have co-authored (in the case of co-authorship links), or the number of publications in which two terms occur together (in the case of co-occurrence links). Sometimes the links between items all have a strength of one. VOSviewer then does not show the strength of a link. Items and links together constitute a network. Hence, a *network* is a set of items together with the links between the items.[1]

Items may be grouped into clusters. A *cluster* is a set of items included in a map.[2] Clusters are non-overlapping in VOSviewer. In other words, an item may belong to only one cluster. Clusters do not need to exhaustively cover all items in a map. Hence, there may be items that do not belong to any cluster. Clusters are labeled using *cluster numbers*. If there is only one cluster, this cluster usually has cluster number 1, if there are two clusters, these clusters usually have cluster numbers 1 and 2, and so on.

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[1] In the literature, a network is sometimes referred to as a graph. Likewise, an item is sometimes called a node or a vertex, a link is sometimes called an edge, and the strength of a link is sometimes called an edge weight. These terms are not used by VOSviewer, but they may be used by other software tools for network analysis and network visualization.

[2] In the literature, a cluster is sometimes referred to as a community, but this term is not used by VOSviewer.

Items may have various attributes in VOSviewer. If items have been assigned to clusters, cluster numbers are an example of an attribute. Of special importance are the *weight* and *score* attributes. These attributes are represented by numerical values. Weight attributes are restricted to non-negative values. Score attributes do not have this restriction. A weight of an item should in some way indicate the importance of the item. An item with a higher weight is regarded as more important than an item with a lower weight.[3] In the visualization of a map, items with a higher weight are shown more prominently than items with a lower weight. A score attribute may indicate any numerical property of items.[4] However, since weight attributes are already used to indicate the importance of items, it is recommended to use score attributes to indicate other properties. Score attributes are considered only in the overlay visualization of a map (see Subsection 3.1.2), not in the network visualization and the density visualization. Items may have multiple weight and multiple score attributes. The weight and score attributes that are used in the visualization of a map can then be selected in the options panel of VOSviewer (see Section 3.2).

There are two standard weight attributes, referred to as the *Links* attribute and the *Total link strength* attribute. For a given item, the *Links* and *Total link strength* attributes indicate, respectively, the number of links of an item with other items and the total strength of the links of an item with other items. For example, in the case of co-authorship links between researchers, the *Links* attribute indicates the number of co-authorship links of a given researcher with other researchers. The *Total link strength* attribute indicates the total strength of the co-authorship links of a given researcher with other researchers.

In addition to the standard *Links* and *Total link strength* attributes, items may also have custom weight attributes. Custom weight attributes are discussed in Subsection 3.5.4.

[3] More precisely, VOSviewer assumes weight attributes to have a ratio scale. In other words, if an item has a weight that is twice as high as the weight of another item, the former item is regarded as twice as important as the latter item.

[4] Unlike weight attributes, score attributes are not assumed to have a ratio scale. Score attributes may also have an interval or an ordinal scale. In other words, the minimum requirement for score attributes is that it makes sense to compare two items based on whether one item has a higher score than the other item.

3 User interface

The main window of VOSviewer is shown in Figure 1. It consists of the following five panels:

- *Main panel*. This panel presents a visualization of the currently active map. Zoom and scroll functionality can be used to explore the map in full detail.
- *Options panel*. This panel can be used to make adjustments to the visualization of the currently active map presented in the main panel.
- *Information panel*. This panel presents descriptions of items in the currently active map.
- *Overview panel*. This panel presents an overview of the currently active map. A rectangular frame indicates the area in the map that is shown in the main panel.
- *Action panel*. This panel can be used to perform different kinds of actions, such as creating a new map, opening or saving an existing map, making a screenshot, and updating the layout or the clustering of a map.

VOSviewer provides three visualizations, referred to as the network visualization, the overlay visualization, and the density visualization. As can be seen in Figure 1, the **Network Visualization**, **Overlay Visualization**, and **Density Visualization** tabs in the main window of VOSviewer can be used to switch between the visualizations.

A status bar is available at the bottom of the main window of VOSviewer. The status bar provides information about the currently active map. It shows the number of items in the map, the number of clusters to which the items have been assigned, the number of links between the items, and the total strength of the links. Moreover, when the mouse pointer is moved over an item in the main panel, the status bar provides information about this item. Likewise, when the mouse pointer is moved over a link between two items, the status bar provides information about this link.

In the next sections, the five panels in the main window of VOSviewer are discussed in more detail.

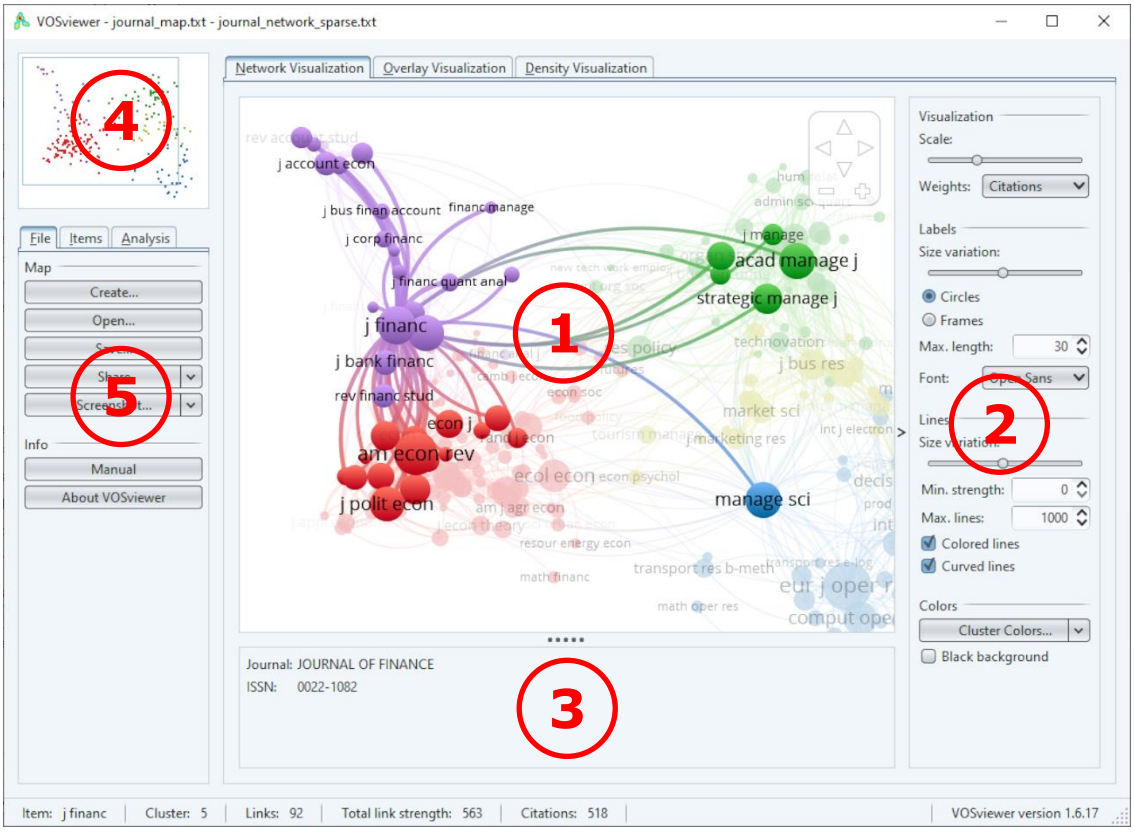

Figure 1. Main window of VOSviewer. The numbers designate (1) the main panel, (2) the options panel, (3) the information panel, (4) the overview panel, and (5) the action panel.

3.1 Main panel

As can be seen in Figure 1, the main panel presents a visualization of the currently active map. Zoom and scroll functionality can be used to determine the area in the map that is shown in the main panel. Three visualizations are available in the main panel: The network visualization, the overlay visualization, and the density visualization.

To illustrate the different visualizations, we use a map of a co-citation network of 232 journals in the fields of economics, management, and operations research (for more details, see Van Eck & Waltman, 2010). The map is available in the files `journal_map.txt` and `journal_network_sparse.txt`, which are distributed together with VOSviewer. To open the map in VOSviewer, click the **Open** button on the **File** tab in the action panel, select the VOSviewer map file `journal_map.txt` and the VOSviewer network file `journal_network_sparse.txt`, and click the **OK** button.

3.1.1 Network visualization

In the network visualization, items are represented by their label and by default also by a circle. The size of the label and the circle of an item is determined by the weight of the item. The higher the weight of an item, the larger the label and the circle of the item. For some items the label may not be displayed. This is done in order to avoid overlapping labels. The color of an item is determined by the cluster to which the item belongs. Lines between items represent links. By default, at most 1000 lines are displayed, representing the 1000 strongest links between items.

An example of the network visualization is shown in Figure 2. The distance between two journals in the visualization approximately indicates the relatedness of the journals in terms of co-citation links. In general, the closer two journals are located to each other, the stronger their relatedness. The strongest co-citation links between journals are also represented by lines.

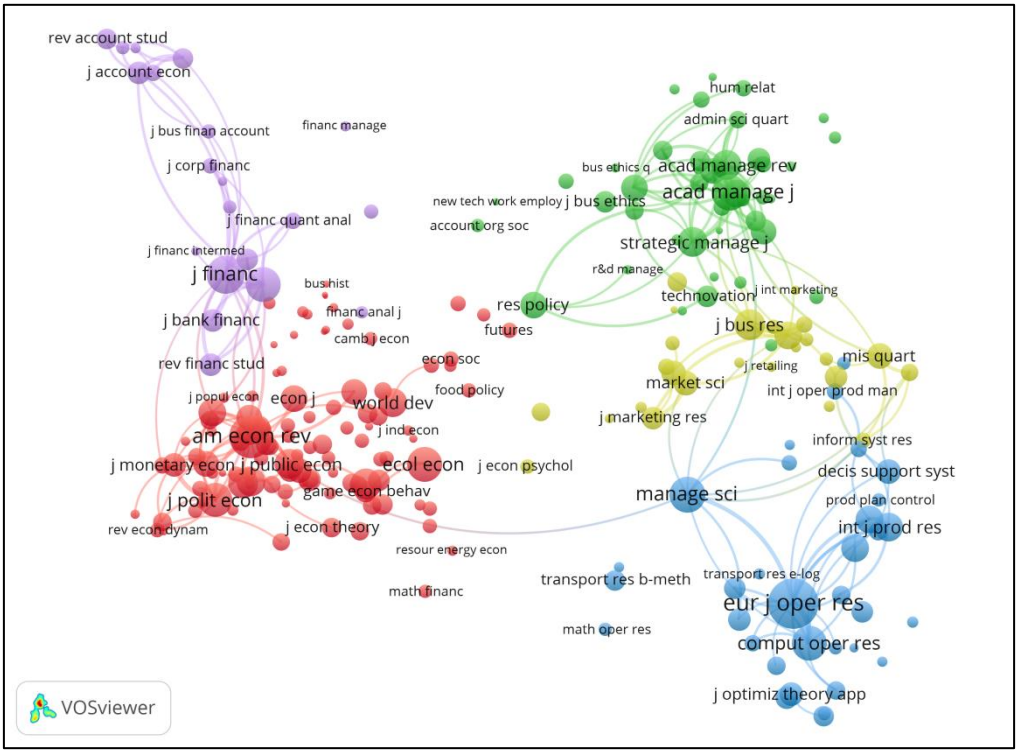

Figure 2. Network visualization.

3.1.2 Overlay visualization

The overlay visualization is identical to the network visualization except that items are colored differently. There are two ways in which items can be colored in the overlay visualization. If items have scores, the color of an item is determined by

the score of the item, where by default colors range from blue (lowest score) to green to yellow (highest score). On the other hand, if items have user-defined colors (specified using the *red*, *green*, and *blue* columns in a VOSviewer map file; see Subsection 4.1.1), the color of an item is determined by the user-defined color of the item. If items have neither scores nor user-defined colors, the overlay visualization is not available.

An example of the overlay visualization is shown in Figure 3. A color bar is shown in the bottom right corner of the visualization. The color bar is shown only if colors are determined by scores of items. The color bar indicates how scores are mapped to colors. In the overlay visualization shown in Figure 3, colors indicate impact factors of journals. For example, journals colored blue have an impact factor below 1, journals colored green have an impact factor around 2, and journals colored yellow have an impact factor of 3 or higher.

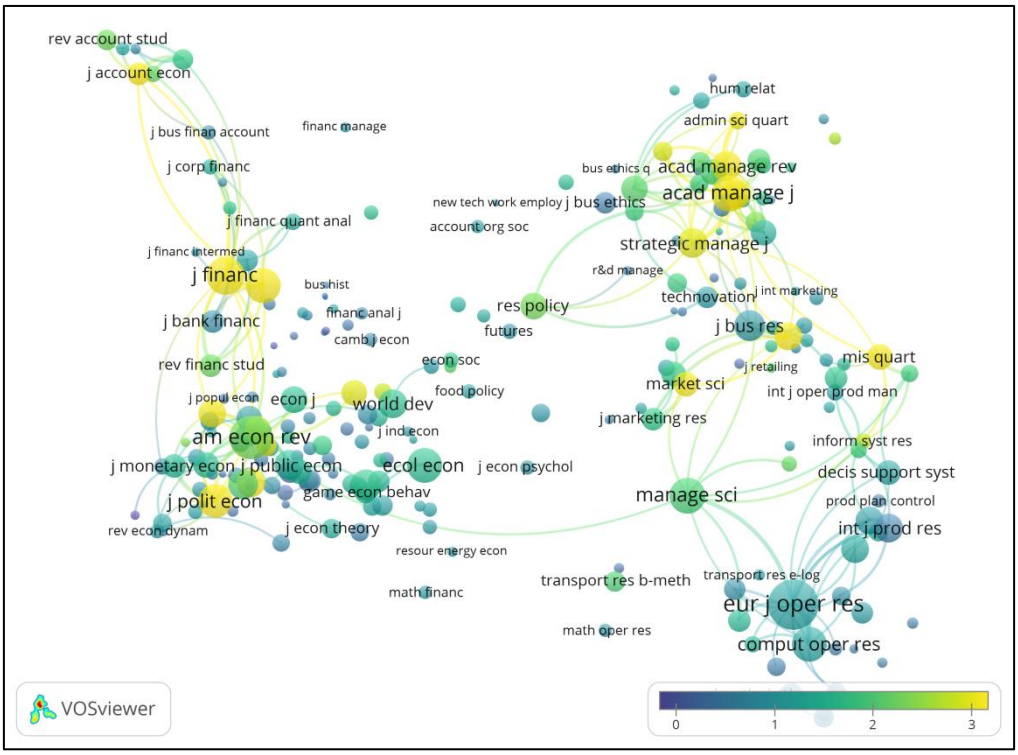

Figure 3. Overlay visualization.

3.1.3 Density visualization

There are two variants of the density visualization. We first discuss the item density visualization, followed by the cluster density visualization. The **Item density** and **Cluster density** radio buttons in the options panel can be used to

switch between the two variants of the density visualization. We refer to Van Eck and Waltman (2010) for a discussion of the technical implementation of the density visualization.

In the item density visualization, items are represented by their label in a similar way as in the network visualization and the overlay visualization. Each point in the item density visualization has a color that indicates the density of items at that point. By default, colors range from blue to green to yellow. The larger the number of items in the neighborhood of a point and the higher the weights of the neighboring items, the closer the color of the point is to yellow. The other way around, the smaller the number of items in the neighborhood of a point and the lower the weights of the neighboring items, the closer the color of the point is to blue. An example of the item density visualization is shown in Figure 4.

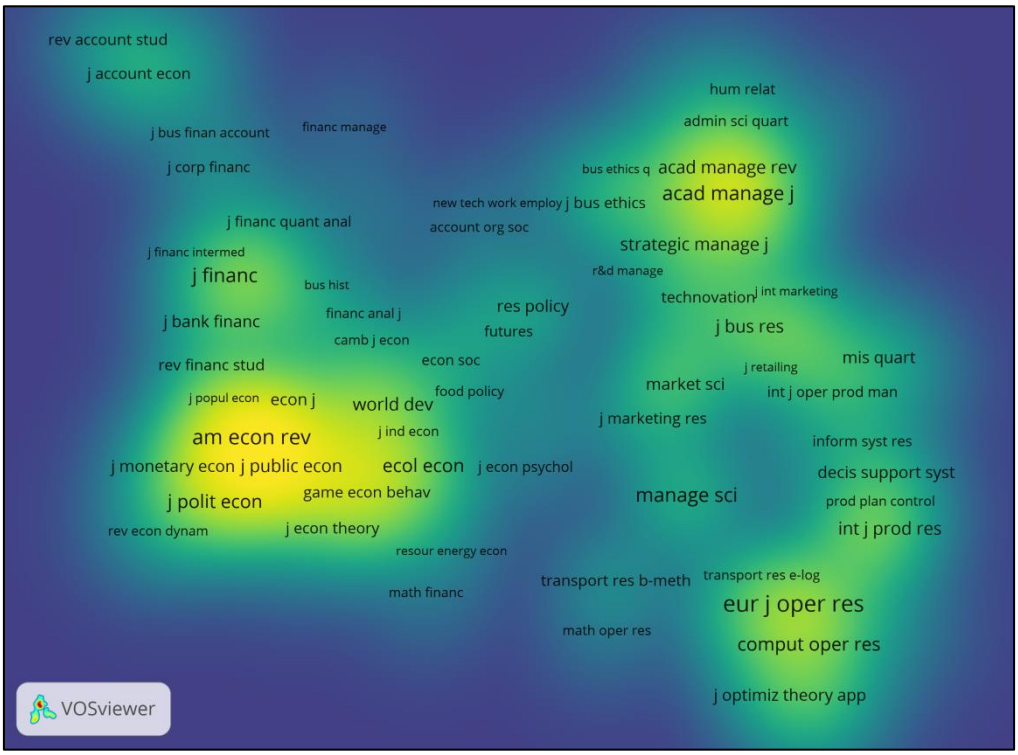

Figure 4. Item density visualization.

The cluster density visualization is available only if items have been assigned to clusters. The cluster density visualization is similar to the item density visualization except that the density of items is displayed separately for each cluster of items. In the cluster density visualization, the color of a point in the visualization is obtained by mixing the colors of different clusters. The weight given to the color of a certain

cluster is determined by the number of items belonging to that cluster in the neighborhood of the point. Like in the item density visualization, the weight of an item is taken into account as well. An example of the cluster density visualization is shown in Figure 5.

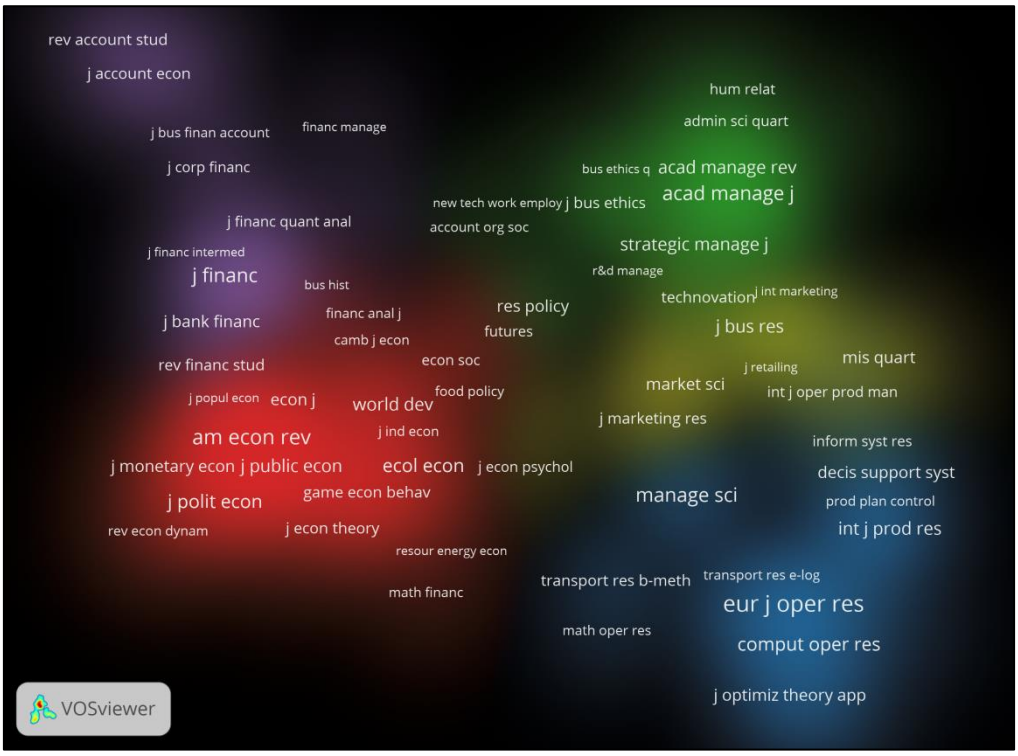

Figure 5. Cluster density visualization.

3.1.4 Zooming and scrolling

To facilitate the detailed exploration of a map, VOSviewer offers zoom and scroll functionality. In the main panel, zooming and scrolling can be done in the following three ways:

- *Using the mouse*. To zoom in, move the mouse upwards while keeping the right mouse button pressed. The other way around, to zoom out, move the mouse downwards while keeping the right mouse button pressed. As an alternative, the mouse wheel can be used to zoom in and out. To scroll through a map, move the mouse while keeping the left mouse button pressed.
- *Using the navigation buttons in the top right corner of the main panel (see Figure 1)*. Use the plus and minus buttons to zoom in and out. Use the arrow buttons to scroll through a map.

- *Using the keyboard*. Use the plus and minus keys to zoom in and out. Use the arrow keys to scroll through a map.

3.2 Options panel

The options panel can be used to make adjustments to the visualization of the currently active map presented in the main panel. The network visualization, the overlay visualization, and the density visualization each provide somewhat different options. Some of the options are not always available. The options panel shows only the options that are relevant for the currently active map.

When the network visualization or the overlay visualization is selected, the following options may be available:

- **Visualization**.
    - **Scale**. This slider determines the size of the labels of items in the visualization of the currently active map. It also determines the thickness of the lines used to display links between items.
    - **Weights**. When items have multiple weight attributes, the **Weights** drop down list determines the currently selected weight attribute. This weight attribute then determines how prominently items are shown in the visualization of the currently active map. The higher the weight of an item, the larger the label of the item in the visualization.
    - **Scores**. This drop down list is available only if the overlay visualization is selected. When items have multiple score attributes, the **Scores** drop down list determines the currently selected score attribute. This score attribute then determines the coloring of items in the visualization of the currently active map. By default, the higher (lower) the score of an item, the closer the color of the item is to yellow (blue).
- **Labels**.
    - **Size variation**. The higher the weight of an item, the larger the label of the item in the visualization of the currently active map. The **Size variation** slider determines the strength of this effect.
    - **Circles** and **Frames**. These radio buttons determine how items are represented in the visualization of the currently active map. If the **Circles** radio button is selected, items are represented by their label and by a circle. If the **Frames** radio button is selected, items are represented by their label displayed within a rectangular frame.

- **Max. length**. This text box determines the maximum length of a label displayed in the visualization of the currently active map. If the length of the label of an item exceeds the maximum length, only the first part of the label is displayed.
- **Font**. This drop down list determines the font that is used to display the labels of items in the visualization of the currently active map. The availability of fonts in the **Font** drop down list depends on the use of CJKV (Chinese, Japanese, Korean, and Vietnamese) characters in the labels of items. If the labels of items do not include CJKV characters, a number of fonts are available, with the **Open Sans** font being selected by default. If the labels of items do include CJKV characters, only the **SansSerif** font is available. The **SansSerif** font ensures that CJKV characters are displayed correctly.

- **Lines**.
  - **Size variation**. The stronger the link between two items, the thicker the line that is used to display the link in the visualization of the currently active map. The **Size variation** slider determines the strength of this effect.
  - **Min. strength** and **Max. lines**. In the visualization of the currently active map, links between items can be displayed using lines. The **Min. strength** and **Max. lines** text boxes determine, respectively, the minimum strength of links displayed in the visualization and the maximum number of links displayed in the visualization. If the number of links that have the required minimum strength exceeds the maximum number of links, only the strongest links are displayed.
  - **Colored lines**. This check box determines whether links are displayed using gray lines or colored lines.
  - **Curved lines**. This check box determines whether links are displayed using straight lines or curved lines.

- **Colors**.
  - **Cluster Colors**. This button is available only if the network visualization is selected. The button offers four options:
    - **Edit colors**. This option is the default choice. Choose this option to edit the current cluster colors in the **Edit Cluster Colors** dialog box.
    - **Import colors**. Choose this option to import cluster colors from a cluster colors file (see Subsection 4.4.14.4).

- **Export colors**. Choose this option to export the current cluster colors to a cluster colors file (see Subsection 4.4.1).
- **Use default colors**. Choose this option to use the default cluster colors.

- **Overlay Colors**. This button is available only if the overlay visualization is selected and if items have scores. The button offers four options:
  - **Set colors range**. This option is the default choice. Choose this option to bring up the **Set Overlay Colors Range** dialog box. This dialog box can be used to change the minimum and the maximum score that determine how the scores of items are mapped to colors. By default, scores less than or equal to the minimum score are mapped to blue, intermediate scores are mapped to green, and scores greater than or equal to the maximum score are mapped to yellow.

    The **Set Overlay Colors Range** dialog box can also be used to determine how the scores of items are normalized. By default, no normalization is applied. If the **Divide by mean** option is selected in the **Normalize scores** drop down list, the scores of items are normalized by dividing each score by the mean score of all items.[5] If the **Subtract mean** option is selected, the scores of items are normalized by subtracting from each score the mean score of all items. Finally, if the **Subtract mean and divide by st. dev.** option is selected, the scores of items are normalized by first subtracting from each score the mean score of all items and by then dividing by the standard deviation of the scores of all items (i.e., a z-score normalization). Working with normalized scores is an advanced feature of VOSviewer that should be used only in special cases. For most purposes, we recommend not to normalize scores.
  - **Import colors**. Choose this option to import overlay colors from an overlay colors file (see Subsection 4.44.4.2).
  - **Export colors**. Choose this option to export the current overlay colors to an overlay colors file (see Subsection 4.4.2).

[5] This option is available only if the scores of items all have the same sign. In other words, the scores of items must either all be non-negative or all be non-positive.

        - **Use predefined colors**. Choose this option to use predefined overlay colors. Eight different color schemes are available.[6] To use the default overlay colors, choose the **Viridis** color scheme.
    - **Black background**. This check box determines whether the visualization of the currently active map has a white or a black background color.

When the density visualization is selected, the following options may be available:

- **Visualization**.
    - **Scale**. This slider determines the size of the labels of items in the visualization of the currently active map.
    - **Weights**. When items have multiple weight attributes, the **Weights** drop down list determines the currently selected weight attribute. This weight attribute then determines how prominently items are shown in the visualization of the currently active map. The higher the weight of an item, the larger the label of the item in the visualization. The selected weight attribute is also used in the calculation of the density of items.
- **Labels**. These options are identical to the options provided when the network visualization or the overlay visualization is selected (except that the **Circles** and **Frames** radio buttons are not available).
- **Density**.
    - **Kernel width**. This slider determines the value of the kernel width parameter. We refer to Van Eck and Waltman (2010) for more information about this parameter.
    - **Item density** and **Cluster density**. These radio buttons determine whether the item density visualization or the cluster density visualization is selected.
- **Colors**.
    - **Density Colors**. This button is available only if the item density visualization is selected. The button offers three options:

[6] The color schemes available in VOSviewer, both for overlay colors and for density colors, have been obtained from Matplotlib, a plotting library for Python. Some color schemes have been slightly adjusted. For more information about the color schemes, see https://matplotlib.org/users/colormaps.html. For a further discussion of the use of different color schemes in VOSviewer, see www.cwts.nl/blog?article=n-r2s274.

- **Import colors**. This option is the default choice. Choose this option to import density colors from a density colors file (see Subsection 4.4.3).
- **Export colors**. Choose this option to export the current density colors to a density colors file (see Subsection 4.4.3).
- **Use predefined colors**. Choose this option to use predefined density colors. Eight different color schemes are available. To use the default density colors, choose the **Viridis** color scheme.

- **Cluster Colors**. This button is available only if the cluster density visualization is selected. The button offers four options:
  - **Edit colors**. This option is the default choice. Choose this option to edit the current cluster colors in the **Edit Cluster Colors** dialog box.
  - **Import colors**. Choose this option to import cluster colors from a cluster colors file (see Subsection 4.4.1).
  - **Export colors**. Choose this option to export the current cluster colors to a cluster colors file (see Subsection 4.4.1).
  - **Use default colors**. Choose this option to use the default cluster colors.
- **White background**. This check box is available only if the cluster density visualization is selected. The check box determines whether the cluster density visualization has a black or a white background color.

3.3 Information panel

The information panel is available only if items have a description attribute. Description attributes may for example have been made available using the *description* column in a VOSviewer map file (see Subsection 4.1.1). The information panel presents descriptions of items in the currently active map. When the mouse pointer is moved over an item in the main panel, the description of the item is shown in the information panel.

3.4 Overview panel

The overview panel presents an overview of the currently active map. Each item in the map is represented by a small colored dot. A rectangular frame is displayed in the overview panel to indicate the area in the currently active map that is shown in the main panel. By left-clicking in the overview panel, it is possible to move to a different area in the currently active map. This new area is then shown in the main panel.

3.5 Action panel

The action panel can be used to perform different kinds of actions. The panel consists of three tabs: The **File** tab, the **Items** tab, and the **Analysis** tab. These tabs are discussed in Subsections 3.5.1, 3.5.2, and 3.5.3. The **Create Map** wizard, which can be accessed from the **File** tab, plays an important role in VOSviewer. This wizard is discussed separately in Subsection 3.5.4.

3.5.1 File tab

The **File** tab can be used to perform a number of basic actions. The following buttons are available on the **File** tab:

- **Map**.
    - **Create**. Use this button to create a new map. The button brings up the **Create Map** wizard. This wizard is discussed in detail in Subsection 3.5.4.
    - **Open**. Use this button to open an existing map. The button brings up the **Open Map** dialog box. To open a map, a VOSviewer map file and optionally also a VOSviewer network file (see Section 4.1) can be provided. Alternatively, a VOSviewer JSON file, a GML file, or Pajek files can be provided.[7]
    - **Save**. Use this button to save the currently active map. The button brings up the **Save Map** dialog box. A map can be saved in a VOSviewer map file and a VOSviewer network file (see Section 4.1). Alternatively, a map can be saved in a VOSviewer JSON file, in a GML file, or in Pajek files.
    - **Share**. Use this button to share the currently active map by making it available online. The map is uploaded to a cloud storage service and opened in VOSviewer Online, a web-based version of VOSviewer. The following

[7] VOSviewer JSON files are used by VOSviewer Online as the default file type. VOSviewer Online is a web-based version of VOSviewer available at https://app.vosviewer.com. For more information about VOSviewer JSON files, see https://app.vosviewer.com/docs/file-types/json-file-type/. GML (graph modeling language) files are supported by various software tools for network analysis and network visualization, for example by Gephi, a software tool for network visualization available at https://gephi.org. Pajek is a software tool for social network analysis (De Nooy, Mrvar, & Batagelj, 2011). It is available at http://pajek.imfm.si/doku.php. VOSviewer supports Pajek network, matrix, partition, and vector files.

cloud storage services are supported: Google Drive, Microsoft OneDrive, and Dropbox.[8]

The share feature can be used only if you have an account for one of the above-mentioned cloud storage services and if you accept VOSviewer's request to get authorization to access your account. The specific permissions that you need to grant to VOSviewer depend on the cloud storage service that you are using. In the case of Google Drive, VOSviewer creates a folder `VOSviewer` in which it stores the maps that you choose to share. In the case of Microsoft OneDrive and Dropbox, maps are stored in a special app folder. VOSviewer does not access or modify any other files in your cloud storage.

Maps are stored in your cloud storage in VOSviewer JSON files. Be aware that these files are publicly accessible. If you no longer want a map to be available online, you need to delete the corresponding the JSON file from your cloud storage.

- **Screenshot**. This button offers four options:
  - **Save**. This option is the default choice. Choose this option to save a screenshot of the visualization of the currently active map presented in the main panel. The screenshot resembles the visualization of the currently active map as closely as possible. However, if the **Optimize labeling** check box in the **Screenshot Options** dialog box (see below) is checked, the visibility of labels in the screenshot is optimized. This means that some labels not visible in the visualization of the currently active map may be visible in the screenshot. Screenshots can be saved in a number of graphic file formats. For most purposes, we recommend the PNG format. Some formats, such as EPS, PDF, and SVG, use vector graphics to save a screenshot. This has the advantage that the screenshot can be resized without loss of quality.
  - **Print**. Choose this option to print a screenshot of the visualization of the currently active map presented in the main panel.
  - **Copy to clipboard**. Choose this option to copy a screenshot of the visualization of the currently active map presented in the main panel.

[8] More information is available in a blog post (https://www.leidenmadtrics.nl/articles/vosviewer-goes-online-part-2) and a video (https://youtu.be/3sEc-6kFRiq).

The screenshot is copied to the clipboard and can for example be pasted into a Word document or a PowerPoint presentation.

- **Options**. Choose this option to bring up the **Screenshot Options** dialog box. This dialog box can be used to change some settings related to screenshots.

  The **Scaling** drop down list determines the resolution (i.e., the number of pixels) of a screenshot. The resolution is calculated relative to the resolution of the main panel. Using a scaling of 100%, screenshots have the same resolution as the main panel. Using the default scaling of 200%, screenshots have a resolution that is twice as high (i.e., twice as many pixels horizontally and vertically) as the resolution of the main panel. The **Scaling** drop down list has no effect on screenshots that are saved in a file format that uses vector graphics.

  The **Optimize labeling** check box determines whether the visibility of labels in a screenshot is optimized. Optimizing the visibility of labels means that some labels not visible in the visualization of the currently active map presented in the main panel may be visible in a screenshot.

  The **Include border** check box determines whether a border is included around a screenshot.

  The **Transparent background** check box determines whether a screenshot has a transparent background. A screenshot can have a transparent background only if the network visualization or the overlay visualization is selected. A transparent background is supported when copying a screenshot to the clipboard and when saving a screenshot in PDF, PNG, or TIFF format. Other graphic file formats do not support a transparent background.

- **Info**.
  - **Manual**. Use this button to open the VOSviewer manual. This requires an internet connection.
  - **About VOSviewer**. This button brings up the **About VOSviewer** dialog box. This dialog box provides information about VOSviewer. It shows the version number of VOSviewer, a copyright notice, a license text, a link to the VOSviewer website, a list of software libraries used by VOSviewer, the version number of Java, and the amount of memory that is used by VOSviewer.

3.5.2 Items tab

The **Items** tab presents a list of items in the currently active map. By default, a list of all items in the map is presented. However, a filter can be used to restrict the list to a subset of the items in the map. To do so, enter a filter string in the **Filter** text box. This yields a list of all items with a label that contains the filter string.

The **Group items by cluster** check box determines how items are listed. If the check box is unchecked, items are simply listed alphabetically. If the check box is checked, items are first grouped by cluster and then listed alphabetically within each cluster.

By double-clicking on an item on the **Items** tab, it is possible to zoom in on the item in the visualization of the currently active map presented in the main panel.

3.5.3 Analysis tab

The **Analysis** tab can be used to update the layout and the clustering of the currently active map. This is done using the VOS layout technique and the VOS clustering technique.[9] The **Analysis** tab can also be used to change the parameters of these techniques. The following options are available on the **Analysis** tab:

- **Normalization**. Use the normalization method drop down list to determine how the strength of the links between items is normalized. Normalized link strengths are used as input for the VOS layout technique and the VOS

[9] Together these two techniques provide a unified framework for layout and clustering. We refer to Van Eck, Waltman, Dekker, and Van den Berg (2010), Waltman, Van Eck, and Noyons (2010), Waltman and Van Eck (2013), and Van Eck and Waltman (2014) for more information about these techniques.

clustering technique. The following options are available in the normalization method drop down list:

- **No normalization**. If this option is selected, no normalization is performed. We generally do not recommend this option.
- **Association strength**. If this option is selected, the association strength method is used for normalizing the strength of the links between items. Apart from a multiplicative constant, this method is identical to Eq. (6) in Van Eck and Waltman (2009). This option is selected by default.
- **Fractionalization**. If this option is selected, the fractionalization method is used for normalizing the strength of the links between items. Apart from a multiplicative constant, this method is identical to Eq. (13) in Van Eck and Waltman (2009).
- **LinLog/modularity**. If this option is selected, normalization is performed in the same way as in the LinLog layout technique and the modularity clustering technique. For more information about these techniques, we refer to Newman (2004) and Noack (2007, 2009).

- **Layout**.
  - **Attraction** and **Repulsion**. These parameters influence the way in which items are located in a map by the VOS layout technique. The **Attraction** parameter must have an integer value between -9 and +10. The **Repulsion** parameter must have an integer value between -10 and +9. The value of the **Repulsion** parameter must be lower than the value of the **Attraction** parameter. For most purposes, our recommendation is to set the **Attraction** and **Repulsion** parameters to values of, respectively, 2 and 1. Values of 2 and 0 or values of 1 and 0 sometimes also yield good results.
  - **Use default values**. This check box determines whether default values of the attraction and repulsion parameters are used when a new map is created using the **Create Map** wizard (see Subsection 3.5.13.5.4). If the check box is checked, default parameters values are used. These default parameters values depend on the type of map that is created.[10] If the check

[10] The repulsion parameter has a default value of -1 when creating a map of a co-authorship network of authors. It has a default value of 0 when creating a map of a co-occurrence network of keywords or a map of a citation network of documents. In all other cases, the repulsion parameter has a default value of 1. The attraction parameter always has a default value of 2.

box is not checked, the parameter values specified in the **Attraction** and **Repulsion** text boxes are used.

- **Advanced Parameters**. This button brings up the **Advanced Layout Parameters** dialog box. This dialog box can be used to change a number of more advanced parameters of the VOS layout technique. The following parameters are available:
  - **Random starts**. This parameter determines the number of times the optimization algorithm of the VOS layout technique is run. Each time the optimization algorithm is run, a different layout may be obtained. The best layout obtained in all runs of the optimization algorithm is used as the final layout. The higher the value of the **Random starts** parameter, the higher the quality of the final layout that is obtained.
  - **Max. iterations**. This parameter determines the maximum number of iterations performed by the optimization algorithm of the VOS layout technique. The higher the value of the parameter, the higher the quality of the layout that is obtained. In general, the default value of the parameter works well and does not need to be changed.
  - **Initial step size**, **Step size reduction**, and **Step size convergence**. These are technical parameters of the optimization algorithm of the VOS layout technique. The parameters must have values between 0.000001 and 1. In general, the default values of the parameters work well and do not need to be changed.
  - **Random seed**. This parameter determines the seed of the random number generator used by the optimization algorithm of the VOS layout technique. The seed must be a non-negative integer.
- **Update Layout**. This button is available only if information is available about the links between the items in the currently active map. Use this button to update the layout of the currently active map using the VOS layout technique.

- **Clustering**.
  - **Resolution**. This parameter determines the level of detail of the clustering produced by the VOS clustering technique. The parameter must have a non-negative value. The higher the value of the parameter, the larger the number of clusters produced by the VOS clustering technique. We recommend to try out different values for the **Resolution** parameter and to

use the value that yields the most appropriate level of detail for one's purposes.

- **Min. cluster size**. This parameter determines the minimum size of clusters produced by the VOS clustering technique. Each cluster produced by the VOS clustering technique is expected to include at least the minimum number of items specified by this parameter. The **Min. cluster size** parameter can be used to simplify the clustering results obtained from the VOS clustering technique by getting rid of small and uninteresting clusters.
- **Merge small clusters**. This check box determines how the VOS clustering technique handles small clusters. Small clusters are clusters that do not have the minimum cluster size specified by the **Min. cluster size** parameter. If the check box is checked, small clusters are merged into larger clusters. If the check box is not checked, small clusters are discarded and their items have no cluster assignment.
- **Advanced Parameters**. This button brings up the **Advanced Clustering Parameters** dialog box. This dialog box can be used to change a number of more advanced parameters of the VOS clustering technique. The following parameters are available:
  - **Random starts**. This parameter determines the number of times the optimization algorithm of the VOS clustering technique is run. Each time the optimization algorithm is run, a different clustering may be obtained. The best clustering obtained in all runs of the optimization algorithm is used as the final clustering. The higher the value of the **Random starts** parameter, the higher the quality of the final clustering that is obtained.
  - **Iterations**. This parameter determines the number of iterations performed by the optimization algorithm of the VOS clustering technique. The higher the value of the parameter, the higher the quality of the clustering that is obtained. In general, the default value of the parameter works well and does not need to be changed.
  - **Random seed**. This parameter determines the seed of the random number generator used by the optimization algorithm of the VOS clustering technique. The seed must be a non-negative integer.
- **Update Clustering**. This button is available only if information is available about the links between the items in the currently active map. Use this button to update the clustering of the currently active map using the VOS clustering technique.

- **Rotate/flip**.
  - **Rotate**. Use this button to rotate the currently active map. The **Degrees to rotate** parameter determines the number of degrees by which the map is rotated.
  - **Flip Horizontally**. Use this button to flip the currently active map in horizontal direction.
  - **Flip Vertically**. Use this button to flip the currently active map in vertical direction.

3.5.4 Create Map wizard

The **Create Map** wizard can be used to create a new map. There are a number of ways in which a new map can be created. The **Create Map** wizard offers a guide through the various options in a number of steps. A summary of the main options provided by the wizard is presented in Table 1.[11]

As can be seen in Table 1, a map can be created based on network data, bibliographic data, or text data. The choice between these three types of data is made in the first step of the **Create Map** wizard, as shown in Figure 6.

When a map is created based on network data, VOSviewer needs to be provided with information about the items in the network and the links between the items. This information can be made available in a VOSviewer network file, possibly complemented with a VOSviewer map file (see Section 4.1). Alternatively, the information can be made available in a VOSviewer JSON file, in a GML file, or in Pajek files. There are no restrictions on the nature of the items and the links in a network. The items and the links will typically be of a bibliometric nature, but this is not a requirement.

[11] The terminology used in Table 1 is identical to the terminology that is used in the **Create Map** wizard. Elsewhere in this manual, we sometimes use a different terminology. Documents may be referred to as publications, sources as journals, and authors as researchers.

Table 1. Summary of the main options provided by the Create Map wizard for creating a new map.

Type of data	Data source	Links	Items
Network data	VOSviewer map and network files, VOSviewer JSON files, GML files, and Pajek files		
Bibliographic data	APIs Bibliographic database files Reference manager files	Co-authorship	Authors Organizations Countries
		Co-occurrence	Keywords
		Citation	Documents Sources Authors Organizations Countries
		Bibliographic coupling	Documents Sources Authors Organizations Countries
		Co-citation	Cited references Cited sources Cited authors
Text data	APIs Bibliographic database files Reference manager files VOSviewer files	Co-occurrence	Terms

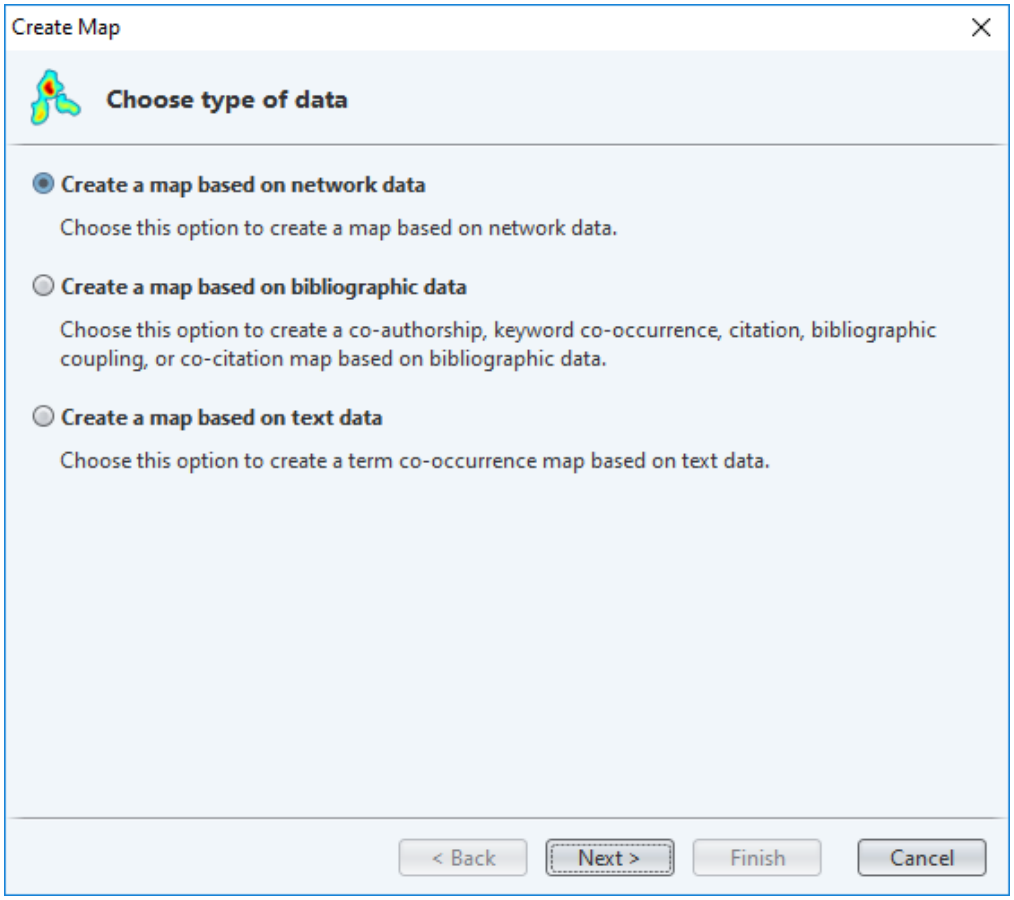

Figure 6. First step of the Create Map wizard.

When a map is created based on bibliographic data or text data, first a network is constructed based on the data that is made available to VOSviewer and then a map is created based on the constructed network. As can be seen in Table 1, different types of networks can be constructed. Bibliographic data can be used to construct a network of co-authorship, co-occurrence, citation, bibliographic coupling, or co-citation links.[12] Depending on the type of link, different types of items are supported, as shown in Table 1. Text data can be used to construct a network of co-occurrence links between terms. As discussed in more detail below, terms are identified in the text data using natural language processing algorithms.

[12] A citation link is a link between two items where one item cites the other. Citation links are treated as undirected by VOSviewer. Hence, no distinction is made between a citation from item A to item B and a citation in the opposite direction. A bibliographic coupling link is a link between two items that both cite the same document. A co-citation link is a link between two items that are both cited by the same document.

Bibliographic data can be downloaded by VOSviewer through an API or the data can be made available to VOSviewer in bibliographic database files and references manager files. VOSviewer supports the APIs of OpenAlex, Crossref, Europe PMC, Semantic Scholar, the OpenCitations Corpus (OCC), the OpenCitations Index of Crossref open DOI-to-DOI citations (COCI), and Wikidata. Furthermore, support is provided for bibliographic database files from Web of Science, Scopus, Dimensions, Lens, and PubMed. Reference manager files from EndNote and RefWorks are supported, in addition to RIS files. APIs, bibliographic database files, and reference manager files can also be used to make text data available to VOSviewer. Text data is obtained from the titles and abstracts of documents. Alternatively, text data can be made available in a VOSviewer corpus file, possibly complemented with a VOSviewer scores file (see Section 4.2).

Below, a number of topics related to the **Create Map** wizard are discussed in more detail.

APIs

The APIs (application programming interfaces) supported by VOSviewer are listed in Table 2. Using these APIs, VOSviewer is able to download data based on which a map can be created. The use of the APIs requires an internet connection. There are four ways in which the APIs can be used. We now briefly discuss each of the four options.

Table 2. APIs supported by VOSviewer.

API	Documentation
OpenAlex	https://docs.openalex.org/how-to-use-the-api/api-overview
Crossref	https://api.crossref.org
Europe PMC	https://europepmc.org/RestfulWebService
Semantic Scholar	https://api.semanticscholar.org
OCC	https://w3id.org/oc/api/v1
COCI	https://w3id.org/oc/index/coci/api/v1
Wikidata	https://w3id.org/oc/index/wikidata/api/v1

The first option is to specify an API request URL. VOSviewer will download data for all documents returned by this request URL. The first option is available only for the OpenAlex, Crossref, and Europe PMC APIs. Only specific URL parameters are

considered. These URL parameters are 'search' and 'filter' for the OpenAlex API, 'query' and 'filter' for the Crossref API, and 'query' for the Europe PMC API. Other URL parameters are ignored. The request URL does not need to include parameters to control paging. Examples of request URLs for the different APIs are provided in Table 3. For more information, we refer to the documentation of the different APIs (see Table 2).

Table 3. Examples of request URLs.

API	Example request URL
OpenAlex	https://api.openalex.org/works?search=vosviewer&filter=type:article,language:en
Crossref	https://api.crossref.org/works?query.bibliographic=vosviewer&filter=type:journal-article
Europe PMC	https://www.ebi.ac.uk/europepmc/webservices/rest/search?query=(TITLE:\"vosviewer\")

The second option is to specify a search query. VOSviewer will download data for all documents that match the specified search criteria. The second option is available only for the OpenAlex, Crossref, and Europe PMC APIs. Moreover, there are various restrictions on the search criteria that can be specified, especially in the case of the Crossref API.

The third option is to provide a set of DOIs to VOSviewer. The DOIs are provided in a DOI file. Any text file that contains DOIs can be used as a DOI file. VOSviewer will identify all DOIs contained in a DOI file. It will then download data for all available documents with a matching DOI. The third option is available for all APIs.

The fourth option is to make an API call outside VOSviewer, to save the data resulting from the API call in a JSON file, and to provide the JSON file as input to VOSviewer. For each API, the documentation (see Table 2) explains how a call to the API can be made. An example in which the Crossref API is called and the resulting data is provided as input to VOSviewer is presented in a blog post available at www.cwts.nl/blog?article=n-r2r294. The fourth option is available for all APIs.

Bibliographic database files

VOSviewer supports five types of bibliographic database files: Web of Science files, Scopus files, Dimensions files, Lens files, and PubMed files.

Web of Science can be accessed at www.webofscience.com. A subscription is required. When exporting data from Web of Science, make sure that the **Web of Science Core Collection** database is selected. We recommend to use the so-

called classic version of Web of Science, since this version offers more extensive possibilities for exporting data than the new version that was introduced recently. To go to the classic version of Web of Science, choose the **Products** option followed by the **Web of Science (Classic)** option. To export data in the classic version of Web of Science, choose the **Export** option followed by **Other File Formats** option, and choose either the **Plain Text** or the **Tab-delimited** file format. Although VOSviewer supports both file formats, we recommend the use of the tab-delimited format. When asked which data elements to download, choose the **Full Record and Cited References** option. Downloading cited reference data is necessary for identifying citation, bibliographic coupling, and co-citation links between items.

Scopus can be accessed at www.scopus.com. A subscription is required. To export data from Scopus, choose the **CSV export** option. (Do not choose the **Download** option!) Make sure that the data is exported in a CSV file and that all data elements are included.

Dimensions can be accessed at www.dimensions.ai. The free version of Dimensions, for which no subscription is needed, can be used. A user account is required. To export data from Dimensions, choose the **Save / Export** option, followed by the **Export for bibliometric mapping** option.

Lens can be accessed at www.lens.org. To export data from Lens, choose the **Export** option. Make sure that the data is exported in a CSV file and that all data elements are included.

PubMed can be accessed at https://pubmed.ncbi.nlm.nih.gov/. To export data from PubMed, choose the **Save** option and the **PubMed** format. Data exported from PubMed cannot be used for identifying citation, bibliographic coupling, and co-citation links between items. Hence, when working with PubMed data, some options in the **Create Map** wizard will not be available.

Different data sources have different limitations for the amount of data that can be exported. Web of Science and Scopus enable users to export data for at most 500 and 2000 documents, respectively. The free version of Dimensions enables users to export data for at most 2500 documents. Larger numbers of documents are supported when a subscription-based version of Dimensions is used. Lens and PubMed enable users to export data for at most 50,000 and 10,000 documents, respectively.

To export larger amounts of data, the data needs to be exported in multiple batches. Each batch needs to be saved in a separate file. To facilitate working with

data exported in multiple batches, VOSviewer offers the possibility to create a map based on data from multiple files. The files must all be from the same data source. Combining data from different data sources is not possible. If there are duplicate documents in the data provided as input to VOSviewer, the documents will automatically be deduplicated.

Reference manager files

VOSviewer supports three types of reference manager files: RIS files, EndNote files, and RefWorks files.

The RIS file format is a general file format for bibliographic data. It is supported by a large number of databases and software tools, such as EBSCOhost, Mendeley, ProQuest, Publish or Perish, and Zotero.

The EndNote and RefWorks file formats are supported by the EndNote and RefWorks reference managers, respectively. They are also supported by other databases and software tools, such as the China National Knowledge Infrastructure.

Data from reference manager files cannot be used for identifying citation, bibliographic coupling, and co-citation links between items.

Thesaurus files

When a map is created based on bibliographic data or text data, there often is a need to perform data cleaning. A VOSviewer thesaurus file can be used for this purpose.

When creating a map based on bibliographic data, a VOSviewer thesaurus file can be used to merge different variants of a source title, an author name, an organization name, a country name, or a cited reference.[13] This may for example be useful when the name of a researcher is written in different ways in different documents (e.g., with the first initial only or with all initials). A VOSviewer thesaurus file can then be used to indicate that different names in fact refer to the same researcher.

When creating a map based on text data, a VOSviewer thesaurus file can be used to merge terms. This may be useful not only for merging synonyms (e.g., 'h-index' and 'Hirsch index'), but also for correcting spelling differences (e.g., 'behavior' and

[13] An alternative approach to data cleaning is the use of the OpenRefine tool available at https://openrefine.org. A tutorial explaining the use of OpenRefine to clean Web of Science or Scopus data can be found at https://bit.ly/2H9l31z.

'behaviour'). In addition, it may also be useful for merging abbreviated terms with full terms (e.g., 'JIF' and 'journal impact factor'). A thesaurus file can also be used to ignore terms. For example, when working with titles and abstracts of scientific publications, one may want to ignore general terms such as 'conclusion', 'method', and 'result'.

We refer to Section 4.3 for a technical discussion of VOSviewer thesaurus files.

Processing of cited references

When constructing citation, bibliographic coupling, or co-citation networks based on Web of Science, Scopus, or Crossref JSON files, VOSviewer needs to process the cited references in these files. This can be a highly challenging task, because cited references may be provided in many different formats and may suffer from various types of ambiguities and inconsistencies. Below we discuss how cited references are processed by VOSviewer.

VOSviewer starts by parsing cited references in order to identify their constituent elements, such as author names, publication years, source titles, volume numbers, and so on. Each of these elements is converted to lower case, so that subsequent processing of cited references is done in a case-insensitive manner. There can be considerable variation in the way in which cited references are formatted, especially when working with Scopus files. Parsing is therefore far from straightforward, and VOSviewer may not always be able to completely parse a cited reference.

After cited references have been parsed, a citation, bibliographic coupling, or co-citation network can be constructed. We first consider the construction of a citation network. To construct a citation network, a so-called match key is created for each cited reference. This is done according to the following three rules:

1. Use as the match key the combination of the name of the first author, the publication year, the volume number, and the begin page number.
2. If no match key has been obtained in step 1, use as the match key the combination of the name of the first author, the publication year, the source title, and if available the begin page number. This rule is applied only if there is no volume number.
3. If no match key has been obtained in steps 1 and 2, use the DOI as the match key.

In rules 1 and 2, only the last name and the first initial are considered in the name of the first author. Also, in rule 2, only the first three alphanumeric characters are considered in the source title. Furthermore, when working with Scopus files, the

begin page number may be replaced by an article number in rule 1. Finally, in the case of Crossref JSON files, rules 1 and 2 are skipped and only rule 3 is applied.

To construct a citation network, VOSviewer also creates two match keys for each document. The first match key is obtained according to rules 1 and 2 described above. The second match key is given by the DOI of a document.

A citation link between two documents is established if one document includes a cited reference that has a match key corresponding with one of the two match keys used to represent the other document.

We now consider the construction of a bibliographic coupling network. Again a match key is created for each cited reference. The rules are the same as described above for the construction of a citation network, except that a fourth rule is added:

4. If no match key has been obtained in steps 1, 2, and 3, use the raw reference string as the match key.

The number of bibliographic coupling links between two documents equals the number of pairs of cited references in the two documents that have the same match key. (This assumes that the default full counting method is used. For more details, see the discussion on full counting vs. fractional counting provided below.) When working with Crossref JSON files, only rules 3 and 4 are used to obtain match keys. Moreover, rule 4 sometimes cannot be used, because raw reference strings are not always available in Crossref JSON files.

When a citation or bibliographic coupling network is constructed at the aggregate level of sources, authors, organizations, or countries, citation or bibliographic coupling links are aggregated from the level of individual documents to the aggregate level. For instance, to calculate the number of bibliographic coupling links between two sources S1 and S2, we consider all pairs of documents D1 and D2 such that D1 has been published in S1 and D2 has been published in S2. The number of bibliographic coupling links between S1 and S2 equals the sum over all pairs D1 and D2 of the number of bibliographic coupling links between D1 and D2.

Finally, we consider the construction of a co-citation network. No match keys are used to construct a co-citation network. When a co-citation network is constructed at the level of cited references, the raw reference strings are used as the unit of analysis. At the level of cited sources, source titles extracted from the raw reference strings are used as the unit of analysis. At the level of cited authors, author names extracted from the raw reference strings are used as the unit of analysis. When working with Web of Science or Crossref JSON files, only first authors are taken into account.

Full counting vs. fractional counting

When a map is created based on bibliographic data, the **Create Map** wizard offers a choice between two counting methods. By default, full counting is used. The alternative is to use fractional counting.

To illustrate the difference between the two counting methods, we consider an example in which a co-authorship network is constructed. As shown in Figure 7, we have four authors, labeled A1, A2, A3, and A4, and three documents, labeled D1, D2, and D3. D1 is authored by A1, A2, and A3, D2 is authored by A1 and A3, and D3 is authored by A2 and A4. The networks constructed using full and fractional counting are presented in Figure 8. We note that the only difference between the two networks is in the strength of the links.

In the full counting network, the link between A1 and A3 has a strength of 2. This indicates that A1 and A3 have co-authored two documents, namely D1 and D2. The other links have a strength of 1, indicating that for each of these links the associated authors have co-authored one document.

The idea of fractional counting is to reduce the influence of documents with many authors. When fractional counting is used, the strength of a co-authorship link between two authors is determined not only by the number of documents co-authored by the authors but also by the total number of authors of each of the co-authored documents. In the case of fractional counting, when an author has co-authored a document with *n* other authors, this yields a strength of 1 / *n* for each of the *n* co-authorship links. The total strength of the *n* co-authorship links then equals 1. This is different from the full counting case, in which each of the *n* co-authorship links has a strength of 1, resulting in a total strength of the *n* co-authorship links of *n*.

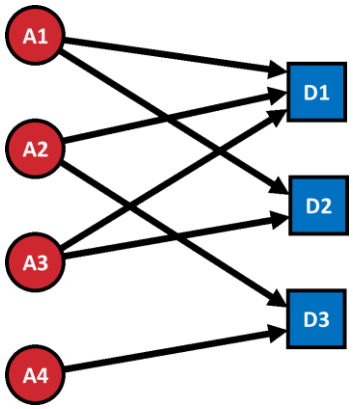

Figure 7. Authorship links between four authors and three documents.

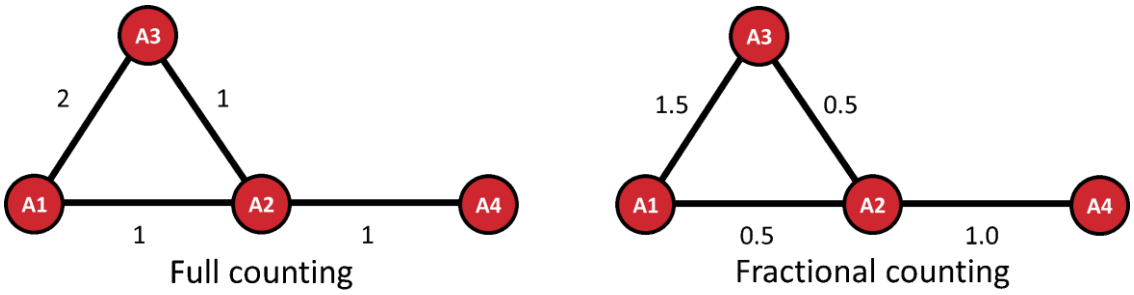

Figure 8. Co-authorship network constructed using full (left) or fractional (right) counting.

As can be seen in Figure 8, in the fractional counting case, the link between A2 and A4 has a strength of 1.0. A2 has co-authored D3 with A4. Because there are no other authors involved, this results in a co-authorship link with a strength of 1 / 1 = 1.0. A2 has co-authored D1 with A1 and A3. In this case, A2 has two co-authors, which results in two co-authorship links with a strength of 1 / 2 = 0.5 each. The link between A1 and A3 has a strength of 1.5. A1 and A3 have co-authored D1 and D2, resulting in co-authorship links with strengths of 0.5 and 1.0, respectively, which yields a total strength of 1.5.

We have now explained the difference between full and fractional counting in the calculation of the strength of co-authorship links. There are similar differences between the two counting methods in the calculation of the strength of co-occurrence, bibliographic coupling, and co-citation links. We refer to Perianes-Rodriguez, Waltman, and Van Eck (2016) for a more in-depth discussion of the differences between full and fractional counting, including a discussion of the advantages and disadvantages of each counting method.

Identification and selection of terms

When a map is created based on text data, terms first need to be identified in the text data and the terms to be included in the map then need to be selected.

The natural language processing algorithms used in the term identification stage assume the text data made available to VOSviewer to be in English. Other languages are not supported. The term identification stage consists of the following five steps:

- *Removal of copyright statements*. In many cases, text data provided to VOSviewer consists of titles and abstracts of scientific publications. Abstracts

may include a copyright statement. VOSviewer removes these copyright statements. We note that this step is carried out only if the **Ignore copyright statements** check box in the **Create Map** wizard is checked.

- *Sentence detection*. A sentence detection algorithm is applied to the text data. Using this algorithm, the text data is split up into sentences. VOSviewer uses the sentence detection algorithm provided by the Apache OpenNLP library.
- *Part-of-speech tagging*. A part-of-speech tagging algorithm is applied to the text data. Using this algorithm, each word is assigned a part of speech, such as verb, noun, adjective, preposition, and so on. VOSviewer uses the part-of-speech tagging algorithm provided by the Apache OpenNLP library.
- *Noun phrase identification*. Noun phrases are identified in the text data. VOSviewer defines a noun phrase as a sequence of one or more consecutive words within a sentence such that the last word in the sequence is a noun and each of the other words is either a noun or an adjective.[14] To identify noun phrases, VOSviewer considers only the longest possible noun phrases that can be found in a sentence. Shorter noun phrases embedded within longer ones are not considered. For example, in the sentence 'The artificial neural network is highly accurate', VOSviewer identifies 'artificial neural network' as a noun phrase, while it does not identify 'neural network' and 'network' as noun phrases. We note that in VOSviewer a noun phrase cannot include a preposition. This for example means that 'degrees of freedom' and 'United States of America' are not identified as noun phrases.
- *Noun phrase unification*. Unification of noun phrases is accomplished by removing most non-alphanumeric characters, by removing accents from characters, by converting upper case characters to lower case, and by converting plural noun phrases to singular. Plural to singular conversion is done by examining the last word in a noun phrase. If the last word is a plural noun, it is converted to singular.

The term identification stage described above yields a set of noun phrases, or terms, that have been identified in the text data made available to VOSviewer. In the second stage, starting from the set of identified terms, a selection of terms is

[14] The following very general adjectives cannot be part of a noun phrase: all, another, any, both, different, each, either, every, few, fewer, fewest, least, less, little, many, more, most, much, neither, other, same, several, some, such, various. Also, if the **Ignore structured abstract labels** check box in the **Create Map** wizard is checked, the following nouns cannot be identified as a noun phrase: aim, background, conclusion, design, discussion, finding, introduction, material, method, objective, purpose, result, setting, summary.

made. The selection is made by excluding terms with a small number of occurrences (e.g., by default, terms with fewer than 10 occurrences are excluded), by excluding terms with a low relevance score, and possibly also by manually excluding certain terms. The selected terms are included in the map that is created.

The use of relevance scores to select terms requires some further explanation. When a map is created based on text data, one typically does not want to include general terms, for example terms such as 'conclusion', 'new method', and 'interesting result'. These terms provide very little information, and the usefulness of a map tends to increase when these terms are excluded. To exclude general terms, VOSviewer calculates for each term a relevance score.[15] Terms with a high relevance score tend to represent specific topics covered by the text data, while terms with a low relevance score tend to be of a general nature and tend not to be representative of any specific topic. By excluding terms with a low relevance score, general terms are filtered out and the focus shifts to more specific and more informative terms. By default, 40% of the terms are excluded based on their relevance score. However, we recommend to also explore the effect of excluding a lower or a higher percentage of terms.

Finally, we need to discuss the consequences of excluding a term. In the term selection stage, when one chooses to exclude a multi-word term, occurrences of this term may be counted as occurrences of a shorter term. To illustrate this, suppose that 'network', 'neural network', and 'artificial neural network' are among the terms identified in the text data made available to VOSviewer. Suppose further that one of the sentences in the text data is the sentence 'The artificial neural network is highly accurate'. As discussed above, only the term 'artificial neural network' is identified in this sentence, not the terms 'neural network' and 'network'. However, suppose now that in the term selection stage one chooses to exclude the term 'artificial neural network'. VOSviewer will then search for a shorter term in the sentence 'The artificial neural network is highly accurate', and it will find the term 'neural network'. If one chooses to exclude this term as well, VOSviewer will search for an even shorter term, in which case it will find the term 'network'. This shows how excluding a multi-word term may cause occurrences of this term to be counted as occurrences of a shorter term.

Custom weight and score attributes

[15] We refer to Van Eck and Waltman (2011) for a brief explanation of the calculation of relevance scores.

When a map is created based on bibliographic data or text data, custom weight and score attributes may be made available. Which custom weight and score attributes are made available depends on the choice of the type of link and the type of item. It also depends on the data source that is used. Citation-related attributes are supported for some data sources but not for others.

The following custom weight attributes may be made available:

- *Occurrences*. When working with keywords, the *Occurrences* attribute indicates the number of documents in which a keyword occurs. When working with terms, the definition of the *Occurrences* attribute depends on the counting method that is chosen in the **Create Map** wizard. In the case of binary counting, the *Occurrences* attribute indicates the number of documents in which a term occurs at least once. In the case of full counting, the *Occurrences* attribute indicates the total number of occurrences of a term in all documents.
- *Documents*. The number of documents published by a source, an author, an organization, or a country.
- *Citations*. When working with co-authorship, citation, or bibliographic coupling links, the *Citations* attribute indicates the number of citations received by a document or the total number of citations received by all documents published by a source, an author, an organization, or a country. When working with co-citation links, the *Citations* attribute indicates the number of citations made to a cited reference, a cited source, or a cited author.
- *Norm. citations*. The normalized number of citations received by a document or the total normalized number of citations received by all documents published by a source, an author, an organization, or a country.[16]

The following custom score attributes may be made available:

- *Pub. year*. The publication year of a document.
- *Avg. pub. year*. The average publication year of the documents in which a keyword or a term occurs or the average publication year of the documents published by a source, an author, an organization, or a country.
- *Citations*. The number of citations received by a document.

[16] The normalized number of citations of a document equals the number of citations of the document divided by the average number of citations of all documents published in the same year and included in the data that is provided to VOSviewer. The normalization corrects for the fact that older documents have had more time to receive citations than more recent documents.

- *Avg. citations*. The average number of citations received by the documents in which a keyword or a term occurs or the average number of citations received by the documents published by a source, an author, an organization, or a country.
- *Norm. citations*. The normalized number of citations received by a document.
- *Avg. norm. citations*. The average normalized number of citations received by the documents in which a keyword or a term occurs or the average normalized number of citations received by the documents published by a source, an author, an organization, or a country.

When a map is created based on text data provided in a VOSviewer corpus file, custom score attributes are made available only if a VOSviewer scores file is provided as well (see Section 4.2 for a discussion of VOSviewer corpus and scores files). In that case, for each score attribute, the score of a term is calculated as the average score of the documents in which the term occurs.

4 File types

In this chapter, we discuss a number of file types supported by VOSviewer. These file types have been designed specifically for VOSviewer. In principle, they are not supported by other software tools.

The file types discussed in this chapter are simple text files that can be viewed and edited using a text editor or a spreadsheet program (e.g., Excel). Files may have multiple columns. Each line in a file then contains multiple fields separated from each other by a comma, a semicolon, or a tab. If a field (e.g., the label of an item) itself contains a comma or a semicolon, the field needs to be enclosed within double quotes.

All example files referred to in this chapter are distributed together with VOSviewer.

4.1 Map and network files

In this section, we discuss map and network files.

4.1.1 Map files

A map file is a text file that contains information about the items in a map. Items are characterized by a number of attributes. Each column in a map file corresponds with an attribute. With the exception of the first line, each line in a map file corresponds with an item. The first line in a map file is a header line that indicates for each of the columns in the file the attribute that is represented by that column. Below, we list the columns that can be included in a map file. For each column, we provide the column header and we describe the corresponding attribute.

id	The ID of an item. Items need to have an ID only if a map file is used in combination with a network file.
label	The label of an item.
sublabel	The sublabel of an item. In the visualization of a map, the sublabel of an item is displayed below the ordinary label of the item. Sublabels are displayed in a smaller font.
description	The description of an item. The description of an item is used to provide information about the item in the information panel. This attribute has a string value that may include HTML formatting.
url	The URL of an item. This attribute can be used to associate a webpage with an item. Clicking on an item in the visualization of a map will cause the webpage associated with the item to be opened in a web browser.
x	The horizontal coordinate of an item.

y	The vertical coordinate of an item.
cluster	The number of the cluster to which an item belongs. This attribute must have an integer value between 1 and 1000.
weight	The weight of an item. This attribute must have a non-negative numerical value. The higher the weight of an item, the more prominently the item is shown in the visualization of a map.
normalized weight	The normalized weight of an item. This attribute must have a non-negative numerical value. The higher the normalized weight of an item, the more prominently the item is shown in the visualization of a map. The default presentation of an item is obtained if the item has a normalized weight of 1. We note that this attribute should be used only in special cases. For most purposes, we recommend not to use it.
score	The score of an item. In the overlay visualization of a map, items can be colored based on their score.
red	The red component of the user-defined color of an item. This attribute must have an integer value between 0 and 255. In the overlay visualization of a map, items can be colored based on their user-defined color.
green	The green component of the user-defined color of an item. This attribute must have an integer value between 0 and 255. In the overlay visualization of a map, items can be colored based on their user-defined color.
blue	The blue component of the user-defined color of an item. This attribute must have an integer value between 0 and 255. In the overlay visualization of a map, items can be colored based on their user-defined color.

A map file always includes only a subset of the above columns. There are a number of restrictions on the columns that can be included in a map file:

- There must be an *id* column or a *label* column. (If there is no *label* column, the ID of an item is used as the label of the item.)
- If there is a *sublabel* column, there must be a *label* column as well.
- The *x* and *y* columns must be used together.
- The *weight* column and the *normalized weight* column cannot be used together.
- The *score* column and the *red*, *green*, and *blue* columns cannot be used together.
- The *red*, *green*, and *blue* columns must be used together.

It is possible to include multiple *weight* and multiple *score* columns in a map file. Each *weight* or *score* column then represents a different weight of score attribute with its own label. For example, a map file may have a *weight*<*Links*> column, a *weight*<*Documents*> column, and a *weight*<*Citations*> column.

For an example of a map file, see the file `journal_map.txt`.

4.1.2 Network files

A network file is a text file that contains information about the links between the items in a map. A network file specifies which pairs of items are connected by a link. It also specifies the strength of each link. The strength of a link is indicated by a positive numerical value.

A network file has either a sparse format or a full format:

- *Sparse format*. In the case of the sparse format, each line in a network file corresponds with a link. A network file has two or three columns. The first two columns specify the IDs of pairs of items that are connected by a link. The third column specifies the strength of a link. If there is no third column, all links have a strength of 1.

  In VOSviewer, there can be only one link between a pair of items. If a network file specifies multiple links between the same pair of items, VOSviewer will combine these links into a single link. The strength of the combined link will be equal to the sum of the strengths of the individual links in the network file.

  For an example of a network file in the sparse format, see the file `journal_network_sparse.txt`.

- *Full format*. In the case of the full format, a network file contains the entire adjacency matrix of a network. The adjacency matrix of a network is a square matrix that indicates for each pair of items in the network the strength of the link between the items. If an element of the adjacency matrix equals 0, this indicates that there is no link between the corresponding items. In the case of a network consisting of n items, a network file has n lines and $n + 1$ columns. The element in the ith row and the jth column of the adjacency matrix is specified on the ith line and in the $(j + 1)$th column in the network file. The first column in the network file contains IDs of items. This column specifies for each row and column of the adjacency matrix the ID of the corresponding item.

  Networks are required to be undirected in VOSviewer. An undirected network has a symmetrical adjacency matrix. If a network file contains an asymmetrical adjacency matrix, VOSviewer will average the values of corresponding elements on both sides of the main diagonal of the matrix.

  For an example of a network file in the full format, see the file `journal_network_full.txt`.

In general, we recommend to use the sparse format. When information about the links between the items in the currently active map is saved in a network file (using the **Save** button on the **File** tab in the action panel; see Subsection 3.5.1), VOSviewer also uses the sparse format.

A network file is usually used in combination with a map file. For each ID of an item in the network file, there must then be a corresponding ID in the map file.

4.2 Corpus and scores files

In this section, we discuss corpus and scores files.

4.2.1 Corpus files

A corpus file is a text file that contains on each line the text of a document. The text of a document must be in English, since the natural language processing algorithms used by VOSviewer (see Subsection 3.5.4) do not support other languages. If documents are scientific publications, the text of a document may for example consist of the concatenation of the title and the abstract of a publication. Unlike the other file types discussed in this chapter, a corpus file does not have multiple columns.

For an example of a corpus file, see the file `corpus.txt`.

4.2.2 Scores files

A scores file is a text file that contains scores of documents.[17] A scores file is used in combination with a corpus file. The number of columns in a scores file equals the number of score attributes. The number of lines in a scores file equals the number of lines in the associated corpus file plus one. The first line in a scores file is a header line. Each column has a header *score*<*...*>, where *...* is replaced by the label of a score attribute. Each of the remaining lines in a scores file corresponds with a document. The second line in a scores file contains the scores of the first document. It corresponds with the first line in the associated corpus file. The third line in a scores file contains the scores of the second document. It corresponds with the second line in the associated corpus file. And so on.

[17] Score attributes in a scores file are assumed to have a ratio or an interval scale. Hence, if the difference between the scores of items *u* and *v* equals the difference between the scores of items *x* and *y*, the difference between items *u* and *v* is regarded as equally large as the difference between items *x* and *y*.

If a scores file contains only one score attribute, the file does not need to have a header line. The number of lines in the scores file then equals the number of lines in the associated corpus file.

For an example of a scores file, see the file `scores.txt`.

4.3 Thesaurus files

A thesaurus file is a text file that can be used to perform data cleaning when creating a map based on bibliographic data or text data (see Subsection 3.5.4). A thesaurus file has two columns, a *label* column and a *replace by* column. The first line in a thesaurus file is a header line containing column headers. With the exception of the first line, each line in a thesaurus file specifies a label (in the *label* column) and an alternative label (in the *replace by* column), indicating that the label is to be replaced by the alternative label. The label may for example represent a source title, an author name, a cited reference, or a term. If no alternative label is specified (i.e., the *replace by* column is empty), the label will not be replaced by an alternative label, but instead it will be ignored. When a map is created based on text data, this for example allows a thesaurus file to be used to ignore certain terms.

For examples of thesaurus files, see the files `thesaurus_authors.txt` and `thesaurus_terms.txt`.

4.4 Cluster colors, overlay colors, and density colors files

In this section, we discuss cluster colors, overlay colors, and density colors files.

4.4.1 Cluster colors files

A cluster colors file is a text file that contains colors of clusters. With the exception of the first line, each line in a cluster colors file corresponds with a cluster. The first line in a cluster colors file is a header line containing column headers. A cluster colors file has four columns, a *cluster* column, a *red* column, a *green* column, and a *blue* column. The *cluster* column contains cluster numbers. A cluster number must be an integer between 1 and 1000. The *red*, *green*, and *blue* columns contain the red, green, and blue components of the colors of clusters. Each color component must have an integer value between 0 and 255.

For an example of a cluster colors file, see the file `cluster_colors.txt`.

4.4.2 Overlay colors files

An overlay colors file is a text file that contains color values and colors. An overlay colors file has the same format as a cluster colors file except that instead of a *cluster* column it has a *color value* column, containing numerical values between 0 and 1.

In the overlay visualization of a map (see Subsection 3.1.2), items can be colored based on their score. The color of an item is then determined in two steps. In the first step, the score of an item is transformed into a color value. A score between the minimum and maximum scores specified in the **Set Overlay Colors Range** dialog box (see Section 3.2) is transformed linearly into a color value between 0 and 1. A score below the minimum score or above the maximum score is transformed into a color value of 0 or 1, respectively. In the second step, the color of an item is determined by matching the color value of the item with the color values in an overlay colors file. Exact matching of color values usually is not possible. The color of an item is then determined by interpolating between two colors in an overlay colors file.

For an example of an overlay colors file, see the file `overlay_colors.txt`.

4.4.3 Density colors files

A density colors file is a text file that contains color values and colors. A density colors file has the same format as an overlay colors file.

In the item density visualization of a map (see Subsection 3.1.3), the color of a point in the visualization is determined by the density of items at that point. This is done in two steps. In the first step, the density of items at a point is transformed into a color value. The higher the density of items, the higher the color value. In the second step, the color of a point is determined by matching the color value of the point with the color values in a density colors file. Exact matching of color values usually is not possible. The color of a point is then determined by interpolating between two colors in a density colors file.

For an example of a density colors file, see the file `density_colors.txt`.

5 Advanced topics

In this chapter, a number of advanced topics are addressed. We first consider the use of command line parameters (Section 5.1). We then discuss how a map can be made available online (Section 5.2) and how the amount of memory available to VOSviewer can be increased (Section 5.3).

5.1 Using command line parameters

VOSviewer supports a large number of command line parameters. These parameters can for example be used to automatically open a map when VOSviewer is started or to override some of the default settings of VOSviewer. The command line parameters supported by VOSviewer are listed below.

Command line parameters for opening or creating a map

gml	Use this parameter to specify a GML file. This file will be used to open or create a map when VOSviewer is started.
json	Use this parameter to specify a VOSviewer JSON file. This file will be used to open or create a map when VOSviewer is started.
map	Use this parameter to specify a VOSviewer map file (see Subsection 4.1.1). This file contains information about the items in a map. The file will be used to open or create a map when VOSviewer is started.
network	Use this parameter to specify a VOSviewer network file (see Subsection 4.1.2). This file contains information about the links between the items in a map. The file will be used to open or create a map when VOSviewer is started.
pajek_network	Use this parameter to specify a Pajek network (or matrix) file. This file will be used to open or create a map when VOSviewer is started.
pajek_partition	Use this parameter to specify a Pajek partition file. This file contains cluster numbers of the items in a map. The file will be used to open or create a map when VOSviewer is started.
pajek_vector	Use this parameter to specify a Pajek vector file. This file contains weights of the items in a map. The file will be used to open or create a map when VOSviewer is started.

Command line parameters for creating a term co-occurrence map based on a corpus file

corpus	Use this parameter to specify a VOSviewer corpus file (see Subsection 4.2.1). This file will be used to create a term co-occurrence map when VOSviewer is started.
counting_method	Use this parameter to specify the counting method to be used to create a term co-occurrence map (1 for binary counting and 2 for full counting).

min_n_occurrences Use this parameter to specify the minimum number of occurrences that a term must have to be included in a term co-occurrence map.

n_terms Use this parameter to specify the number of terms to be included in a term co-occurrence map. VOSviewer will select the terms that are considered most relevant.

scores Use this parameter to specify a VOSviewer scores file (see Subsection 4.2.2). When a term co-occurrence map is created when VOSviewer is started, this file will be used to calculate scores of terms.

thesaurus Use this parameter to specify a VOSviewer thesaurus file (see Section 4.3). When a term co-occurrence map is created when VOSviewer is started, this file will be used to merge synonyms into a single term.

Command line parameters for saving a map

save_gml Use this parameter to specify a GML file. When a map is opened or created when VOSviewer is started, the map will be saved in this file.

save_json Use this parameter to specify a VOSviewer JSON file. When a map is opened or created when VOSviewer is started, the map will be saved in this file.

save_map Use this parameter to specify a VOSviewer map file (see Subsection 4.1.1). When a map is opened or created when VOSviewer is started, information about the items in the map will be saved in this file.

save_network Use this parameter to specify a VOSviewer network file (see Subsection 4.1.2). When a map is opened or created when VOSviewer is started, information about the links between the items in the map will be saved in this file.

save_pajek_network Use this parameter to specify a Pajek network (or matrix) file. When a map is opened or created when VOSviewer is started, the map will be saved in this file.

save_pajek_partition Use this parameter to specify a Pajek partition file. When a map is opened or created when VOSviewer is started, the cluster numbers of the items in the map will be saved in this file.

save_pajek_vector Use this parameter to specify a Pajek vector file. When a map is opened or created when VOSviewer is started, the weights of the items in the map will be saved in this file.

Command line parameters for saving a screenshot

save_screenshot_bmp Use this parameter to specify a BMP file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_emf Use this parameter to specify an EMF file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_eps Use this parameter to specify an EPS file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_gif Use this parameter to specify a GIF file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_jpg Use this parameter to specify a JPG file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_pdf Use this parameter to specify a PDF file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_png Use this parameter to specify a PNG file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_svg Use this parameter to specify an SVG file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_swf Use this parameter to specify an SWF file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

save_screenshot_tiff Use this parameter to specify a TIFF file. When a map is opened or created when VOSviewer is started, a screenshot of the map will be saved in this file.

Command line parameters related to the layout and clustering techniques

attraction Use this parameter to specify the initial value of the **Attraction** text box on the **Analysis** tab in the action panel.

largest_component The network of links between items may consist of multiple components. Use this parameter to indicate that only items included in the largest component must be kept when the layout technique is run when VOSviewer is started.

merge_small_clusters Use this parameter to specify the initial value of the **Merge small clusters** check box on the **Analysis** tab in the action panel ('true' for checked and 'false' for unchecked).

min_cluster_size Use this parameter to specify the initial value of the **Min. cluster size** text box on the **Analysis** tab in the action panel.

repulsion Use this parameter to specify the initial value of the **Repulsion** text box on the **Analysis** tab in the action panel.

resolution Use this parameter to specify the initial value of the **Resolution** text box on the **Analysis** tab in the action panel.

run_clustering Use this parameter to indicate that the clustering technique must be run when a map is opened or created when VOSviewer is started (even if a clustering is already available).

run_layout Use this parameter to indicate that the layout technique must be run when a map is opened or created when VOSviewer is started (even if a layout is already available).

skip_clustering Use this parameter to indicate that the clustering technique must not be run when a map is opened or created when VOSviewer is started.

Visualization-related command line parameters

black_background Use this parameter to specify the initial value of the **Black background** check box in the options panel ('true' for checked and 'false' for unchecked).

circles_frames Use this parameter to specify how items are represented in the network

	visualization and the overlay visualization (1 for circles and 2 for frames).
cluster_colors	Use this parameter to specify a VOSviewer cluster colors file (see Subsection 4.4.1). Cluster colors will be imported from this file when VOSviewer is started.
colored_lines	Use this parameter to specify the initial value of the **Colored lines** check box in the options panel ('true' for checked and 'false' for unchecked).
curved_lines	Use this parameter to specify the initial value of the **Curved lines** check box in the options panel ('true' for checked and 'false' for unchecked).
density	Use this parameter to specify whether the item density visualization or the cluster density visualization is selected in the density visualization (1 for item density visualization and 2 for cluster density visualization).
density_colors	Use this parameter to specify a VOSviewer density colors file (see Subsection 4.4.3). Density colors will be imported from this file when VOSviewer is started.
density_visualization	Use this parameter to select the density visualization when VOSviewer is started.
kernel_width	Use this parameter to specify the initial value of the **Kernel width** slider in the options panel.
label_size_variation	Use this parameter to specify the initial value of the **Size variation** slider for labels in the options panel.
line_size_variation	Use this parameter to specify the initial value of the **Size variation** slider for lines in the options panel.
max_label_length	Use this parameter to specify the initial value of the **Max. length** text box in the options panel.
max_n_lines	Use this parameter to specify the initial value of the **Max. lines** text box in the options panel.
max_score	Use this parameter to specify the initial value of the **Max. score** text box in the **Set Overlay Colors Range** dialog box.
min_line_strength	Use this parameter to specify the initial value of the **Min. strength** text box in the options panel.
min_score	Use this parameter to specify the initial value of the **Min. score** text box in the **Set Overlay Colors Range** dialog box.
network_visualization	Use this parameter to select the network visualization when VOSviewer is started.
overlay_colors	Use this parameter to specify a VOSviewer overlay colors file (see Subsection 4.4.2). Overlay colors will be imported from this file when VOSviewer is started.
overlay_visualization	Use this parameter to select the overlay visualization when VOSviewer is started.
scale	Use this parameter to specify the initial value of the **Scale** slider in the options panel.

scores_normalization — Use this parameter to specify the option that is initially selected in the **Normalize scores** drop down list in the **Set Overlay Colors Range** dialog box (1 for **Do not normalize**, 2 for **Divide by mean**, 3 for **Subtract mean**, and 4 for **Subtract mean and divide by st. dev.**).

show_item — Use this parameter to zoom in on a specific item when VOSviewer is started. The item is indicated by its ID.

white_background — Use this parameter to specify the initial value of the **White background** check box in the options panel ('true' for checked and 'false' for unchecked).

zoom_level — Use this parameter to specify the initial zoom level in the main panel. The higher the zoom level, the more the main panel will be zoomed in on the center of a map. The zoom level must have a value of at least 1. This is also the default value.

Interaction-related command line parameters

pan_step_size — Use this parameter to specify the step size for scrolling through a map in the main panel using the navigation buttons or the keyboard. The default value is 0.25.

zoom_speed — Use this parameter to specify the speed for zooming in and out in the main panel using the right mouse button. The default value is 0.01.

zoom_step_size — Use this parameter to specify the step size for zooming in and out in the main panel using the mouse wheel, the navigation buttons, or the keyboard. The default value is 0.2.

Miscellaneous command line parameters

encoding — Use this parameter to specify the character encoding that is used by VOSviewer to read and write text files. For a list of the available encodings, see https://docs.oracle.com/javase/8/docs/technotes/guides/intl/encoding.doc.html. If this parameter is not used, VOSviewer will attempt to automatically recognize the correct encoding when reading a text file (which in some cases may result in the use of an incorrect encoding).

file_location — Use this parameter to specify the folder that is used by VOSviewer as the default file location.

To use the above command line parameters, VOSviewer needs to be run from the command line. When the Windows executable of VOSviewer is used, this can for example be done as follows:

```
VOSviewer –map map.txt –density_visualization –zoom_level 2.5
```

Using these command line parameters, the map in the VOSviewer map file `map.txt` will be opened when VOSviewer is started. Also, the density visualization will be selected, and the main panel will be zoomed in on the center of the map. When instead of the Windows executable of VOSviewer the VOSviewer JAR file is used, VOSviewer can for example be run in the following way:

```
java –jar VOSviewer.jar –map map.txt –density_visualization
   –zoom_level 2.5
```

We note that some command line parameters cannot be used together. For example, the `map` and `pajek_network` parameters and the `map` and `corpus` parameters cannot be used together. On the other hand, some parameters can be used only in combination with other parameters. The `pajek_partition` parameter for example can be used only in combination with the `pajek_network` parameter. Similarly, the `counting_method` parameter can be used only in combination with the `corpus` parameter.

5.2 Making a map available online

There are two ways in which a map can be made available online. The first approach is to use the **Share** button on the **File** tab in the action panel. This approach makes use of VOSviewer Online, a web-based version of VOSviewer. We refer to Subsection 3.5.1 for more information about this approach. The second approach makes use of the regular version of VOSviewer. This approach is discussed below. The first approach is simpler and offers a better user experience. We therefore recommend to use this approach. We discuss the second approach mainly because it was used a lot in the past, when the first approach was not yet available.

To make a map available online, a VOSviewer map file and a VOSviewer network file (or only a VOSviewer map file) need to be made available at an online location. Suppose these files are made available at

```
https://www.example.com/map.txt
```

and

```
https://www.example.com/network.txt
```

The following URL can then be used to open the map in VOSviewer:

```
https://www.vosviewer.com/vosviewer.php?map=https://www.example.com/ma
   p.txt&network=https://www.example.com/network.txt
```

The command line parameters discussed in Section 5.1 can also be used in a URL. For example, to open a map, to select the density visualization, and to zoom in on the center of the map, the following URL can be used:

```
https://www.vosviewer.com/vosviewer.php?map=https://www.example.com/ma
   p.txt&network=https://www.example.com/network.txt&density_visualiza
   tion&zoom_level=2.5
```

URLs for opening a map in VOSviewer tend to be quite lengthy. It may therefore be convenient to create simplified URLs using a URL shortener (e.g., https://bitly.com, https://rebrandly.com, or https://tinyurl.com).

5.3 Increasing the availability of memory

When using VOSviewer with large amounts of data, the memory requirements may be substantial. If there is not enough memory available, an out of memory error will occur. However, it may be possible to increase the amount of memory that is available to VOSviewer. This can be done by running the VOSviewer JAR file from the command line and by specifying the amount of memory that one would like to be available to VOSviewer. For example, if one would like 4000 MB of memory to be available to VOSviewer, the VOSviewer JAR file can be run as follows:

```
java –Xmx4000m -jar VOSviewer.jar
```

We note that the **About VOSviewer** dialog box (see Subsection 3.5.1) shows both the amount of memory that is used by VOSviewer and the amount of memory that is available to VOSviewer.

When working with large amounts of data, it is also possible that a stack overflow error will occur. The stack size then needs to be increased. This can be done by running the VOSviewer JAR file from the command line in the following way:

```
java -Xss1000k -jar VOSviewer.jar
```

In this case, the stack size is set to 1000 KB, but other values are possible as well.

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