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Authoring and Reviewing Bibliographies: Design and Development of a Visual Analytics Online Platform

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ABSTRACT Researchers are daily engaged in bibliographic tasks concerning literature search and review, both in the role of authors of scientific papers and when they are reviewers or evaluators. Current indexing platforms offer powerful tools for searching bibliographic references, but in general they poorly support the integration, visualization and comparative analysis of metadata coming from subsequent searches. To address these issues, we designed and realized VisualBib^(va), an online analytics solution, where a visual environment includes analysis control, bibliography exploration, automatic metadata extraction and metrics visualization for real-time scenarios. Starting from an analysis of tasks, associating them to different user *roles*, this study enabled us to define a taxonomy of *tasks*, strictly linked to a set of system *requirements* for our platform. We introduce and discuss here some relevant functions through two usage scenarios related to the creation and the review of a bibliography. The maturity of the system implementation has allowed us to propose a set of evaluation activities, both carried out by two groups of users with different levels of experience in managing bibliographies, and to collect detailed results based on specific tasks and on general aspects of our framework. VisualBib^(va) proved an effective and efficient system for the authoring and reviewing processes of a bibliography.

INDEX TERMS Information visualization, bibliography evaluation, bibliography exploration, bibliometrics, visual analytics.

I. INTRODUCTION

The production of scientific papers is following a rising trend, particularly for scientific disciplines, with an increasing number of works for a researcher to cope with when proposing or reviewing a novel contribution. As a consequence, some bibliographic activities like the construction, refinement, evaluation and analysis of a bibliographic corpus, are becoming key tasks in many fields [1] and researchers spend a considerable portion of their time on them. In this context, one of the main tasks to accomplish is to collect (and analyze) the state of the art in a specific research field and contextualize the contributions about it. Moreover, different users could assign different relevance to a characteristic of a bibliography [2], [3]: an author might be more interested in the building of a bibliography, identifying novel works

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to include in it and then evaluating its properties; while a reviewer could be more focused on the properties themselves as a way of assessing its quality. Furthermore, considering that for each of the potentially citable works there is a plethora of information and indicators that describe its quality [4], the managing of this information can be a complex activity for a user. With this research, we intended to design a tool that provides users with both real-time searches and, at the same time, the management and the integration of the results in a bibliography allowing visual exploration and analysis of the collected metadata.

In a previous paper [5], we proposed a first conceptual model for managing bibliographic metadata based on a formal extension of *zz*-structure [6], [7], and elaborating a first visual interface aimed at the pure visualization of those data. Starting from the results of the evaluation conducted on this initial study, in this paper we propose a more articulated platform where we have completely reformulated the original

proposal concerning the available functions, environments, and metadata, using an approach based on visual analytics to better support the authoring and reviewing processes of a bibliography. VisualBib^(va) is a real-time visual analytics platform that supports different user roles in accomplishing bibliographic tasks, ranging from the creation of a bibliography to the evaluation of 7 bibliographic corpora of authors, making sense of their information and helping users to improve the quality of a bibliography. Among the original contributions of this work are:

- A taxonomy of user roles and tasks, which are at the basis of a set of system requirements that any bibliographic platform could satisfy;
- A usable visual analytics environment. Starting from the taxonomy, we have worked on the back-end of the platform and designed a rich visual environment that collects data from some of the major scientific indexing systems (Elsevier Scopus, OpenCitations, and Cross-Ref/Orcid) and supports bibliographic analysis, construction and exploration, providing details, metadata and metrics on papers and authors, and advanced visual modalities for interacting with the system;
- A deep evaluation. We have designed and implemented evaluation activities, ranging on three main coordinates: the presentation of *two usage scenarios*; an *expert evaluation*; a *task-based user evaluation*.

This paper is structured as follows: Section II illustrates related work; Section III is about the proposed taxonomy of user roles and tasks, and the interconnected requirements; Section IV presents the proposed solution; Section V considers two usage scenarios, while the user's evaluation is described in Section VI. Conclusions and future work end the paper.

II. RELATED WORK

Bibliometric data and analysis of research production are meaningful topics of research for information visualization and, later, visual analytics: specifically, several works have been dedicated to data on research productivity [8], analysis of scientific communities and topics [9], fine-grained analysis [10], or visual narration [11] of an author's career. The used approaches may be divided into different categories according to the data they handle, as extensively reported in the survey by Federico *et al.* [1]: among them, we single out the category that includes approaches using only paper metadata, and the one that focuses on the paper's textual content [12]. VisualBib^(va) is a solution belonging to the first category.

Most existing systems - Biblioviz [13], Citeology [14], Citewiz [3], CitNetExplorer [15], PaperQuest [16], PaperLens [17], PaperVis [18], PivotPaths [19] - *are no longer under active development* (exceptions are Citespace [20], [21], Cocoa [22], and VosViewer [4], which are currently active), and query *pre-built, static datasets*. Some of them have been specially dedicated to collect specific metadata,

for example from past editions of the IEEE VIS conferences (Vispubdata [23]), or have been tested on specific contests (like, PaperVis [18] on the Infovis 2004 Contest dataset).

Generally, they provide *overviews of large corpora* of bibliographic data (VOSViewer [4] on more than 5,000 papers) and metrics on them, and have as their main aim to identify trends in scientific literature [17], [20], look at the genealogy of a publication [14], identify the importance of a paper using the chain of its citations [3], characterize research areas and their evolution, and highlight the relationships between two or more authors [13]. They do not focus on the process of building and reviewing a single bibliography. For example, in [24], VOSViewer has been used to identify the publication trend of a specific field in the decade 2010-2019, collecting data from Scopus.

Several of them propose different visualization paradigms, such as node-link diagrams and heatmaps [4], [18], [20], tables and networks [13], generalized fish-eye views [14], and interactive visualizations of structural and temporal patterns [21]. However, the co-existence of a variety of views could negatively affect usability. Interesting is the approach proposed by PivotPaths [19], which presents an interactive visualization for exploring faceted information resources, instantiated on data coming from academic publications: the technique is general and allows users to explore multiple facets at the same time. Similarly, Cocoa [22] integrates co-citation and co-authorship information in the same visualization. We apply aspects of this technique in our work for visualizing multiple elements of a bibliography (e.g., subject areas, keywords) while we keep this kind of interaction and selection separated. VIS Author Profiles [25] uses natural language text combined with visualizations for presenting an author-centric analysis of publication records, and exploring the profiles of researchers. A visually based browsing experience is provided by Forager [26], which allows users to rapidly explore large collections of research documents, using a sample corpus of 5,055 papers published at the ACM CHI and UIST conferences.

VisualBib^(va) is a general platform, not limited to specific contexts; it extracts metadata in real-time by API (Application Programming Interface); it supports users in the construction and enrichment of a bibliography, offering a holistic and visual representation for it; it proposes tools and metrics for bibliographic analysis and exposes details on whole bibliographies and on papers/authors.

Lastly, for what concerns enterprise solutions, two main tool families are proposed: online academic platforms and reference manager systems. While many of these systems, like A-Miner [27] and Microsoft Academic [28], are very rich in terms of available data and propose in some cases an interesting visualization for author's metadata and co-authorship networks, they do not specifically support the management and refinement of individual bibliographies. We foresee this typology of systems as possible future data sources. On the other hand, there are reference manager tools that support different aims, from creating and managing references in

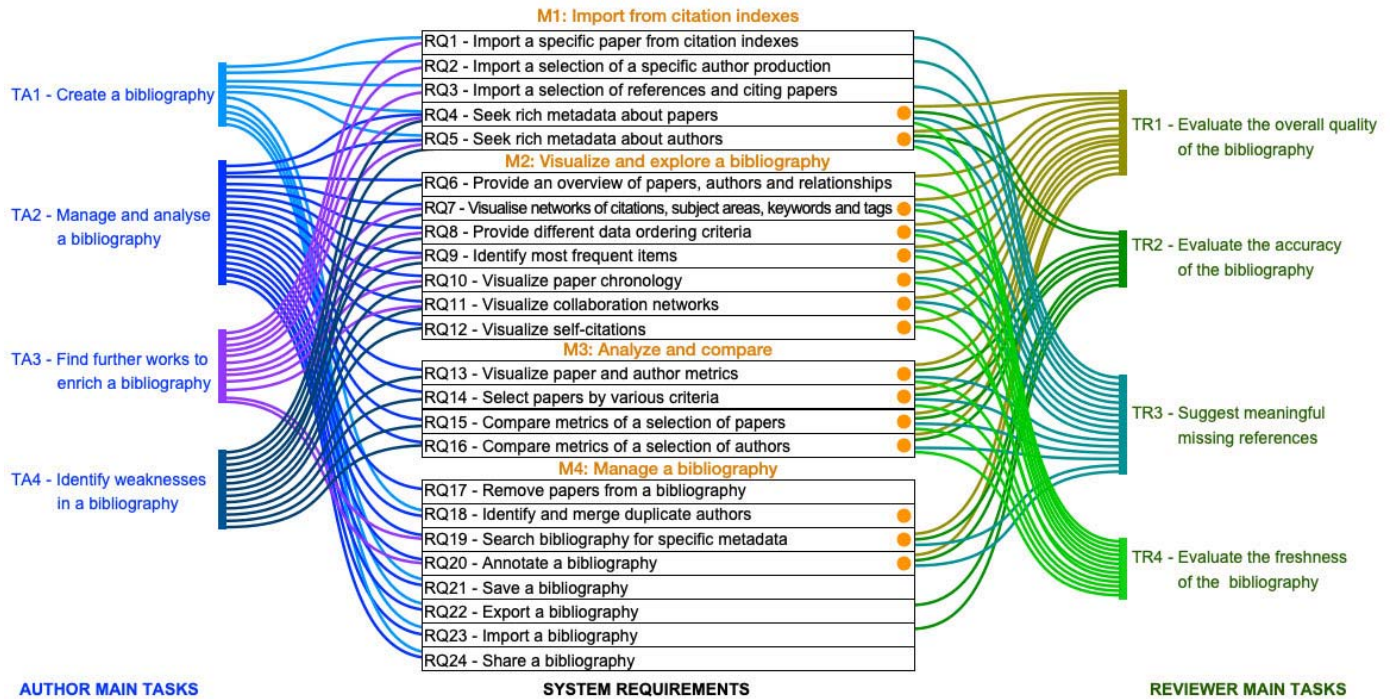


FIGURE 1. A sankey diagram for our taxonomy of tasks, roles, and system requirements. The requirements marked with an orange circle are new and not supported in [5].

different formats (e.g., BibBase, BibDesk) to searching for interesting articles and producing bibliographies for scientific publications (e.g., EndNote, Refworks, Mendeley, Read-Cube, Zotero) [29], [30]. Although these systems share with VisualBib^(va) the final goal of managing a bibliography, they are limited in terms of visual representation and usually work with tabular data and fast search functionalities. In this sense, we think that VisualBib^(va) provides a contribution for overcoming existing limitations, providing functionalities of visual exploration and analysis.

III. TAXONOMY OF USER ROLES AND TASKS AND SYSTEM REQUIREMENTS

Scholars are daily involved in operations on bibliographic references [31]; when they write, review or evaluate a paper, they take up different scientific roles, which require them to perform sets of specific tasks. We started from their analysis to identify the requirements that any bibliographic platform could satisfy. According to current literature [1]–[3], [16], we identified three main classes of user roles, characterized by the following specific tasks:

- *Author* is usually tasked with creating a new bibliography (TA1), managing and analyzing (TA2), expanding an existing one with novel works (TA3), or finding out possible weaknesses in it (TA4).
- *Reviewer* has the general task of evaluating the quality of a paper under review. This activity contextualizes the quality assessment of the proposed bibliographic materials. Typical questions to be answered are: “How is the overall quality of the bibliography?” (TR1); “Are references accurate?” (TR2); “Do any

missing references exist?” (TR3); “How timely are the references?” (TR4).

- *Evaluator* is in charge of analyzing the whole scientific production of one or more authors in order to assess their work. Evaluator is usually tasked with identifying a pool of candidate authors (TE1), evaluating them comparatively (TE2), expressing filtering constraints (TE3) and collectively assessing the quality of a set of profiles (TE4), as in a selection stage for a steering committee or a professional qualification. In this paper, we focus our attention on the first two roles and will not consider the evaluator, which is not explicitly supported by current VisualBib^(va).

In order to define the set of atomic requirements for our system, we have considered the contributions coming from papers that explicitly listed requirements for a literature review activity, such as [32], that collected, through a qualitative user study, high-level requirements and recommendations for visualizing the literature knowledge domain. Furthermore, we have analyzed the 51 feedbacks collected in [5], ranging from user experience to usage convenience. Among them we can cite, for example, “I suggest to enable users to...”: “visualize collaboration network”; “see all the documents of a certain type as highlighted (journal, conference or book, same year, same author) with one click”; “visualize subject areas and keywords”; “apply ordering criteria for choosing and selecting papers”; “tag or annotate a paper”; “visualize and compare metrics on papers and authors”, “seek rich metadata from citation indexes”.

As a result, we have identified the 24 system requirements that we list in the taxonomy of Figure 1: on the left, we show

the typical tasks of an author, while on the right are those of reviewers; in the center, the system requirements needed to realize the tasks. We have organized these requirements in 4 macro-areas:

M1 - Import from citation indexes groups the requirements related to importing a specific paper or a selection from the production of an author, or, starting from a paper, references or citing papers; furthermore, a mechanism that enables the system to seek and upload rich metadata for papers and authors is needed.

M2 - Visualize and explore a bibliography adds to the previous interconnected overview of papers and authors a set of requirements not only for visualizing the citation networks but also for grouping papers by subject areas or keywords, automatically extracted by the indexing platforms or through personal and customized tags, which may be input by users.

M3 - Analyze and compare contains the requirements related to the visualization of metrics and the introduction of tools for comparing authors and papers, but also for applying ordering criteria on the loaded metadata.

M4 - Manage a bibliography identifies more basic requirements (e.g., save, import/export, share a bibliography) but also introduces advanced requests to identify duplicated authors and looks for specific metadata.

IV. THE VISUALBIB^(va) PLATFORM

In this section we describe the system architecture of the VisualBib^(va) platform (Subsection IV-A), freely available at <http://visualbib.uniud.it>, focusing our attention on its visual environment (Subsection IV-B).

A. SYSTEM ARCHITECTURE

VisualBib^(va) is a single page Web application, based on W3C standard languages such as HTML5, CSS3 and SVG, Javascript ES6; it adopts the D3.js [33] framework for data and DOM manipulation, and visual elements management; it uses AJAX technology to perform Cross Origin Resource Sharing (CORS) calls and client-server interactions. The architecture of VisualBib^(va) is organized in three main modules, as shown in Figure 2:

- *Data Sources.* VisualBib^(va) retrieves metadata in real-time from four existing bibliographic indexes,

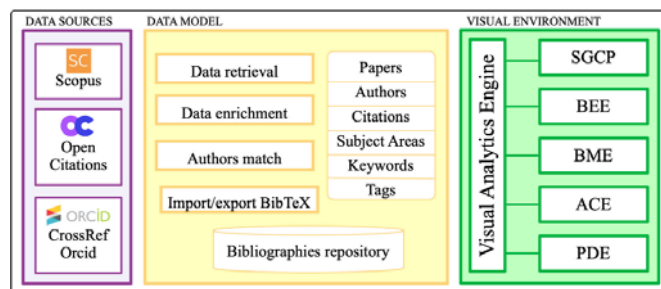


FIGURE 2. VisualBib^(va)'s architecture.

i.e., Scopus, OpenCitations, and CrossRef/Orcid, using dedicated API. To query Scopus, being a commercial service, it is necessary to use the platform from a subscriber's domain. The choice of interfacing our platform with these four specific citation indexes derives from the availability of a set of API, which are free to consult for clients; however, the system is modular, extensible, and we plan to interface with other existing popular indexes, such as Web of Science, Microsoft Academic, Google Scholar, aMiner, PubMed.

- *Data Model.* The data model uses zz-structures [6], [7], [34] for representing metadata about papers, authors, citations, subject areas, keywords and tags. Specialized modules support data retrieval from sources and data enrichment, applying the seek metadata and authors match functionalities, and enable users, at present, to import and export bibliographies in BibTeX format. We have planned to extend the import/export functionalities to other standard interchange formats, such as RIS (Research Information Systems), or CSV (Comma-Separated Values).
- *Visual Environment.* With its five main panels, this module (illustrated below) manages visualizations and interactions through the Visual Analytics Engine, applying the well-known visual analytics cycle [35], [36].

B. VISUAL ENVIRONMENT

An overview of the whole environment can be seen in Figure 3.¹

SGCP - Sources & General Commands Panel. At the top we have the SGCP, mainly dedicated to macro-areas M1 and M4 of our taxonomy. Starting from the left, it is possible to select one of the sources (Elsevier Scopus, OpenCitations, CrossRef/Orcid) and visualize a dialog menu (as shown at the top of Figure 4) where users may look for and retrieve bibliometric information (RQ1) according to several criteria: paper search by doi, by paper ID (Scopus) and author search, by last/first name, orcid, author url (OpenCitations) or author ID (Scopus).

When we import a paper, the system presents us with some metadata and the lists of cited and citing papers (RQ3), while when we look for an author, as shown in the right dialog box in Figure 4, the list of their papers will be shown. User may choose to import all the papers or create a selection of them and leave out the others (RQ2). The papers already selected in the bibliography will be marked by a blue background color in the list.

When we decide to load new papers, their metadata may be automatically downloaded (RQ4 and RQ5). On the right, the SGCP provides a set of general commands:

- 'seek metadata' explicitly retrieves metadata from indexing platforms in real-time (RQ4 and RQ5);

¹A video demo of the platform is available at <http://bit.ly/3fKuZNg>

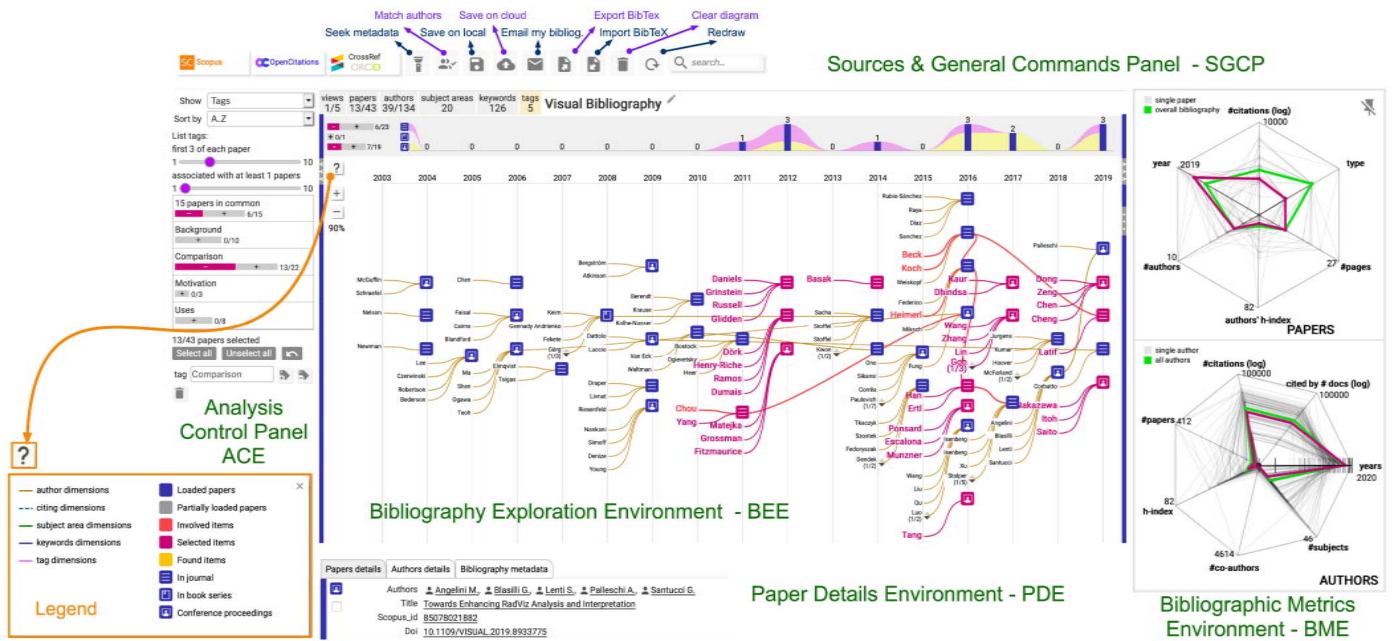


FIGURE 3. An overview of the visual environment with its five panels labeled in green and, at the bottom-left, the legend for the central view (in the BEE).

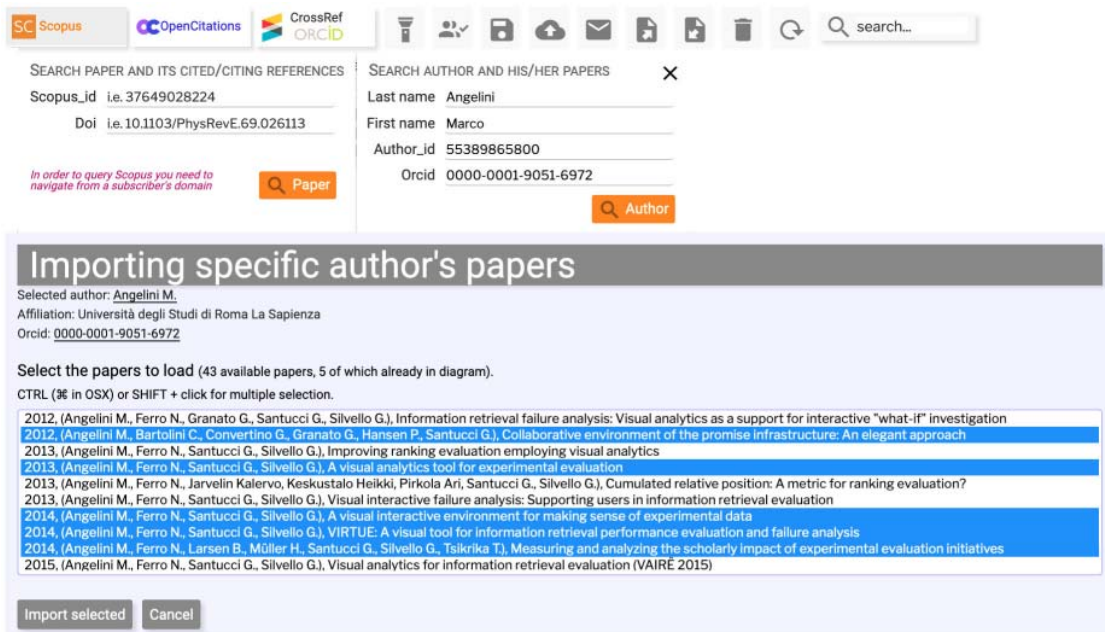


FIGURE 4. Papers currently loaded in the environment are highlighted in blue.

- ‘match authors’ suggests a guided detection of duplicate names, which should actually refer to the same author (RQ18). Such a duplication may occur when importing data from different sources that do not use the same unique author identifier, as for example in ORCID. Furthermore, when importing from a BibTeX archive, a unique identifier is not available and the system must rely only on the author’s name, which may also have been entered incorrectly. In order to support users in identifying such duplicate names and typos, the

- “match authors” wizard automatically proposes groups of names that could refer to the same author and allows users to compare the list of associated publications for each name. If users decide that they are the same author, they can merge the proposed selection of names into a single author and correct the spelling at this stage. If not, they can modify the selection to find the actual set of duplicate names and apply the correct merge.
- ‘save on local’ downloads the current work on local storage (RQ21), while ‘save on cloud’ (RQ21 and RQ24) is

useful for future sharing or for retrieving it at any later time to resume the analysis. This command requires an email address to which the system will send the link of the current bibliography; if a user created or modified some bibliographies, they may use the command ‘email my bibliographies’ in order to retrieve the entire list;

- ‘export BibTeX’ (RQ22), ‘import BibTeX’ (RQ23), ‘clear diagram’, and ‘redraw’ are self-explanatory. When we export a bibliography in BibTeX format, some specialized fields are included in the output document to faithfully reconstruct the visual bibliography.

BEE - Bibliographic Exploration Environment. The visual core of VisualBib^(va) is the BEE (Figure 3-center), characterized by a visual representation of a bibliography called narrative view. It mainly satisfies the requirements of macro-area M2 of our taxonomy. A *narrative view* occupies a two-dimensional space where the horizontal dimension is the time, discretized by years, while the vertical dimension is spatial and is used to organize authors’ names, papers and their relationships (RQ6, RQ10). The papers are represented by colored, round-cornered square items, containing specific icons for distinguishing journal papers, books or book chapters, papers in conference or workshop proceedings, as specified in the legend; items are generally in blue, but turn orange-red on mouse-over and magenta when the associated paper is selected. The diagram includes the last names of the authors involved in at least one paper from the current bibliography. Each author is associated with a goldenrod line that connects all their papers from the oldest to the newest. Then, for example, in Figure 3, we find three journal papers associated with the year 2014. Only the first one (from the top to the bottom) has been selected. The last name of an author turns magenta if all their papers are included in the selection, while it turns orange-red if the selection includes only a part of them. On top of the narrative view, we positioned the theme river, a histogram representing the types of papers (journal, book, and conference papers) over time. A blue bar shows the number of papers for each year. By mouse-hovering on one of the rivers, the related papers will be highlighted in the narrative view. At the top of the theme river, we find statistics about the current state of the bibliography, such as the number of papers, authors, subject areas, keywords, and tags.

In the narrative view, the mouse over an author or a paper icon highlights co-authors and papers written by at least one of them (RQ11) in orange-red. Moreover, as shown in Figure 5-left, *clicking on an author* opens up a two-icon menu in which it is possible to search for the author on an external index (allowing us to integrate/extend the bibliography with additional papers belonging to that author) (RQ5), or look for detailed data on the author (‘i’ icon), that will be visible in the PDE environment (RQ1, RQ2). *By clicking on a paper* a contextual menu appears (mixed in representation with icons and menu items) (see Figure 5-right). This menu allows users to: review the default information already included in the menu that acts as a tool-tip; add the paper to the current selection by marking the checkbox in the top-left corner;

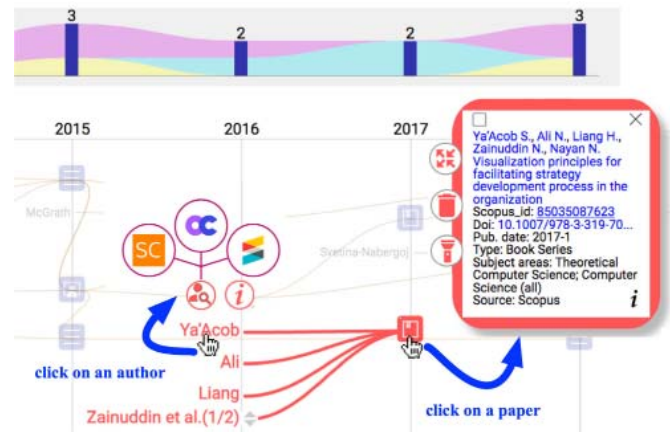


FIGURE 5. Two contextual menus appear by clicking on an author or on a paper icon.

load paper citations in order to add new papers that cite it (the four-arrow icon) (RQ7); load additional metadata from indexing platforms (the torch icon has the same function as ‘seek metadata’ but it is actionable for each individual paper by clicking on the torch icon) (RQ4); delete the paper from the current bibliography (RQ17); review the full information available again in the PDE environment (RQ5, RQ6). Finally, a click on the year label will add the related papers to the current selection, assigning them a magenta background.

ACE - Analysis Control Environment. The analytical core of VisualBib^(va) is the ACE: it mainly satisfies the requirements in macro-areas M2-M3 of our taxonomy. The ACE enables users to apply ordering criteria on authors, papers, subject areas, keywords and tags (RQ8, RQ9) and selects specific (or sets of) papers (RQ14). Any selection is coherently propagated to the other panels, independently from any sorting criteria. As shown in Figure 6, the ACE is located on the left and is composed of six main sub-panels:

- *Views* enables users to visualize, by default, a bibliography showing the relations between its papers and authors (co-authorship network [37]) (RQ11); by selecting a different filter, one can visualize the citation network and information about subject areas, keywords or tags (RQ7); in Figure 6, we may observe how the BEE environment is enriched by vertical structures containing the bibliography keywords, organized by year; their layout makes up a global word-cloud where the size of each keyword considers its prominence in the whole bibliography, although the element belongs to the first year it appeared (RQ5, RQ7).
- *Papers* shows the list of the publications included in the bibliography, which can be sorted by year of publication, title, authors, number of citations, number of authors and type of publication (RQ8).
- *Authors* shows the list of authors, sorted by several criteria. The number of papers associated to the selected authors is represented as a bar-chart, employing the table-lens technique [38]. This interactive bar colors

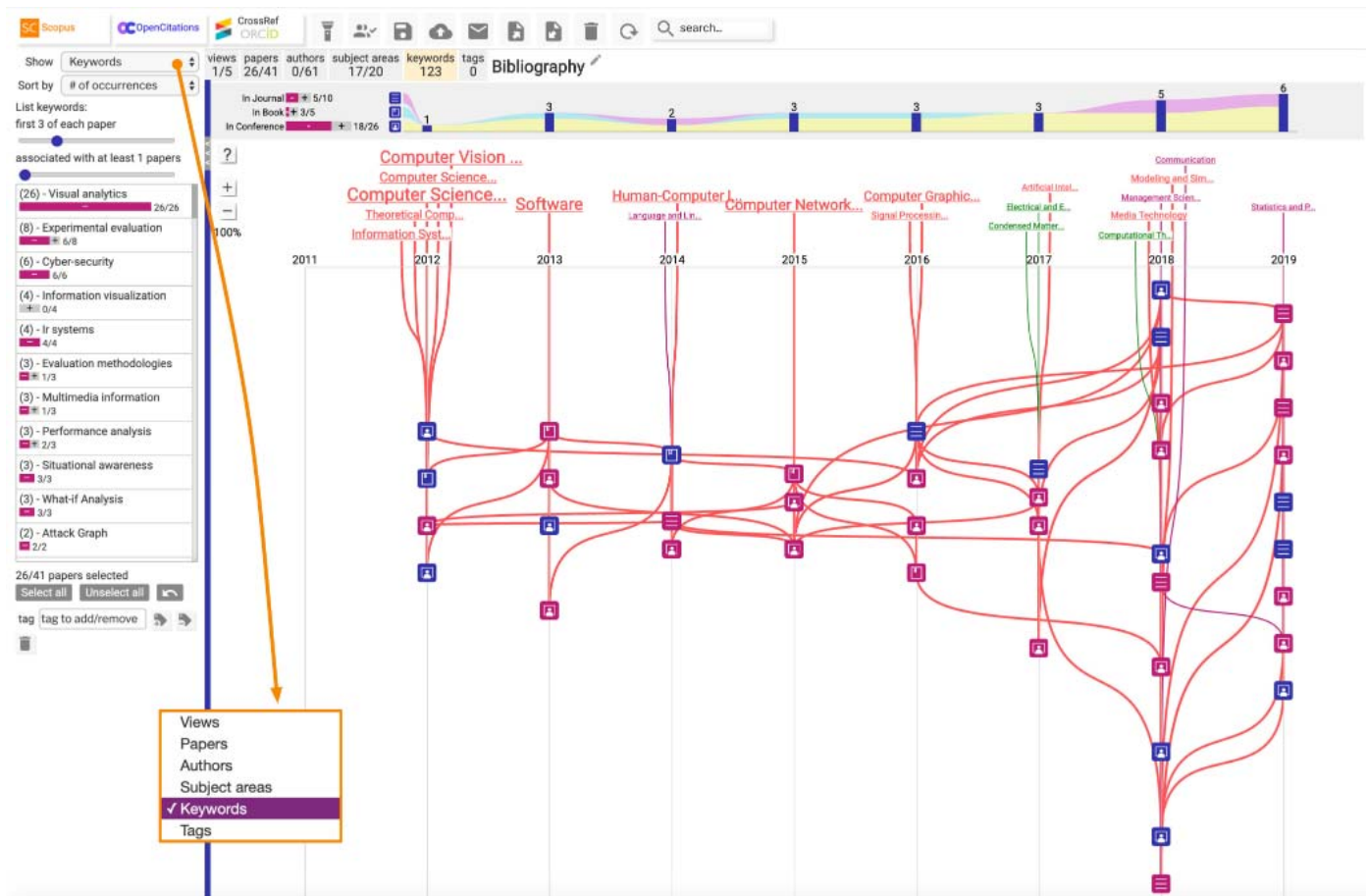


FIGURE 6. In the ACE, the 'Visual Analytics' keyword is shared by 26 papers.

- the fraction of papers that are selected in magenta and allows to select all the papers by author, to complete the selection of the author's papers by adding the missing ones, or to remove the ones already selected (RQ14). Of course, this behaviour has an effect on the other authors as well.
- *Subject Areas* contains information about aggregated subject areas from the bibliography. Its behaviour is similar to that of the Authors panel, with additional slider controls that allow users to dynamically set a threshold on the maximum number of subject areas to consider for each paper and the minimum number of papers that a subject area should contain. These controls are useful because subject areas could often be ill defined and a wide range of definitions is employed by the different indexing platforms.
 - *Keywords* works in the same way as Subject Areas and contains information about the keywords linked to the papers. In the example of Figure 6, we have clicked on the prominent keyword (Visual Analytics) and selected the related papers with propagation to the keyword lists: 26 out of 41 papers contain "Visual Analytics", while almost all keywords are covered by the selection, except three elements (Electrical Engineering,

Computational Theory and Condensed Matter Physics - highlighted in green).

- *Tags* works in the same way as Subject Areas and contains information about the tags linked to the papers in the bibliography. Differently from all the other data, tags are metadata defined by users and not extracted by the indexing platforms. In the bottom part of the ACE environment, one can insert a new tag or delete the existing one. In order to assign a tag, an active selection of papers must exist; tags are then reviewed and interacted with in the tag panel (RQ14, RQ20).

Below the panels area, we can find the general commands for selecting all the elements (e.g., papers, authors, tags), deselecting all the elements of that panel in the current selection, or undoing previous operations.

BME -Bibliographic Metrics Environment. The BME consists of two radar-charts [39], [40], and can be found on the right part of the layout, as showed in Figure 7. The first radar focuses on papers, the second one on authors (RQ13). In the first radar, it is possible to review and compare bibliographic information concerning the full bibliography (green line) and the selected papers (magenta line). Specifically, the information available concerns the distributions of: paper types; number of pages per paper; medians of the authors'

h-index; number of co-authors per paper; year of publication; number of citations per paper. This area is useful to check the relevance of a bibliography, compare a specific paper with it in order to figure out whether to add it to the bibliography or not, or to evaluate the quality of a bibliography associated to a paper under review. By exploiting one of the characteristics of the radar-chart, it is possible to visualize the metrics associated to an individual paper, the overall bibliography or a selection of papers (RQ15).

The second radar-chart, instantiated on authors, shows the profiles of all the authors in the bibliography and enables users to compare them to the median metrics of the authors of the selected papers (RQ16). An example is given in Figure 7, where the selection of papers (icons in magenta) consists of journal publications only.

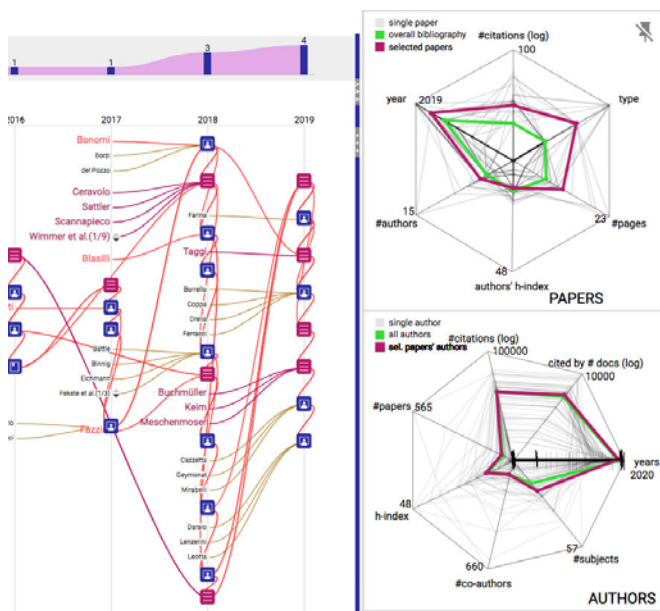


FIGURE 7. The thin gray lines in the radars show the features of each paper or author in the bibliography while the magenta and green ones highlight the median values of the metrics for the selected papers and the entire bibliography, respectively.

We can notice how the metrics associated to the current selection of papers are of a higher quality (e.g., number of citations, more recent publications) with respect to the whole bibliography, meaning that the selected papers are more relevant; similar observations can be made about the metrics associated to the involved co-authors.

Finally, the Paper Details Environment - PDE (shown in Figure 8) lists, in three different panels (Paper details, Authors details, Bibliography metadata), all the extracted, analyzed, or created (meta)data. Given the vast amount of textual information available, like abstracts and paper descriptions, it is organized as a list of (often expandable) contents. Each of the interactions, described for the other environments, allows users to directly visualize a specific paper or author in the PDE at any point. Also, it is easy to look for strings both using the textual search provided by the browser

and the SGCP search box (RQ19); the latter will highlight in yellow the papers that contain the searched string.

Furthermore, we notice that it is possible to annotate a paper (RQ20) - see the 'User's notes' at the bottom of Figure 8 - or highlight the paper in the BEE, by clicking on the bottom-right blue arrow.

V. USAGE SCENARIOS

This section describes two foreseeable usage scenarios, the former related to the process of creating a bibliography and the latter related to the evaluation of an existing bibliography.

A. USAGE SCENARIO 1: CREATING THE BIBLIOGRAPHY OF A PAPER

The first case study concerns the task of creating the bibliography of this paper: with this aim, VisualBib^(va) has been actively used for collecting and analyzing the current literature on information visualization applied to citation networks. The result of this process can be seen in Figure 3. The analysis started from three seed papers: [1], [12], and [9]. We proceeded by importing their cited and citing papers into the VisualBib^(va) environment, and collecting a set of prospective candidates to be included: during this process, we focused on their effects on the global quality of the overall bibliography and on the contributions of the authors related to the theme at hand. These actions were conducted by evaluating the fitness of each paper for the topic; analyzing subject areas and keywords; evaluating the delta that each publication provided in the ACE; comparing the metrics of the last two papers to the overall bibliography in the BME. If after this analysis the paper was deemed suitable, it was tagged according to the taxonomy of classes - Background, Motivation, Uses, Extension, Comparison or Contrast, Future - proposed by Jurgens et al. [41], to make the rationale of the paper explicit in the context of our bibliography. These tags can be applied using the corresponding feature that can be found in the ACE.

The action of importing cited and citing papers enriches the bibliography with new papers to evaluate. The import functions allow users to identify the already selected papers and generate a convergent process toward a finite number of papers to evaluate. The exploration of the cited and citing papers may also be performed in the BEE by clicking on the four-arrow icon of each paper. Again, in this scenario, decisions may be taken basing on paper contents, too; supporting this activity, still strongly related to human judgement, is out of the scope of this paper.

In Figure 9, we highlight how each component of the visual environment contributes to the evaluation. Starting from the three seed papers and using the BEE, we notice that [9] and [12] mutually cite themselves (Figure 9-a) and the three seed papers share 12 cited and citing papers: six contained in the cited papers (Figure 9-b) and the remaining in the citing papers; in the ACE we tagged these papers (plus the three seed papers) as '15 papers in common', [9] as 'Background', [12] as 'Comparison', and [1] as

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Abstract © 2019 The Eurographics Association and John Wiley & Sons Ltd. Published by John Wiley & Sons Ltd. Visualizing contextual information to a map often comes at the expense of overplotting issues. Especially for use cases with relevant map features in the immediate vicinity of an information to add, occlusion of the relevant map context should be avoided. We present SurgeryCuts, a map manipulation technique for the creation of additional canvas area for contextual visualizations on maps. SurgeryCuts is occlusion-free and does not shift, zoom or alter the map viewport. Instead, relevant parts of the map can be cut apart. The affected area is controllably distorted using a parameterizable warping function fading out the map distortion depending on the distance to the cut. We define extended metrics for our approach and compare to related approaches. As well, we demonstrate the applicability of our approach at the example of tangible use cases and a comparative user study.

User's notes

FIGURE 8. Example of PDE usage: the full details of the paper are available here for deep inspection. A magenta border on the left indicates its inclusion in the current selection.

‘Motivation’ (Figure 9-c). Then, in the PDE, we annotated some of these papers as ‘work in progress’ (Figure 9-d). Starting from 12 co-cited papers and three seeds (15 papers), in the ACE (Figure 9-e) we identified six keywords relevant for number of occurrences (‘Information Visualization’, ‘Visualization’, ‘Citation networks’, ‘Literature reviews’, ‘Scientific literature’, and ‘Interactive visualizations’) which we used as a basis to add new papers. Then, in the BME, we compared the features of this selection of 15 papers to the other cited and citing papers (Figure 9-f), and we extracted new candidates comparing the overall bibliography to the current selection. So we added, for example, survey [4], selected by numbers of citations greater than 1000 (Figure 9-g).

B. USAGE SCENARIO 2: REVIEWING A BIBLIOGRAPHY

The second usage scenario is that of a reviewer to whom a paper is assigned; the reviewing activity is often complex and concerns the reviewer’s knowledge and point of view with respect to a paper content, an issue that we have not addressed in this work; instead, this section provides an example of usage concerning a qualitative evaluation of the paper references.

First of all, reviewers need to extract from the paper’s PDF the references using a text analysis tool (e.g., CERMINE [42], PDFExtract) and deriving the BibTeX file from it. Although this operation still requires human intervention, we are working on automating the second step in order to allow users an easier import of the bibliographic references. Alternatively, if they can access a BibTeX file (e.g., when reviewing a student’s master’s thesis or Ph.D. thesis), they may easily import the whole bibliography by using the dedicated function of importing a BibTeX file in the SGCP. The references of the paper “Towards enhancing RadViz analysis and interpretation” (doi: 10.1109/visual.2019.8933775) (Figure 10) are used as follows as a demonstrative case to simulate a reviewing process. They are 28 papers including 13 journal papers,

one book and 12 conference papers (Figure 10-a). Using our system, we may analyze the bibliography as it is, looking at its freshness (given by the temporal distribution of works), its maturity (given by the predominant types of publications) and its coreness (looking at the subject areas/keywords associated with the documents).

Through a tag analysis, we labelled the papers as ‘background’, ‘motivation’ and ‘comparison’ (related work) papers; the selection targets the topic related to “RadViz visualization” and amounts to 17 out of 28 papers, where eight of them are journal papers, one is a book and the remaining eight are conference papers (Figure 10-b).

This selection confirms that the aggregated indicators for the selection (colored in magenta), visible in the papers radar-chart (Figure 10-c), are in line with the overall bibliography (colored in green), while most of the indicator values come from this set of papers that are core to the theme of the paper under review.

Focusing on temporal analysis, from the papers radar-chart we can see that most of them lie in the 2004-2019 period (median = 2009); again, the active selection is distributed within the same period, with most papers concentrated in the years 2009-2019, confirming the freshness of the selected bibliography. Remaining papers refer to well-known techniques used (e.g., PCA, Davies-Bouldin index) or applications of the RadViz (under the ‘uses’ tag).

Focusing on the author view, metrics show a good (579) median of citations by authors on their papers included in this bibliography and a similar amount of citing papers (506). Interestingly, we may appreciate how the h-index of the authors included in the references has a median = 14.

Comparing the author view of the bibliography (Figure 10-d) to the citation network (Figure 10-e), we may see how most of the core works (in magenta) are directly connected between them (except two works that seem not to be linked or for which some metadata could be missing);

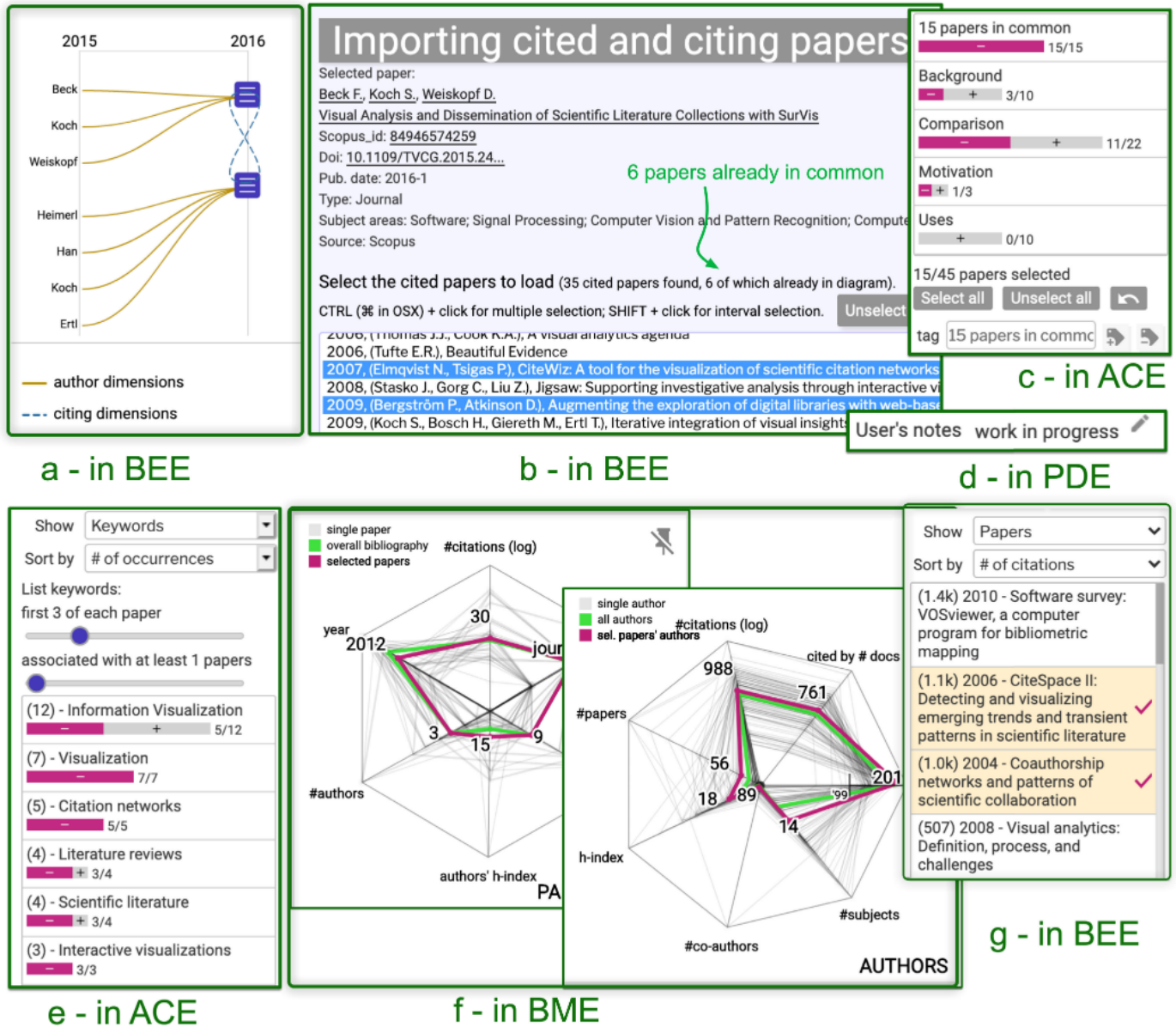


FIGURE 9. Collecting info and suggestions by ACE, BEE, PDE and BME to create a bibliography starting from few seed papers.

they outline a continuous evolution of the theme that is visible from 1997 to 2019.

VI. EVALUATION

The maturity of the system implementation allowed for a range of evaluation activities. In addition to what we have described in terms of usage scenarios, in this section we present two expert evaluation activities, the first conducted with two professors (PE1 and PE2), and the second, based on analysis tasks, with nine subjects (P1-P9).

A. EXPERT EVALUATION

The first evaluation conducted was the expert evaluation. Two professors were involved in this activity, one full professor (PE1) and one associate professor (PE2) with a long

research experience (more than 30 years), both in terms of paper writing and paper reviewing. In particular, PE1 is even involved in scientific evaluation and assessment of research quality, making the subject very knowledgeable in terms of bibliometrics and scientometrics. The methodology used for this activity was the same for both subjects: the system was described to them first using a slideshow, lasting approximately 20 minutes, in order to explain its visual encodings and capabilities. After this stage, a live demo based on the expert's bibliography (starting from author search) was proposed, with the subject using the system and one of the authors in support for any questions or doubts arising during this interactive session. This session was mainly exploratory and lasted about 30 minutes for both subjects. Finally, they were given instructions for freely using the

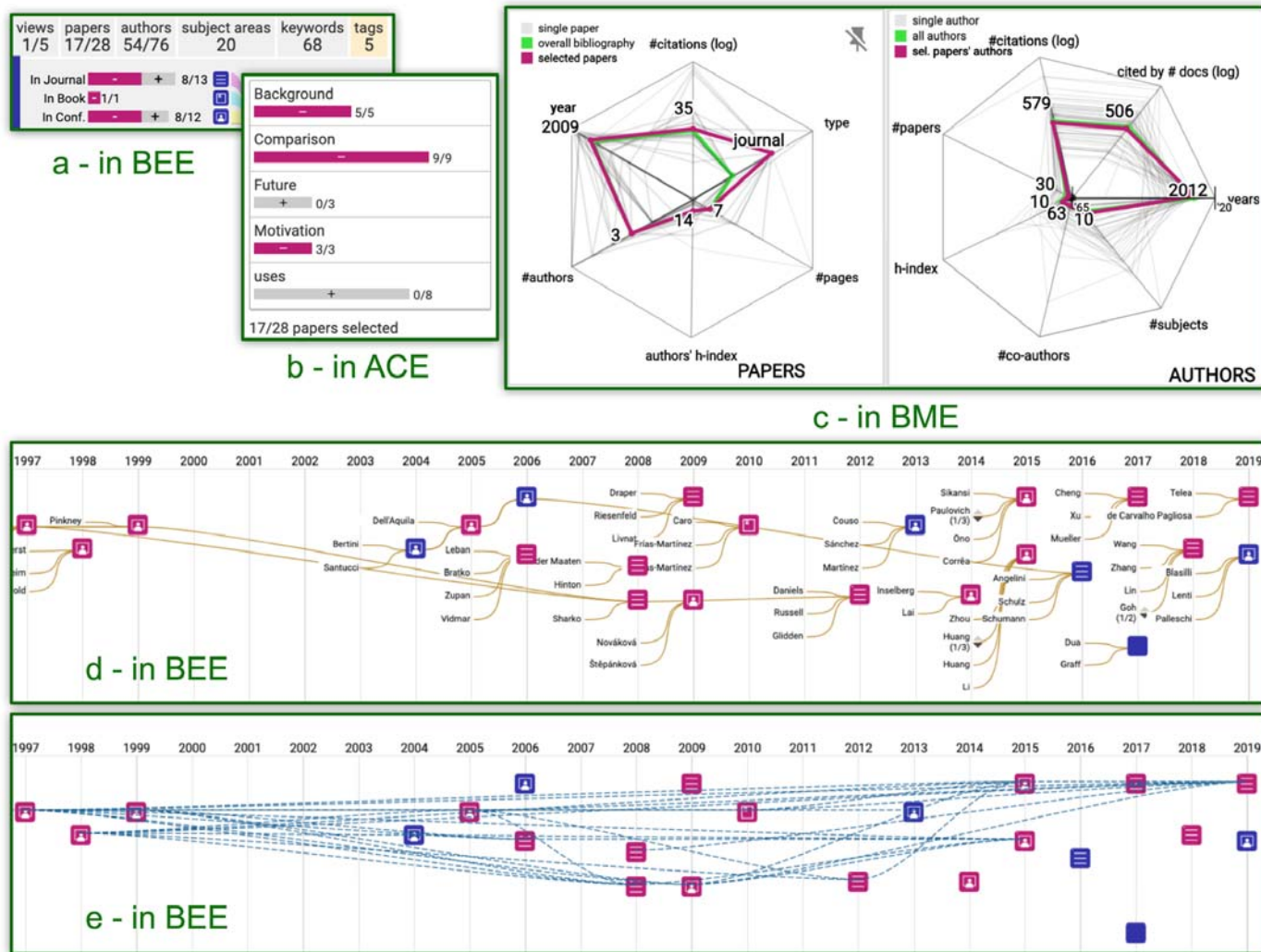


FIGURE 10. Reviewing the bibliography of the paper.

system for 10 days, after which they were again asked to provide feedback in terms of their usage experience and any needed corrections/additional functions they would like to have embedded in it. The collected feedback has been used in order to improve the VisualBib^(va) system and to prepare it for the second broader user evaluation. Excluding bug fixing activities and minor comments, we report the main observations collected from the experts:

- improve the visual encoding of radar-charts (PE1); more in detail, the requests concerned the foreground and background contrast, and the maximum values for each of the axes to be always visible;
- introduce comparative analysis between individual papers on the radar chart (initially it was missing but PE1 explicitly asked for it); this resulted in the implementation of a comparison function automatically activated when the active selection consists of two or three papers;
- introduce a per year selection (clicking on an year, all the papers published in that year get added to the current selection) (PE2).

Both participants pointed at some usability problems, too (e.g., “the tooltip overlaps on the rest of the graph”, “when returning from the list of papers to the BEE, the view appears not centered on the selected paper”) that have been corrected.

Concerning usage, both participants highly appreciated the quick exploration of an author’s scientific production and the capability to import a bibliography directly from a BibTeX file and obtain a statistical overview of the bibliography. They also appreciated the high customizability of the BEE in conjunction with the ACE. Finally, PE2 praised the system’s summarizing capability, also for communication purposes. On the other hand, PE2 noted the need for an instruction manual or more training about advanced functions, and both PE1 and PE2 expressed considerations on the system’s learning curve. In addition, participants asked for more analytic functions to improve the suggestion of new papers to add (e.g., automatic recommendation) and to better compare papers (e.g., more sophisticated similarity functions) for assisted tagging. Finally, we also showed the system to two experts coming from Elsevier Scopus and Web of Science; while no deep investigation was conducted with

TABLE 1. Questions with expected and perceived degrees of complexity and other metrics.

Degrees of complexity		Avg		Std dev.		Time	
expected	perceived	score	time	score	time	min	max
Q4 : 1 = <i>easy</i>	$\bar{x} = 1, s = 0$	10.00	26.89	0.00	18.40	4	56
Q5 : 1 = <i>easy</i>	$\bar{x} = 1, s = 0$	7.78	59.44	4.41	32.04	19	111
Q6 : 2 = <i>medium</i>	$\bar{x} = 1.67, s = 0.71$	7.89	36.44	3.41	29.26	11	88
Q7 : 2 = <i>medium</i>	$\bar{x} = 1.22, s = 0.44$	7.11	145.44	4.26	140.82	47	503
Q8 : 2 = <i>medium</i>	$\bar{x} = 1.56, s = 0.53$	6.67	134.89	5.00	119.04	23	411
Q9 : 1 = <i>easy</i>	$\bar{x} = 1, s = 0$	10.00	129.78	0.00	58.36	53	216
Q10 : 1 = <i>easy</i>	$\bar{x} = 1, s = 0$	10.00	88.11	0.00	31.15	50	147
Q11 : 3 = <i>hard</i>	$\bar{x} = 2, s = 0.71$	6.44	53.67	4.88	27.70	23	103
Q12 : 1 = <i>easy</i>	$\bar{x} = 1, s = 0$	10.00	260.33	0.00	195.66	4	622
Q13 : 1 = <i>easy</i>	$\bar{x} = 1, s = 0$	9.78	59.44	0.67	37.31	27	132
Q14 : 1 = <i>easy</i>	$\bar{x} = 1.33, s = 0.50$	8.33	46.44	3.16	24.37	23	102
Q15 : 2 = <i>medium</i>	$\bar{x} = 2.11, s = 0.60$	9.44	96.67	0.73	50.96	27	192
Q16 : 1 = <i>easy</i>	$\bar{x} = 1.11, s = 0.33$	9.78	197.67	0.67	102.00	83	413
Q17 : 3 = <i>hard</i>	$\bar{x} = 2.33, s = 0.71$	5.00	125.44	3.93	56.79	50	233
Q18 : 2 = <i>medium</i>	$\bar{x} = 1.67, s = 0.87$	6.88	290.00	3.09	172.63	114	539
Q19 : 3 = <i>hard</i>	$\bar{x} = 2.11, s = 0.93$	8.75	72.33	3.54	87.03	11	292
Q20 : 2 = <i>medium</i>	$\bar{x} = 1.44, s = 0.73$	8.00	269.22	3.38	144.01	115	478

them, they showed interest and recognized potentiality in this approach.

B. USER EVALUATION

The second user study was based on specific tasks to be solved using the system: nine participants (8M,1F), were selected among people who actively work in the research field, either enrolled in a Ph.D. program (eight participants) or holding a higher position (one post-doc). Age ranged from 24 to 32 ($M = 27.66$, $S = 3.04$).

1) METHOD

The participants were gathered in a room for an initial explanation of the system, using the same materials used for the expert evaluation (updated where needed) in a session lasting 40 minutes. Immediately afterwards, they were involved in an interactive session, lasting 30 minutes, in order to freely explore the system and conduct their analysis with the support of the authors. After this session, they were given a task-based questionnaire with the following structure:

- *three positioning questions* (age, title, etc.). [Q1-Q3];
- *a first training task*, lasting 15 minutes, in which they could freely explore a preset bibliography that we labeled as simple as per its richness of contents;
- after this training task, *a set of 10 questions* to solve on a second preset bibliography, labeled by us as medium complex as per its richness. The tasks were all quantitative but at different degrees of complexity (e.g., report base data, report derived data from base indicator) and encompassed all the elements of a bibliography (papers, authors, evaluation metrics). For each of these questions, participants were also asked to express their perceived task difficulty on a 3-level scale (easy, medium, hard) [Q4-Q13];
- *a second training task*, this time on a bibliography labeled as complex as per its richness of contents;

- *a set of seven reviewer-oriented tasks*, both quantitative and qualitative, in order to push the limits of the system in cases where both the tasks and the bibliographies grow in complexity. For each of these questions, participants were also asked to express their perceived task difficulty on a 3-level scale (easy, medium, hard) [Q14-Q20];
- *a set of four questions* concerning the usefulness of each of the environments of VisualBib^(va) [Q21-Q24];
- *a SUS (System Usability Scale) test* [43] in order to quantify the system's usability and in case evaluate how it could influence a proficient use of VisualBib^(va) [Q25-Q34];
- *final questions* concerning the overall rating of VisualBib^(va) and comments [Q35-36].

Supplemental materials include the questionnaire made up of these 36 items. We used the STEIN platform [44] to distribute the evaluation questionnaire and collect answers and timings.

2) RESULTS

In this section we describe the results of the quantitative evaluation. The first data we analyzed is the overall average score obtained by the participants to each task. As shown in Table 1, scores take into account the exactness of the answer provided in a 0.0 – 10.0 continuous scale.

By analyzing these results we can see how 10 out of 17 reach a score above or equal to 8.0 (Q4, Q9-10, Q12-16, Q19-20), four tasks have a perfect score (10.0) and six an almost perfect score (above 9.78). Concerning the seven tasks with less than a 8.0 score, Q5 and Q6 almost reach this value (7.78 and 7.89), leaving out five tasks. For these (Q7-8, Q11, Q17-18), in increasing order of score, from 5.00 (lowest) to 7.11 (highest) we investigated the additional collected metrics, namely the task difficulty experienced by the users (average) and the completion time per task (average): completion time for these tasks is quite high, ranging from

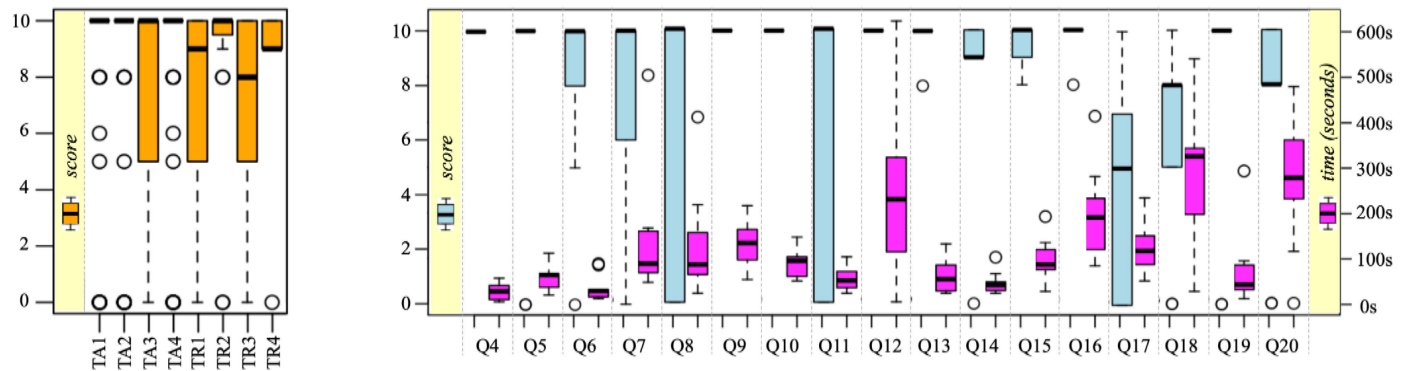


FIGURE 11. Distributions of scores for tasks supporting authors and reviewers (left); distributions of scores and completion times referred to questions Q4-Q20 (right).

134 seconds to 290 seconds, with only Q8 as an outlier (53 seconds) more in line with the other tasks. Interestingly, Q7, Q8 and Q11 are about creating a bibliography, while Q17 and Q18 are about reviewing a bibliography task. Concerning the task difficulty, we preassigned a level to each task before the evaluation and then collected the experienced difficulty level from each participant. The result obtained by the users seems to confirm a rising difficulty experienced for both activities, with more differences for the reviewing activity (higher standard deviation among scores). Compared to what we had modelled before the study, judgement was for the most part in line with the expected task difficulty, with some outliers represented by Q14 (participants reported higher perceived difficulty on average) and Q17 and Q19 (lower difficulty on average). In any case, the differences between the estimated and perceived difficulty were less than one.

These results are confirmed if we look at the score distributions paired with the distribution of answer times reported in Figure 11-right. We observed very good median values (score ≥ 8) for all questions except Q17, that has median=5 and a spread distribution. Q8 and Q11 show a wide distribution but with still high median value (10) showing that a majority of participants identified the correct answer. These can be partially explained by the perceived difficulty of this question by the users. At the same time, the score trend seems not to be largely affected by the questions' difficulty. Looking at the completion times, many of the questions remain below four minutes per question with Q12, Q18 and Q20 presenting a distribution that is spread above this threshold. Interestingly, these questions have got good score distributions, meaning that the respondents needed more time and more operations to answer them correctly. Completion times present a slightly rising trend that is reflected in the rising difficulty of the questions (by design).

After this analysis, we focused on the support that the questionnaire provided about the tasks identified in Section III for authors and reviewers. For the eight listed tasks (TA1-TA4, TR1-TR4), we have an average of 48 scores per task depending on the set of questions supporting the task. Results are

provided in Figure 11-left. Boxplots show that our proposal supports fairly well all the tasks related to author, with only four outliers on average that lower the maximum results for TA1, TA2 and TA4. Task TA3 (identification of novel works) presents a more spread distribution, still with the median set on the maximum score. We justify these results by the different workflows that the respondents used in answering the questions related to this task. In sum, we can conclude that VisualBib^(va) convincingly supports authors in the tasks for creating a bibliography.

For reviewers, tasks TR2 and TR4 present a very compact distribution with a median on the maximum score or close to it and very few outliers. Tasks TR1 and TR3 have a similar distribution with median close to 8 and 9 scores and a more spread distribution. Overall, the vast majority of users answered correctly to questions related to these tasks. Summarizing these and the previous results, we can conclude that *while not at the same level of the bibliography creation tasks*, VisualBib^(va) supports reviewing tasks with a good degree of quality.

We have also investigated which parts of the environment the respondents found more useful. Looking at the results (questions Q21-Q24), we see how the users scored last the paper details environment - PDE (2.55), then the BEE (4), the BME (4.22) and finally the ACE (4.55). Given that the highest scored environments are central in allowing visual analysis and quality evaluation of a bibliography, we consider this result as a proof that the users considered the exploration and analyses provided by those environments valuable. Conversely, the less useful environment was the one that provided the full details of each paper. We plan to revise this environment in a future version to enrich this area with more exploration capabilities and statistics. The overall satisfaction with the system (Q35) is at 3.88 with a standard deviation of 0.33, making the result very positive even if with margins for improvements (Q40). On this end, participants report two desired features, like "a brush selector on the BEE (on the temporal scale)" and "ability to sort items in the ACE related to the current selection as well as to the whole bibliography". The second suggestion is very interesting - the

system actually allows to see the projected selection on each of the sorted lists, but it is not possible to sort the elements considering only the current selection. We are working to add this functionality.

Finally, we report the result of the SUS questionnaire (Q25-Q34) concerning the system's usability. We evaluated it using the rules provided by its authors. We found an average SUS score of 68.05 that corresponds exactly to the threshold given by the authors for a C score, meaning that "You are doing OK but could improve". Breaking down the results, three participants (P2, P4 and P8) give good values (77.5, 72.5 and 80.0), with P2, P3 and P5 assigning average scores (67.5, 70.0 and 67.5 respectively). Finally, P6, P7 and P9 give not good enough scores (55.0, 62.5 and 60.0 respectively), while still being in the D evaluation band. No score goes below 51.0. These results confirm that the usability can still be improved, while at the same time it is not to be considered a disturbance or a factor in the qualitative results obtained during the task-based evaluation. Better selection methods for the BME and the BEE are currently being considered.

VII. CONCLUSION

In this paper, we have analyzed a set of eight tasks and 24 requirements needed by authors and reviewers; we have described how our system supports them; then we have examined in bigger depth two scenarios, related to the creation and review of a bibliography, respectively, focusing our attention on two profiles: authors and reviewers. The maturity of the VisualBib^(va) implementation allowed us for two levels of evaluations: by experts and by generic users. The results highlight how the *complexity* and *variety* of innovative functionalities offered by VisualBib^(va) are appreciated by experts and generic users, who evaluated the system as useful and usable. As future work, we would like to extend: the number of indexing platforms - including, possibly, Web of Science, Microsoft Academic, aMiner, Google Scholar, and PubMed; the import/export functionalities to other standard interchange formats - including possibly, RIS, and CSV. In the future, we plan to work on developing additional analytics that support the evaluator persona and enhance author analysis. Additionally, we foresee to include more automatic and semi-automatic recommending capabilities into the system, also modelling and taking advantage of a user's previous working history with VisualBib^(va) along with similar activities conducted by other platform users as possible data inputs for these recommendations.

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