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SIMILAR – Systematic iterative multilayer literature review method

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ABSTRACT

As the number of published scientific articles has increased exponentially and the interdisciplinary nature of scientific research has strengthened over the past decades, the process of conducting efficient literature reviews has played an increasingly important role in helping scholars make sense of previous research results. Although current literature review methods provide insightful results, they are either cross-sectional or longitudinal studies and are unable to simultaneously model the structure and evolution of a research field. In addition, only a few methods apply the iterative refinement of the extracted categories, and none integrate the powerful multilayer network theory during the literature review. To fill this gap, the current paper develops a systematic iterative multilayer literature review (SIMILAR) method. The proposed method helps researchers to (1) refine the initial classification rules of the selected papers through iterations, (2) integrate the multilayer network theory into the literature review process, and finally (3) conduct longitudinal and cross-sectional analyses at the same time. We demonstrate the added value of the SIMILAR method by extending research results recently obtained in the field of information systems.

1. Introduction

The massive emergence and rapid diffusion of knowledge both within and across disciplines and domains requires researchers to find a way to quickly synthesize prior research, address relevant gaps and stimulate future research. Recognizing that cumulative knowledge development increasingly relies on the integration of previous studies, several scholars have made calls for more literature reviews (Bandara, Miskon, & Fielt, 2011; Hunter, Schmidt, & Jackson, 1982; Paré, Trudel, Jaana, & Kitsiou, 2015; Pfeffer & Sutton, 2006; Reay, Berta, & Kohn, 2009; Rousseau, Manning, & Denyer, 2008; Templier & Paré, 2015; Watson & Webster, 2020). Conducting effective literature reviews plays a vital role not only for their own knowledge contributions, such as advancing the knowledge and understanding the breadth of the research on a topic of interest, synthesizing knowledge, building theory, aggregating empirical evidence, and becoming oriented in an emerging domain (Cohn & Becker, 2003; Cooper, 1988; Fink, 2019; Mulrow, 1994; Paré et al., 2015; Pfeffer & Sutton, 2006; Rowe, 2014;

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Schryen et al., 2017), but also for their capacity to stimulate subsequent research, which, in turn, validates and extends their contributions (Paré et al., 2015; Prester, Wagner, & Schryen, 2018).

A literature review can be the background for a primary research article, a part of a thesis, a part of a project proposal (Baker, 2000), or an important type of publication in its own right (standalone review) (Schryen et al., 2017; Schwarz, Mehta, Johnson, & Chin, 2007; Templier & Paré, 2018). In addition, review articles frequently become core or milestone papers in a field (Paré et al., 2015). Literature reviews have been studied in several fields, such as health sciences (Grant & Booth, 2009; Liberati et al., 2009), management (Alvesson & Sandberg, 2011; Zorn & Campbell, 2006), nursing (Cronin, Ryan, & Coughlan, 2008; Whittemore, 2005), psychology (Baumeister & Leary, 1997), social sciences (Hart, 2018; Petticrew & Roberts, 2008), and software engineering (Kitchenham & Charters, 2007). Unsurprisingly, the diversity of disciplines has led to the adoption of several perspectives on literature reviews, including definitions (Blaxter, 2010; Blumberg, Cooper, & Schindler, 2005; Fink, 2019; Hart, 2018; Rowe, 2014; Watson & Webster, 2020), purposes (Okoli, 2012; Paré et al., 2015; Templier & Paré, 2015), types and classifications (Grant & Booth, 2009; Paré et al., 2015; Schryen et al., 2017), methodological approaches (Sylvester, Tate, & Johnstone, 2013; Wolfswinkel, Furtmueller, & Wilderom, 2013) and review process (Cronin et al., 2008; Hart, 2018; Petersen, Feldt, Mujtaba, & Mattsson, 2008; Templier & Paré, 2018).

In this article, we focus on the methodological aspects of the literature review. A growing number of scholars have called for systematic, well-explicated and rigorous methods that enhance the value of literature reviews (e.g. Cronin et al., 2008; Kitsiou, Paré, Jaana, & Gerber, 2017; Liu, Lu, Lu, & Lin, 2013; Paré et al., 2015; Schryen et al., 2017; Templier & Paré, 2018); such methods help literature reviews to become not only more useful to the field but also more replicable (Templier & Paré, 2018; Wolfswinkel et al., 2013). Attempts made in this direction include citation-based methods (Liu et al., 2013; Marra, Emrouznejad, Ho, & Edwards, 2015; Merigó, Pedrycz, Weber, & de la Sotta, 2018; Yu, Xu, Pedrycz, & Wang, 2017), growth curve analysis, grounded theory (Wolfswinkel et al., 2013), thematic analysis (Bandara et al., 2011), and the hermeneutic framework (Boell & Cecez-Kecmanovic, 2015).

In addition, algorithmic-assisted approaches were developed to significantly decrease the manual work while conducting the literature review. Brisebois, Abran, Nadembega, and N'techobo (2017) used machine learning to identify and build the relevant literature corpus. Xiong et al. (2018) conducted a literature review in which relevant papers were classified by the maximum entropy algorithm. Yu and Menzies (2019) developed FAST^2, an automatic assistant, to help researchers find more relevant papers faster.

While providing insightful results, these methods have some shortcomings despite the algorithmic assistance. They are either cross-sectional or longitudinal studies, and they do not allow scholars to model the structure and evolution of a research field at the same time. In addition, current citation network-based solutions do not refine the extracted network structure iteratively during the literature search, and multilayer citation networks have not yet been applied in literature reviews.

In this paper, we fill this gap by advancing a state-of-the-art systematic iterative multilayer literature review (SIMILAR) method to help researchers conduct literature reviews without error-prone and methodological rigor. Specifically, we apply multilayer networks to allow researchers to conduct both longitudinal and cross-sectional analyses at the same time. Furthermore, in this method, more opportunities are available since layers can be defined not only by the time dimension but also based on various features such as journal quality or geographical location of the research laboratory.

As such, this paper contributes to the literature in the following ways: (1) we adopt a novel citation network-based literature review method, which allows researchers to iteratively refine the predefined categories for the examined papers and identify all relevant papers in the investigated discipline; (2) based on a new exact procedure, we extend the review process with multilayer network theory; (3) we show that by highlighting the significance of identifying the emergence, growth, reduction and the network of literature in a domain or discipline, scholars can conduct longitudinal and cross-sectional analysis at the same time. To evaluate and show the added value of the SIMILAR method, we extend the research results addressed by Templier and Paré (2018), who conducted the analysis in the field of information systems.

The rest of this paper is organized as follows. Section 2 provides the theoretical background of the study. Section 3 introduces the proposed method. Section 4 presents quantitative results through an example in the field of information systems research. Section 5 concludes the paper.

2. Background of the study

The literature review process is an important part of any scientific paper or research. It is valid to say that an appropriate and effective literature review is necessary to obtain updated information about the latest scientific results and to understand and identify the existing gaps within the selected research area (Hunter et al., 1982). It is important to introduce how our proposed method fits into the typology of the literature reviews, how it supports the proposed literature review processes and how it contributes to the existing citation network-based approaches. Therefore, we discuss the related works in three categories: (1) the typology of literature reviews, (2) the literature review process and guidelines, and (3) citation networks.

2.1. Typology of literature reviews

The typology of literature reviews has been constructed and examined by several scholars. Furthermore, several literature review typologies have been constructed based on different aspects (Templier & Paré, 2015). In this subsection, we introduce the frequently applied typologies.

Cooper (1985) categorized literature reviews based on the focus, goal, perspective, coverage, organization, and audience of the papers. Cook, Mulrow, and Haynes (1997) distinguished between narrative and systematic literature reviews. The structure of such reviews was later refined, and systematic reviews were further distinguished into qualitative systematic literature reviews and quantitative systematic literature reviews (or meta-analyses), as described by Green, Johnson, and Adams (2006), who also discussed the different subcategories of narrative reviews. Another typology was used by Cronin et al. (2008), where not only meta-analysis but also metasynthesis was described as a nonstatistical method with the aim of integrating the outcome of multiple qualitative literature reviews.

The aforementioned typologies were developed in the medical research area; however, the typology of literature reviews is also a frequently discussed topic in the research field of information systems (Bandara et al., 2011; Templier & Paré, 2018). Rowe (2014) classified the literature reviews across four dimensions: goal with respect to theory, breadth, systematicity, and argumentative strategy. Paré et al. (2015) extended this structure and provided a more detailed typology including nine review types (see a short description of each type in Table 1). Later, the two schemes were nested, and a combined typology was developed (Templier & Paré, 2018).

To show the contribution of our method to the different literature review types, we will use the combined typology used by Templier and Paré (2018) because it is newly developed and due to its combination of two typologies, it covers multiple aspects.

2.2. Literature review process and guidelines

Not only typologies but also several guidelines have been provided to support scholars in the literature review construction process. In 1982, Cooper developed scientific guidelines for conducting integrative research reviews. His model included five steps: (1) problem formulation, (2) data collection, (3) data evaluation, (4) analysis and interpretation, and (5) public presentation (Cooper, 1982). Although this research focused on the review process of psychological sciences, strong literature review methodologies were developed later in other disciplines as well (Templier & Paré, 2015), such as health sciences (see Aveyard, 2014; Hewitt-Taylor, 2017; Higgins & Green, 2011; Liberati et al., 2009), software engineering (see Brereton, Kitchenham, Budgen, Turner, & Khalil, 2007; Kitchenham & Charters, 2007; Petersen et al., 2008), management sciences (Durach, Wieland, & Kembro, 2014; Rousseau et al., 2008) and information systems (Okoli, 2015; Okoli & Schabram, 2010).

In 2007, Kitchenham and Charters (2007) concluded that three main phases need to be included to provide an effective literature review: (1) planning, (2) carrying out and (3) reporting. The first phase contains the formulation of the research question and design of the review methodology. The carrying out phase includes several tasks, such as collecting, validating, and evaluating papers and analyzing results. The reporting phase refers to the writing of the literature review based on the outcome of the previous steps (Kitchenham & Charters, 2007; Templier & Paré, 2015).

The fundamental framework was later refined by extending it to a six-step process as follows: (1) formulating the problem, (2) searching for literature, (3) screening for inclusion, (4) accessing quality, (5) extracting data and (6) analyzing and synthesizing data (Templier & Paré, 2015).

This paper proposes a citation network-based systematic literature review process that allows the researcher to iteratively refine the predefined categories for the examined papers and identify all relevant studies in the investigated research field.

2.3. Citation networks

The analysis of citation networks has its origins in the work of Garfield, Sher, and Torpie (1964), who showed that a strong pattern can be observed between historical description events and citational data related to the events. Later, the analysis opportunities by citation network analysis were extended through the research work of Hummon and Doreian. These authors proposed graph indices that help to identify the most important subgraph of the citation network (Hummon & Dereian, 1989; Hummon & Doreian, 1990; Hummon, Doreian, & Freeman, 1990). In 2003, Batagelj (2003) proposed an improvement regarding the aforementioned indices, which allowed researchers to apply them to large citation networks. In the following years, the identification of the most influencing articles within the citation network became an outstanding research area (see Bergsma, Mandryk, & McCalla, 2014; Davletov, Aydin, & Cakmak, 2014; de la Pena, 2011; Hong & Do, 2018; Huang et al., 2018; Pichardo-Corpus, Contreras, & de la Peña, 2019; Su, Sun, Xuan, & Shi, 2015). The visualization and analysis of citation networks are also supported by several solutions, such as VOSviewer (Leydesdorff, Carley, & Rafols, 2013; Leydesdorff & Rafols, 2012), HistCite (Garfield, 2009; Lucio-Arias & Leydesdorff, 2008) or CiteNetExplorer (Maheswaran, 2019). Nevertheless, these solutions do not allow using multilayer networks. The analysis of research trends with citation networks also received outstanding attention; however, the proposed methods are either longitudinal only or compare the cross-sectional results of two periods (e.g., Asatani, Mori, Ochi, & Sakata, 2018; Benckendorff, 1994; Dawson, Gašević, Siemens, & Joksimovic, 2014; Ho, Saw, Lu, & Liu, 2014). In this paper, we develop a citation network-based literature review

Table 1
Description of the literature review types.

Type	Description	Example
Narrative	Narrative reviews attempt to identify what has been written on a subject or topic. They summarize the extant literature and provide a comprehensive report on the current state of knowledge on the topic of interest. They usually selectively focus on literature and evidence that are readily available to researchers.	Aloini, Dulmin, and Mininno (2007)
Descriptive	Descriptive reviews investigate mature topics and aim at determining the extent to which a body of empirical studies reveals any interpretable patterns or trends over a given period of time. They collect and analyze numeric data that reflect the frequency of the topics, authors or methods found in the extant literature. Structured search methods are typically used to form a representative sample of a larger group of published works that are related to a particular area of investigation.	Avison, Dwivedi, Fitzgerald, and Powell (2008)
Scoping	Scoping reviews are primarily concerned with emergent topics and aim at assessing the size and scope of the available literature and informing researchers about a new area. They usually address a broad spectrum of topics, where many different study designs might be applicable. Scoping reviews usually conclude with potential implications for practice and research.	Archer, Fevrier-Thomas, Lokker, McKibbon, and Straus (2011)
Critical	Critical reviews aim to critically analyze the extant literature on a broad topic to reveal weaknesses, contradictions, controversies, or inconsistencies. They attempt to take a reflective account of the research that has been done in a particular area of interest and assess its credibility using appraisal instruments or other methods. Critical reviews are either selective or representative and rarely involve a comprehensive search of all of the relevant literature.	Schryen (2013)
Meta-analysis	Meta-analyses use specific data extraction techniques and statistical methods to summarize and synthesize prior empirical results on a given topic. Meta-analyses provide precise estimates of relations between variables because they adjust for the sample size and reliability of measures. They are considered to be a powerful method of synthesis that allows researchers to draw meaningful inferences by settling existing controversies that arise from conflicting empirical studies.	Ortiz de Guinea, Webster, and Staples (2012)
Qualitative systematic	Qualitative systematic reviews use narrative methods to bring together the quantitative findings of a group of heterogeneous studies. They employ the typical systematic review process but use narrative and more subjective methods to bring together the findings of the included studies. The defining element of qualitative systematic reviews is the adoption of a textual approach in the process of analysis and synthesis.	Petter, DeLone, and McLean (2008)
Umbrella	Umbrella reviews aim at synthesizing the findings of prior reviews. They integrate relevant evidence from multiple systematic reviews into one accessible and usable document to address a narrow research question. Umbrella reviews appraise the methodological rigor and quality of evidence of systematic reviews by means of explicit criteria.	Mbemba, Gagnon, Paré, and Côté (2013)
Theory development	Theoretical reviews draw on existing conceptual and empirical studies to provide a context for identifying, describing, and transforming into a higher order of theoretical structure and various concepts, constructs or relationships. They bring together diverse streams of work and use various structured approaches such as classification systems, taxonomies and frameworks to organize prior research effectively, examine their interrelationships, and discover patterns or commonalities that will facilitate the development of new theories.	von Krogh, Haefliger, Spaeth, and Wallin (2012)
Realist	Realist reviews are theory-driven interpretative reviews that inform, enhance, extend or alternatively supplement conventional systematic reviews by making sense of heterogeneous evidence of complex interventions applied in diverse contexts. They usually start by articulating likely underlying mechanisms and then scrutinize available evidence to determine whether and where these mechanisms are applicable.	Wong, Greenhalgh, and Pawson (2010)

method that can be extended to a multilayer structure in which longitudinal and cross-sectional analysis can be conducted at the same time.

3. Methods

In Section 3.1, the applied terms and definitions are presented. In Section 3.2, the steps of the proposed method are shown. Finally, in Section 3.3, the operationalization of the proposed method is introduced.

3.1. Terms and definitions

Graph: Graph is a tuple $G=(V, E)$, where V is a set of nodes ($V = \{v_1, v_2, \ldots, v_n\}$) and E is set of edges where e_{ij} represents the edge between nodes v_i and v_j ($i, j \in \{1, \ldots, n\}$, n is the number of nodes). Different metrics can be used to determine the "importance" of the papers or to characterize each category (in other words, a group of specific studies) across the citation network. For this purpose, we use density, number of components and mean path length.

Graph density: Density can be calculated as follows:

$$D = \frac{a}{n(n-1)/2} \tag{1}$$

where a is the number of actual edges in a graph (or subgraph), and $n(n-1)/2$ denotes the possible number of edges among the n nodes of the graph. We use graph density to measure how the studies in a particular area rely on each other's outcomes (cite each other).

Connected graph: A graph is connected if it has a path between every pair of nodes.

Number of components: If G is a graph with H subgraph, then H is a component of G if (1) it is connected and (2) H is not connected to any connected subgraph of G (Chartrand, 1977). The number of components reveals information about isolated research within a specific part of a research field.

Mean path length: Mean path length (l_G) can be calculated as follows:

$$l_G = \frac{1}{n(n-1)} \sum_{i \neq j} d(v_i, v_j) \tag{2}$$

where $d(v_i, v_j)$ is the shortest path between nodes v_i and v_j. This metric is used to characterize the length (speed) of information spreading across the specific research subarea (subgraph).

Multilayer network: The proposed method based on a multilayer network analysis, where a multilayer network is a pair $\lfloor M = (\lfloor G, \lfloor C)$ $\lfloor G = \{G_\alpha = (V_\alpha, E_\alpha), \alpha \in \{1, \ldots, M\}\}$ is a family of (directed or undirected, weighted or unweighted) graphs (called layers of $\lfloor M$), V_α is the set of nodes (vertices), E_α is the set of edges (arcs) of graph G_α, and the following:

$$\lfloor C = \{E_{\alpha,\beta} \subseteq V_\alpha \times V_\beta, \alpha, \beta \in \{1, \ldots, M\}, \alpha \neq \beta\} \tag{3}$$

is the set of interconnections between nodes of different layers G_α and G_β with $\alpha \neq \beta$.

Reducibility of multilayer network: The number of layers in the multilayer citation network is an important question. To determine the optimal number of layers, we follow the approach developed by De Domenico, Nicosia, Arenas, and Latora (2015), who used the Jensen–Shanon divergence to measure the pairwise similarity between the layers. The Jensen–Shanon divergence ($\lfloor D_{JS}$) is a modification of the Kullback–Liebler divergence ($\lfloor D_{KL}$). Let $\boldsymbol{\rho}$ and $\boldsymbol{\sigma}$ be two density matrices with respect to two different layers (G_α and G_β); then, $\lfloor D_{KL}$ can be described as follows:

$$\lfloor D_{KL}(\boldsymbol{\rho} \| \boldsymbol{\sigma}) = Tr[\boldsymbol{\rho}(\log_2(\boldsymbol{\rho} - \log_2(\boldsymbol{\sigma}))] \tag{4}$$

Tr denotes the trace of the square matrix, which is the sum of all elements in the main diagonal of the matrix. Since $\lfloor D_{KL}$ is not symmetric ($\lfloor D_{KL}(\boldsymbol{\rho} \| \boldsymbol{\sigma}) \neq \lfloor D_{KL}(\boldsymbol{\sigma} \| \boldsymbol{\rho})$), $\lfloor D_{JS}$ is used instead as follows:

$$\lfloor D_{JS}(\boldsymbol{\rho} \| \boldsymbol{\sigma}) = \frac{1}{2} \lfloor D_{KL}(\boldsymbol{\rho} \| \boldsymbol{\sigma}) + \frac{1}{2} \lfloor D_{KL}(\boldsymbol{\sigma} \| \boldsymbol{\rho}) \tag{5}$$

The results can be illustrated through a dendrogram indicating how the initial structure can be aggregated. Reducibility analysis is very important because it determines the unit of analysis, e.g., the optimal step size if citation network layers are constructed based on time.

3.2. Steps of the proposed method

The proposed method consists of the following four fundamental steps:

1. Metastructure search
2. Exploration of citation network
3. Relevance examination
4. Classification

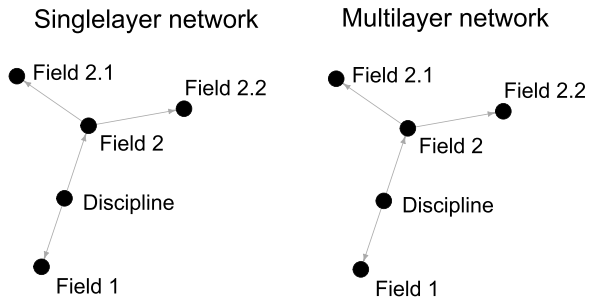


Fig. 1. Metastructure example.

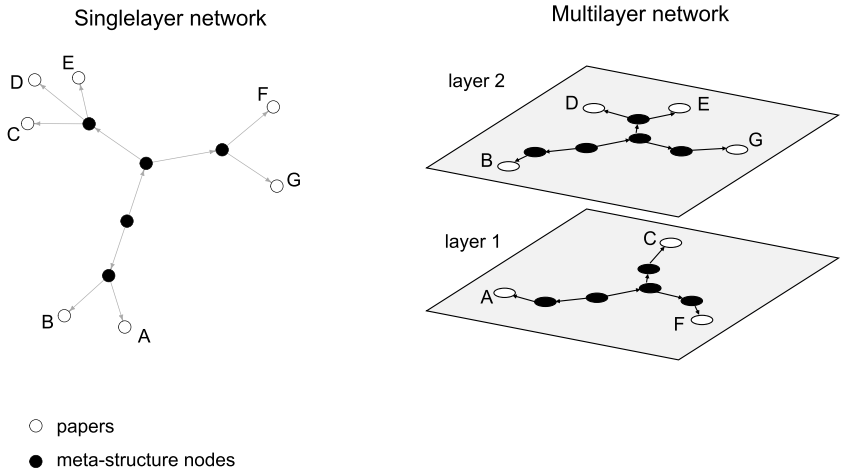


Fig. 2. Metastructure with connected papers.

Table 2 provides an overview of the steps of the proposed approach.

Step 1: Metastructure search. In the first step, a published and relevant literature review must be selected for use as an initial point for the current literature review process. The selected literature review must contain the classification of reviewed articles because its classification rules will be used and further expanded or improved in the remaining steps if necessary. In this paper, we refer to the rules of classification as "metastructure". This metastructure will be expanded and validated iteratively during the application of the proposed method. Nodes represent different research areas within the selected discipline, and edges represent the structure among them (Figs. 1 and 2).

Classified papers based on the selected literature review need to be connected to the built metastructure. Basically, this step summarizes and visualizes the results given by the initial literature review.

Step 2: Exploration of the citation network. The second step is the exploration of the citation network according to the derived metastructure and its classified papers. A list of citing papers must be collected for all the initially classified papers (from step 1) without consideration of relevance, since irrelevant papers (nodes) will be removed as part of a further step. Not only collection but also connection to the appropriate nodes is necessary. Let node "A" represent the classified paper by the initial literature review and node "B" represent one element of the list of citing articles regarding node (paper) "A". In this case, a directed edge needs to be drawn pointing from node "B" to "A", indicating that paper "A" was cited by paper "B". This step must be conducted for all the papers (nodes), including those in the initially selected literature review (Fig. 3).

Step 3: Relevance examination. In this step, the relevance of the explored citing papers is examined, and irrelevant papers must be removed from the constructed citation network (given by step 2). To judge the relevance of the collected papers, the titles, abstracts, keywords and content can be used. Although this step is time intensive, there is an opportunity for further research to build machine learning-based classifiers to support this task and decide whether the examined paper is relevant from the perspective of the literature review (Fig. 4).

Step 4: Classification. The last step is classification, where the constructed citation network needs to be revised. Each connected paper must be analyzed in terms of its relation to the metastructure. If the *i*th paper's topic fits to the area described by the path of the metastructure, then its location can be kept. Otherwise, if its topic is a new area within the analyzed discipline, the path within the metastructure (that includes the current paper) needs to be revised. The following actions can be made:

- Create a new research area

Table 2
Steps of the proposed approach.

Nr	Step	Description	Assumption	Outcome	Stoppage criteria	Opportunities to support
1	Finding a relevant literature review.	A published and suitable literature review must be found, which also describes the typology/classification of approaches in the selected research topic. If more reviews can be found, the researcher can decide to use the (1) union or (2) the set of multiple literature reviews, or (3) the most suitable/cited review can be selected.	At least one literature review exists in the studied research field that describes the typology of the of the selected research topic.	1. A metastructure that describes the typology of the selected research topic. 2. A set of classified papers based on the selected metastructure.	1. An appropriate literature review was found with suitable classification rules 2. An appropriate literature review was selected from several candidates.	Google Scholar keyword search. Specific terms: literature review survey.
2	Exploration of the citation network.	The citation list must be extracted for all the categorized papers given by the literature review defined at step 1. In this way, the number of categorized papers will be increased significantly. The list of citing and cited articles must be stored in order to ensure all the relevant papers are included in this expanded data set.	Citation information must be known to be related to the papers.	An explored citation network based on the selected metastructure.	1. Only new applications of existing solutions but no further approaches can be found in the examined field. 2. Further articles have a low citation number (low relevance).	Existing citation connections can be found automatically with scripts/macros.
3	Relevance checking.	By adding all the cited and citing articles, the network is also increased with by the addition of papers that are not relevant according to the selected research topic. These articles must be identified and removed from the data set.	Title, abstract, keywords of the explored papers.	A cleaned citation network based on the selected metastructure.	All the explored and saved papers are examined from the perspective of relevance.	1. Filtering by keywords 2. Filtering by bigrams/trigrams using the abstract.
4	Classification.	If the citation network is cleaned properly (i.e., all the nonrelevant papers are removed), then the newly explored papers must be examined from the classification perspective. If papers can be found in which new approaches were developed, the metastructure needs to be adjusted, and if necessary, new categories/subcategories need to be added to the initial metastructure.	A cleaned and explored citation network that includes the initial classification of the explored papers.	An updated, relevant citation network based on the refinement of the initial metastructure.	All the relevant papers in the data set were examined regarding the correctness of the classification.	

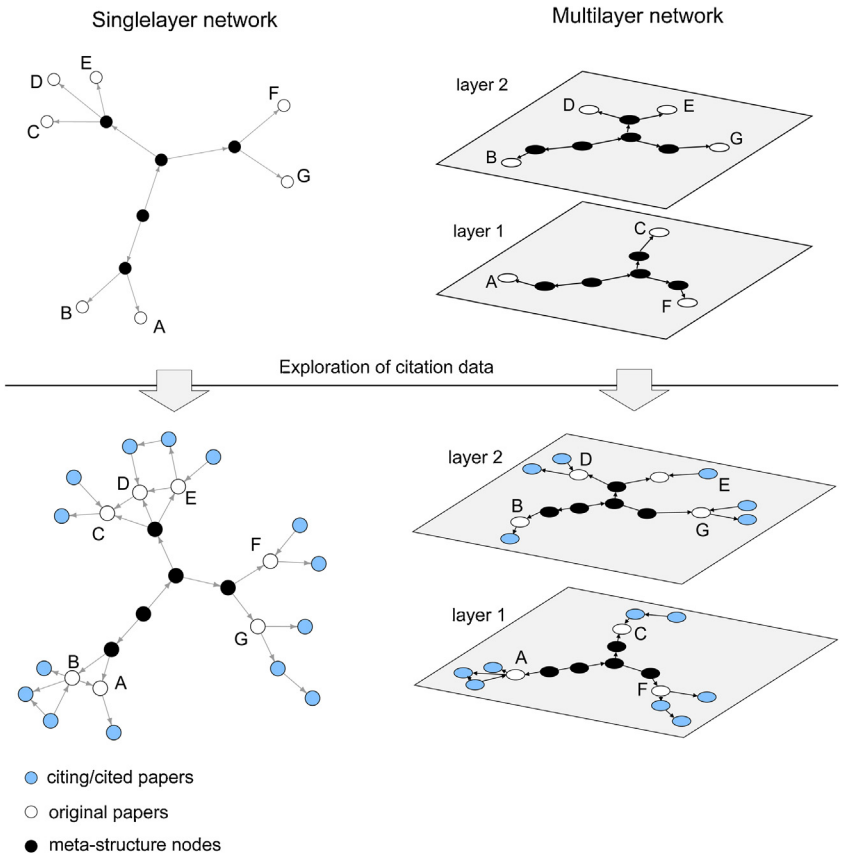


Fig. 3. Exploration of citation network.

- Merge multiple research areas
- Split the existing research area into multiple areas

This phase ends when all the papers are revised (note that only relevant papers are included at this step because nonrelevant nodes were removed as the outcome of step 3). This step ensures that the researcher finds those research areas that came to existence after the original metastructure was created by the selected literature review (Fig. 5).

3.3. Evaluation process

To demonstrate the applicability of the proposed method, we apply the following steps during the evaluation:

I. Data Collection
  (a) Noniterative phase: Search for and selection of an existing systematic literature review.
  (b) Iterative phases: Application of the proposed method for finding additional papers and transforming them into the network structure.
II. Data Analysis
  (a) Single-layer network analysis
  (b) Multilayer analysis
    - Reducibility analysis
    - Analysis across different layers

To facilitate the reproducibility of the proposed method, we give a detailed description of the evaluation process.

I. a. Data Collection - Noniterative phase. This phase covers step 1: *metastructure search* described in Section 3.2. The example focuses on the categorization of existing literature review types, in which we perform a keyword search in Google Scholar to find the most appropriate one. The literature review conducted in the field of information systems by Templier and Paré (2018) was the starting point of the analysis; we used their typology as a metastructure since it is a comprehensive and well-presented overview of the field.

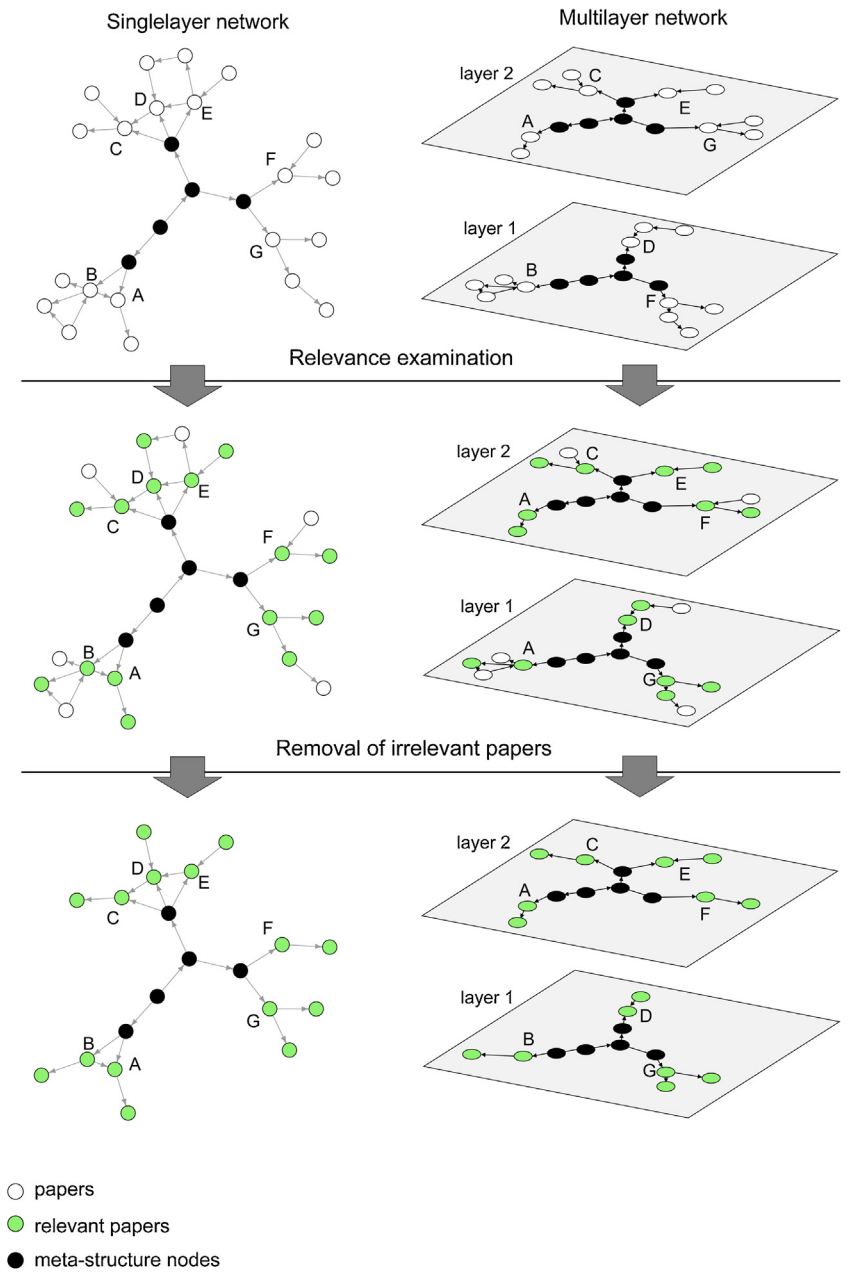


Fig. 4. Relevance examination.

I. b. Data Collection – Iterative phases. This phase covers the iterative steps, i.e., step 2: *exploration of the citation network*, step 3: *relevance examination* and step 4: *classification*, introduced in Section 3.2. First, we explored the citation data among the papers categorized by the results of Templier and Paré (2018). Then, this citation network was further extended by additional papers found by a keyword search in Google Scholar. A relevance examination and classification were performed by two reviewers. To examine the relevance, the title, abstract and keywords of the papers were reviewed (these information were obtained from the given journal's homepage). For the classification, the definitions of each category provided by Templier and Paré (2018) were considered. After assigning the appropriate category, the citations between the newly found paper and the already included ones were determined by a pairwise comparison of the reference lists. The next iteration includes one of the citation references of the newly added paper. These steps were iterated until no further relevant paper was found.

II. Data Analysis. To conduct the citation network analysis, additional data, such as the yearly number of citations and journal H5 indices (representing the journal quality), were collected for each paper in the review. The number of citations

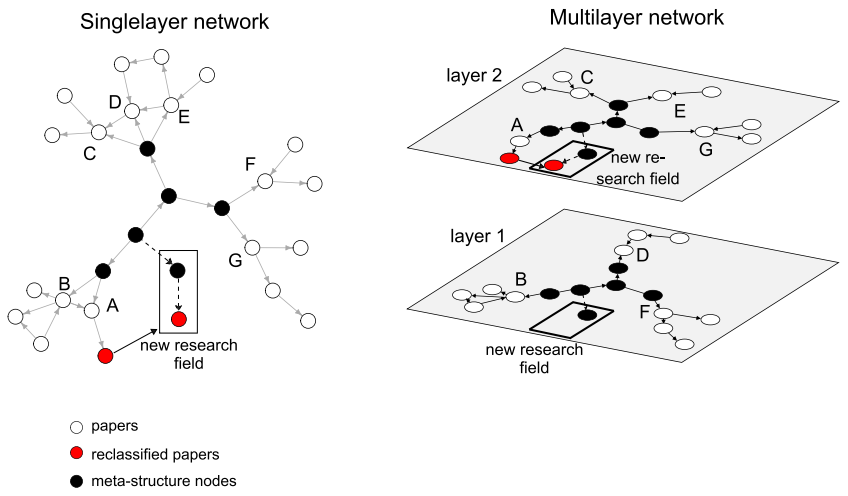


Fig. 5. Classification.

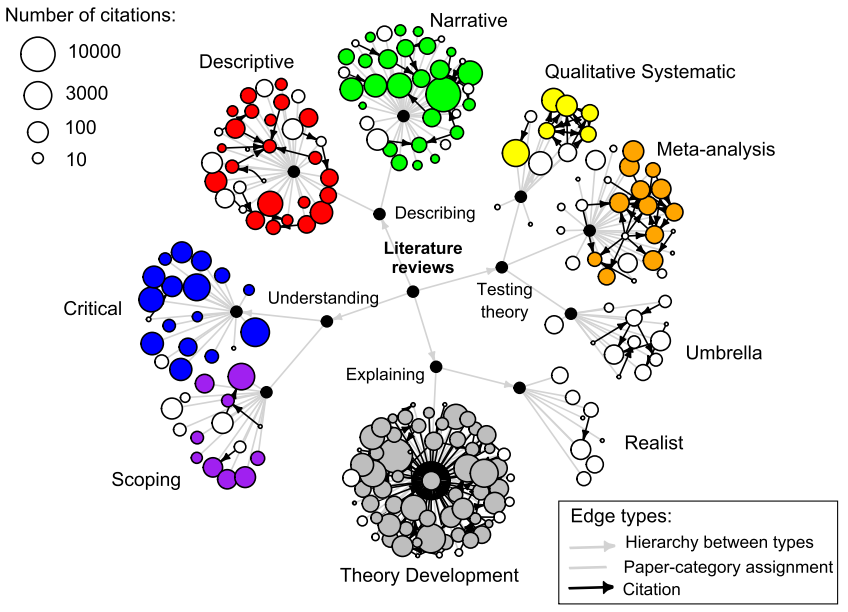


Fig. 6. Single-layer citation networks on literature reviews.

and H5 indices were extracted using Google Scholar's features. As the input, two tables, i.e., one listing the nodes (papers) and one listing the edges (citations), were populated in MS Excel. Single-layer network analysis was conducted in the R program using the "*igraph*" package (Csárdi & Nepusz, 2006). For multilayer network analysis, we used the MuxViz (De Domenico, Porter, & Arenas, 2014) open-access platform. To support reproducibility, all multilayer networks were attached to the paper.

Section 4 introduces the research results obtained by following the structure described above.

4. Results

The aim of this section is threefold. First, the study shows how the proposed iterative method can find new and relevant papers based on the types of literature review. Second, with the proposed general multilayer network approach, the evolution of literature reviews is analyzed. Third, the impacts of the different categories of literature reviews are also analyzed by their existence in the higher prestigious layers.

Table 3
Descriptive properties of the subgraphs.

Subgraph	n	Edges	D	C	MPL_G	All citations
Critical	19	1	0.003	18	1.00	9326
Descriptive	33	14	0.013	20	1.13	8397
Meta-analysis	26	24	0.037	11	1.32	4705
Narrative	35	15	0.013	20	1.12	20,105
Qualitative systematic	11	15	0.136	5	1.06	4205
Realist	8	1	0.013	7	1.00	910
Scoping	15	3	0.014	12	1.00	3619
Theory development	65	97	0.023	5	1.28	39,324
Umbrella	12	7	0.053	5	1.36	715

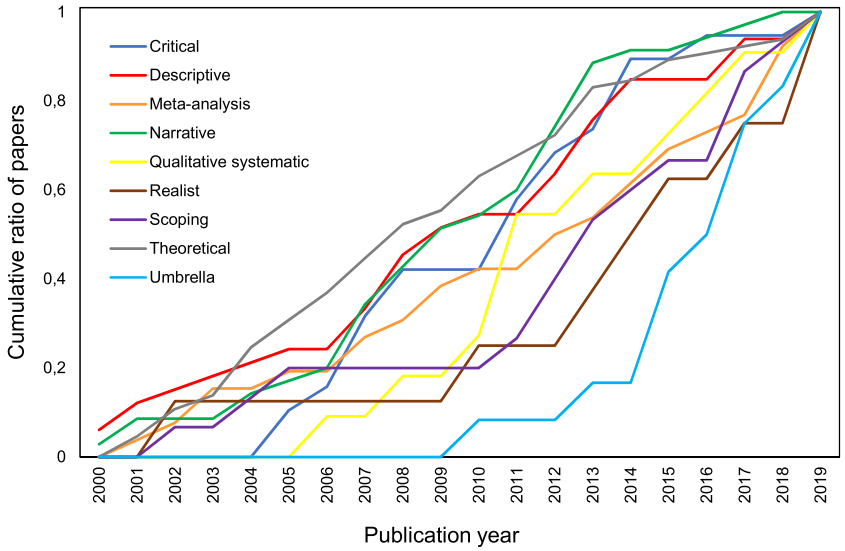


Fig. 7. Cumulative ratio of published articles by year.

4.1. Data source and citation network construction

The initial dataset collected by Templier and Paré (2018) included 142 papers across seven literature review types (there were no papers included in the realist or umbrella review categories). After an iterative data collection based on the proposed method, the dataset was extended with the addition of papers for a total of 224; however, this study is not limited to the specific journals specified by Templier and Paré (2018). As Section 3.3 describes, not only additional papers but also supplementary citation data were collected: (1) citations among papers in the data set were revealed, and (2) the annual number of citations (number of citations by articles within or outside the collected dataset) was extracted for each article.

4.2. Single-layer network analysis

Fig. 6shows the results of the exploration. The size of the nodes is related to the number of citations. Black nodes (14) represent the metastructure, the colored nodes (142) represent the originally collected and classified papers, and the white nodes (82) are the additionally explored papers. Not only was the original list of the papers extended, but even empty categories, such as realist and umbrella reviews, were filled by applying the SIMILAR method. Nevertheless, we can conclude that neither Templier and Paré (2018) nor the SIMILAR method found a new research field as an additional literature review category.

The SIMILAR method proved itself to be a comprehensive method in finding all the relevant literature. Templier and Paré (2018) limited their research to only eight high-quality journals. The SIMILAR method was able to find further relevant highly cited review papers within and outside the initially selected journals of Templier and Paré (2018). Therefore, the extended dataset can include new top papers even from the first quartile, which is also indicated by the size of the white nodes in Fig. 6. When conducting a comprehensive literature review, this paper suggests the consideration of citation numbers during relevance checking in addition to the preliminary specified set of journals.

The SIMILAR method also reveals some important features of the different literature review types. First, the citation network depicts that the number of edges (i.e., the number of citations) is the highest in the theory development category (97, see Table 3), indicating that this category is the most popular. Second, the density of the subgraphs provides additional

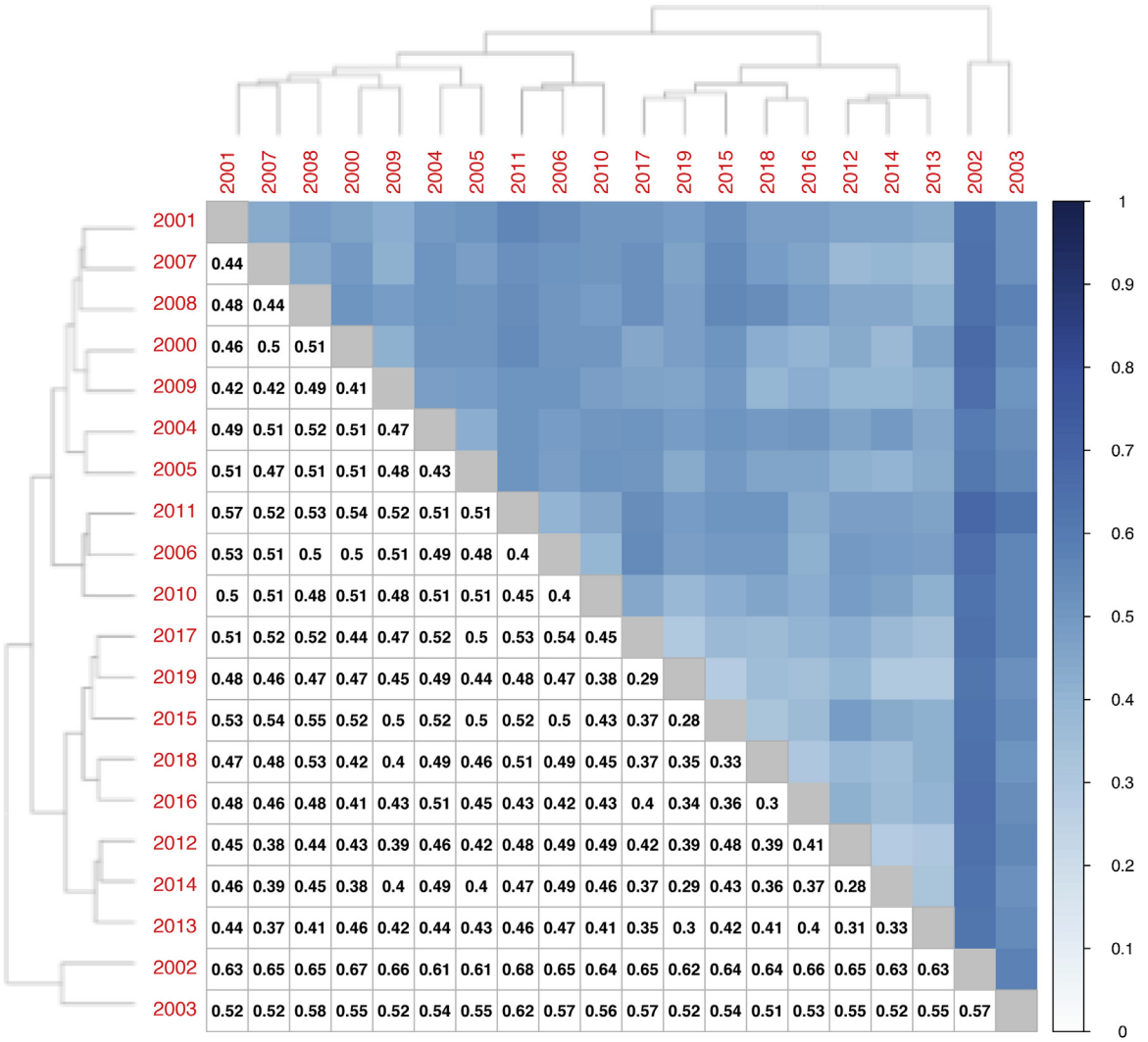


Fig. 8. Reducibility analysis of the multilayer network.

information on categories. The subgraphs in the main category of "testing theory" show high density (see Figure 6), indicating that despite the lower number of papers (nodes), scholars rely on papers from the same category more strongly in the case of qualitative systematic, meta-analysis and umbrella reviews (see Table 3). In contrast, the density of critical reviews is the lowest (0.003), which indicates that critical reviews are very rarely cited by other critical reviews. Third, the analysis of the components shows the fragmentation of the subgraphs. Compared to the number of papers in critical reviews (19), the number of components is outstandingly high (18), which means that this category is very fragmented. Theory development, however, has only 5 components but also the highest number of papers (65), indicating that the research results are separated into a low number of segments. Fourth, the high value of the mean path length shows that umbrella review papers sequentially utilize their results over time. Finally, considering the number of citations, we conclude that theory development and narrative reviews are the most cited types of all.

4.3. Multilayer network analysis

In addition to the single-layer network analysis, the proposed multilayer network enables the analysis of the dynamics of citation behavior. It is necessary to note that this dynamic can represent time or other features, such as journal quality, location, and institute. This section focuses on publication year and journal quality features as the basis of the multilayer structure.

Multilayer network analysis based on publication year. First, we analyze the network structure based on the year of publication. As the initial step of any dynamic multilayer network analysis, the unit of analysis needs to be specified. To overcome the

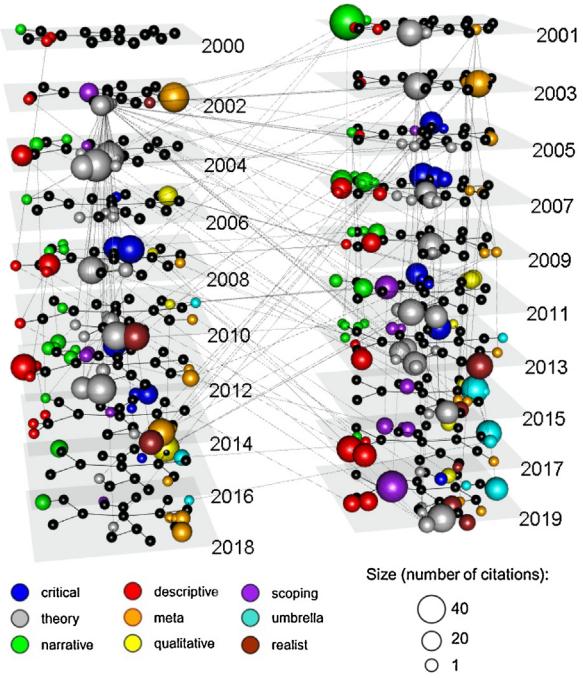


Fig. 9. Multiplex multilayer network-based on year of publication.

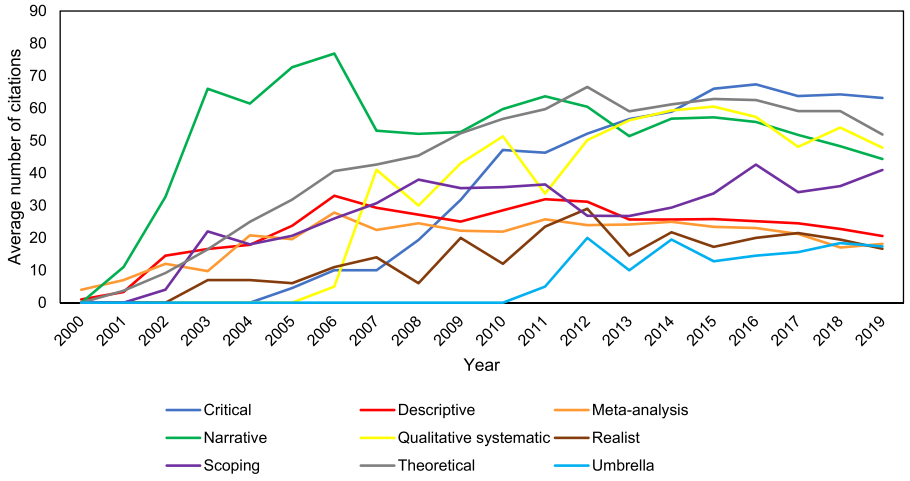


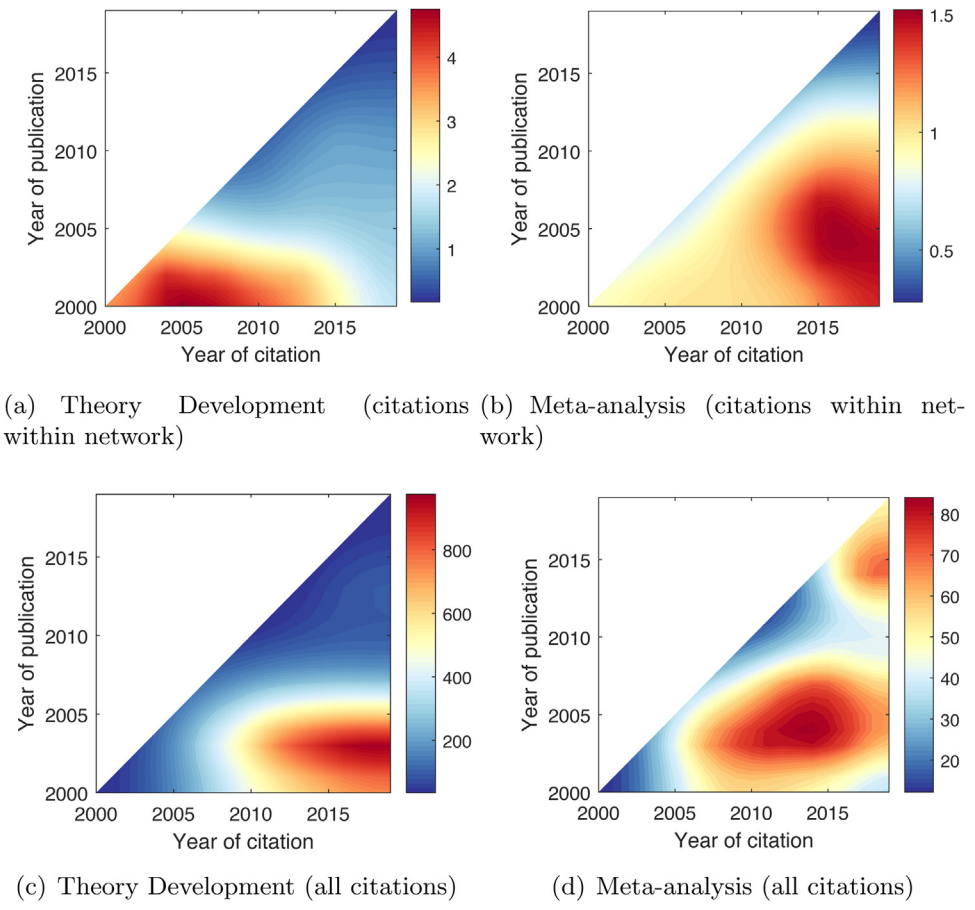
Fig. 10. Average citation number by year.

distortion of the frequencies by category, we calculate the cumulative ratio of papers in each publication year per literature review type (see Fig. 7).

The cumulative ratio of papers can be described well by linear trends, and shifts cannot be observed, indicating the homogeneous behavior of publication activity over time. This suggests that multilayer analysis should be conducted on a yearly basis. We use these results as a reference to analyze whether the multilayer reducibility analysis returns are similar; however, it is a more sophisticated outcome (see Fig. 8).

The result given by the reducibility analysis confirming the initial assumption shows that every single layer should be treated as a standalone layer except layers “2002” and “2003”. In this case, however, merging layers “2002” and “2003” does not grant any remarkable simplification related to the analysis. Thus, in this paper, we conduct multilayer network analyses on a yearly basis. Fig. 9 shows the multilayer citation network in which each layer represents one publication year.

Similar to the single-layer analysis (see Fig. 6), in this type of analysis, black nodes represent the metastructure, and colored nodes denote the collected papers in a particular publication year (layer). The node size represents all the number of citations received in the same year (layer). The intralayer edges show the citations among the articles published in the same year, while the interlayer connections represent the citations from different years. The multilayer citation network



(a) Theory Development (citations within network)

(b) Meta-analysis (citations within network)

(c) Theory Development (all citations)

(d) Meta-analysis (all citations)

Fig. 11. Citation behavior of review papers in the theory development and meta-analysis categories.

is a powerful tool for examining multiple characteristics at the same time. Fig. 9 clearly indicates that narrative reviews densified in the time period of 2004–2012, while umbrella reviews received increased attention from 2013. In addition, the multilayer analysis also indicates that a number of theory development reviews are highly cited even in the year of their publication.

In addition, Fig. 10 presents the average number of all citations (citing papers even outside the collected dataset) for each category per year. Narrative reviews rapidly emerged until 2003 and remained highly cited afterwards. The citation trends for all of the categories except scoping reviews became flat after 2013. This analysis also highlights that the examined review categories can be classified into two groups based on the average number of citations in 2019. The upper group contains 5 review types, namely, critical, theory development, qualitative systematic, narrative and scoping reviews, with greater than 40 citations for a paper on average.

Fig. 11 grants further analysis opportunities by extending the examination with an additional dimension such as the year of publication. The nature of the citations is presented by smoothed contour maps based on frequency matrices. The horizontal axis shows the year of the citing papers, while the vertical axis denotes the year of publications. The upper triangle is missing because the citations come up only after publication. Two categories, namely, theory development and meta-analysis, are selected to characterize their citing behavior.

In Fig. 11a and b, the contour maps are only calculated according to the collected dataset, while Fig. 11c and d shows all the citations extracted from Google Scholar. In the case of the theory development category, considering citations among the collected IS literature reviews (Fig. 11a), the most cited papers were published in 2000–2001, and the citations mainly came from the period of 2002–2012. This pattern is still valid if all the citations are taken into account (Fig. 11c); however, the emphasis shifts to the period of 2010–2019. In the case of meta-analysis reviews, most of the cited papers were published around 2004, and they received the most citations after 2012, considering the citations among the collected IS literature reviews (Fig. 11c). However, the citing behavior shows a different pattern if all the citations are taken into account. Two peaks can be observed, meaning that high-quality meta-analysis papers were written first in the 2002–2006 period and second in the 2012–2017 period (Fig. 11d).

Multilayer network analysis based on journal quality. Journal quality is another important feature that can be used to construct the multilayer citation network structure because it reveals which categories are published by prestigious journals.

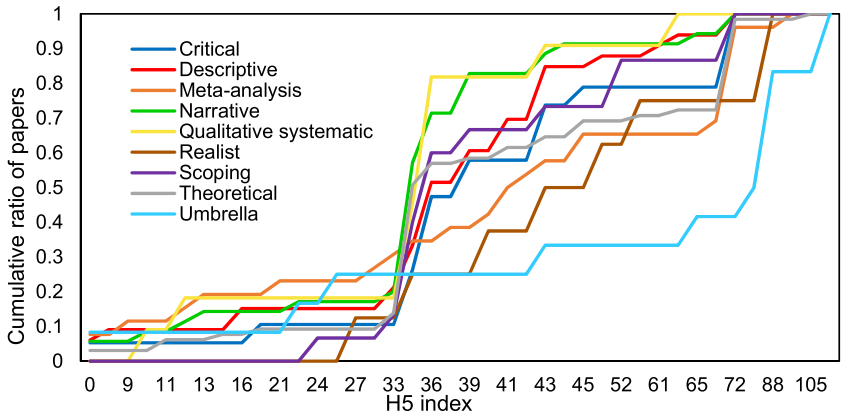


Fig. 12. Ratio of papers by H5 index (cumulative).

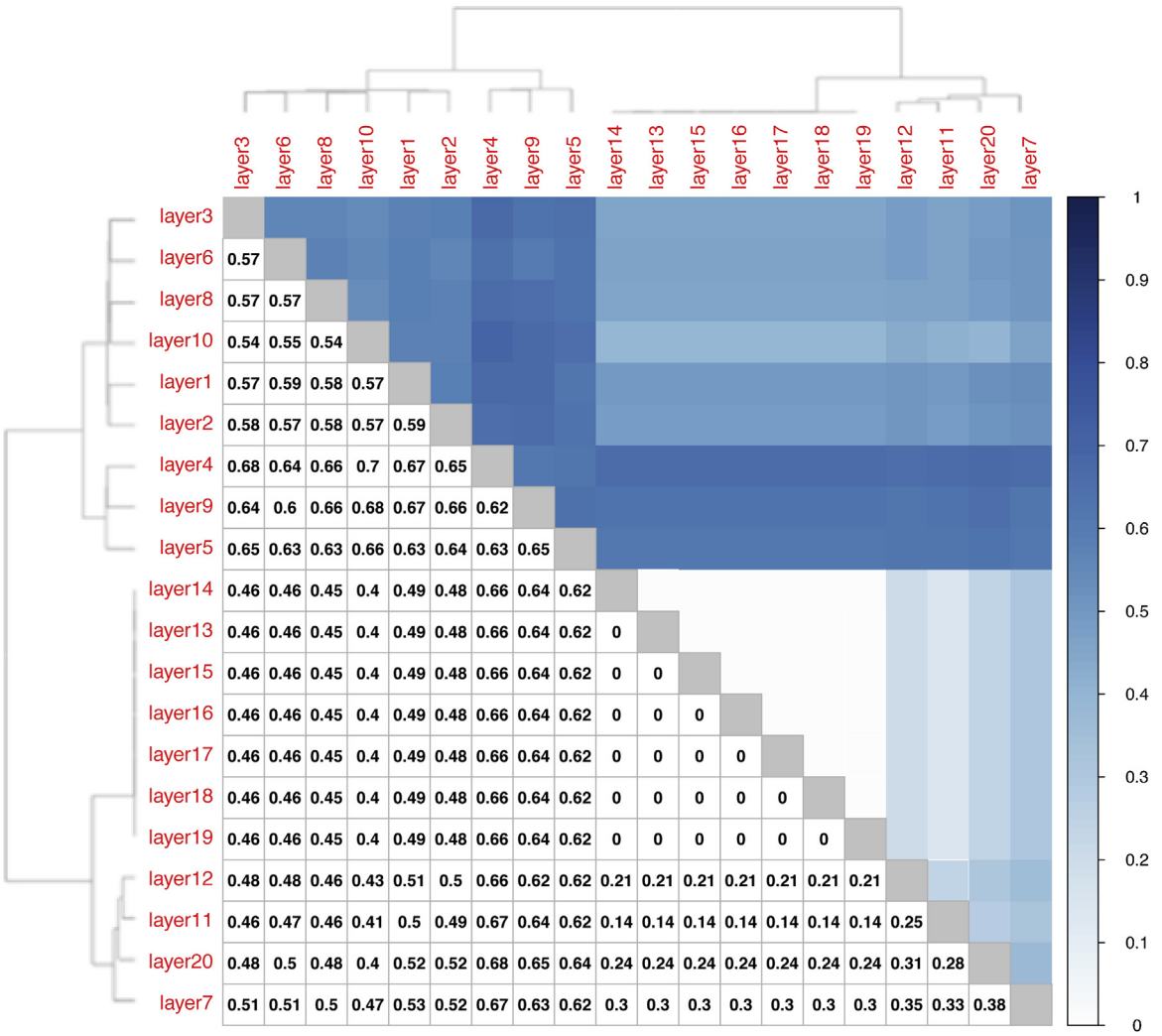


Fig. 13. Structural reducibility.

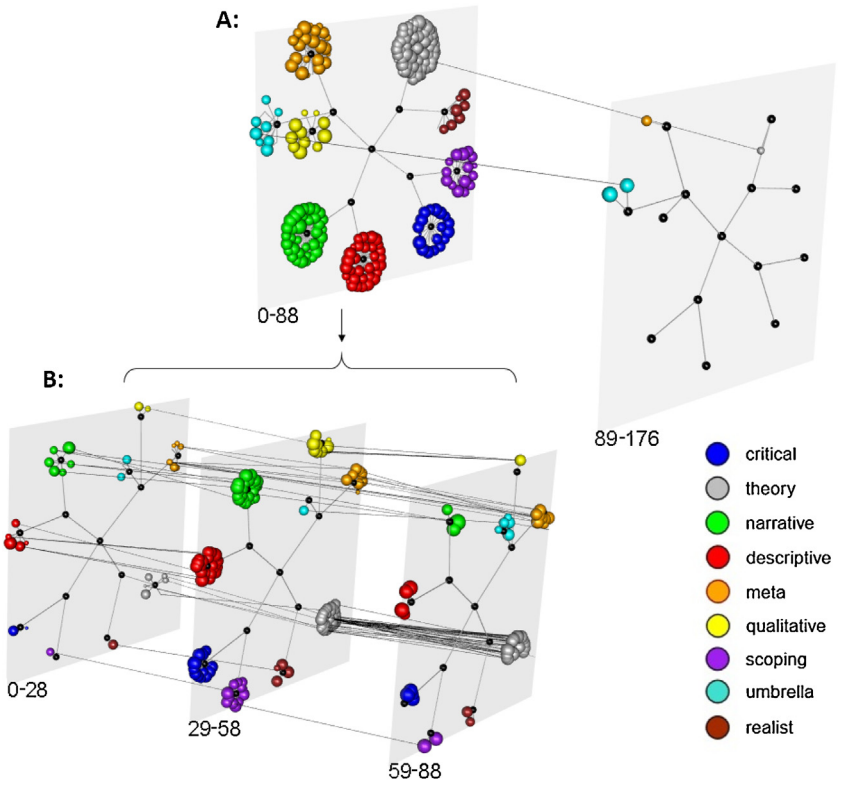


Fig. 14. Multilayer network-based on journal quality.

Following the logic applied in the yearly analysis, the cumulative ratio of papers is calculated by the H5 index to overcome the distortion of the frequencies by category (see Fig. 12).

Unlike that for the yearly analysis, Fig. 12 shows a remarkable shift in the cumulative distributions, suggesting that layers could possibly be merged by the multilayer analysis related to journal quality. To specify the unit of the analysis, a reducibility analysis was conducted. Fig. 13 shows the clustered distance matrix of layers, suggesting two layers for multilayer network construction (see Fig. 14a). Fig. 14b confirms that using an additional layer does not indicate any structural differences.

The results show that only a few literature review types, such as umbrella, meta-analysis and theory development, are published in the highest prestigious journals (see Fig. 14a, layer 89–176).

5. Conclusion

As the number of published scientific papers has increased exponentially over the past decades, conducting effective and efficient literature reviews is essential. This paper presents a novel method called **S**ystematic **I**terative **M**ult**ILA**yer literature **R**eview (SIMILAR), which can overcome several shortcomings of existing methods. The proposed SIMILAR method consists of four fundamental steps: (1) metastructure searching, (2) exploration of citation network, (3) relevance examination and (4) classification; this exact procedure enables the comprehensive exploration of a given disciplinary field or research area. The merits of our method include the following: (1) the SIMILAR method iteratively builds a citation network that ensures the minimization of information loss and a comprehensive literature review; (2) the citation network is transformed into a multilayer structure allowing the simultaneous longitudinal and cross-sectional analysis of a disciplinary field or research area; (3) multilayer analysis enables the spread of modeling information across the network; and (4) multilayer citation network subgraphs can be characterized objectively by using appropriate network features such as density, diameter and mean path length.

By demonstrating the proposed method in the field of information systems, we extended the research results addressed by Templier and Paré (2018) as an initial dataset. We revealed new papers and filled a gap by finding literature based on two missing review types; we also provided additional information about the yearly publication activity and the quality of review articles based on the H index.

Finally, choosing the most appropriate literature review as the initial structure can be challenging, especially when multiple candidates are available. To choose the most appropriate one, we suggest considering the publication year of the review as a decisive factor, since using a newer categorization will result in fewer changes in the metastructure during the iterations. Furthermore, if no significant difference exists between the publication years of several reviews, we propose

choosing the one that provides a clearer categorization and interpretability to make the classification (step 4) more precise and objective.

6. Limitations and future works

In this paper, we selected a given literature review as the metastructure. We did not investigate how starting from a different review would affect the findings provided in Section 4. Another limitation of SIMILAR is that it assumes the existence of a given metastructure. Future research lies in extending the proposed method to use machine learning approaches such as topic modeling to construct the initial metastructure of the selected research field.

Authors' contribution

Zsolt T. Kosztyán, Tibor Csizmadia and Attila I. Katona: conception; study design, methods used; acquisition and collation of data; analysis, interpretation of data; writing the manuscript; critical revision of paper.

Conflict of interest

None declared.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.joi.2020.101111.

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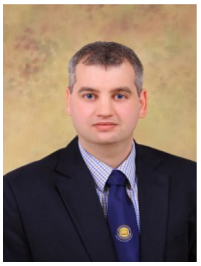

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