Method and Tool for Generating Table of Relevance in Literature Review (MTTR)

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Abstract— Every day, researchers in computing and IT are challenged with several articles that they need to rate, classify and separate quickly and effectively to contextualize and further advance their research effectively. It is considered that literature review is the most important step of discovery. Notably, a literature review is a part that allows the researcher to adjust the perspectives and limitations of an area of study. However, there is a lack of effective methods and tools for this activity. Often, traditional knowledge management techniques result in the "Gordian Knot" slowing down the process of literature review considerably.

In this article, we present a Method and Tool for Generating Table of Relevance in Literature Review (MTTR). The MTTR is an innovative organizing method supported by software tools that make the literature review activity more efficient, faster and cheaper. An interesting feature of MTTR is data visualization using the Heat Map technique, Word Cloud and statistical techniques in designating and comparing each scientific article with the other relevant articles. The productivity gains in MTTR occur due to the automation in structuring and sorting scientific articles. In addition to efficiency, the lowest cost has the potential to place the MTTR as a preferred tool for the researcher. The anecdotal evidence reported in this article suggests that it is possible to carry out a literature review in a much shorter time with MTTR than in the traditional manner.

Keydords: Review Method, Heat Map, Word Cloud, Active learning tools, Systematic Review

1   Introduction

A literature review is a careful selection of relevant literature to understand the research background and the context of the problem. It allows appreciation of the earlier studies and contributions of other researchers in the field. It also consolidates the basis in which the logic of intellectual research is being structured and helps to open new avenues of unexplored terrain. In the domain of knowledge management and curation, there are many articles that discuss methods to improve and ease the selection and prioritization of the processes for systematic (Biolchini *et al.*, 2005; Budgen and Brereton, 2006) or quasi-systematic literature reviews (Da Silva *et al.*, 2017). Automated or semi-automated literature review protocols and processes consist of parameters such as bases and indices; search phrases; inclusion and exclusion criteria; and extracts of synthesised or preliminary analysis of the works being available in the pool. Despite variations in format, style and emphasis, the literature review surveys usually have a basic structure such as: Title, Abstract, Keyword, Introduction, Method, Discussion, Conclusion, and References. In general, the structure of the research paper is a subjective and imprecise model as it is based on researchers' diverse preferences of drafting, reading, interpreting, and organising the content under consideration. Hence, many literature review processes and tools are susceptible to various errors and a considerable amount of time in classifying the articles. Despite being tedious and complex, efficient development of the protocols and processes for the literature review of a large number of scientific articles are necessary to further advance the existing knowledge in any discipline. The Heat Maps are important visualization tables for viewing and interpretation of data. Since they add relevance factor (Whetten, 1989), they are used in various methods presented in (Laura M. Stapleton University of Maryland, 2008). In

study of multidisciplinary cooperation, a way to value the science of computation provided by (Surveys, 1994) mentions the generation of tools to support research in other areas such as generating new ideas, designs and tools for task assignment, information routing, and group decision-making. In simple terms, adding or subtracting some factor from an existing model may be sufficient for a novel theoretical framework (Whetten, 1989).

This work proposes a novel method - Method and Tool for Generating Table of Relevance in Literature Review (MTTR) intended as a support tool for systematic and non-systematic reviews (Figure 1) following the complete cycle between acquisition of relevant articles and ending with visualization through the heat map (Figure 3). The proposed method exploits the content of the key sections (e.g. Title, Abstract, etc.) of the set of sample papers to generate the word clouds in selecting and organizing the related research works. The heat map shows how much any word or expression appears in each article and produces a relevance table as an indicator for prioritizing and ordering the selected works in terms of 'meaningfulness' in the literature review. In particular, the emphasis is on an improved objective criteria that use counting of words and expression in the text to provide the relevance of each article into a heat map. MTTR offering accurate determination of the relevance of articles to a search presents advantages such as: drastic reduction in article review time, data visualization using a heat map, unequivocal indication of the relevance of the evaluated articles, rapid search refinement, improvement in the quality of the analysis and objective classification of articles. Compared to other methods presenting subjective results, deficient or incomplete interpretation, and excessive time, the results presented by the MTTR are objective, measurable and repeatable. In summary, the main contributions of this research are: i) the method for generating relevance tables in literature review (MTTR) as shown in Figure 2; and ii) a software tool for supporting MTTR.

The remainder of this paper is organized as follows: Section 2 provides Literature Review; Section 3 presents a summary of related work; Section 4 outlines conceptual architecture of MTTR and related concepts; and finally in Section 5, we present our conclusions and future work for the MTTR.

2   Literature Review

The literature review is the process of searching, analysis and description of a body of knowledge in quest of an answer to a specific question. The systematic review process can be understood as a three-step approach as follows (Biolchini *et al.*, 2005):

- The first phase begins from the concepts that formally represent the problem in question, make it explicit. It encompasses the study of works that can provide evidence on the specific topic of research;
- In the second phase, works are detailed or categorized according to their content and compared in a systematic manner with to identify results or trends that that can be analysed;
- The third phase begins with the results of the previous phase and focuses on the analysis and synthesis to reach the conclusions.

Regardless of the phases of the literature review, researchers are expected to look at all the relevant material such as books, journal articles, newspaper articles, historical records, government reports, theses, dissertations written on the topic of interest.

On the subject of literature review specific to the area of computer science, particularly Software Engineering, the guidelines of (Biolchini *et al.*, 2005) assist researchers on "what" rather than "how " when it comes to engaging in methods and techniques for literature review. (Bond and Acheson, 2017) present the literature review as a mandatory step in scientific work. The theme of the work addresses systematic review in Health Sciences. The objective is to evaluate, summarize and communicate the results and their implications. Despite all the guidelines contained in the article, the researchers need to go through all the steps of the literature review manually.

The article written by (Miley and Read, 2011) examines students response to a technique for summarizing available information based on word frequency. The article reports students' experience with the technique of creating 'word clouds' to enhance personal and small group study. The survey result indicates that it is accommodative of students' learning style preferences. Kolb's learning styles inventory was used. The research also found that word clouds have potential in the workplace and that students enjoy using word clouds and it a

potential learning tool. (Ennis, 2010) explores the use of word clouds for abstracts as indicators of documents content in an academic context. The author identifies current uses for abstracts, issues in their production, and the use of Web 2.0 technologies as content indicators. Author considers a survey of six participants who completed questionnaires to determine their initial impressions of abstracts, before viewing multiple word cloud summaries and filling out additional questionnaires about the usefulness of those summaries. It advocates that word clouds are useful indicators of document content that help researchers to decide whether an article is relevant to their research topic. It shows that large clouds were preferred by participants over clouds with fewer words. The research found that clouds are useful and quick to create, they are relatively inexpensive, they can be used as document summaries in place of traditional narrative summaries. The article by (Reyes-Foster and DeNoyelles, 2016) presents exploratory research on the influence of word clouds on students' critical thinking when they are incorporated into online discussions. In an online discussion, students were asked to critically analyse two speeches, with the task assigned under two conditions: one in linear text format and the other the text was presented in the form of word clouds. Students who observed the word cloud exhibited more instances of critical thinking than students in the linear text reading condition. The article concludes with recommendations for other educators to use the word cloud in similar approaches.

(Vieira, Vieira and Coelho, 2019b) proposed a data-driven approach to developing a taxonomy on a data structure in a list of triple bottom line (TBL) metrics. The approach is built on the authors' reflection on the subject and a review of the literature on TBL. The predicted taxonomy framework grid developed through this approach allows existing metrics to be sorted, grouped, and standardized. The reported approach aims to develop a taxonomic structure that can be seen as a two-dimensional table, focused on characteristic questions and on the characterization of responses. The method proposed in (ACM, 2019) as seen in Table 1 adds a further dimension to the concept matrix to handle the unit of analysis after the interpretation of a number of papers. The distribution provided by search engines in ordering the papers in consolidating the literature review was proposed in (Webster and Watson, 2014). In Table 1, we can observe three concepts: O = Organizational; G = Group and I = Individual. The criteria to classify each paper into this concept depends on the subjective interpretation of the reader.

Table 1 – Table that adds a further dimension to the concept matrix to handle the unit of analysis

Concept Matrix Augmented with Units of Analysis														
Articles	Concepts (Organizational; Group; Individual)													
	A			B			C			D			…		
Units of Analysis	O	G	I	O	G	I	O	G	I	O	G	I	O	G	I
1					X				X						X
2	x				X	X		X							
…								X	X			X			

Table 2 - Example paper's table to show the paper's contribution in a survey paper

Summary of the main references and contributions
LEGEND: A = Paper Reference; B = Performance; C = Reputation; D = Security design; E = Recommendation; F = User context aware; G = Contractual guarantees; H = Certification; I = Resources involved; J = Transparency; K = Information Disclosure (security incidents); L = Domains; M = Contribution type

Id	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Alhanahnah, et al. (2018)[5]	X	X	X				X		X		GV, IS	Taxonomy
2	Kanwal, et al. (2015) [6]					X	X	X		X		IS	Taxonomy
3	Lansing, et al. (2016)[21]	X	X	X		X	X	X				GV, IS	Taxonomy
4	Chrysikos, et al. (2018) [7]		X	X	X	X			X			IS	Taxonomy, Framework
5	Dasgupta, et al. (2011) [32]			X		X	X					GV	Framework

In the article (A. B. Filho, F. de Franco Rosa, R. Ruiz, 2019), authors summarize a manual survey as implemented in Table 2 of word clouds from 39 papers. This process did take three full days of work. The reading and interpretation to mark the papers' contribution in columns B to K were also dependent on the subjective interpretation of the reader.

The proposed method aims to show usefulness of a combination of automatic or semi-automatic ways of exploration and presentation of the literature review to assist the researchers effectively.

3   Related Works

The analysis of the complex survey was dissected in several aspects in (Laura M. Stapleton University of Maryland, 2008). Since the criteria for the formulation of the questions, the composition of the data from the dataset, and sampling design, the tables are essential for viewing and interpretation of data and they are used in various methods presented in (Laura M. Stapleton University of Maryland, 2008). Most of the work dealing with the theme survey is focused on questionnaires that will be answered by humans in interview or structured and standardized as numbers, economic indices, or census data. When we talk about a survey of scientific literature review, we still encounter subjectivity, even in tables. As the columns are defined by the subjective criteria by the author, the answers that match article criteria are very dependent on the individual interpretation of the reader.

In (Fowler *et al.*, 2014), the authors argue that the research methodology seeks to identify principles on research design, collection, processing and analysis and are linked to the cost and quality of research estimates. In short, this means that research methodology focuses on improving the quality of output within cost constraints, or alternatively reducing costs to some fixed level of quality. (Fowler *et al.*, 2014) argue that in high-quality research, in addition to the methodological and scientific aspect of the questionnaires used, care must be taken in the selection of statistical samples and the universe surveyed. The didactic reading of the text is a function of the layout, analysis and comparisons, and the presentation of surveys and data tables (Figure 1). In Figure 1, the method presented is unidirectional whereas our method is cyclic (Figure 2). In our work, the table is not only a dataset but a representation of the analysis of the data collected. In fact, our method aims for an automation, objective analysis, and pragmatic applications by transforming the conventional methods based on manual and subjective approaches.
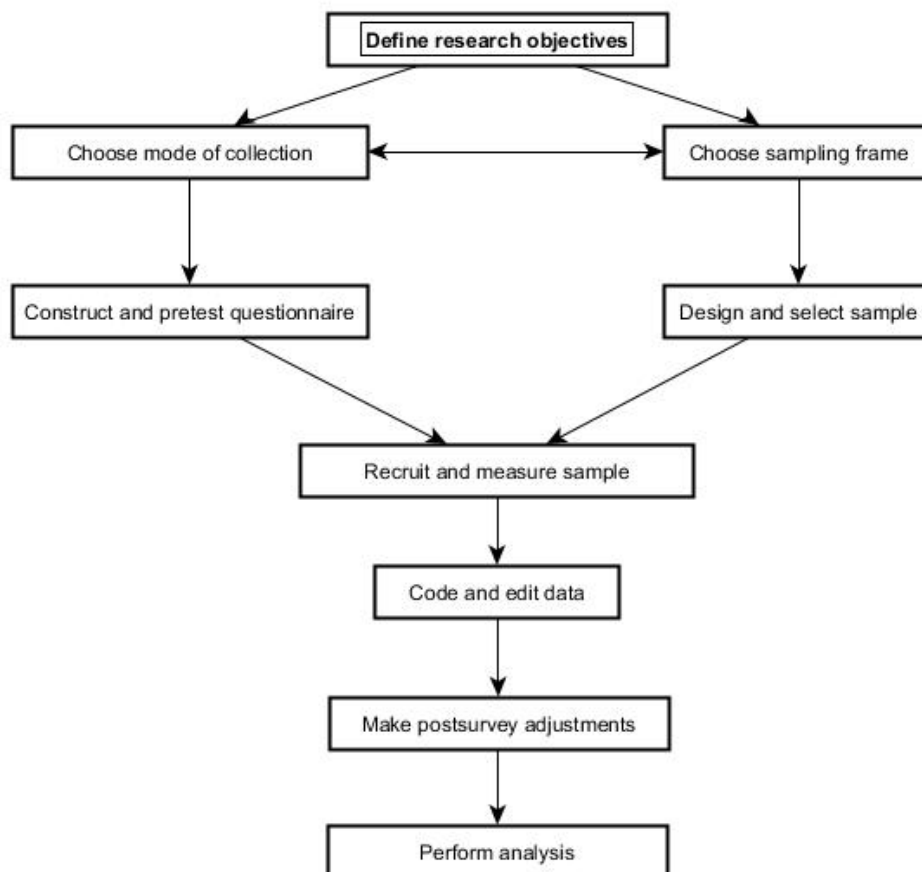

Figure 1 A survey from a process perspective

4 Conceptual Formalization

Based on the articles presented in Section 2 (Literature Review) and Section 3 (Related Works), we developed a Method and Tool for Generating Table of Relevance in Literature Review (MTTR) to provide better performance and reliability to researchers during their literature review tasks. The core aim of MTTR is to drastically reduce the time for literature review compared to other table based traditional methods. MTTR methodology tries to mechanise the usual logic of conducting the literature review through steps that allow the researcher to efficiently automate and direct the work. MTTR allows the researcher to obtain relevant cues from a large number of articles those that are directly linked to the main interest.
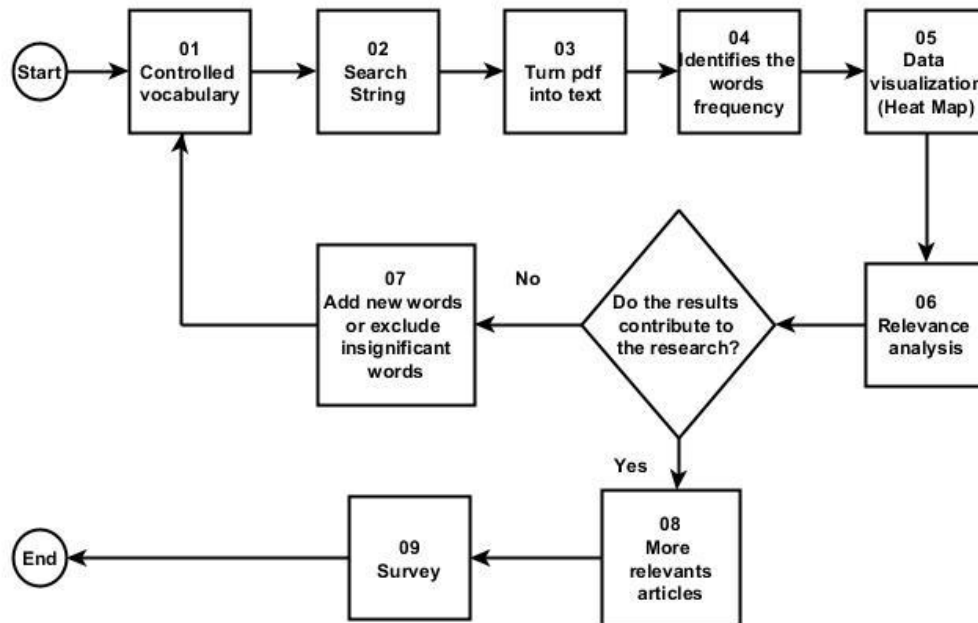

Figure 2 Process of MTTR

The process of MTTR of shown in Figure 2. This process can be seen as acquiring text files of relevant papers and ending with the taxonomy table. To work with MTTR method in a personalised manner, the researchers can adopt database-based solutions such as use of separate folders to store PDF papers, spreadsheets to organize the content or other third-party software of their choice. The MTTR is elaborated in nine steps as follows:

- **Step one** - Define controlled vocabulary, i.e., definition of the Title of the Survey.
- **Step two** - Define a search string, i.e., a priori. The researcher already has a research idea and needs to define a search string that will be used in searches of different scientific article databases (IEEE, ACM, SPRINGER, RESEARCHGATE, ACADEMY). The search string will help find potential articles useful for the search.
- **Step three** – Convert PDF to text. In order to carry out the work of establishing the relevance of the words, the articles are converted from PDF format to plain text, excluding images and tables. The result is stored in the MTTR database.
- **Step four** - Identify the word frequency. In this step, the MTTR performs the automatic counting of the frequency of words and expressions in each article that the researcher selected. We developed a Python algorithm that performs statistical operations and does automatic counting of words and expressions. In this way, a dataset containing words and expressions in each article is generated. This is a necessary step in order to ensure the process proceeds to the Word Cloud Generation (Figure 3). As discussed earlier, the word cloud makes it easy to see the relevance of words.
- **Step five** - Heat Maps. The words generated in the previous step are used for the integration and visualization of the most important words and expressions. The data is transformed into word clouds and heat maps (Figure 4) for each article to enable more efficient analysis. The visualization of information through the heat map helps the researcher to adjust the search expression and to select relevant articles.

- **Step six** - Relevance analysis. It exploits definition of expression dictionary based on the results of the previous items and the intent and point of view of the researcher.
- **Step seven** - Add or exclude terms. Each new 'term item' needs to be linked to the word dictionary;
- **Step eight -** Selection of relevant papers. Analysis and attribution to rate each paper for individual word clouds item on the scale of 1 to 5 according to the relevance of word cloud of the individual paper in comparison of all word clouds.
- **Step nine** – Write the survey. Summarize a short paragraph for each paper to describe the paper resulting into the Survey topic; create introduction topic; generate heat map of classification of each paper; create discussion topic including the table; create a brief of this method and cite it; create conclusions; create references; format the survey paper.

Figure 3 Word cloud

articles	cyber	security	system	information	mission	network
02-DesigningMethodDiscoveringExpertise.txt	203	238	222	390	2	55
23-Cyber-ARGUS - A mission assurance framework.txt	0	73	115	91	200	0
18-frameworkfortheethicalimpactassessment.txt	0	13	13	93	0	16
62-Mission-Centric Automated Cyber Red Teaming.txt	87	56	65	0	153	84
21-UnderstandingInformationAssuranceSecurity.txt	0	313	89	350	1	9
20-Fundamental Concepts of Cyber Resilience.txt	149	18	228	14	9	107
36-The Human Factor in Cybersecurity.txt	229	58	72	55	5	51
25-Simulations in Cyber-Security.txt	110	101	43	30	0	122

Figure 4 – Partial view of heat map of 56 papers, 46 terms, and their relevance for each word.

Table 3 Main contributions and a conceptual characterization

Reference	Main Contribution		Software				Performance	
	Concepts	Method	Word cloud	Heat map	word statistics	Summarization	Low	high
(Biolchini *et al.*, 2005)	Yes	Yes	No	No	No	No	Yes	No
(Borja, no date)	Yes	Yes	No	No	No	No	Yes	No
(Whetten, 1989)	Yes	Yes	Yes	No	No	No	Yes	No
(Bond and Acheson, 2017)	Yes	Yes	No	No	No	No	Yes	No
(Miley and Read, 2011)	Yes	Yes	Yes	No	No	No	Yes	No
(Ennis, 2010)	Yes	Yes	Yes	No	No	No	Yes	No
(Vieira, Vieira and Coelho, 2019a)	Yes	Yes	Yes	No	No	No	Yes	No
(Reyes-Foster and	Yes	Yes	Yes	No	No	No	Yes	No

DeNoyelles, 2016)							
(Fowler *et al.*, 2014)	*Yes*	*Yes*	*No*	*No*	Yes	*No*	*Yes*	*No*
(Groves *et al.*, 2004)	*Yes*	*Yes*	*No*	*No*	*No*	*No*	*Yes*	*No*
Our proposal	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	**Yes**	*No*	**Yes**

In Table 3, we summarize the main contributions, and show a conceptual characterization, by highlighting specific characteristics of the conceptual formalization on literature review. A "Yes" in a cell indicates that the reference explicitly addresses the set of concepts or provides the contribution. Table 3 is not exhaustive and does not show all set of proposed concepts.

5 Proof of concept

In our proof of concept, an experienced researcher was asked to perform the task of literature review so that we could compare the execution time of the same task and its quality. Thus, the researcher performed the task with 40 previously selected articles on cloud services (Amândio Balção Filho; Ferrucio de Franco Rosa; Rodrigo Ruiz; Rodrigo Bonacin; Mario Jino, 2019) and it took 20 hours to evaluate and produce a table with contributions with the same establishment of relevance of the articles. In another Cyber Operations literature review (Amândio Balção Filho; Ferrucio de Franco Rosa; Rodrigo Ruiz; Rodrigo Bonacin; Mario Jino, 2019), we used 56 previously selected articles and the MTTR took 20 minutes to complete the task. The result of the word cloud and heat map, respectively, of this review can be seen in Figure 3,
Figure 4 and Figure 5. In this case, the MTTR also summarized the articles. In
Figure 4, the result of our process and software shows the name of the articles in the first column with key words from word clouds in other columns with relevance scores.

Figure 5 - Relevance table with all 56 articles

In order to facilitate MTTR to work in integrated manner, a process was developed that integrates several technologies, as explained below:

- **Step one** - Define controlled vocabulary - e.g., cyber, cybersecurity, system, information
- **Step two** - Define a Search String. Example of search string: ((word1 OR word 2) AND ("word 3") AND ("word 3" OR word 4)) and survey or review

- **Step three** – Convert. We use *pdftotext* for this task. The *pdftotext* is a command line utility that converts PDF files to plain text.
- **Step four** - Identify the word's frequency. We developed an algorithm in Python, which is responsible for reading files in text format and categorizing keywords and expressions. For a better understanding of the text, we provide a heat map (
- Figure 4) with the inferred contribution of each work in the literature review.
- **Step five** - Heat Map. Words and expressions are loaded directly into an excel spreadsheet for viewing via the heat map. The algorithm also produces the word clouds as shown in Figure 3.
- **Step six** - Relevance analysis. Heat map and word clouds makes it possible to identify the most relevant words and the most relevant articles in the search.
- **Step seven** - Add or exclude terms. This is a recursive step where the researcher will make the necessary adjustments.
- **Step eight** - Selection of relevant papers. The process allows list control by inputting a fixed number (N) to list N most important articles for the given research topic.
- **Step nine** – Write the survey. After selecting the most relevant articles, it is time to write the survey. Text Compactor - a free online automatic text summarization tool was use for that purpose.

- After MTTR, We found an experience author to subjectively articulate percentage of relevance for each article. What we found that the practice of fully manual reading and classification, where an article whether meets or does not meet the criteria, is bases on the subjective perception of the author. As shown in the articles, several papers have a cloud of words for easy visual identification of topics discussed. The researcher needs to work on the spreadsheet to classify, summarize, define colours grades and cosmetic aspect of the heat map shown in

Figure 4. It was valuable to consider some kind of groups or taxonomy. In our example in Figure 5, the reader can quickly identify three elements for reflection:

a) The top papers by subject from top to bottom in a table;
b) Subjects most researched starting from the left side to the right side;
c) Fields and Subjects free and unexplored that can be new opportunities for study. (See the right side of the table in red colour)

6 Conclusion and future perspective

The proposed MTTR work attempts to change the current logic in conducting a literature review by automatic counting the frequency of words in the articles. The generation of the dataset containing every word of every article reviewed, interpreting the dataset, and turning it into a heat map and word clouds for each article allows greater efficiency in the analysis. Our method uses word clouds associated with a table that shows the gradient of colours indicating the relevance of the key words found in articles closely aligned to the research topic. Compared to other traditional methods, our method has the advantages such as objective classification of articles, significant reduction in the runtime of the literature review, visualization of results, quick search and refinement in listing of the relevance of articles. The proposed method permits structured analysis of many relevant papers and enables personalised innovation and creativity of the researcher for each survey. In summary, MTTR archives: i) significant reduction of time for article selection and classification; ii) heat map based visual indicator of the relevance of the literature; and iii) an objective criterion of classification that permit to repeat and reproduce the same results. The MTTR was used in the article (Winter *et al.*, 2020) which allowed the approval of the event ITNG 2020 and in this real example, it reduced the bibliographic review execution time by 95% compared to a similar article produced by the authors (Amândio Balcão Filho; Ferrucio de Franco Rosa; Rodrigo Ruiz; Rodrigo Bonacin; Mario Jino, 2019) in the traditional format.

Our short-term perspective is to make the MTTR freely available to students and researchers who need to review the literature for academic work. This will help as obtain practice-based feedback to further enhance and automate our method.

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