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Selected Papers Book

A number of selected papers presented at ICSOFT 2010 will be published by Springer-Verlag in a CCIS Series book. This selection will be done by the Conference Co-chairs and Program Chair, among the papers actually presented at the conference, based on a rigorous review by the ICSOFT 2010 Program Committee members.

FOREWORD

This volume contains the proceedings of the Fifth International Conference on Software and Data Technologies - ICSOFT 2010, sponsored by the Institute for Systems and Technologies of Information, Communication and Control (INSTICC) and organized in cooperation with the Interdisciplinary Institute for Collaboration and Research on Enterprise Systems and Technology (IICREST) and also the Workflow Management Coalition (WfMC), and hosted by the University of Piraeus.

The purpose of this conference is to bring together researchers and practitioners interested in information technology and software development. The conference tracks are "Enterprise Software Technology", "Software Engineering", "Distributed Systems", "Data Management" and "Knowledge-Based Systems".

Software and data technologies are essential for developing any computer information system, encompassing a large number of research topics and applications: from programming issues to the more abstract theoretical aspects of software engineering; from databases and data-warehouses to management information systems and knowledge-base systems; distributed systems, ubiquity, data quality and other related topics are included in the scope of ICSOFT.

ICSOFT 2010 received 266 paper submissions from more than 50 countries in all continents. To evaluate each submission, a double blind paper evaluation method was used: each paper was reviewed by at least two internationally known experts from the ICSOFT Program Committee. Only 25 papers were selected to be published and presented as full papers, i.e. completed work (8 pages in proceedings / 30' oral presentations), 57 additional papers, describing work-in-progress, were accepted as short paper for 20' oral presentation, leading to a total of 100 oral paper presentations. As well, 40 papers were selected for poster presentation. The full-paper acceptance ratio was thus 9.4%, and the total oral paper acceptance ratio was 30.8%.

In its program, ICSOFT includes panels to discuss aspects of software development both from the perspectives of theory and practice, with the participation of distinguished world-class researchers and practitioners; furthermore, the program is enriched by several keynote lectures delivered by renowned experts in their areas of knowledge. These high points in the conference program definitely contribute to reinforce the overall quality of the ICSOFT conference, which is becoming already one of the most prestigious yearly events in its area.

The program for this conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research efforts are recorded here. Secondly, we thank the members of the program committee and the additional reviewers for their diligence and professional reviewing. Next, we would like to personally thank the local organizers and the secretariat that have worked hard to provide smooth logistics and a friendly environment, so we must thank them all and especially Ms. Monica Saramago for their patience and diligence

in answering many emails and solving all the problems. Last but not least, we thank the invited speakers for their invaluable contribution and for taking the time to synthesize and prepare their talks.

A successful conference involves more than paper presentations; it is also a meeting place, where ideas about new research projects and other ventures are discussed and debated. Therefore, a social event including a conference diner has been organized for the evening of July 23 (Friday) in order to promote this kind of social networking.

We wish you all an exciting conference and an unforgettable stay in the city of Athens. We hope to meet you again next year for the 6th ICSOFT, to be held in Seville, details of which will shortly be made available at http://www.icsoft.org.

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José Cordeiro
Polytechnic Institute of Setúbal / INSTICC, Portugal

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SLR-TOOL
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Keywords: Systematic Literature Review, SLR, Tool, Text mining.

Abstract: Systematic literature reviews (SLRs) have been gaining a significant amount of attention from Software Engineering researchers since 2004. SLRs are considered to be a new research methodology in Software Engineering, which allow evidence to be gathered with regard to the usefulness or effectiveness of the technology proposed in Software Engineering for the development and maintenance of software products. This is demonstrated by the growing number of publications related to SLRs that have appeared in recent years. While some tools exist that can support some or all of the activities of the SLR processes defined in (Kitchenham & Charters, 2007), these are not free. The objective of this paper is to present the SLR-Tool, which is a free tool and is available on the following website: http://alarcosj.esi.uclm.es/SLRTool/, to be used by researchers from any discipline, and not only Software Engineering. SLR-Tool not only supports the process of performing SLRs proposed in (Kitchenham & Charters, 2007), but also provides additional functionalities such as: refining searches within the documents by applying text mining techniques; defining a classification schema in order to facilitate data synthesis; exporting the results obtained to the format of tables and charts; and exporting the references from the primary studies to the formats used in bibliographic packages such as EndNote, BibTeX or Ris. This tool has, to date, been used by members of the Alarcos Research Group and PhD students, and their perception of it is that it is both highly necessary and useful. Our purpose now is to circulate the use of SLR-Tool throughout the entire research community in order to obtain feedback from other users.

1 INTRODUCTION

An SLR is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest (Kitchenham & Charters, 2007). These reviews differ from traditional literature reviews in their rigorous and impartial nature, which makes them of great scientific value.

The first methodology for conducting SLRs in Software Engineering was presented by Barbara Kitchenham (Kitchenham, 2004). This methodology provides specific details of each of the phases and activities evolved in carrying out an SLR. The methodology was based on ideas taken from medicine, a discipline in which SLRs are indispensible, signifying that their realization is considerably more mature in this area. Later, and after three years of using the original methodology, the same author proposed a new improved version of the original method (Kitchenham & Charters, 2007).

SLRs have been gaining a significant amount of attention from Software Engineering researchers since 2004. They are becoming increasingly important as the fundamental methodology through which to contribute to the maturity of what is denominated as "Evidence-Based Software Engineering" (EBSE), whose main goal is ''To provide the means by which current best evidence from research can be integrated with practical experience and human values in the decision making

process regarding the development and maintenance of software" (Dybå et al., 2005).

The relevance of SLRs is reflected in the numerous papers that have been written since 2004 which either present SLRs of a specific subject or deal with methodological aspects. For example, (Brereton, et al., 2007; Turner, et al., 2008) present lessons learned which were obtained after performing several SLRs by following the proposed methodology. (Dieste & Padua, 2007) present a means to develop optimal search strategies that retrieve as much relevant information as possible, while maintaining low costs and effort. (Babar & Zhang, 2009) present preliminary results from interviews with researchers which were carried out with the goal of independently exploring the experiences and perceptions of the practitioners of SLRs in order to gain an in-depth understanding of various aspects of SLRs as a new research methodology in Software Engineering. In (Kitchenham, et al., 2009) an observer-participant case study is used to analyse the impact of limited search procedures for SLRs. In (Kitchenham, et al., 2009) an SLR of SLRs is presented whose objective is to review the current status of EBSE since 2004. 20 SLRs published between 2004 and 2007 are analysed in this paper.

Further evidence of the relevance that SLRs are taking on as a research methodology in Software Engineering is that from 2005 onwards the Information and Software Technology Journal has included SLRs as a new type of paper for submission. Moreover, since 2007 there have been special sessions related to SLR issues at the EASE and ESEM conferences.

While there is an established methodology for conducting SLRs, most of the authors of papers containing SLRs stress the difficulty of carrying them out, which is particularly caused by the low amount of flexibility of searches that most digital libraries provide and the lack of a tool to support the entire process of SLRs which would reduce the time and resources required for effectively and efficiently carrying out SLRs without compromising their quality (Babar & Zhang, 2009).

The objective of this paper is to present the SLR-Tool that we have designed and implemented to support each of the phases in the SLR process. The main advantage of this tool is that, unlike other existing tools, it is free, and reduces the effort required to carry out the SLR manually.

With regard to the SLR-Tool's functionality, it has the following advantages:

- It can store data related to each of the activities in each of the phases of the process used to perform SLRs.
- It allows the searches to be refined by using text mining techniques.
- It permits the definition of classification scheme which helps the researcher to perform data synthesis and analysis.
- It uses text mining techniques to cluster the review documents by using the similarities among them.
- It exports all the data collected in the review process to Excel files in table or graphic formats. It also permits the export of all the references of the documents uploaded in the tool to the format accepted by bibliographic packages such as EndNote, BibTeX and Ris.

The remainder of the paper is structured as follows: Section 2 presents a summary of the tools that currently exist to perform SLRs, emphasizing the differences between them and the tool that we propose in this paper. In Section 3 shows the processes for performing SLRs. Section 4 presents design and implementation details of SLR-Tool and Section 5 shows an example of how the tool has been used. Finally, Section 6 presents some conclusions and future work.

2 RELATED WORK

To the best of our knowledge, several tools covering some or all of the phases in the SLR process presented in (Kitchenham & Charters, 2007) exist, and these are summarized below:

- EPPI-Reviewer (EPPI-Reviewer, 2010). This web tool can be used by various researchers to carry out a collaborative systematic review. Besides supporting bibliographic management, and inclusion and exclusion criteria management, EPPI-Reviewer focuses most of its functionality on plotting results, generating reports and applying certain meta-analysis techniques.
- TrialStat's SRS software (TrialStat, 2010) is a commercial tool. It is necessary to pay a substantial amount to obtain a license to use this tool.
- Tools to manage bibliographies also exist. Some of these act as metasearchers, which allow searches to be made in digital libraries such as ACM or IEEE, or in reference managers such as CiteSeer. They also permit the searches to be

refined with their own searchers. The problem with this type of tools is that they do not support the complete process involved in SLR process, since they only support the search for candidate papers for primary studies. Some examples of these tools are presented in (JabRef, 2010; Skidmore, 2002).

- There are also numerous tools that allow empirical data to be integrated through meta-analysis, thus enabling general conclusions about the empirical data found in SLRs to be obtained.

Those tools that support the whole SLR process need a license for their use, while those tools whose functionality is limited to part of the SLR are free. There is thus a need to develop an SLR-Tool in order to provide a tool for performing SLRs that is freely available and which can overcome some of the limitations of digital library search engines, such as the difficulty involved in defining complex search strings, or in allowing searches to be made in different fields of documents such as the title, the abstract, the keywords or the full text.

SLR-Tool is available on the http://alarcosj.esi.uclm.es/SLRTool/ website, and can therefore be used by researchers from the Software Engineering community, from whom we hope to obtain feedback in order to adapt the tool to the real needs of researchers.

3 SLR PROCCESS

According to (Kitchenham & Charters, 2007) an SLR is an evaluation and interpretation of all existing research that is relevant to a specific research question, an area of knowledge or a phenomenon of interest. SLRs aim to provide a fair assessment of a research topic through a reliable, rigorous and auditable methodology.

The importance of SLRs lies in their impartiality. Many researchers carry out small research studies that may initially appear to be SLRs. However, unless it is a thorough and impartial process the results may lack scientific value.

The three main phases of an SLR consist of planning, conducting and reporting the review, each of which will be expalined as follows.

3.1 Planning the Review

The first action that must be performed in this phase is that of identifying the need to carry out a review, which arises from researchers' needs to summarize all existing information on a phenomenon in a thorough and impartial way.

Sometimes an organisation requires information about a specific topic but does not have the time or expertise to perform an SLR itself. In such cases it will commission researchers to perform an SLR of the topic. When this occurs the organisation must produce a commissioning document specifying the work required.

It is then neccesary to specify the research questions, which is the most important part of any SLR. The review questions drive the entire systematic review methodology:

- The search process must identify primary studies that address the research questions.
- The data extraction process must extract the data items needed to answer the questions.
- The data analysis process must synthesise the data in such a way that the questions can be answered.

The following step should be that of developing a review protocol. Its implementation is necessary to avoid the possibility of researchers' bias. The components of a protocol include all the elements of the review plus some additional planning information:

- Background, and reason for carrying out the review.
- The research questions that the review intends to answer.
- The strategy used to search for primary studies, including the terms and resources (digital libraries, specific journals and conference proceedings) that will be searched.
- Study selection criteria. These criteria are used to determine which studies will be included in or excluded from the review.
- Study selection procedures. These indicate how researchers should apply the selection criteria, i.e. how many people have to evaluate each potential primary study, how to resolve disagreements, and so on.
- Study quality assessment checklists and procedures. The researchers should develop quality checklists to assess the individual studies.
- Data extraction strategy. This defines how the information required from each primary study will be obtained. If the data require manipulation or assumptions and inferences to be made, the protocol should specify an appropriate validation process.
- Synthesis of extracted data. Define the synthesis strategy.

- Dissemination strategy. Where and when the results are intended to be presented. This point is included only if it is not specified in the review commission document.
- Project timetable. This should define the review schedule.

Finally, the review protocol must be evalueted. If sufficient funding is available then it is advisable to ask an independent panel to review the protocol.

3.2 Conducting the Review

In this phase, it is first necessary to identify the search with regard to the research in question, thus generating a search strategy and documenting the search. Strategies are often iterative, and benefit from:

- Previous research aimed at identifying existing SLRs and assessing the volume of potential studies.
- An attempt to use various combinations of research terms to discover the question. One approach is to divide the question into parts, find synonyms, abbreviations, or to use logical operators like "AND" and "OR", etc. The most common places in which to carry out this search are reference lists, magazines, newspapers, conferences, research and Internet records.
- Consult experts in the field.

The study selection is then carried out, i.e. the primary studies are selected. This step seeks to assess the relevance of the primary studies with regard to the research questions. Final decisions for inclusion or exclusion should be made after reviewing the full text, and it is important to indicate the reason for exclusion. It is then necessary to analyze the reliability of the listing decisions. Two or more researchers must evaluate each document, and discuss and resolve their differences. This can be done by evaluating all the documents, or by selecting a random sample to serve as an example.

The following step is to assess the quality of the primary studies in order to determine the individual importance of each study, interpret the strength of inferences, recommend future research, etc. Researchers can use hierarchies of evidence to restrict the primary studies that they wish to include in their systematic review.

It is then necessary to design a means to extract the data that connect the information from the primary studies. At this point, it is advisable to create a classification scheme and classify the primary studies in accordance with this.

Finally, we sintethize the data, summarising the results obtained from of the primary studies.

3.3 Reporting the Review

The final phase involves writing up the results of the review and circulating them to potentially interested parties. It is first important to prepare a report, which should contain all information related to the various phases of the review and a summary of all the results obtained. This report may then be disseminated in official publications such as conferences, magazines, or workshops, or in other forms such as web pages, etc.

4 SLR-TOOL DESCRIPTION

This section presents some details related to the design and implementation of SLR-Tool. SLR-Tool has been developed by using the JAVA programming language. The integrated development environment (IDE) chosen has been Eclipse. The tool runs under the Windows operative system (XP version and latter). SLR-Tool is a multi-language tool in which both English and Spanish interfaces are available.

The development of SLR-Tool has followed the Rational Unified Process (RUP) (Jacobson, et al., 1999). The modeling language used is UML 2.0 (OMG, 2003).

The tool has been designed through a three-layer architecture (Larman, 2001), which isolates each of the main elements of operations so that the presentation is independent of processing rules and business logic which are, in turn, independent of data. This model significantly reduces maintenance costs and increases long term functional flexibility.

The functionality of the tool is summarized in the activity diagram shown in Figure 1. The stages may appear to be sequential, but it is important to recognise that many of the stages involve iteration. In particular, many activities are initiated during the planning of the review, and refined when the review itself takes place.

The filled in activities are those activities that will be carried out externally to the tool, and the double circled activities are those activities which are characteristic of the tool itself and were not proposed by (Kitchenham & Charters, 2007), and are therefore our own contribution.

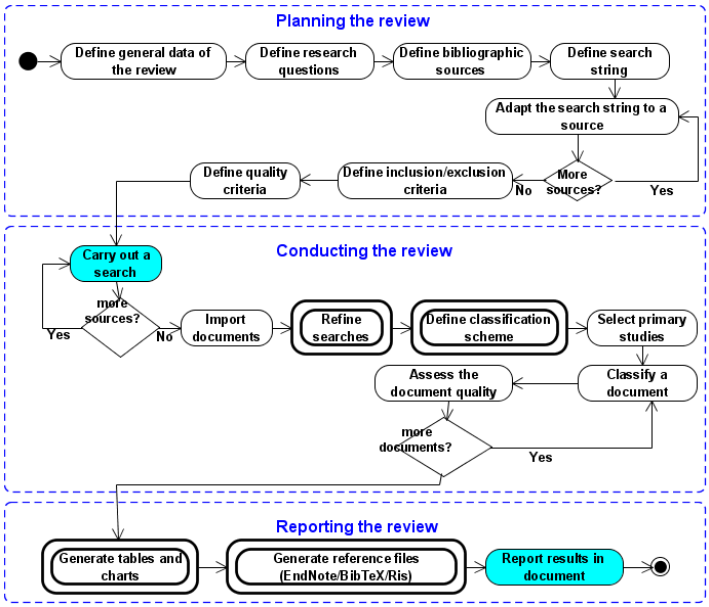

Figure 1: Activity diagram of SLR-Tool.

SLR-Tool enables all the information needed to carry out the SLR process proposed in (Kitchenham & Charters, 2007) to be stored and managed. This differentiates it from other existing tools that simply manage the bibliographic stages as with the previously mentioned JabRef (JabRef, 2010) or similar.

SLR-Tool allows the searches to be refined by using text mining techniques. The number of relevant papers can therefore be reduced by filtering only those that fit with the full search string. Most search engines in the major digital libraries have limitations in defining complex search strings or do not allow all the fields of the document to be searched. The refinement of the searches was carried out by using the Lucene (Lucene, 2009) search engine. It is worth noting that SLR-Tool is not a metasearch but that the search for documents is performed manually and independently of the tool, and once the documents have been obtained, they are uploaded into SLR-Tool.

The tool provides three possible ways in which to import or store the documents found:

- Manually. The user introduces the metadata related to the document being imported, along with the document in PDF format. If the abstract field is not added, the tool will read the PDF file and try to locate it.
- From EndNote, BibText, Ris files. The user introduces an EndNote/BibTex/Ris reference archive (from which the metadata are extracted) and the document in PDF. As with the first option, if the abstract has not been recovered from the reference file, it can be extracted from the PDF file.
- Automatically from a PDF file. In this case the user only introduces the document in PDF format and the tool attempts to extract the metadata by analyzing the file.

Furthermore, when the documents are loaded into the tool, it automatically detects the existence of duplicates, removing the copy that the user indicates, and keeping count of duplicated documents.

It is worth highlighting that SLR-Tool permits a classification scheme to be defined that helps the researcher to perform data synthesis and analysis.A classification scheme can be used to define the categories and subcategories required to classify the primary studies in order to sinthetize the results of the review. The classification scheme that can be created with this tool permits a tree of two levels to be created, i.e., it either permits categories that the possible values depend on when a document is assigned, or categories with sub-categories, in which case the values to be assigned depend on the latter.

Once all the primary studies have been classified with the classification scheme defined, SLR-Tool can generate tables and charts to summarize the data. The researcher will therefore have visual access to this data thus allowing him/her to form a rapid and easy idea of the situation, therefore facilitating the synthesis of data and the extraction of conclusions. If it is necessary to carry out meta-analysis to integrate empirical data, this must be done by using

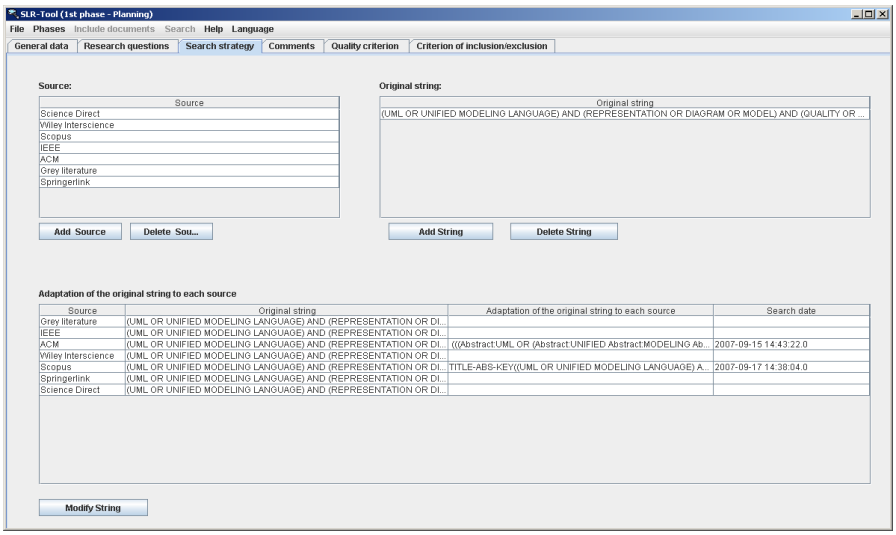

Figure 2: Search strategy.

another tool, since SLR-Tool does not have this functionality.

SLR-Tool exports all the data collected in the review process to Excel file sheets and the charts to PDF files. This makes the data more manageable, allowing them to be used in any documents or papers in which it is intended to report the conclusions obtained. SLR-Tool also allows all the bibliographic data from the primary studies uploaded in the tool to be exported to the format accepted by bibliographic packages such as EndNote, BibTeX and Ris. This facilitates the use of these references in subsequent publications.

Finally, it is important to note one of the tool's other functionalities. It uses text mining techniques to cluster the documents by using the similarities among them, highlighting key words that identify each group of documents. This is of assistance when it is necessary to know whether the documents found in the search are really related to the subject under study, thus permitting the exclusion of those documents that centre on a subject, which is too far removed from the subject under study.

5 EXAMPLE

An example of the use SLR-Tool to perform an SLR on "Quality of UML models "(Genero et al., 2009) is shown below.

The data related to the planning phase recommended in (Kitchenham & Charters, 2007) was first stored in the tool. As is shown in Figure 3, general data such as the title of the review, the dates of commencement and completion, the background, and so on were stored.

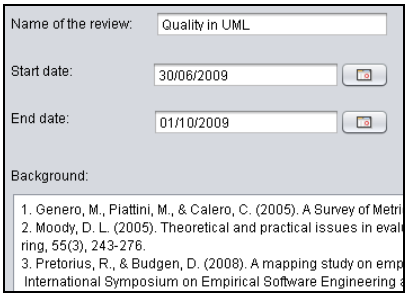

Figure 3: General data.

We then posed the research questions that were intended to be answered through the results obtained by the SLR (Figure 4). Once the results had been analyzed in later stages, answers to these questions were obtained and stored in the attachment column.

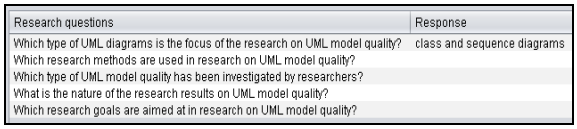

Figure 4: Research questions.

At the beginning of the phase which involved conducting the review, it was necessary to define the search strategy that had to be followed. This was done by first loading the different digital libraries to be used as bibliographic sources (top of Figure 2). SLR-Tool automatically generates a source of information called gray literature in which it is

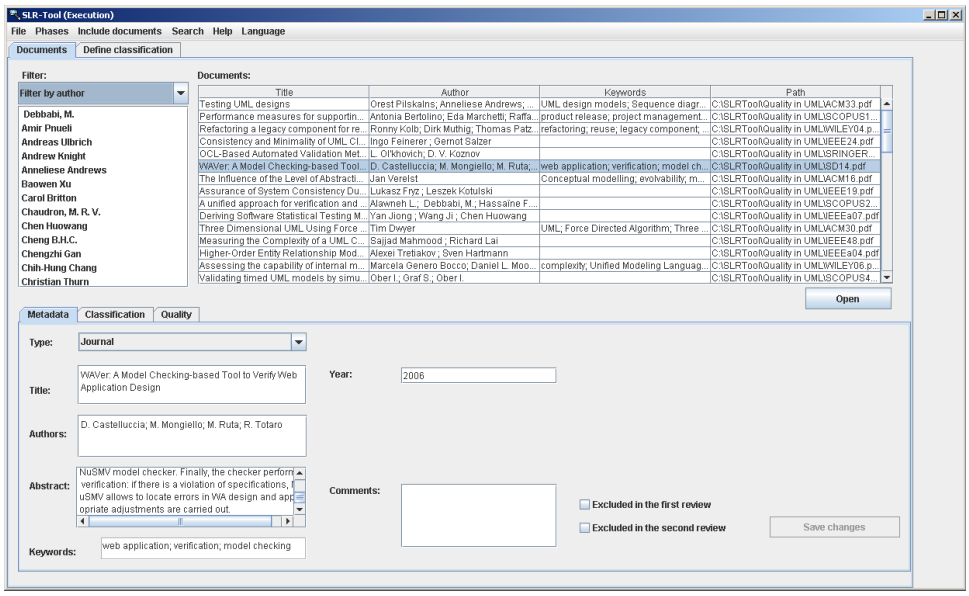

Figure 5: Execution phase.

possible to add all those relevant documents that are known by experts but have not been returned by any search.The next step was to add the search strings that were originally intended for the search engines of each digital library. One or more search strings are possible. The adjustment of each string then had to be added to each of the search engines defined above, using each of their operators. It is also important to add the date on which the search is conducted (bottom of Figure 2).

The inclusion and exclusion criteria are defined here (Figure 6). The quality criteria are also defined in a similar manner.

Criterion of inclusion
Papers that dealt with UML and the tangible results of the modelling process
papers published between 1997 and 2007
papers written in English
Criterion of exclusion
papers dealt with the quality and complexity of UML as a language
papers where quality is mentioned only as a general introductory term
studies available only in the form of abstracts or PowerPoint presentations
the paper is a chapter of a book
the paper is a summary of a workshop
papers about research focusing issues other than UML model quality
papers related with pure discussion and opinion

Figure 6: Inclusion/Exclusion criteria.

The search was conducted independently of SLR-Tool, and the documents obtained were stored in the tool using one of three possible methods previously described by the tool. Once the documents had been loaded into the tool (Figure 5), the search was refined.

For example, the IEEE Computer search engine presents the two fields that can be filled in to carry out the search with logical operators as being an "advanced search" (Figure 7). However, this search cannot be limited to the document's abstract. In highly studied research themes many more documents than those desired are therefore obtained, since the terms being sought may appear in the complete text as introductory or isolated terms, which do not ensure the document's relationship with the subject of interest. It is therefore of interest to limit the search for relevant terms to the abstract.

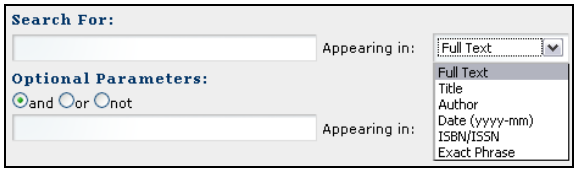

Figure 7: Advanced search in IEEE Computer.

Our original search string was: (UML or unified modeling language) and (representation or diagram or model) and (quality or consistency or maintainability or understandability or completeness or comprehension or comprehensability or testability or defect or effectivennes or complexity or readability or efficiency or validation or verification or layout).

In this search the search engine returned 109 documents. These were all loaded into the tool, and the search was refined by using the tool to search for

the search string in the abstract (Figure 8). The number of documents was therefore reduced to 66.

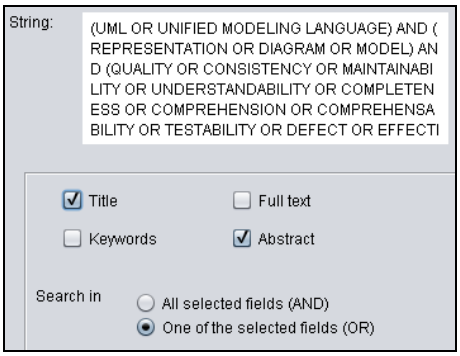

Figure 8: Refine the search.

Table 1: Example of the classification scheme.

Category	Subcategory	Value
Type of quality	Syntactic	Correctness
	Semantic	Consistency
		Completeness
		Correctness
	Pragmatic	Maintainability
		Analyzability
		Understandability
		Testability
		Functionality
		Executability
		Reusability
		Complexity
		Dependability
Type of diagram		Class diagrams
		Sequence diagrams
		Activity diagrams
		Use case diagrams
		Statechart diagrams
		Collaboration diagrams
		Component diagrams
		Package diagrams
		Interaction overview diagrams
		UML models
		UML 2.0 new diagrams
		View
		Checklist, rules, modeling conventions, and guidelines

We then defined the classification scheme used to classify the documents that were considered to be relevant, as was explained in Section 5. Table 1 shows part of the classification scheme used.

We next read each of the 399 documents found (from IEEE and from the other search engines), to decide which we considered to be relevant, bearing in mind the inclusion/exclusion criteria defined during the planning phase. The tool allows us to indicate which review of the document led to its exclusion (Figure 9): the first (in which only the title and abstract of the document were used) or the second (using the full text).

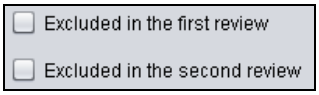

Figure 9: Exclusion of a document.

All those documents that were not excluded from the review (193 in total) were considered as primary studies. These were then classified in accordance with the classification scheme defined (Figure 10). We also decided how each of the documents fulfils the quality criteria defined in the planning stage.

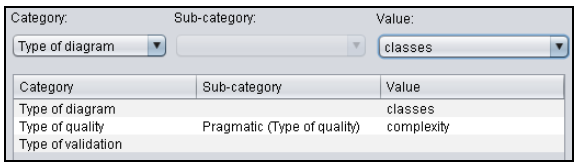

Figure 10: Classification of a document.

Finally, we used the Report Results option to automatically generate tables and charts such as:

- Summary of documents found by each search engine, detailing those that were initially found, were eliminated owing to repetition and were excluded.
- Summary of classified documents for each category or subcategory of the defined classification scheme. Figure 11 shows an example of this type of charts generated by the tool.
- Summary of compliance of the documents with each defined quality criterion.
- Summary of documents found by year and by document type (journal, book, etc).

6 CONCLUSIONS

The main contribution of this paper is the presentation of SLR-Tool, a freely-available tool for performing SLRs by following the process proposed in (Kitchenham & Charters, 2007).

SLR-Tool has been tested through its use in (Genero, et al., 2009). SLR-Tool has also been used by the university teachers who are members of the

ALARCOS Research Group, and it is currently being used by our Ph.D students.

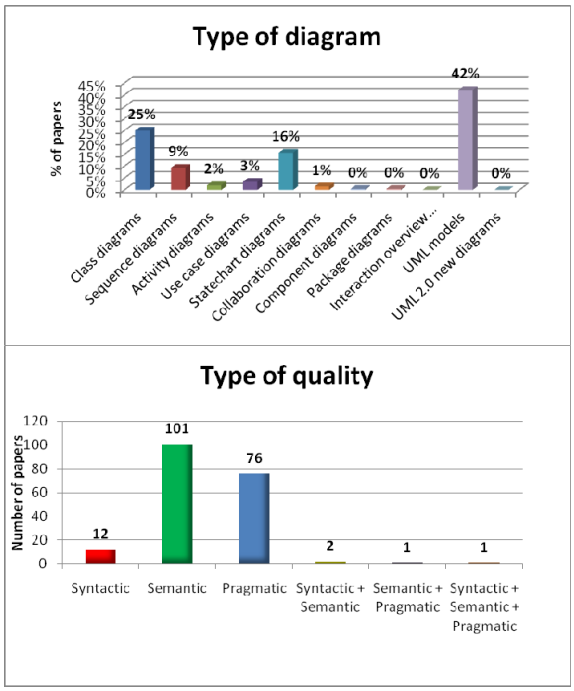

Figure 11: Charts generated by SLR-Tool.

The main advantage of the SLR-Tool is that its use implies a significant reduction in effort when compared to that involved in carrying out all the activities manually. Although it is rather difficult to upload all the primary studies included in the review, the tool allows the search among the documents found to be refined, thus reducing the number of papers with which it is necessary to work. The tool also permits the definition of a classification scheme, which facilitates the classification of documents. The tool uses this classification to automatically generate charts and graphs that summarize the results, so that if there is a change in the classification of a document it will not be necessary to do any additional work to update the tables and graphs. Finally, also note that it is possible to export the primary studies to files in different formats such as EndNote, BibTeX or Ris, thus permitting their use as bibliographical references in other documents.

Possible improvements that could be made to the tool are:

- The addition of a wizard to adapt the search strings to each bibliographic source.
- Allowing the initial search for papers to be made directly in the tool, by directly accessing the search engines of the bibliographic sources.
- Allowing SLRs to be carried out in a collaborative manner.
- Allowing the tool to be used via the Web.
- Allowing document metadata to be imported from Excel files.
- Allowing review data to be exported to open source formats.
- The addition of a "scheduling module" to plan the timetable of each review phase in advance.
- Making the tool available in other languages, and not only English and Spanish.

All appropriate suggestions made by researchers who have downloaded and used the tool will also be incorporated.

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