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The APISSER Methodology for Systematic Literature Reviews in Engineering

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ABSTRACT [Background] Every research topic is first to be addressed by understanding its current state of the art. A systematic literature review is a trustworthy method for establishing the published state of the art of any given topic. In engineering sciences, we have failed to consistently, methodologically, and thoroughly execute systematic literature reviews at the beginning of every research path, and to standardize the method to do so. Currently available methodologies fail to link a method to a customized and much-needed tool support. If the high-effort demanding task of executing a systematic literature review is not well tool-supported, it will soon become manually unmanageable to handle the large amount of data involved. [Objective] Therefore, we want to take a step forward towards standardizing the methodology for executing systematic literature reviews in engineering by proposing a tool-supported and task-oriented engineering flow methodology to execute systematic literature reviews in engineering. [Method] Based on the well-known and proven Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology from medical sciences, we adapted and enhanced the method to follow a task-oriented engineering flow and to be supported by customized tools. [Results] In this paper, we first present the APISSER methodology for systematic literature reviews in engineering, and then show its practical application in a case study. [Conclusion] We have shown how the method successfully results in the collection of valid literature to report a trustworthy published state of the art in engineering sciences.

INDEX TERMS Engineering method, PRISMA, systematic literature review, state of the art.

This paper presents the APISSER methodology to conduct a systematic literature review (SLR) in engineering, and it is organized as follows: Section I will provide the context and motivation (rationale) that drove us to propose the methodology. Section II presents a brief background of the existing methodologies for literature reviews and how this work builds upon them. Section III presents the APISSER methodology. Section IV shows a case study where we successfully applied the method. Finally, section V concludes the paper and provides an outlook.

I. INTRODUCTION

Engineering research follows the scientific method. This method involves an initial observation of a knowledge gap or problem, a clear motivation to address it, and the statement of research questions (RQs). After this initial stage, we first need to establish what has been done so far in the field of interest, that is, to establish its state of the art (SoA). Therefore, unless we are leader authors in the field of interest it is a requisite to conduct a *literature review*. The latter implies going through existing relevant literature of a reasonable time frame in the past on a specific topic. The number of publications to review will depend on the innovative character of the topic we are dealing with and the timeframe of interest, but most likely the number of publications will rapidly explode. If we do not methodologically address this process, it may result in the reviewers ‘drowning in a sea of literature‘ or not covering it thoroughly. Once a literature review has a defined, auditable and reproducible methodology, it becomes a *SLR*. A SLR utilizes a clearly defined method to identify, select, synthesize, and report the findings of prior work relevant to answer specific RQs.

The ‘diving into a sea of literature‘ to establish the SoA of a given topic is a real challenge that every scientist faces at the beginning of a new research topic. SLRs, as a literature genre [1], represent a check-point in time of human knowledge for a specific topic and RQs, and can potentially identify

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new research directions. In the best case, a recent literature review already exists or it needs to be updated [2]. But if it does not yet exist, it must be conducted by the research team at the beginning of the research cycle. Unfortunately, it is often skipped or executed in a superficial, incomplete, and nonsystematic manner. In the latter case, the scientific method is incomplete, as the SoA has not been properly established. Therefore whatever research is carried out, does not necessarily extend previous work and knowledge. As scientists, we need to approach every step of our research in a methodological, reproducible, and efficient way.

The query of the term: ‘systematic literature review’ in the Web of Science (WOS) data base (DB) [3] (Figure 1) shows engineering sciences ranking 13th in research categories where SLR are found, and a clear dominance is shown by medical sciences. In medical sciences, the execution of SLRs is very common, as it is a trustworthy method to make evidence-based decisions that directly affect the life of patients. Therefore, they have developed a clear methodology to guide its execution and reporting: the PRISMA methodology [4], [5]. Since its inception in 1999 [6] and further development [7], [8], the methodology has proven to be trustworthy and efficient. The PRISMA 2020 methodology provides a reporting guidance of a 27-item checklist to report a SLR, a 12-item abstract checklist, and a flow diagram to guide the execution of the process for original and updated reviews.

Technological advancements have also changed the way publication data is stored. Nowadays all scientific DBs have a web-based interface, and using a search query is the most common method for finding publications in a relevant field. When executing a literature review using a web-based DB engine, the results of a single query rapidly explode. The number of publications rapidly increases and soon enough it becomes humanly impossible to manually manage the amount of information that is obtained. This exposes the need of information technology tools to support the execution of a SLR.

In engineering, no standardized methodology exists for the execution of SLRs. The process to execute a SLR is well stablished [9], but we have found a loop hole in its structured practical execution linked to tool support. For that purpose, we propose to take the advantage of the widely proven PRISMA methodology and adapt it to a simplified, tool-supported and task-oriented engineering flow. Therefore, in this paper, we present the APISSER methodology, a spin-off of the PRISMA methodology, to execute a SLR in engineering.

II. BACKGROUND

Performing a literature review is the action of searching through a trustworthy literature source for relevant publications that represent the published SoA of a specific topic. A SLR has the add-on of having a defined, auditable, and reproducible method for doing so. The results of a SLR will lead to proof-of-evidence (PoE) based decision-making, yet

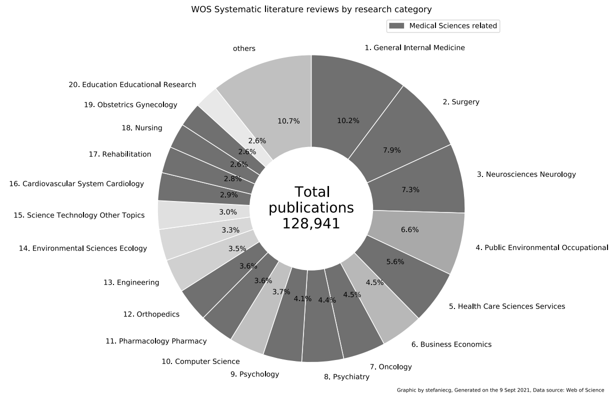

FIGURE 1. Results of the search query of the term: ‘SLR’ in the WOS DB [3].

the review is only as good as the method behind it. The conceptual method behind executing such a review is well defined in literature across fields, e.g. [10], [11], yet its structural framework and the tools to support it, are not yet clearly defined.

Medicine is the leading field in published SLR studies; one of the main reasons for this is that these are necessary to enable evidence-based medicine (EBM) [12]. This led to the standardization of the method in the PRISMA methodology. In engineering, we have failed to adopt such a methodological approach and consistency in the execution of SLRs. Nevertheless, this type of publication has been increasing in the field of engineering over the past few years (Figure 2), which indicates the need for the standardization of the method. The first steps in defining a standard methodology were taken by computer engineering scientists when Kitchenham in 2004 proposed the evidence-based software engineering (EBSE) method [13]. In 2018, Torres [14] adapted the method to engineering and education. A recently released (2020) work-in-progress study [15] intends to identify whether SLRs in engineering follow a specific method, but we await further results. All these methodologies have advantages and disadvantages, but none of them are truly linked to a much-needed customized tool support.

The need for automation (tool support) in SLRs is clear [16]. There are many commercial tools available in the market for a paying fee [17]–[21], as well as open-source web-based solutions [22]. However, most teams use these tools to support only certain parts of the execution of the SLR, but end up diverging at some point due to the tool not supporting exactly the method they intend to apply. We see the need for a customized open-source tool approach to fully meet the requirements of the research team and topic of the SLR at issue. All the previously mentioned tools have advantages and disadvantages, but none of them is truly linked to a methodology.

In the present work, we aim to link the methodology for executing SLRs to a customized tool support and to make this a task-oriented process, following an engineering flow.

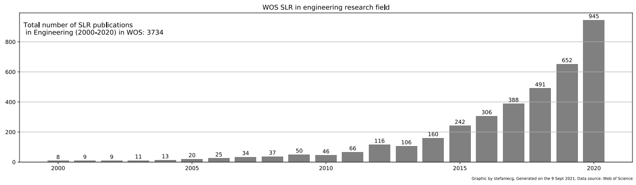

FIGURE 2. Number of SLRs in the past 20 years in the field of engineering found in the WOS DB [3].

Consequently the method provides a structure and speeds up this process. The PRISMA methodology includes a sub-set of the full PRISMA methodology to simplify the process and show that a basic SLR can be realized with a reduced number of steps, therefore encouraging the community to execute these more often at the initial phase of every research.

III. THE APISSER METHODOLOGY

The APISSER methodology is based on the PRISMA methodology. However, it is reduced and adapted to a task-oriented engineering flow and enhanced with tool support to efficiently manage the vast amounts of information. The APISSER method comprises six phases: A priori, Plan, Identify, Screen, Select, Extract and Report. The checklist for the method is presented in Table 1.

TABLE 1. The APISSER methodology checklist.

Phase			ID	Task
1	A	A priori	A1	Topic
			A2	Rationale
			A3	Research questions
2	P	Plan	P1	Study characterization
			P2	Eligibility criteria
			P3	Data items
			P4	Search strategy
			P5	Selection process
			P6	Tools and data management
			P7	Protocol
3	I	Identify	I1	Search queries
			I2	Publication data
			I3	Local data base
4	SS	Screen & Select	S1	Screen basics
			S2	Screen overview
			S3	Select
5	E	Extract	E1	Data items
6	R	Report	R1	Publication
			R2	Internal review
			R3	Publish

A. A PRIORI

A priori, we must have identified a knowledge gap/problem
A1 to have a (A1) *topic*, from which we want to establish its SoA. We must then justify the significance of addressing the
A2 topic/problem, which states a (A2) *rationale*. Finally we need
A3 to list the (A3) *RQs* we will answer with our SLR.

B. PLAN

P1 We define five criteria as the (P1) *study characterization*: the reach of the study (boundaries), keywords, type of publications, databases, and target journal. The *reach of the study* (boundaries) defines the assumptions and limitations of our study. The *keywords* is a list of terms that covers the topic and RQs. These keywords will then be used as terms in the search queries that we will execute in the DBs to identify relevant publications. The *type of publications* is to be a selection of the following list: journals, conferences, patents, books, and dissertations (bachelor, master, doctoral). The *electronic DBs* to be used are defined and its search syntax should be reviewed. For topics in engineering we suggest the use of the Web of Science [3] and Scopus [23] DBs. If patents are part of the research scope, we suggest using the European Patent Office [24]. We find an appropriate *journal* for later publication of our findings. We recommend the Elsevier [25], Wiley [26] or Institute of Electrical and Electronics Engineers (IEEE) [27] online journal finders. This last step is important because our publication should fit the intended journal; the latter may help to better formulate the RQs and adjust the characterization of the study.

From the characterization of the study, we can derive the
(P2) *eligibility criteria* that must be fulfilled by the publi- P2
cations included in our study. These are of two categories: inclusion and exclusion. The inclusion criteria (INC) is a set of numbered qualifications that the publications included in our study must fulfill. The INC will be checked as Boolean values, which, if true, will unequivocally determine the inclusion of a publication in the study. The exclusion criteria (EXC) is the set of characteristics that we want to avoid in the publications selected for our study, which will ease the process of rejecting publications. We recommend the definition of tags, which will help the reviewer to faster determine the inclusion or exclusion of a publication. The EXC and tags will be color-highlighted on specific information fields of the publication in the tools used by the reviewers to execute the screen & select and extract phases; they are a visual aid.
We now define and number the (P3) *data items* to extract from P3
the selected publications. Each data item to extract is to be linked to a specific RQ. The possible values and data types for each item are also be defined.

We define the DB (P4) *search strategy*, that is: to define P4
the method by which we execute the search queries in the DBs (manually vs. automized) and define the stop criteria that identifies the point when sufficient search queries have been
executed. We then define the (P5) *selection process*, through P5
which we methodologically prove the eligibility criteria to identify the selected publications. This process describes the actions to take in the identify, screen & select, and extract
phases. We also define (P6) *tools and data management*, P6
which supports the execution of the selection process as it will become manually unmanageable. We recommend the development of two tools, one for the screen & select phase and the other for the extract phase. We define the DB structure (tables-fields), and the required software to develop, i.e. the number of tools, their graphical user interface (GUI) and the method by which these tools will access the study DB to display publication data, and fill the INC.

All the information, data, and plan generated until now
P7 must be collected in a document called the SLR (P7) *protocol*.[1] The use of a project management workflow is recommended to assign tasks and schedules to the team. This document should be submitted for internal review and agreed upon by all parties involved.

C. IDENTIFY

From this point onwards, we will start to manage a large amount of information and there will be much human effort needed, as it is time to 'dive into the sea of publications' to identify the ones that are relevant for our study. Reviewers will be needed, but they will be supported by automated tools that will ease the organization, storage, and processing of information, thereby accelerating the entire process. We encourage the management of all data processing with a high-level general-purpose script-based programming language.

Using the previously defined keywords, we conduct DB
I1 (I1) *search queries*. The search strategy that we took is the manual[2] execution of search queries in the previously defined DB until[3] a reasonable logical combination of ALL keywords with some selected INC and EXC terms was achieved.

I2 From each search query, we proceed to export the (I2) *publication data* in a machine-readable format for further processing. We remind the reader that the fields exported from each publication are DB dependent.

The exported data of the publications is to be built into
I3 a (I3) *local data base (L-DB)*. We recommend importing each search query into a table in the L-DB to maintain order. A machine-readable L-DB file is to be created and a version control system used to back it up and track changes. After loading the search query results in the DB, each item (publication) is to be extended with the columns shown in Table 2. The repeated field in the L-DB (*REP*) should be marked in all publications at this stage, based on wether it is repeated in-between search queries of the study, the latter can be done script-based. Repeated publications are to be reviewed only once.

D. SCREEN AND SELECT

In this phase, we aim to determine and fill the INC fields in the L-DB (*INx*) for each publication, in order to determine whether it will be included or excluded from our study. This phase of the method is better supported by a GUI. In this GUI the publication data is to be displayed, and the previously defined EXC and tags are to be color-code highlighted in the selected fields. The GUI helps the user to better visualize the information of the publication and to easily determine and mark the boolean value of each INC.

The screen phase has two stages, a screen basic and a screen overview stage. The INC are to be split into two subsets: one to be checked during the screen basics stage and the other to be checked during the screen overview stage.
In the (S1) *screen basics* process, the reviewer's task is to S1
check the first set of INC based only on three items from each publication: title, author, and abstract. The publications that comply to the first set of INC, will move forward to the
(S2) *screen overview* stage. In this second stage, the reviewer S2
evaluates the remaining set of the INC by downloading the paper and performing an overview read of the paper (not yet a full read), just enough to determine the remaining INC. In each stage the reviewer can add useful notes to the L-DB in the according field (*SBN* or *SON*). By the end of the screen phase (basic and overview), all INC fields in the L-DB should be marked as *true* or *false* for all the publications.

The publications that comply with all INC are marked as
(S3) *selected* publications in the L-DB (i.e. $SEL = true$). S3
We have now selected the publications that will be part of our SLR study.

TABLE 2. Extended fields in L-DB to be filled in the given phase for each publication.

Phase	ID	Criteria	Data Type	Description
Identify	REP	repeated publication	BOOLEAN	true when the publication has been found in a previous search query
Screen & Select	INx	inclusion criteria	BOOLEAN	each is true if the criteria is met
	SBN	screen-basic notes	TEXT	notes made by the reviewer in the screen-basic stage
	SON	screen-overview notes	TEXT	notes made by the reviewer in the screen-overview stage
	SEL	selected	BOOLEAN	true if all INx are true
Extract	Dxx	data items	various	values to be extracted from the publication
	SLC	selection category	LIST	classification of selected publications

E. EXTRACT

Finally, the selected publications move forward to the (E1) E1
data items extract phase, in which the reviewer identifies, extracts and inputs all previously defined data items in the L-DB (*Dxx*) for each selected publication. The publication should be accessed through its digital object identifier (DOI) web link and its file downloaded. It is recommended that a categorization of the publications be made at this point, for sorting of the information. A limited number of categories are to be defined, and the reviewer should assign for each selected publication one of these categories. This category is to be

[1]In medical sciences, this protocol is publicly released.

[2]We hypothesize that the search process in the DBs can be automized by using a script to open a connection to the DB server. As an example, we found libraries that can access the WOS DB using a Python script, but this process is yet to be evaluated.

[3]The algorithm used to determine when enough search queries have been executed is still an open topic in this methodology; that is, the algorithmic-based search strategy is yet to be defined, opposed to the manual combinatorial approach adopted here. The algorithmic approach might be based on the criteria of achieving all reasonable logical combinations of the keywords, in combination with the information of the number of repeated publications found in each successive query.

recorded in the selection category field of the L-DB (*SLC*). This is manual work in which a reviewer is required to fully read through each publication to determine the value of each data item and fill it in the L-DB. The knowledge gained by the reviewer will then mold the analysis of the extracted data and discussion in the report. The reviewers should be the authors of the report. This phase of the method is better supported by another GUI, which displays basic publication data and writes data items and category for each selected publication in the L-DB.

F. REPORT

R1 We then write the (R1) *publication* to report our findings. This should be based on the requirements, format, and structure imposed by the selected journal or conference, and using academic writing practices and guidelines.[4] The focus of the publication should be on answering the initial RQs in combination with an analysis of the collected data items; however, any work can be extended after that initial aim. Inspired by the recommended report items of the PRISMA methodology, we recommend that the SLR report has the following structure[5]: Title, Abstract, Keywords, Introduction, Method, Background, Results, Discussion, Conclusion, and References.

R2 The publication draft should undergo an (R2) *internal review* process. We recommend a technical and an English-proofread[6] review. Finally, we summit the publication to the
R3 journal for consideration to be (R3) *published*.

IV. PROOF OF CONCEPT: A CASE STUDY

We applied this methodology in [37]. In the following sections, we describe the elements of the methodology for that study.

A. A PRIORI

A1 The (A1) *topic* of our SLR is the review of electronic control systems (ECSs) for ion-trap quantum computers (ITQCs).
A2 (A2) *Rationale*: as we upscale ITQCs, the ECS must efficiently scale and adapt. With this SLR, we aim to obtain a clear understanding of how these ECSs were designed and the challenges they faced. Thus, in future research, we may propose an efficient system-level architecture for the ECS of an ITQC. We will address the following (A3) *RQs*: RQ0. A3 What is the use-case for the ITQC? RQ1. What are the physical requirements of the ECS? RQ2. What are the electrical requirements of the ECS? RQ3. What system-level architecture and technologies are used in the ECS?

B. PLAN

(P1) *Study characterization*: The *reach of the study* of the SLR is to find publications that describe an ITQC with at least minimal included information about its ECS design, implementation, and/or verification. We focus on Paul trap-based ITQCs with a quantum charge-coupled device (QCCD) architecture and the required shuttling of ions. The *keywords* that will drive our study are quantum, computer, control, electronics, ion trap, shuttling, cryogenic, and vacuum. The *types of publications* we will evaluate are Journal Articles and Conference Proceedings Articles. The online *DB* we will use to execute our search queries is the WOS [3]. The *target Journal* for the publication of this SLR is: IEEE Systems Journal [38]. P1

The (P2) *eligibility criteria* is composed of the INC shown in Table 3, and the EXC shown in Table 4, which also shows P2 the defined tags, their category, and color-code. The (P3) *data* P3 *items* to extract are listed in Table 5. The DB (P4) *search strategy* P4 we employ was to manually execute search queries in the previously defined DB until a reasonable logical combination of ALL keywords with some selected INC and EXC terms was achieved. The (P5) *selection process* is shown in Table 6. P5

As for the (P6) *tools* needed, we will develop two GUIs P6 in Python [39]. One to support the screen & select phase (*ss_gui.py*) and the other to support the data extract phase (*ex_gui.py*). According to the steps in the selection process, the *data management* proceeds as follows. From each search query, a full record of all identified publications is exported from the WOS DB in comma-separated value (CSV) format (*wos*_raw.csv*). Using Python scripts, the data are parsed, imported, and organized in tables of a SQLite DB [40] (*slr.db*). We extend each item (publication record) in the database to add the extended fields listed in Table 2. This extended DB is our starting data pool and is referred to as L-DB, from which the GUIs will read and write data. The L-DB will be placed under the global information tracker (GIT) open-source version-control system [41]. Through scripts, we recognize repeated publications and mark accordingly the field *REP* in the L-DB. We use the screen & select GUI to fill the *INx*, *SBN*, *SON* fields of the L-DB. Publications that comply with all INC (i.e. $INx == true$) are denoted as $SEL = true$ in the L-DB. The data extract GUI will then be used to fill the *Dxx* and *SLC* fields in the L-DB. Using Python scripts, we will access the filled DB and generate a report of the selected publications; all the data collected will then be available for the report.

All previous information was collected in the SLR (P7) P7 *protocol* and was handed to all parties involved for review.

[4]We recommend using LaTeX [28], [29] as a software system for document preparation to report publications in engineering sciences. A template is typically available at the journal/conference or can be generated [30]. In [31] some recommendations on how to organize a research publication can be found. The language should be academic English; some valuable recommendations and guidelines can be found in [32]–[34].

[5]The *Title* should have either one of the following structures: (1) A systematic literature review on *topic* or (2) *Topic*: a systematic literature review. The *Abstract* should include the following sections in brackets: Background, Objective, Method, Results, Conclusion. The latter is a common practice in medical sciences for it eases readability. The *Keywords* is the list of previously defined index items. The *Introduction* section should include the 'A Priori' items (A1-A3). The *Method* section should include the 'Plan' items (P1-P7). The *Background* section provides a basic overview of the field, and/or references a previous SLR. The *Results* section classifies and displays the SLR's findings. The *Discussion* section gives the authors interpretation of the results and potentially identifies future research directions. The *Conclusions* section provides an outlook of the work. The *Reference* section lists all the selected publications and other relevant used literature.

[6]There are online tools for English language polishing [35], [36].

TABLE 3. Inclusion criteria.

ID	Criteria	Value
IN0	Type of publication	journal OR series
IN1	Years considered	2000-2021
IN2	Language	English
IN3	Peer reviewed	Yes
IN4	Quality	Published in WOS
IN5	Topic	ITQCs with a described ECS design, implementation AND/OR verification
IN6	Accessibility	full paper accessible trough UIBK libraries
IN7	Type of electronics	control OR shuttling OR cryogenic OR vacuum
IN8	Minimal included content requirement	Publications/studies that include a minimal comprehensive description of the ECS.
IN9	Use-case	control of an ITQC

TABLE 4. EXC and tags to be marked in the publications seleted fields[a].

Category	Colour	Words
EXC terms	red	penning, diamond, quantum dot, superconducting, spectroscopy, spectrometer, chemi*, astronomy, theor*
Basic terms	yellow	quantum comput*, quantum information, quantum processor
Type of ITQC terms	plum	ion trap, ion-trap, trapped ion, trapped-ion, paul trap
Electronic terms	gold	electronic, architecture, hardware, control, fpga, asic, processor, voltage, current, electrode, ieee, channel
Relevant terms	cyan	cryo, vacuum, shuttling, shuttle, qccd, transport, rotation
Paper structure terms	green	we, this paper, propose, here, here, this work, present, presented, manuscript, work

[a] The selected publication fields in which we will tag these words are: Title (TI), Abstract (AB), Keywords author (DE), Keywords WOS (ID), Publisher (PU), Publication Name (SO), WOS category (WC).

TABLE 5. Data items.

Research question		ID	Data item
RQ0	Use-case	D00	Aim of publication
RQ1	Physical requirements	D10	Type of ion-trap
		D11	Temperature
		D12	In-Vacuum
		D13	Size
RQ2	Electric requirements	D20	Voltages
		D21	Processing rate
		D22	Number RF/DC channels
RQ3	System Architecture	D30	System architecture
		D31	Technologies used

C. IDENTIFY

We start now the execution of the selection process, described
I1 in Table 6. The DB (I1) *search queries* performed in the WOS DB are listed in Table 7. The search queries already assure the fulfillment of $IN0-4$, by using the *keywords* and eligibility criteria to find relevant publications for our study.

TABLE 6. Selection process.

Phase	Action	To comply	To fill in DB
Identify	DB search	IN0-4	REP
Screen-basic	title, author & abstract	IN5	IN0-5, SBN
Screen-overview	paper overview	IN6-9	IN6-9, SON
Select	proceed data extraction	IN0-9	SEL
Extract	Full-Text paper read	SEL	Dxx, SLC

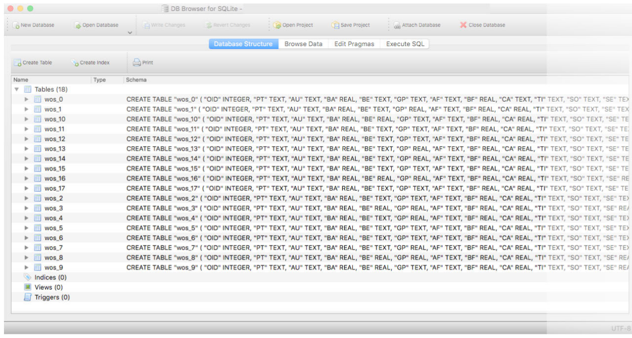

FIGURE 3. Generated L-DB, visualised with [42].

As planned, from each search query, we export the (I2) *publication data* by using the export function of the WOS DB. I2 We generated and downloaded a CSV file from each query, which includes the publication data of the results.

We build the (I3) *L-DB* by loading all CSV files into it, each I3 search query in a table, and extending the fields according to Table 2. The repeated field in the L-DB (*REP*) was filled for all publications. The generated L-DB (*slr.db*), shown in Figure 3, was placed under version control.

D. SCREEN AND SELECT

As planned, we developed the *ss_gui.py* GUI[7], as shown in Figure 4. It shows all relevant fields for each publication, so that the reviewer can easily determine and store the INC in the L-DB (*INx*). The EXC and tags depicted in Table 4 are highlighted in the selected fields.

In the (S1) *screen basics* phase, solely based on the title, S1
abstract, and keywords of each publication, the reviewer
determines $IN0-5$[8] for that publication. The (S2) *screen* S2
overview phase allows the reviewer to determine $IN6-9$ by performing a quick overview of the paper. Notes from the reviewers were added to the corresponding fields in the L-DB (*SBN* and *SON*). Finally, we can script-check the L-DB to look for the publications in which $IN0-9$ are
all true, namely, these are the (S3) *selected* publications for S3
our study and their selected field in the L-DB (*SEL*) is to be marked as *true*.

[7] This is a custom-developed tool for this work. At request, the Python source code can be made available as an open-source GitHub repository project by writing to the corresponding author.

[8] The previous identify phase should ensure that $IN0-4$ are met; however, we recommend these to be manually reviewed by the reviewer and officially marked in the L-DB in the screen-basics stage.

TABLE 7. DB search queries[a,b].

DB	Search query	total	repeat	screen[c]	select
wos_0,1	TS = (*quantum* AND *electronic* AND ion trap) AND PY = (2000- 2021) AND LA = english	509	0	24	6
wos_2	TS = (trap ion quantum computer control system) AND PY = (2000- 2021) AND LA = english	83	9	30	8
wos_3	TS = (trap ion quantum computer cryogenic) AND PY = (2000- 2021) AND LA = english	5	0	5	5
wos_4	TS = (ion trap quantum computer vacuum) AND PY = (2000- 2021) AND LA = english	12	4	1	8
wos_5	TS = (ion trap quantum computer architecture) AND PY = (2000- 2021) AND LA = english	112	59	23	4
wos_6	TS = (ion trap quantum computer fpga) AND PY = (2000- 2021) AND LA = english	4	3	1	1
wos_7	TS = (ion trap quantum computer electronic) AND PY = (2000- 2021) AND LA = english	24	24	0	0
wos_8	TS = (ion trap quantum computer control electronics) AND PY = (2000- 2021) AND LA = english	3	3	0	0
wos_9	TS = (ion trap quantum computer stack) AND PY = (2000- 2021) AND LA = english	2	0	1	0
wos_10	TS = (ion trap quantum computer shuttling) AND PY = (2000- 2021) AND LA = english	13	6	6	2
wos_11	TS = (ion trap quantum computer hardware) AND PY = (2000- 2021) AND LA = english	35	22	6	0
wos_12	TS = (ion trap quantum computer) AND ALL=IEEE AND PY = (2000- 2021) AND LA = english	22	15	3	0
wos_13	TS = (ion trap (multichannel OR multi-channel) voltage) AND PY = (2000- 2021) AND LA = english	13	0	6	5
wos_14	TS = (ion trap quantum cryo*) AND PY = (2000- 2021) AND LA = english	83	19	10	2
wos_15	TS = ((ion OR paul) trap (transport OR shuttling) quantum NOT dot) AND PY = (2000-2021) AND LA = english	223	61	35	11
wos_16	TS = (ion trap waveform generator) AND PY = (2000-2021) AND LA = english	10	2	3	0
wos_17	TS = (ion trap quantum processor) AND PY = (2000- 2021) AND LA = english	127	59	17	3
	total of items	1280	286	171	43

[a] This table shows information acquired from the identify and screen & select phase. [b] Data as of: wos_0-1 on 01.04.2021, wos_2-3 on 25.04.2021, wos_4-10 on 30.04.2021, wos_11-15 on 06.05.2021, wos_16 on 13.05.2021, wos_17 on 18.05.2021 [c] Data after screen-basic stage.

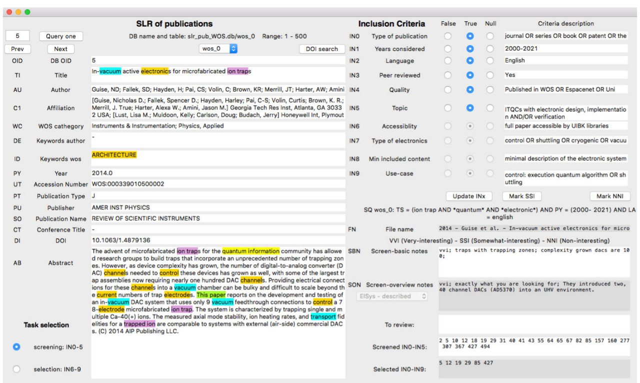

FIGURE 4. GUI for the screen & Select phase (*ss_gui.py*)[7].
***Interface description:* The interface reads and writes publication data to the L-DB. On the left pane, the GUI shows the main information about the publication in evaluation. The defined EXC and tags are color-highlighted in the selected fields. On the right pane, the GUI allows the user to fill in the INC and notes for that publication. The interface allows to launch a web browser to access the article's DOI link.**

E. EXTRACT

In this phase, from the selected publications we proceed to
E1 extract the (E1) *data items* and record them in the L-DB
(*Dxx*). The data items are filled in the L-DB by the reviewer

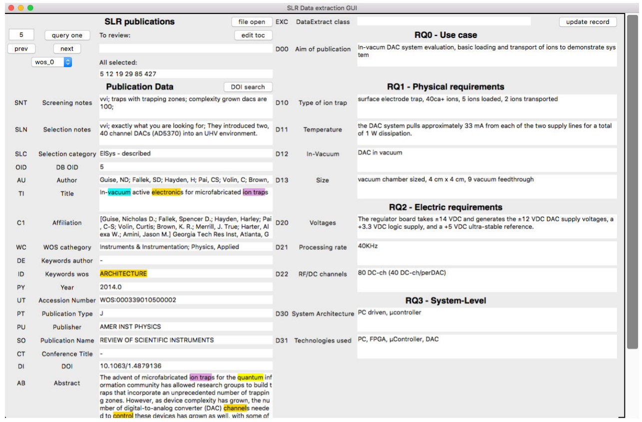

FIGURE 5. GUI for the data extraction phase (*ex_gui.py*)[7].
***Interface description:* The interface reads and writes publication data to the L-DB. On the left pane, the GUI shows the main information about the publication in evaluation and notes about the previous screen & select phase. The defined EXC and tags are color-highlighted in the selected fields. On the right pane, the GUI allows the user to fill in the data items for that publication. The interface allows to open the article file from the local drive.**

as he/she reads through the full publication. As planned, we developed the *ex_gui.py* GUI which is shown in Figure 5. The EXC and tags listed in Table 4 are color-code highlighted in the selected fields. The publications were classified in one of the following categories: electronic system fully described, mentioned/referenced, or review paper; and marked accordingly in the category field of the L-DB (*SLC*).

F. REPORT

Finally, we summarize all of the findings and write the (R1) R1
publication. An (R2) *internal review* process occurred and R2
after finalizing it, we (R3) *published* the results in [37]. R3

V. CONCLUSION

We have shown the need to standardize the methodology to execute SLRs in engineering. Following the steps of our medical science colleagues, we have taken the effective-proven PRISMA methodology and developed a spin-off version: the APISSER methodology, which is enhanced by a tool-supported and task-oriented engineering flow approach. This methodology provides a structural framework that speeds-up the execution of a SLR. We have shown how this method can be applied to the successful conception, execution, and publication of a SLR in engineering.

We encourage the use of this method as it best serves the needs of the research teams in engineering sciences. Furthermore, we encourage future work, extending this initial work, towards the standardization of the method to execute SLRs in engineering. We trust that the present work will encourage engineers to execute a SLR at the beginning of every research process, given that the failure to do so can turn out into not building on each other's work and knowledge.

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