Scientific Writing: A journey from the idea to the published paper

A guide for students, researchers and practitioners

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March 1, 2024

Contents

Chapter 1.

Introduction

This document describes how to write and publish a scientific paper. Target audience are students, researchers or engineers in industry aiming to publish a paper. In addition, students working on their Bachelor or Master Thesis, or starting a PhD, may find the information helpful.

The author's background is in computer science, specifically data science/machine learning. Hence, the recommendations have a certain bias and will best fit papers in the fields of computer science and information systems.

As a warning: While there are acknowledged concepts for the key points in scientific papers (e.g. the need to properly cite other work, or the need to critically evaluate the own paper), the judgement of some aspects of a paper depends on the background of the reviewers, on the research field, or just on personal taste. If one searches the internet or refers to books regarding guidelines on how to write a scientific paper, quite different suggestions can be found. Some are similar while others are contradictory. The reason is simple: in contrast to e.g. experiments in physics, or theories in computer science, the parameters of a good paper are not fully measurable.

Although not comparable to writing novels, scientific writing is still a creative process. It is, however, highly advised to obey the commonly agreed recommendations. This document offers a self-contained set of recommendations on various aspects of scientific writing. Obeying these recommendations will not guarantee a paper to be published. Yet, the author strongly believes it will improve the chances.

1.1. Content covered in this document

In this document it will be shown

- how to find a research problem and a research question,
- how to structure and write a paper,
- how to assess your paper with a proposed checklist,
- and how the publication and review process works.

In addition, hints on writing a Master or Bachelor Thesis will be given.

1.2. The fictitious(!) cake-cutting problem

A **fictitious(!) research problem** will be used in some examples and exercises: *the cake-cutting problem*. If you search the internet, you will find some papers having addressed this problem, with some humour attached. However, when referring to the fictitious(!) problem, also fictitious citations and theories will be used – purely made up by this document's author.

The reason for presenting a fictitious problem in this course is, that it is impossible

a) to present a research problem that is thoroughly and equally understood by all participants,

b) to do a real literature research to back statements by real citations, due to the limited time in a course.

Obviously, with much more time available when writing a real paper, a) and b) are absolutely necessary and are quite time-consuming.

With a touch of humour, we define the cake-cutting problem (see Figure 1.1) as follows:

Definition 1. *The **cake-cutting problem** is the problem of cutting a cake C into a set of pieces $\mathcal{P} = \{P_1, ...P_N\}$ such that the trade-off between the cutter's effort $\mathcal{E}_{cutter}$ and the cake-eaters satisfaction level $\mathcal{S}_{eater}$ is optimized. The number of pieces is denoted as N and one piece is referred to as P_i. Furthermore, $\bigcup_{i=1}^{N} P_i = C$ has to hold.*

It is assumed the problem has been addressed by various researchers using equally-sized or variable-sized pieces. However, we assume the idea of *adaptively* determining the size of the cake pieces was not previously addressed. The idea for the examples and exercises is to use machine learning to learn something about eating behaviour and cut the cake accordingly.

1.3. Notation used to highlight parts of the text

Throughout this document, parts of the text are highlighted as follows:

[INFO]

This indicates some additional information.

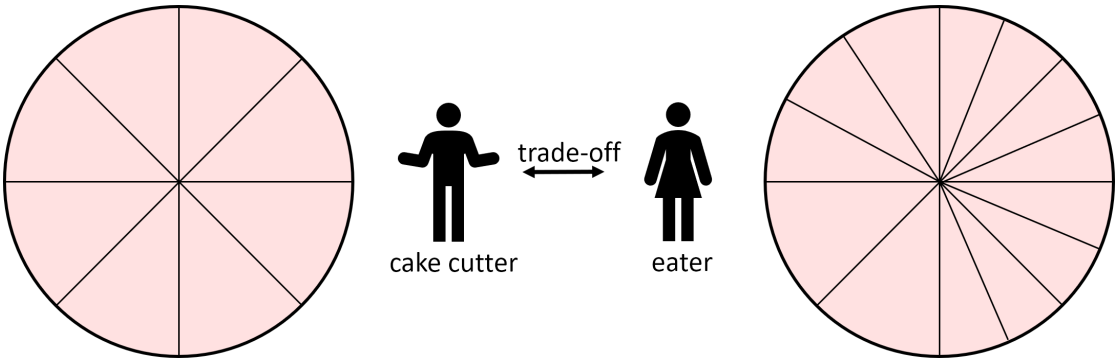

Figure 1.1.: The fictitious(!) cake-cutting problem: How to cut a cake C into N pieces?

[HINT]

Hints, checklists, best practices, etc. will be shown in these boxes.

[BE CAREFUL]

This type of box points the reader to common mistakes.

EXAMPLE 1.1: An example

Examples will be shown in this format. Created bad examples as well as examples from published papers are shown.

EXERCISE 1.1: An exercise

Exercises are shown in this format.

Chapter 2.

Finding a research problem

Finding a research problem and formulating a research question or hypothesis is the starting point of writing a scientific paper. At the same time finding a good research problem is far from trivial. It typically requires several iterations. In the following, some hints on how to find a research problem are discussed:

1. **Becoming an expert in some field:** Experts in a specific field will find it easier to identify research problems. These can be deduced from research gaps from own research, i.e. open issues from previous research. In addition, experts typically have an overview of what has been published and what issues are still unsolved or leave room for further research. Also see (Reis and Reis, 2013) for an interesting discussion, they refer to it as "Knowing the Frontier of Knowledge". Reaching such a level takes time, however, at the end of e.g. a Master Thesis, students will have reached a state to be able to formulate research questions based on their identified research gaps within the scope of their Thesis.

2. **Discussing with experts:** Experience in some research field is a key factor to identify research problems. Discussing with experts about open research problems will, hence, be highly helpful. Experts can be supervisors, other researchers in a group, or people met at conferences.

3. **Identifying research gaps in literature:** Having identified a topic of interest, current scientific papers should be read to identify potential research gaps and research questions. This can be done in any of the following ways:
   - In papers proposing some approach or theory, often limitations and future work are discussed towards the end of the paper.
   - Furthermore, papers should be critically evaluated trying to identify open issues that have not been covered in the given paper.
   - In addition, there are papers explicitly reporting open research problems. This can for example be found in literature reviews (some of them even indicate this in the title or Abstract, for example "xxx: A review and open research directions").

Following that, literature should be reviewed regarding the identified research gaps and questions to check if they are still unsolved and relevant.

4. **Starting from a practical problem:** A natural starting point for the search for a research question is a practical problem encountered, say, in an industry or a research project. It should be critically assessed if the problem setting might lend itself to yield a scientific question and if certain requirements are fulfilled, e.g. data availability, possibility to publish, etc. If the problem setting is promising, the practical problem should be abstracted and formalized and the scientific literature be reviewed.

Finding a research problem is a mixture of creative thinking and following established procedures. In (Booth et al., 2016), two promising procedures are shown. The first procedure is to **incrementally narrow down a subject to a research question and a research problem**. Narrowing down can be achieved with the aforementioned points 1 to 3. The process is shown in Figure 2.1 and is described in the following:

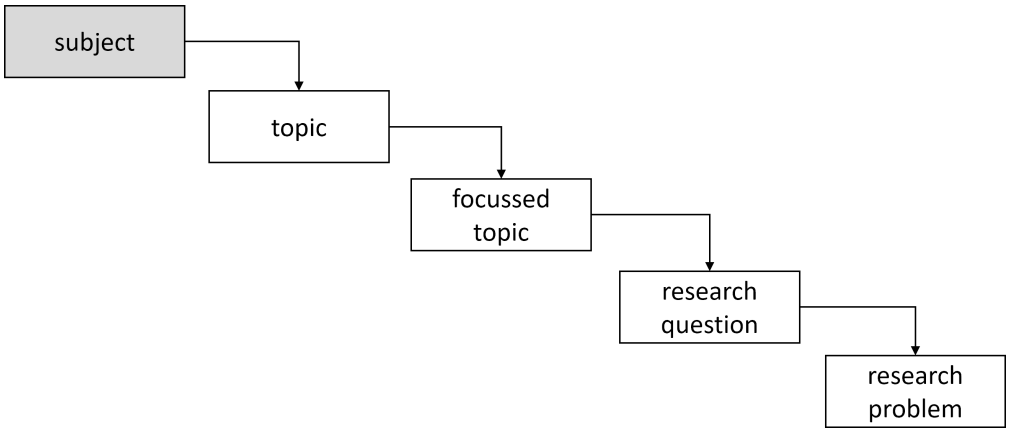

Figure 2.1.: Finding a research problem by narrowing down from subject to topic and focussed topic. Following that, a research question is deduced and the answer to that question poses our research problem. (Process taken from (Booth et al., 2016))

- As a first step, (Booth et al., 2016) suggest the researcher should identify a *subject* (see Figure 2.1)of his or her interest (in some cases, subjects are assigned in some project). A subject, which could also be called research area, is rather coarse and may be covered in an entire text book. An example could be "machine learning".
- Following that, a *topic* – which could also be called a subarea or subfield – should be identified. For the aforementioned example of "machine learning", a topic could be "interpretable machine learning".

- A topic is still too coarse to define some research questions. The next step is to narrow down the topic to reach some *focussed topic*. For the example of "interpretable machine learning" this could be "interpretable machine learning for time series data".
- With a focussed topic, the literature can be reviewed in a goal-oriented way in order to identify research gaps (as discussed above). Based on the identified research gaps, one or more *research questions* should be formulated.
- Answering these research questions in a methodological way forms the *research problem*.
- The steps above are typically iterated several times, for example the researcher may not be able to find research gaps for a focussed topic or may not be able to formulate a research question.

A second procedure described in (Booth et al., 2016) is to **deduce a research problem from a practical problem** encountered in some research or industry project. This corresponds to "Starting from a practical problem" from the numbered list above. The procedure is shown in Figure 2.2.

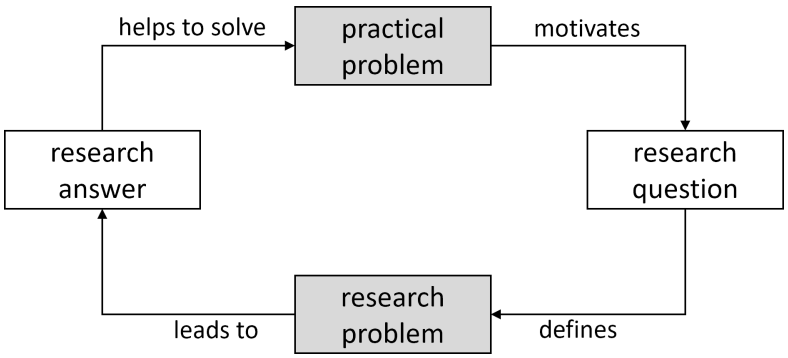

Figure 2.2.: Finding a research problem, starting with a practical problem. (Process taken from (Booth et al., 2016))

Some further options to identify a research problem are:

- **Identifying and connecting topics:** Interesting topics can be identified and combined. This can be done by first collecting topics and in a second step trying to organize and connect them. While trying to connect them, questions can be asked like: Have these topics been connected in literature? Is it easily possible to connect them? If not, why not – could this be a potential research question and a scientific contribution? What benefit would the connection yield? What could it

reveal? Examples are the connection between explainable AI and the classification of time series, blockchain and health data bases, etc.

- **Taking a different perspective:** For a research problem that was addressed in papers, a different perspective can be taken – if it can be justified that taking this perspective makes valuable scientific contributions. For example there are various literature reviews on explainable AI in general. So an option is, to investigate the problem from the perspective of predictive maintenance (see (Vollert et al., 2021)), etc.

- **Using a different research method:** A research question that was addressed in some paper, can be addressed with a different research method. For example a paper might investigate the question with a literature review. An alternative can be to conduct expert interviews, user studies, simulations, case studies, etc.

- **Identifying research gaps from published literature:** In some cases research gaps can be directly identified from literature. For example in the case of literature reviews: if an established topic is identified to be relevant but there are no literature reviews that are newer than, say, 5 years, a current literature review might add a scientific contribution.

Furthermore, a quite pragmatic way to identify potential research problems is to **consider different problems and approaches to address these problems**: Combinations of a *new* approach applied to an *known* problem, an *known* approach applied to a *new* problem, or a *new* approach applied to a *new* problem may present a research problem (see Figure 2.3). However, the identified combinations should be checked regarding relevance, novelty and scientific contribution.

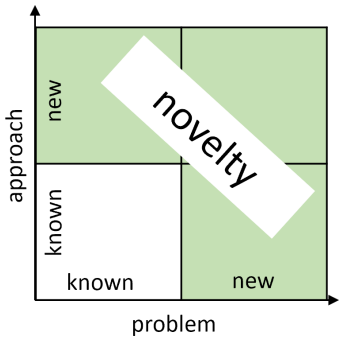

Figure 2.3.: A new approach applied to an known problem, an known approach applied to a new problem, or a new approach applied to a new problem *may* present an interesting research problem.

Chapter 3.

Working with literature

Working with literature is an essential part of writing a scientific paper.

3.1. Why to refer to and cite other work

In some cases, the formulated research question is answered by critically analysing published papers. This is for example the case for literature reviews, see (Renner et al., 2022; Snyder, 2019; Wee and Banister, 2016) for hints on how to write these [1]. Hence, it is crucial to follow a methodological way to search, select, and analyse literature.

In computer science and information systems, often prototypes are developed and experiments are conducted. This type of research work also requires to analyse and report the state-of-the-art and related work in the research field. As a consequence, it is an essential part of science to build on work of others and, thereby, cite other work.

Regardless of the type of paper, it is necessary to reference, summarize, analyze and discuss other published papers. Furthermore, the own work needs to be contrasted to published work. By doing so, the own work is connected to other work in a research field thereby showing its novelty, its relevance, and in some cases also its limitations. (Derntl, 2014) even states that "embedding the own work in related literature is one of the essential parts of research writing".

3.2. Plagiarism

The writer of a scientific paper needs to make clear which ideas are new, which are taken from other sources and which are adapted from other sources. Failing to do so is called plagiarism and will lead to papers being rejected, the authors being banned and, for Bachelor or Master Theses, students failing the exam.

There are **various forms of plagiarism**. Some are shown in the following, based on a sentence taken from a published paper:

[1] The paper (Renner et al., 2022), which was co-authored by this document's author, can be found in the appendix. Note, the own paper is included, because this is allowed by the publisher's copyright rules. However, reading the other two papers (Snyder, 2019; Wee and Banister, 2016) is highly recommended.

EXAMPLE 3.1: Text from a published paper (Theissler et al., 2022)

While computer vision is undeniably an important research field of machine learning, we argue that there might be a bias in explainable AI (XAI) research toward image data.

[BE CAREFUL]

Plagiarism 1: copying the text without citation

While computer vision is undeniably an important research field of machine learning, we argue that there might be a bias in explainable AI (XAI) research toward image data.

Reason: Replicating text from other work without citing the original is plagiarism. This is trying to "sell" ideas of others as own ideas.

[BE CAREFUL]

Plagiarism 2: copying the text with citation

While computer vision is undeniably an important research field of machine learning, we argue that there might be a bias in explainable AI (XAI) research toward image data (Theissler et al., 2022).

Reason: Replicating text from other work and just adding a reference to the original paper is plagiarism. This is often misunderstood by students: while the original source is cited, this way of citing indicates that an idea was taken from that source, but it is presented in own words – referred to as "paraphrasing" – which is not the case here. Presenting something in own words, shows that the writer has analysed and understood the original source. This is probably not the case in this fictitious example.
In contrast to paraphrasing, text can be enclosed in quotation marks indicating it is a word-for-word quotation. However, this should be rarely used, for example for definitions or other text that really needs to be presented word-by-word.

[BE CAREFUL]

Plagiarism 3: slightly adapting the text with citation

Computer vision is undeniably an important research field of machine learning. We argue that there might be a bias in explainable AI (XAI) research toward image data (Theissler et al., 2022).

Reason: Slightly adapting text from other work and adding a reference to the original paper is still plagiarism. Minor editing of grammar is not of scientific value. Hence, again, the reader believes the text was analysed and presented in own words. But this is not the case in this example.

EXAMPLE 3.2: Properly citing the text from the example above

(Theissler et al., 2022) point out that in XAI research, there might be a bias towards image data, while acknowledging that computer vision is an important research field. This is confirmed by (Maier et al., 2023), stating that.... As opposed to that, (Johnson et al., 2023) point out that ...

Reason: From the above text it is clear, that the statements were made by the original authors. They statements are used, but not word-by-word. Furthermore, the work is related to other work, showing that the writer can put the work into context and contrast them which requires to – at least to some degree – understand the cited work.

[HINT]

From my experience supervising Bachelor and Master Theses, students are often worried about using the correct citation style when citing, e.g. [1] vs. (Maier, 2003) or [1],[3] vs. [1,3].

There are different common citation styles (bibliography styles). For a paper, the citation style is usually given by the journal or conference. When using templates, it is automatically set to the desired citation style. Writing a Bachelor or Master Thesis, it is recommended to check the desired citation style with your supervisor.

Yet, **much more important** than the type of brackets when citing, is to make sure it is clear what the own contributions are. For example, which are own ideas and which are taken or adapted from other sources, which analyses are own work and which the are taken from sources, etc.

Chapter 4.

Writing a scientific paper

Scientific papers contain four main parts, commonly referred to as the **IMRaD**[1] format:

IMRaD: **I**ntroduction, **M**ethod, **R**esults, **a**nd **D**iscussion.

These four parts are often mapped to sections of a paper, often with further sections added. The common components and sections of scientific papers are introduced and discussed in the following. In addition, check-lists are proposed by this document's author (shown in [HINT]-boxes).

Common components of a research paper – not necessarily using the exact names – are:

- Title
- Abstract
- Introduction
- Related work
- (Background – optional, not necessarily a separate section)
- Methods
- Results
- Discussion
- Conclusion
- Bibliography

4.1. Finding a Title

A paper's title is usually the first thing a potential reader sees and is likely to be the part of the paper that is read most (Day et al., 1989). Based on the title, a decision is made whether to have a look at the paper. To some extent, whether a title is good is – probably more than all other parts of a paper – a matter of taste. Finding a good title is about finding the right balance between various factors. For a scientific paper, a title

[1] The origin of the **IMRaD** format can not be traced back to a publication proposing it. It appears to have developed over the centuries. In the 1989 paper (Day et al., 1989), a discussion of this can be found.

should not have the goal to attract *as many readers as possible*, it should rather attract as many readers as possible *from the desired readership*.

The title should reflect the true content of the paper. A very catchy title that attracts many readers who then realize the paper's content is actually not what the title promised or what they thought the content was, will leave those readers disappointed, probably not finishing to read the paper. On the other hand, an uninformative or very boring title will not convince the desired readership to have a look at the paper.

[INFO]

The importance of a good title:

- Based on the title, a potential reader decides whether to have a look at the paper, then checking the Abstract for a final decision whether to read the paper.
- The title is one important component for the paper to be included in search results.
- The title is a first criterion that determines if other researchers reference the paper in own papers, e.g. in literature reviews.

The title of a paper should contain the following:

1. The paper's topic.
2. Some indication about the paper's difference to other works in the field, for example the novelty, the research problem or the type of approach.
3. The title should implicitly or explicitly express the paper type, i.e. literature review, approach, experimental evaluation of existing approaches, etc.

The title's length is a trade-off between being too uninformative and being hard to read. While a three-line title can hold a lot of information, it is usually too long to be easily understandable. A title of 3-4 words might sound catchy and easy to understand but is probably not specific enough to attract the desired readership.

[HINT]

(Alley, 2018) suggests a pragmatic test to determine if a title is good: Run a web search for papers in the area of your paper. Then imagine your paper title to be among them and ask yourself how your candidate title compares to the other titles in the field. Would your title attract the desired readers?

[HINT]

To easily memorize important properties of a good title, without claiming to be an exhaustive list, the **SPICE** properties are proposed. A title should be:

- **S**pecific
- **P**recise
- **I**nteresting
- **C**ompact
- **E**asy to understand

EXAMPLE 4.1: Bad titles for the fictitious cake-cutting research problem

(to be discussed...)

1. Cutting cakes
2. The cake-cutting problem
3. Optimization using Hierarchy Regularization and Negotiation Simulation for Cutting Algorithms of Cakes with Height Estimation and Content Synthesis
4. Optimizing cake-cutting under the RDN-condition using AD and LT
5. A literature review of research papers addressing the cake-cutting problem
6. A review of the cake-cutting problem: Cake-cutting algorithms and cake-cutting user studies

EXERCISE 4.1: Finding titles

a) Discuss the bad titles above.

Initial discussion of the bad titles: Titles are a matter of taste. However, given the previous titles, one could argue that the first title is highly unspecific. A potential reader does not know which problem the paper addresses, if an approach is proposed, if papers are reviewed, or if it is a basic tutorial. The second title could be a good title, for the first paper introducing the problem. However, not for papers addressing specific subfields of that topic. Furthermore, the title looks more like a text book. Hence, readers would expect a full coverage of all relevant aspects including fundamentals...

b) Try to rephrase the titles, in order to improve them.

c) Find three own titles for a paper on the cake-cutting problem (or for a paper on your own research topic).

EXAMPLE 4.2: Real-world examples

1. Dropout: a simple way to prevent neural networks from overfitting
2. Acoustofluidic separation of cells and particles
3. Binary B-Trees for Virtual Memory
4. "Why Should I Trust You?": Explaining the Predictions of Any Classifier
5. Support Vector Data Description
6. Anomaly detection for industrial quality assurance: A comparative evaluation of unsupervised deep learning models
7. Joint Sensing and Transmission Optimization for IRS-Assisted Cognitive Radio Networks
8. Explainable AI for Time Series Classification: A review, taxonomy and research directions
9. A Review on Multi-Label Learning Algorithms
10. A Survey on Contrastive Self-Supervised Learning
11. Blockchain: A Review from The Perspective of Operations Researchers

While the title is the first part of the paper, it is commonly one of the last parts to be finalized. However, it is recommended to have a draft title early during writing a paper and regularly check if it still reflects the paper's content, as the paper is being developed.

4.2. Writing the Abstract

Following a paper's title, the Abstract is the second part of the paper a potential reader will look at. It is important to know that an Abstract is published online on the publisher's website, free for anyone to access. The paper on the other hand is often only accessible having paid some fee[2]. Based on the Abstract, potential readers decide whether to read – or even buy – the paper. This requires the Abstract to be **self-contained**, i.e. the Abstract needs to be understandable without having to refer to the content of the paper. Hence, one should not refer to e.g. figures, citations, sections etc. in the paper.

[2]Institutions like universities typically have some subscription allowing to access many, but not all, papers without individual payment.

An Abstract must be short **short**, summarizing the key points of the paper including the **novelty** and the **most important results**. The exact length of an Abstract is specified by the journal or conference. A typical length for an Abstract of a scientific paper is between 150 and 250 words.

[HINT]

Make sure to check the Abstract's maximum length for the journal or conference you are aiming to submit the paper to. Typically the Abstract needs to be copied in some web form during the submission process. The web form checks the Abstract length, so it might prevent you from submitting your paper requiring you to shorten the Abstract during the submission process – as we all know, submissions often take place last-minute.

Abstracts are structured in a way, that is dependent on the research field. While Abstracts for medical papers typically have a real structure with subheadings, the structure is not so evident for computer science or information systems papers. A typical structure are subsequent sentences with the following points where each point is described with 1-2 (!) sentences (adapted and enhanced from (Zobel, 2014)). A first Abstract draft can have five sentences, possibly adding a second sentence to some of the points:

1. A brief introduction into the paper's topic.
2. The problem statement or research question.
3. Current solutions for 2., together with their limitations, or a statement about an identified research gap.
4. The proposed approach, solution, etc. clearly stating its novelty together with the methodology used.
5. Brief summary of the evaluation and results.

Furthermore, the Abstract should be written **specific** enough for experts to see the difference to existing approaches in the field, however, general enough to allow non-experts to get an idea about the content and the novelty. This can be achieved by not using acronyms, specific terms and mathematical formulas.

Regarding the writing style, the Abstract is mainly written in present tense, with typical terms like example "we propose...", "we present...", etc.

[HINT]

In order to check your Abstract, **The-5-S** quality criteria are proposed:

- **S**hort
- **S**elf-contained
- **S**pecific
- **S**tatetement of novelty
- **S**ummary of most important results

Usually the Abstract is finalized as one of the last steps of the paper. The Abstract does not present information that is not as well contained in the paper itself. It is quite common to initially extract the required sentences for the Abstract from the paper, mainly from the introduction, discussion, and conclusion sections. The sentences should, however, be adapted to give the Abstract a natural flow and not give the reader the feeling of reading the same sentences twice.

EXAMPLE 4.3: Bad example of an Abstract for the fictitious cake-cutting research problem

(to be discussed...)

Manufacturing, selling and consumption of cakes is a major industry branch and has recently been addressed by various researchers. The Association of Cake Science (ACS) estimates the amount of consumed cake per year to be 10 million tons and the generated annual turn-over to be 50 billion US dollars [1]. As stated in [2], the major stakeholders are cake-eaters, manufacturers, cake-sellers as well as logistic companies.
A problem setting frequently encountered by cake-eaters and cake-sellers is the cake-cutting problem which was first defined by Miller et al. as the problem setting of cutting a cake C into pieces P_i such that the cutter's effort is optimized [3].

EXERCISE 4.2: Evaluating and writing Abstracts

a) Discuss the "bad example of an Abstract" above. You may use The-6-S criteria.

b) Try to rephrase the Abstract, in order to improve it.

c) Formulate an Abstract for an own paper on the fictitious cake-cutting problem (or for a paper on your own research topic).

EXAMPLE 4.4: Abstract of a published paper (Theissler et al., 2022)

Explainable AI for Time Series Classification: A review, taxonomy and research directions

Time series data is increasingly used in a wide range of fields, and it is often relied on in crucial applications and high-stakes decision-making. For instance, sensors generate time series data to recognize different types of anomalies through automatic decision-making systems. Typically, these systems are realized with machine learning models that achieve top-tier performance on time series classification tasks. Unfortunately, the logic behind their prediction is opaque and hard to understand from a human standpoint. Recently, we observed a consistent increase in the development of explanation methods for time series classification justifying the need to structure and review the field. In this work, we (a) present the first extensive literature review on Explainable AI (XAI) for time series classification, (b) categorize the research field through a taxonomy subdividing the methods into time points-based, subsequences-based and instance-based, and (c) identify open research directions regarding the type of explanations and the evaluation of explanations and interpretability.

4.3. The Introduction section

In the introduction section, the context of the paper is described, a problem is presented and the paper's response to that problem is stated (Booth et al., 2016). (Derntl, 2014) roughly summarizes the reason of the introduction as establishing a territory, establishing a niche, and then occupying the niche.

A typical introduction section will look as follows:

1. An introduction into the paper's topic.
2. The motivation, for example shown by a research gap or shortcoming of current research in a field (shown by referencing papers from the field).
3. Research questions, hypotheses, and/or research problem statement:
   - Research questions can be formulated as questions, but are also often formulated as statements, for example "we address the question, if X is superior to Y ...".
   - Hypotheses[3] are statements that will be tested in the research work. These are not necessarily hypotheses in the form of statistical hypotheses (although in some cases they are tested with statistical hypothesis tests).

[3]Hypothesis: Note the resemblance to the word "thesis" as in Bachelor Thesis and Master Thesis, which is not a coincidence.

4. The research method, i.e. showing how the research question will be answered. Examples are the proposed approach, the idea, the statement that the paper is a literature review, or that expert interviews or user studies will be conducted.
5. The paper's novelty.
6. An explicit statement of the scientific contributions.
7. A brief description of the paper's structure, i.e. an overview over the sections[4].

[HINT]

The importance of a good introduction section

After having read the introduction section, readers should have a clear understanding of what will be presented in the paper, why it is worth reading, the novelty, and the scientific contributions. (Booth et al., 2016) have an interesting view on what the introduction should do: They state that one can work with readers saying "I do not agree". There are chances they will continue reading the paper out of curiosity. So you have the full paper to try to convince them. If you did not succeed, but the paper is methodologically sound, they might judge the paper as an alternative idea that was properly researched.
In contrast to that, (Booth et al., 2016) state that one can not work with readers saying "I do not care". This may happen if you did not succeed to formulate the motivation, novelty or scientific contribution clearly enough. In that case, readers will likely not continue to read and reviewers are likely to reject the paper.

[HINT]

The motivation, research gap or shortcoming can be boiled down to showing **"Why"** the research was done. The research method can be summarized as **"How"** the research was done. Finally, the novelty and scientific contributions show **"What's new"** in the presented paper. Hence, the **WHWN-questions** are proposed which should be answered by an introduction section:

- **W**hy ?
- **H**ow ?
- **W**hat's **n**ew ?

[4]This document's author believes these sentences are rarely read. Papers are typically short, so an overview does not seem to add a lot of value. However, it is common to have them at the end of the introduction, hence, it is recommended to do so.

[HINT]

It is not enough that a paper *is* novel and *makes* a scientific contribution. The authors must *show that* the paper is novel and makes a contribution. Readers (and reviewers!) should not have to search for a paper's novelty and contributions themselves.

EXAMPLE 4.5: Bad example of a paper introduction section for the fictitious cake-cutting research problem

(to be discussed...)

It is widely known that the segmentation of a cake C into $|P|$ pieces is highly relevant. Segmentation into $N \geq N_{\text{min}}$ pieces of static sizes and with shape S is a common approach. However, the quality of current research in the field is not sufficient.
Our approach to solve the cake-cutting problem is novel and makes significant scientific contributions which will revolutionize the research in the field.
The cake-cutting problem is the problem of cutting a cake C into a set of pieces $\mathcal{P} = \{P_1, ...P_N\}$ such that the trade-off between the cutter's effort $\mathcal{E}_{cutter}$ and the cake-eaters satisfaction level $\mathcal{S}_{eater}$ is optimized. The number of pieces is denoted as N and one piece is referred to as P_i.
For cake-cutting we have to minimize the cake cutter's effort. It has been shown that this allows to cut more cakes in less time. So the question is, if an algorithm can minimize the cutter's effort.
In Section 2, [...]

EXERCISE 4.3: Evaluating and writing Introductions

a) Discuss the "bad example of an Introduction" above. You may use the aforementioned list of typical components and the WHWN-questions.

b) Start to rephrase parts of the introduction, in order to improve it.

c) Start formulating an introduction for an own paper on the cake-cutting problem (or for a paper on your own research topic).

EXAMPLE 4.6: Introduction of a published paper (Theissler et al., 2022)(shortened)

Machine learning (ML) models have achieved unprecedented performance in recent years. While the models become more accurate and complex, the lack of model explainability or interpretability is one of the key challenges of ML research. Such a challenge may prevent the use of ML in applications that call for interpretable decisions, such as [...] there is a need to overcome this problem.
The research field of eXplainable AI (XAI)[1] or interpretable machine learning [2] tackles explainability challenges to give insights into model behavior.
A large part of the work in explainability is done on tabular data or in the field of computer vision, where deep neural networks typically achieve state-of-the-art performance. While computer vision is undeniably an important research field of machine learning, we argue that there might be a bias in XAI research toward image data due to *(i)* the availability of data, e.g. Imagenet [3] or CIFAR-10 [4] and – more importantly – *(ii)* the inherent semantics present in images: explaining the classification of a rooster based on the rooster comb is easily interpretable and verifiable, while a time series is often not intelligible without domain knowledge [5].
We believe that time series should receive the same research attention since they are omnipresent, e.g., in technical systems [6][7], the medical domain [8], [...] such models can outperform experts in certain time series tasks, enabling their application in various use cases, e.g., [...].
The research field of XAI for time series classification has become more popular since around 2019, a variety of valuable papers have been published in recent years (see Figure x). This was the motivation to structure the field with a review of the most important works and to deduce open research directions to close gaps.
The primary goals of this work are to (1) give an overview of the current body of literature on XAI for time series classification, (2) categorize the research field through a sound taxonomy, and (3) deduce new insights, identifying open research challenges in order to inspire new research in this emerging field. We achieve these goals by surveying papers in the field: We present the first literature review on XAI for time series classification. [...]

Thus, in the following, we contribute:

1. a *semi-structured literature review* of the most recent explainable AI approaches for time series classification;
2. a *taxonomy* of approaches for XAI deduced from the reviewed work
3. insights into the differences and advantages of such explainable AI techniques;
4. highlights of applications and evaluation strategies to showcase applied XAI techniques;
5. research directions in order to inspire future research in the field of XAI for time series classification.

The rest of the paper is organized as follows [...]

4.4. Related Work

The Related Work part of a paper gives an overview of previous work that has addressed similar problems or proposed similar approaches. The previous work should not only be summarized but **it must also be stated how the own paper is different from the related work**. By doing so, the own work is embedded into the work in the research field (Derntl, 2014).

An own paper can be different from related work for example by enhancing previous work, closing gaps not addressed by previous work, by setting a different scope, or taking a different perspective.

Essentially, related work might be papers addressing a similar topic, research question or problem setting. For a paper proposing an approach, typical related works are other papers proposing a different approach for a similar problem or a similar approach for a different problem. For a literature review, related works are other literature reviews on the topic.

[INFO]

Discussing related work should convince the reader that

- the **research problem is relevant** – this is shown by the fact that various other papers have been published
- the own paper **makes a scientific contribution** – this is shown by contrasting the own paper to previous work

There are several common ways to include related work in a paper where each of these options has benefits and drawbacks:

1. In an own section following the introduction *(frequently used in papers)*.
    - *Benefit:* It is clearly visible for the reader where the own work is related to other works in the field.
    - *Drawback:* There will be some repetition, briefly referring to some of the papers in the introduction and in more detail in the related work section.
2. In the introduction within the text or as a subsection *(frequently used in papers)*.
    - *Benefit:* There are no repetitive references to the same papers. Furthermore, when first stating novelty and contributions these are directly related to all relevant works.
    - *Drawback:* The introduction can get quite long and, hence, can appear unfocussed. This makes it harder to highlight the paper's most important points.

3. Towards the end of the paper *(rarely used in papers)*.
    - *Benefit:* Terminology and knowledge established throughout the paper can be used when discussing related work.
    - *Drawback:* The reader might develop doubts about the paper's novelty while reading the paper.
4. Distributed throughout the paper, i.e. related work is discussed where needed for example in the method section *(sometimes used in papers)*.
    - *Benefit:* More specific terminology and knowledge can be used and readers do not need to remember what was introduced earlier on.
    - *Drawback:* For the reader (and reviewer) it becomes harder to relate the full list of novelties and contributions of the paper to existing work. Hence judging the novelty of the paper can become harder.

While all of the aforementioned options are valid, this document's author recommends to use either option 1 or 2.

[HINT]

To quickly validate the Related Work, the **RICK** questions are proposed:

- **R**ecent papers cited ?
- **I**mprovement of own work w.r.t. related work shown ?
- **C**ontrasted to own work ?
- **K**nowledge gap deduced ?

[BE CAREFUL]

- Own work in the field should be included, if it is relevant. Only or predominantly citing own work makes the research problem look like an isolated one, relevant for a very small number of researchers. Furthermore, it may look as if the authors are not aware of the state-of-the-art in a field.
- Stating that the research problem is so specific and novel that no previous work exists, should not be done. Even the most successful researchers build on works of others.

EXAMPLE 4.7: Bad example 1 of a Related Work section for the fictitious cake-cutting research problem

(to be discussed...)

Artificial Intelligence (AI) was introduced in the 1950s where the idea of a Perceptron was published by Rosenberg [1]. The idea is that it mimics the human brain in order to make decisions [2]. The human brain consists of neurons and synapses, these are reflected by the architectures of artificial neural networks.
Machine learning is a subfield of AI. Machine Learning comprises tasks like classification [3], clustering [4], forecasting [5], ...

[...]

Recently the importance of AI was shown by text generation in the form of ChatGPT [6] and image generation [7]. Furthermore, it achieved great success in playing games against human experts [8].
In this paper we address the cake-cutting problem with machine learning.

EXAMPLE 4.8: Bad example 2 of a Related Work section for the fictitious cake-cutting research problem

(to be discussed...)

There are almost no scientific publications on the cake-cutting problem. The only papers that could be found are [1] and [2].

EXERCISE 4.4: Evaluating and writing Related Work sections

a) Discuss the two "bad examples of Related Work sections" above.

b) Start to rephrase parts of the Related Work, in order to improve it.

c) Start formulating a Related Work section for an own paper on the fictitious cake-cutting problem (or for a paper on your own research topic).

EXAMPLE 4.9: Related Work of a published paper (Theissler et al., 2022)(shortened)

[...] The proliferation of XAI methods working in different domains has been accompanied by various surveys categorizing these methodologies [1][2]. An introduction to frequently used explainers in XAI can for example be found in [...] However, while explainers for data types such as relational data, images, and texts are illustrated from various perspectives in different literature reviews, explainers for other data types, like time series, are not reviewed sufficiently in detail. In the rest of this section, we report general surveys on XAI not specifically addressing time series, surveys on TSC, and two preprints of surveys on explainability methods for TSC, highlighting the differences to our paper.
In [3], a classification of XAI methods according to the problem they are able to solve is presented. The first categorization is between (1) *explanation by design* or *intrinsic interpretability*, and (2) *black-box explanation* or *post-hoc explanation*. In [3][4], the same principal categorization is adopted. The second categorization further classifies the black-box explanation problem into model explanation, outcome explanation, and black-box inspection.
Another distinction shared among [3][4][5] is between *model-specific* and *model-agnostic* explanation methods. In this survey, we adopt and exploit the same taxonomy of [3][4] which is detailed in the next section. However, while these surveys are generalists, we focus on explainers for time series classification problems. [...]
Concerning surveys for TSC not addressing XAI, the works of [6][7] and [8] are probably most updated and complete. In [6] the focus is more on classical approaches [...] in [7], the focus is on neural network-based approaches [...]
However, none of the surveys above touches on questions related to interpretability or explainability. [...]
To the best of our knowledge, the only existing review papers at the intersection of XAI and TSC are the pre-prints [9][10]. The authors of [9] present an overview of XAI methods for TSC and illustrate the types of explanations they produce. They categorize XAI methods by the type of model to be explained [...] whereas we focus on the type of explanation returned by the explainers. In addition, differently from [10], we also discuss evaluation measures for explainers of time series classifiers. In [10], XAI with respect to TSC is faced at a high level and the survey only reports generalist explanation methods such as [...], and explanation methods for neural networks. In contrast to [10], we focus more on explanation methods designed explicitly for TSC, including many different kinds of XAI approaches, such as transparent models and non-neural network-based methods, thus providing an extended overview of the state-of-the-art.

4.5. Background material

At some point in a paper, background material needs to be introduced. Background material can be viewed as knowledge that was previously established in literature and is required to understand the paper *and* cannot be assumed to be known by the target audience.

In that sense, the background material does not present new ideas but rather makes sure the reader can follow the rest of the paper. Hence, the background material depends on the target audience. For example, if a machine learning paper is submitted to a machine learning conference, it should not contain a general introduction into machine learning. It can, however, introduce some specific subfield that cannot be assumed to be general knowledge in the machine learning community. On the other hand, if a machine learning paper is submitted to a manufacturing conference, the background material may introduce some concepts of machine learning that are required to understand the paper.

The background material can be introduced in different parts of the paper:

- In the introduction section which is only recommended if it is very short.
- In a separate background section. This has the benefit that (a) readers very familiar with the topic can skip the section and (b) it can be referenced from text later in the paper. The section is sometimes just named with general headers like “Background” or “Setting the stage”, while in other papers the title reflects the topic that is introduced, e.g. “Anomaly detection in time series”.
- In the method section, i.e. where the specific background knowledge is needed to understand the ideas of the paper. The benefit is that background is introduced when needed. However, a drawback is that own ideas are mixed with previously known ideas and knowledge. If not done 100% clearly, this makes it hard for reviewers or supervisors to judge the own contributions.

[INFO]

Background vs. Introduction (some sources have different views)

Some sources view the items that were proposed to be in the Introduction section (see Section 4.3) as the background of a paper. This is a different viewpoint. In this document the background is viewed as the described above.

EXAMPLE 4.10: Background section from a published paper (Theissler et al., 2022)

This section presents formal definitions for Time Series Classification (TSC) and recalls basic notions. We define a time series as follows:

Definition 2. *A time series* $x = \{t_1, t_2, \ldots, t_m\} \in \mathbb{R}^{m \times d}$ *is an ordered set of* m *real-valued observations (or time steps), with dimensionality* d*.*

We say that a time series is *univariate* when $d = 1$, i.e., each observation $t_i \in \mathbb{R}$ is a real value. On the other hand, when $d > 1$ we name x a *multivariate time series* (also referred to as *multidimensional time series*), i.e., each observation $t_i \in \mathbb{R}^d$ is a vector containing multiple real values. From another perspective, a multivariate time series is formed by d univariate time series with length m. Often, the univariate time series which are part of a multivariate time series are also referred to as signals, or channels [11].
A set of time series, either univariate or multivariate, with attached labels, forms a time series classification dataset.

Definition 3. *A time series classification dataset* $D = (X, Y)$ *is a set of* n *time series,* $X = \{x_1, x_2, \ldots, x_n\} \in \mathbb{R}^{n \times m \times d}$*, with a vector of assigned labels (or classes),* $Y = \{y_1, y_2, \ldots, y_n\} \in \mathbb{N}^n$*.*

For a dataset D containing l classes, y_i can take l different values. When $l = 2$, D is a binary classification dataset, while for $l > 2$, D is a multi-class classification dataset. We can now define the TSC problem as:

Definition 4. *Given a TSC dataset* D*, Time Series Classification is the task of training a function or mapping* f *from the space of possible inputs* X *to a probability distribution over the class values* Y*.*

[...]

4.6. The Method section

The concrete shape of the method section is highly dependent on the type of paper, the research method, the proposed novelty and the contributions made by the paper. Checking previous literature resembling the own procedure is highly recommended.

One possible and high-level categorization of research methods, described for example in (McNeill, 2006), is the distinction between **quantitative and qualitative research methods**. One possible categorization of paper types is given in (Derntl, 2014), categorizing papers into

- **Empirical papers** which address some research question or hypothesis for example

with experiments, expert interviews or user studies.

- **Case study papers**, referring to papers applying some methods or theories to a (real-world) problem.
- **Methodology papers**, which propose some new approach, etc. (quite frequently found in data science papers)
- **Theory papers** which in a purely theoretical way show some new theory.

In addition to this categorization, **literature reviews/surveys** are a common paper type – see e.g. (Renner et al., 2022; Snyder, 2019; Wee and Banister, 2016). These should not just summarize literature but make scientific contributions e.g. by relating work in a way not done before, introducing some categorization or taxonomy, identify open research questions, etc. Hence, writing a good literature review requires a thorough understanding of the field and analytical capabilities.

Due to the wide range of methodologies, the possibilities cannot be covered in this document. Yet, some indications about further reading are given: (McNeill, 2006) gives some generic idea of research methods categories. For research in information systems, the Design Science Research Method is often used (Hevner et al., 2008). For literature reviews/surveys (Snyder, 2019; Wee and Banister, 2016) give information about working with literature in a scientific way.

Yet, independent from the concrete method used, some properties are generally desired from a Method section: First, the followed research procedure should be **backed by acknowledged research methods**. It should be clearly **understandable** how the research was conducted. Moreover, the procedure should be described detailed enough to allow readers to **reproduce** the study, given that the readers have the necessary skills and access to the underlying data, see e.g. (Cuschieri et al., 2019; Derntl, 2014; Jain et al., 2018; Teodosiu, 2020). Furthermore, the **novel** aspect should be made clear where the novelty can take on different forms: For example it can be a novel approach if the paper's aim is to propose an approach, or a novel selection or perspective on literature in case of a literature review. Finally, the research procedure must be **systematic** which can be achieved by following acknowledged steps and guidelines or by clearly defining and justifying the steps if they deviate from common procedures.

[HINT]

To quickly check the quality of a Method section, the **BURNS** properties are proposed. The described research method should be:

- **B**acked by acknowledged research methods
- **U**nderstandable
- **R**eproducible
- **N**ovel
- **S**ystematic

EXAMPLE 4.11: Method section of a published paper (Theissler et al., 2022) (a literature review)

The overriding goals of our paper are to *(i)* give an overview, *(ii)* categorize, and *(iii)* deduce new insights from the current body of literature on XAI for time series classification. These goals are achieved by reviewing papers in the field.
While a systematic literature search might seem like a natural choice, we found that it will yield an incomplete review in this emerging field. Reasons are different terminologies used in different research subfields. Examples are the papers on shapelets that are quite different from deep learning papers. Hence, we opted for a semi-systematic literature review [x]:

1. we conducted a systematic search on Scopus using a set of search terms (see Table 1);
2. we conducted a dynamic search to uncover additional papers in the different subfields;
3. the found papers were judged by the authors based on exclusion and inclusion criteria (Table 2) in order to decide whether to include a paper.

Table 1: Systematic search on Scopus (title, abstract, keywords). The rows were combined with AND operators into one search query.

criterion	**search terms**
XAI	(interpretab* OR explainab* OR XAI)
ML	("machine learning" OR "deep learning" OR "artificial intelligence" OR "AI" OR "neural network")
TSC	(classif*) AND ("time series")
type	journal article OR conference paper
language	English

Table 2: List of inclusion and exclusion criteria, where IC refer to inclusion and EC to exclusion criteria, respectively.

ID	**criterion**
IC1	- only time series classification, no forecasting
IC2	- anomaly detection papers only if achieved by some sort of classification with supervised learning
IC3	- only papers that explicitly address and enhance explainability or interpretability
IC4	- only work on raw time series data including the time-frequency domain, no hand-crafted features
IC5	- only papers that show their approach for time series or are trivially adaptable
EC1	- no preprints
EC2	- no papers published prior to 2011
EC3	- no papers without any citations
EC4	- no surveys or reviews (these would be included in the related work section, though)
EC5	- no papers that conduct explorative analyses on the statistics of inner network components
EC6	- no papers massively relying on domain- or application-specific characteristics of the time series data
EC7	- no papers on time series streams, online or real-time classification

4.7. The Results section

The results should be reported in a way to allow the reader to evaluate their validity and their relation to the paper's research question or hypothesis (Antić, 2009; Cuschieri et al., 2019; Davidson and Delbridge, 2012).

The reported results must be linked to the research method and must **address the research question or hypothesis**. The reasons to conduct experiments, expert interviews, user studies or literature reviews should be to be able to answer research questions or to confirm/reject hypotheses and, furthermore, to **inspire a discussion** based on the results. The discussion of the results is usually done in a separate section, sometimes it is included in the Results section making it necessary to clearly separate between reporting results and interpreting them. As a consequence, the way results are obtained should be planned with some expectation of possible outcomes and how these would support the discussion. In that sense, results that yield simple "yes" or "no" answers may in many cases not be sufficient to start a fruitful discussion. An example could be a result "algorithm A is more efficient than algorithm B" compared to "for an increasing number of data items N, algorithm A becomes more efficient than algorithm B".

For readers to potentially replicate the results as well as for own future work, the setup used to obtain the results should be **reproducible**. To trust and to be able to validate the results, it is essential they are easily understandable. Hence, in addition to textual descriptions, it is recommended to present the results **visually** with figures and tables (Dekanski, 2014; Jain et al., 2018; Tokić, 2017). For the authors, the interesting parts in figures or tables might seem obvious, yet, this is not necessarily the case for readers. Consequently, results should not just be reported, they should also be **explained**. Finally, authors should make sure to properly **label** figures, axes, variables, equations, etc.

In some papers, the results are also discussed in the result section. However, quite a few sources, e.g. (Leach, 2002; Maiorana and Mayer, 2018), recommend not to do so, since it mixes up reporting the results and interpreting them.

[HINT]

To assess the quality of a Results section, the **ELVIRA** properties are proposed. The results should/should be:

- **E**xplained
- **L**abelled
- **V**isually supported
- **I**nspire discussion
- **R**eproducible
- **A**ddress the research question or hypothesis

EXAMPLE 4.12: Excerpt of Result section from a published paper (Theissler et al., 2022) (a literature review)

In the following, we highlight the advantages and characteristics of our semi-systematic literature review. We report the papers analyzed in Table 3. The papers are organized according to the following taxonomy (see Figure x). First, we discriminate on the granularity of explanation returned depending on the portion of a time series used to illustrate the causes for the decision process. [...]

Table 3: List of reviewed papers and taxonomy for XAI methods for Time Series Classification. Table legend: Post/Ante-hoc: P-Post, A-Ante; Model-Agnostic/Specific: A-Agnostic, S-Specific; We considered all Ante-hoc methods as Model-Specific methods.

Name	Ref	Year	Expl. Type	Expl. Method	Post/Ante -hoc	Model- Agnostic/Specific
Integrated Gradients	[1]	2017		Attr.	P	S
FCN	[2]	2017		Attr.	P	S
LIME	[3]	2016		Attr.	P	A
LRP	[4]	2015		Attr.	P	S
ExcitationBP	[5]	2016		Attr.	P	S
...	...	...	...	...	...	...

In [x], a dual-channel 1D-CNN is used to detect rock fracturing in univariate time series: one channel is used to process the temporal domain, and the other to process the frequency domain. The explanation is based on Grad-CAM [7] and is evaluated by visualized examples and, in addition, w.r.t. to domain knowledge. While these approaches are not directly generalizable, we believe the ideas are transferable to selected domains, where the underlying data is well-understood and shows clear, acknowledged patterns.

[...]

Summary and analysis:
[...] Attributions are used to attribute a relevance score to each input value of a model. [...] However, due to the non-intelligible nature of time series, [...] Regarding surrogate-and-sampling methods that can be applied to time series, considering each time step as a feature, we like to point the reader to two recent papers: [x] discusses challenges of LIME, SHAP, and related methods, independent of their use on time series. They emphasize the known fact that the methods' underlying assumption is feature independence. However, feature independence is not respected for adjacent observations in a time series. The authors of [y] stress that Shapley values, which are the fundamentals of SHAP, assume that adding players to the game does not decrease its overall value. However, adding features to an ML model may decrease the model's performance. [...]

4.8. The Discussion section

The discussion section is the place to **analyse, evaluate, discuss and possibly interpret the results**[5]. From the results, **findings should be deduced**. These should refer to the initially stated research question or hypothesis. Furthermore, additional findings can be reported.

Every research paper has **limitations**. It is recommended, e.g. by (Giordano et al., 2021), to honestly state these either in the Discussion or the Conclusion section – or in both. This has several benefits:

a) It allows readers to evaluate the applicability to a different problem, the validity and the scope of the results.

b) It shows readers (and reviewers !) that the own work was critically evaluated and the weaknesses are understood by the author.

c) It allows readers to deduce future research in order to work on some of the limitations.

A further important component of the Discussion section (or the Conclusion section) is the **identification of open issues**, i.e. stating which aspects were not solved or not addressed in the paper, or which future work/follow-up research is possible based on the presented paper. This is backed by the statements in (Ashton, 1998; Giordano et al., 2021).

[HINT]

In the Discussion of the paper, the proposed **REFLOW**-components should be contained:

- **R**esults discussed
- **E**valuation conducted
- **F**indings stated
- **L**imitations stated[a]
- **O**pen issues identified[a]
- **W**ork critically evaluated

[a]Sometimes limitations and open issues (future work, identified research gaps, future research directions, etc.) are presented in the Discussion section, sometimes they are discussed in the Discussion section and summarized in the Conclusion.

[5]Note that some papers discuss results in the results section. This is a matter of taste and is dependent on the type of results and discussion. Discussing results in a separate section has the benefit of not mixing plain reporting and explanation of results with – possibly speculative – interpretation and discussions, see also (Leach, 2002; Maiorana and Mayer, 2018)

EXAMPLE 4.13: Discussion from a published paper (Theissler et al., 2022) (shortened)

During the analysis of the selected papers, we identified various trends and challenges [...]. In the following, we discuss our perspective of the review on these challenges and highlight future research opportunities to close the gaps we identified.
We found interesting relationships between different categories of the proposed taxonomy. From Table xy, it becomes obvious that the granularity of the explanation is related to the locality or globality of the XAI approaches. For example, [...] Next, we identified connections between the explanation method and ante/post-hoc approaches [...] From the reviewed papers, model-agnostic approaches are rarer compared to model-specific approaches [...]
While the use of subsequences is more challenging, there appears to be a research gap due to the high practical relevance of multivariate time series. It is clear from the publication dates that subsequences-based methods [...] have a rich history with many solid methods. However, in that field, computational efficiency is frequently given more attention.
Since we believe that the evaluation of XAI methods is challenging and has not yet reached a satisfactory state [15][16], we analyzed how the XAI methods proposed in the reviewed papers were evaluated (see Table x): [...]. Classification accuracy is frequently used, however, it can not assess the methods' interpretability. To a much lesser degree, other quantitative explanation measures like user studies are used. We view the lack of user studies as an important observation that, from our point of view, points to a deficiency in a research field that aims to make machine learning interpretable for human beings. We believe that [...] is still missing.
As a critique of our taxonomy, we observe that a small subset of papers, not aligned with typical XAI works, could not be classified under it [...] Furthermore, we acknowledge that our selection of reviewed papers might have missed interesting work. For example, we did not include preprints and PhD theses, which might also hold compelling ideas.

EXAMPLE 4.14: Discussion from a published paper (Theissler et al., 2022) (continued)

We identified a number of research directions that we believe can contribute to inspire research in the field:

1. **Higher-order explanations are desirable:** We often observed visualizations showing the time series with a heatmap on top of the line plot or behind it [...] We see an opportunity for higher-order representations besides line plots of the explanations to enable a more straightforward explanation.
2. **Model-agnostic approaches are particularly useful for TSC:** For TSC, a variety of different model types is used. In order to compare the interpretability of these entirely different model architectures, model-agnostic methods are required. Model-specific methods may then be used at a later stage of the model selection process.
3. **Domain-specific explanations for specific applications:** In general, building models and explanations that work in a wide range of fields is desirable. However, we believe some cases require domain-specific explanations when [...]
4. **Easy-to-use explainers are desirable:** Some XAI methods to explain black-box models might be viewed as black-boxes themselves. For example, some XAI methods come with assumptions like [...]. For these reasons, there is a risk that the XAI methods will produce invalid explanations.

[...]

4.9. The Conclusion section

The Conclusion[6] section is obviously the last part that is read. Hence, it significantly contributes to the impression a paper makes and must summarize the key take-aways.

The conclusion should be kept short, however, there is no fixed limit on the length. It is often a paper's shortest section, however, longer than the Abstract[7]. A typical structure of a conclusion is as follows

- A repetition of the paper's **research question, hypothesis or goal** (possibly one sentence).
- A **brief(!) summary** of what was done in the paper.
- The **findings**, i.e. overriding results, insights, conclusions.
- The **implications**, i.e. how does it influence the research field, what are possible applications, etc.

[6] Some publishers prefer "Conclusions" rather than "Conclusion", owing to the fact that several conclusions are drawn.

[7] The Abstract is not viewed as a "section"

- The **limitations**[8], i.e. which issues were not addressed but a reader might expect them to be. Examples could be limitations in the experimental results due to data availability, experiments on simulated data, user studies with laymen rather than experts, etc.
- Potential **future work**[8]: ideas how to address the aforementioned limitations, identified research gaps, research directions, and the transferability to other problem settings or domains.

The Conclusion is mainly written in the past tense, for example "we evaluated...", "we identified...", "we showed that...". General findings are formulated in the present tense, e.g. "in our experiments we showed that X *is* superior to Y".

The Conclusion should be consistent with the Abstract and the Introduction section. While this might sound obvious, it is something that should be checked: The research question and method are defined as one of the first steps and a first draft of the introduction can be written early during the research work. The conclusion is written several months later.

[HINT]

To evaluate a Conclusion, the **RIB**-check is proposed. In the Conclusion there should be:

- **R**esearch summary
- **I**nsights summary
- **B**eginning of new research

[HINT]

While the Conclusion is the end of your paper, it is best to view it as the beginning of new research (for yourself or other researchers): In the Conclusion you can broaden the paper's scope suggesting the applicability to related problem settings or to other application domains. Furthermore, the suggestion of future research directions is precious.
Think back to the beginning of your research for the paper, desperately looking for research gaps. Your conclusion should allow other researchers to build on your work, addressing your identified limitations, research gaps, or applicability to other problems. It is exactly this, that will help your paper to make an impact.

[8]Sometimes limitations and future work are discussed in the Discussion prior to the conclusion

EXAMPLE 4.15: Bad example of a Conclusion for the fictitious cake-cutting problem

(to be discussed...)

In this paper the cake-cutting problem was addressed. This problem was first addressed by Miller et al. and describes the segmentation of a cake C into $|P|$ pieces. A machine learning approach was proposed. Machine learning is the research field of computer programs learning from data in order to make autonomous decisions. The research question was stated and addressed systematically. An approach was proposed and evaluated successfully.

EXERCISE 4.5: Evaluating and writing Conclusion sections

a) Discuss the "bad example of a Conclusion section" above.

b) Start to rephrase parts of the Conclusion, in order to improve it.

c) Start formulating a Conclusion section for an own paper on the fictitious cake-cutting problem (or for a paper on your own research topic).

EXAMPLE 4.16: Conclusion of a published paper (Theissler et al., 2022)

In this review, we presented the first extensive overview of the current body of literature regarding XAI for time series classification. We proposed a taxonomy based on the granularity of the explanation, categorizing the reviewed methods into three groups of approaches: time points-, subsequences-, and instance-based. We further highlighted the main approaches to evaluate explanations and the practical challenges of developing quantitative and qualitative metrics towards human and automatic techniques. To inspire further research in the field, we identified various research directions. Specifically, we believe there are research gaps in the fields of higher-order explanations, model-agnostic approaches, domain-specific explanations, easy-to-use explanations, more advanced evaluation of explanations, evaluation of interpretability as well as a unified framework with XAI methods for time series classification and benchmark data sets for their evaluation. Explainability is a fast-growing subject in the literature, and it is clear that the interest on the topic is rising. XAI approaches for time series data are helpful in building trust towards the decisions of machine learning algorithms, to better support experts and their accountability and responsibility in the decision-making, bringing insights in many critical domains.

4.10. The Bibliography / References

The Bibliography contains the **complete list of work** referenced throughout the paper. One reason for citing papers is to **embed the paper into the research field** (Derntl, 2014).

As references are added, the Bibliography of the paper grows, i.e. this section is not written manually. However, the bibliography should be checked – it should be proof-read like the other sections. Some requirements are discussed in the following:

The individual references should be complete, for example title, authors, year, journal, volume, etc. must be contained. If in doubt, it is best to refer to the original publisher's website (they sometimes offer citation exports). Furthermore, cited work should be from **acknowledged** sources to ensure they are of appropriate quality. An example is citing papers from journals, conferences and possibly workshops. Moreover, the **relevant** papers must be cited, i.e. the ones that the own work builds on, the ones that are viewed as necessary for the reader to see the work in the context of the research field, the ones that support own statements, etc. On the other hand, it should be made sure that the cited papers **are relevant** for the reader.

[HINT]

The **YEAR**-criteria are proposed to quickly check a paper's Bibliography. The Bibliography should contain:

- **Y**our full list of cited work
- **E**mbedding of own work in related work
- **A**cknowledged sources
- **R**elevant papers

4.11. The STRaWBERRY-checklist: Is your paper ready to submit?

In the previous sections, criteria for a quick quality check of the paper's components were proposed. These are unified into one checklist denoted as the **STRaWBERRY-checklist**[9] presented in Figure 4.1.

The checklist does not represent the full list of content expected to be in a section, but rather focuses on essential properties allowing for a high-level quality check during writing the paper and prior to submission.

[9]Note, that this checklist is currently not published, hence it cannot be cited. It is solely contained in this document. Yet, the author works on the publication of this proposed checklist.

Title: **SPICE**	Abstract: **The-5-S**	Related Work: **RICK**		Introduction: **WHWN**
S	**T**	**R**	**a**	**W**
☐ **S**hort ☐ **P**recise ☐ **I**nteresting ☐ **C**ompact ☐ **E**asy to understand	☐ **S**hort ☐ **S**elf-contained ☐ **S**pecific ☐ **S**tatement of novelty ☐ **S**ummary of most important results	☐ **R**ecent papers cited ☐ **I**mprovement of own work w.r.t. related work shown ☐ **C**ontrasted to own work ☐ **K**nowledge gap deduced		☐ **W**hy? ☐ **H**ow? ☐ **W**hat's **n**ew?
Methods: **BURNS**	Results: **ELVIRA**	Discussion: **REFLOW**	Conclusion: **RIB**	Bibliography: **YEAR**
B	**E**	**R**	**R**	**Y**
☐ **B**acked by acknowledged research methods ☐ **U**nderstandable ☐ **R**eproducible ☐ **N**ovel ☐ **S**ystematic	☐ **E**xplained ☐ **L**abelled ☐ **V**isually supported ☐ **I**nspire discussion ☐ **R**eproducible ☐ **A**ddress the research question or hypothesis	☐ **R**esults discussed ☐ **E**valuation conducted ☐ **F**indings stated ☐ **L**imitations stated ☐ **O**pen issues identified ☐ **W**ork critically evaluated	☐ **R**esearch summary ☐ **I**nsights summary ☐ **B**eginning of new research	☐ **Y**our full list of cited papers ☐ **E**mbedding own work in related work ☐ **A**cknowledged sources ☐ **R**elevant papers

Figure 4.1.: The **STRaWBERRY**-checklist: an easy-to-remember, component-wise checklist to critically evaluate a paper draft.

Chapter 5.

Publishing a scientific paper

A scientific paper is written with the aim to submit it to some journal, conference or workshop in order to get the paper published. The scientific community has established a review process to evaluate papers and make sure only papers of appropriate quality are published. Furthermore, the reviewer comments help authors to improve their work. Publication types and the review process are introduced in the following.

5.1. Paper submission

The most common types of scientific papers are journal articles, conferences papers, workshop papers, and to a lesser degree work-in-progress papers.

As a rule of thumb, **journal articles** are usually the ones requiring most work and might need several resubmissions. Getting a journal article published can easily take 1-2 years. Journal papers tend to be the longest papers of the aforementioned. Some journals have a strict page limit, others a recommended number of pages, and other journals have no restrictions.

Conference papers are typically published as part of the conference proceedings and a talk is given at the conference. The page limit for conference papers is usually strict, for example 6-8 pages in double column layout or 12-16 for single column (exact number for a given paper may be different! Please check the "call-for-papers" (CFP).). Not obeying to the page limit may result in rejection of the paper.

The properties of **workshop papers** depend on the specific workshop. While many workshops have papers quite similar to conference papers, other workshops look for papers that discuss new ideas, that are possibly not fully evaluated. The scope of a workshop is usually more narrow compared to a conference.

When starting to write a paper, the paper type should be defined and possible journals, conferences, or workshops be selected. They differ in the templates, page limits, scope, etc.

[BE CAREFUL]

Regarding the page limit of a paper, do not only consider the number of pages but also the required template. The number of pages of a paper is dramatically different depending on the used template (e.g. double column vs. single column, IEEE vs. Elsevier vs. Springer). Hence, it is highly recommended to use the final template as early as possible – if not requested differently by the publisher.

5.2. The review process

Whether a paper is accepted is determined by a **peer-review process**. The paper is assessed by at least two independent researchers. The identity of these reviewers is not known to the submitting authors. Regarding the authors' identity, there are two options: **single-blind submission** and **double-blind submission**. For the first one, the authors put their names on the paper, for the latter one no author identities may be disclosed in the paper – not in the list of authors and not in the citations of own previous work (see call-for-papers).

A paper is usually submitted via some website and is then handed to reviewers who write critical evaluations, commonly referred to as "reviewer comments" or "reviewer remarks". These comments are assessed by a program chair or a journal's editor and a decision is made.

The best possible outcome is *accept*, the worst *reject*. The names and number of the intermediate decision types between these two are not standardized. For a journal, typical decisions are:

- *accept (as is)*: The paper is accepted for publication which occurs quite rarely for a first submission.
- *minor revisions*: Requires to fix the reviewer's comments and re-submit the revised version. Examples are clarifications of unclear statements, refinement of discussion, improvement of figures, text or grammar.
- *major revisions*: This points to major weaknesses and problems identified by the reviewers. Examples are the need for an additional evaluation, a deeper analysis or some corrections. The revised version can be re-submitted.
- *reject*: The paper is not accepted for publication. Usually it is not allowed to re-submit the paper to that journal. Some journals distinguish between a final reject and a reject with encouragement to submit a substantially improved version of the paper.

For a journal submission it is not unusual to undergo several revisions: For example the decision on the first submission might be *major revisions*, requiring to revise the paper and re-submit. The second submission might then be assessed as *minor revisions*. If these are fulfilled and the paper is resubmitted, a final decision might be *accept*.

In contrast to journals, most conferences have a three-level system from the likes of:

- *accept*: The paper is accepted with no changes required.
- *conditional accept*: The paper is accepted, given that the paper is revised according to the reviewers' comments.
- *reject*: The paper is not accepted for publication at the conference. A resubmission is not possible.

Some conferences have a multi-stage process that resembles the one described for journals.

If a paper is accepted (Congratulations!), the journal or conference will ask for a so-called *camera-ready version (CRV)*. This is the authors' final version of the paper, possibly undergoing some further changes of the layout and very minor editing by the publishers.

[BE CAREFUL]

Avoid "desk rejects"

A program chair or editor may reject a paper before passing it on to be reviewed. This is referred to as a "desk reject".

Reasons can be:

- page limit is exceeded
- there is a double-blind submission policy, but author names are on the paper
- from the title and abstract it is clear that the paper is not in the scope of the journal, conference or workshop
- the paper did not pass some plagiarism tests, the authors might additionally be banned from submitting to this journal, conference or workshop in the future
- in the future, papers are likely to be checked for AI-generated text, so this will likely lead to rejection and the authors might additionally be banned from submitting to this journal, conference or workshop in the future

[HINT]

Rejection – what then?

Having your paper rejected accompanied by a huge list of negative points about the paper is not a particularly pleasant experience. So how should you move on? First of all: The worst idea would be to instantly write an angry mail to the program chair or editor, complaining about the paper being rejected. What you should rather do, is to put the reviewer comments aside for 2-3 days. Then return to the comments with a positive mind set: Not you as a person has been criticized, but "just" the paper in the form you submitted it. Receiving critical comments on submitted papers is a natural part of science, it is part of a scientific discussion.
With common acceptance rates for conferences being 30-45%[a] and journals accepting 20-30% of submissions, more papers are rejected than accepted. Having papers rejected happens to novice researchers as well as experienced researchers, while novice researchers are likely to encounter higher rejection rates.
Whatever the outcome of the review process was, you should use it in a positive way: The reviewers have probably identified some weak spots in your paper that you can fix and submit an improved version of the paper to a different journal, conference or workshop.
If you feel the paper was misunderstood, clarify those parts of the paper. If the reviewer comments are devastating, you should reflect[b] whether the negative comments address the way of writing the paper, or the paper's core ideas:

- If the way of writing the paper was criticized (e.g. "lacks clarity...", "it is not clear why...", "it is not convincing...") you should be thankful for the comments, and there is a good chance to improve the paper based on the comments.
- If the core ideas of the paper were criticized (e.g. "lacks novelty...", "the paper's contribution is not sufficient", "the results do not confirm the validity of the approach"), the positive point is that those weaknesses were found prior to the paper being published to the public. Reflect, whether your current line of research is promising or if you should adapt.

[a] these numbers vary, some top conferences have acceptance rates of less than 15%
[b] possibly discussing your paper and the comments with other researchers

Chapter 6.

Writing a Master or Bachelor Thesis

The presented and discussed issues are transferable to writing a Bachelor or Master Thesis (in the following referred to as Thesis). A Thesis is a scientific work. Hence, it should have a clear topic, research question or hypothesis and address these in a methodological way. Towards the end of a Thesis, insights, limitations and future work should be discussed.

Yet, there are some differences between a Thesis and a paper:

- The Thesis is assessed by supervisors and/or examiners. In contrast to the review process for scientific papers, students will typically know their supervisors and examiners. It is highly recommended to use this knowledge, i.e. find out what their preferences are.
- A typical Thesis is much longer compared to a paper. Typically the state-of-the-art is much more extensive guiding readers towards the specific topic. Hence, much more fundamentals are presented in a Thesis which would not be appropriate for a paper for a specialized conference.
- A Thesis can spent some pages to educate the reader and also to show the student has thoroughly understood the topic and the research problem.

[HINT]

Frightened by the seemingly high quality of papers while starting with your Thesis?

At first sight, scientific papers often have a higher quality compared to Theses. This might be frightening for students reading papers while starting their Thesis. Note, however, that papers are reviewed by the scientific community, i.e. they will only be published if they have a high quality – typically after some revisions. Many papers are written, however, the ones we see are only the ones that were selected for publication.
Pragmatically, there are some very good Theses that might even be developed further to become published scientific papers, some examples are (Beil and Theissler, 2020), (Grimmeisen and Theissler, 2020), (Vollert et al., 2021), (Vollert and Theissler, 2021). But there are many average Theses, sufficient to get a degree and offering some scientific contribution, but not sufficient for a scientific publication – these works will not be seen when searching for scientific work.

After having worked through this document, chances are you belong to the more advanced scientific writers. Good luck!

Appendix A.

An overview paper on writing literature reviews

In the following you will find a published paper co-authored by this document's author. The paper reviews papers on writing literature reviews, gives a tabular overview of these papers, discusses acknowledged ideas, and extracts some agreed guidelines. The first draft of that paper was developed in a semester project mainly by the first two authors who were final-year students at that time, under guidance of this document's author.

Paper reference:

Alena Renner, Jenny Müller, Andreas Theissler (2022), State-of-the-art on writing a literature review: An overview of types and components. In Proceedings IEEE Educon 2022. IEEE.

Published paper can be found on IEEE Xplore:
`https://doi.org/10.1109/EDUCON52537.2022.9766503`

State-of-the-art on writing a literature review: An overview of types and components

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***Abstract*— In many academic fields, literature review has become an established research method of technical writing. In this process, it serves as a method for identifying relevant findings in a research area by synthesizing existing data, identifying knowledge gaps, and critically evaluating results. We systematically reviewed the literature on writing literature reviews and found that a number of papers on that topic has been published, but they do not include suggestions and guidelines for all typical components of a literature review. Therefore, this paper deals with the research question, what are the typical components of a literature review and what should they contain to achieve a high-quality literature review. This paper first explains the goals of literature reviews and then introduces the most common types of literature reviews. Afterwards, the main components are described, and methodological approaches of different authors are brought in. In addition, the goal-oriented process of individual components is presented. Thereby, the paper does not focus on a specific research area but takes an interdisciplinary approach to the given topic.**

Keywords—Literature review, survey, overview, research methods, technical writing, scientific writing

I. INTRODUCTION

Literature reviews, no matter what type, are more important than ever as a research method of technical writing. For students, academics, and researchers, they are a crucial tool in the academic or professional career. In this context, reviews are helpful to become familiar with a specific topic and to obtain a well-structured overview of the current state of research.

Regardless of the scientific discipline, the basis of any academic research activity is to summarize, compare and contrast relevant literature in order to build their own research on this knowledge [1, 2]. Literature reviews do this by relying on existing knowledge on a particular topic, which is selected by the authors.

By merging data, research gaps can be identified, and results analysed. On this basis, decisions can be made for the own paper and new theories can be developed. These, in turn, serve as a theoretical background for subsequent literature reviews; as well, new directions for future research can be suggested [3].

Alternatively, the review paper can also present the advantages and disadvantages of the methods used and discuss the implications of the results, which can be very helpful for the reader who needs to interpret and use the results. Furthermore, a review paper can also serve to update a researcher's information status [4]. The goal of a literature review is to summarize the current state of the art in the selected field.

Due to the increasing amount of research papers, writing literature reviews is becoming more and more complex as it is difficult to be up to date with the latest research. There are already some papers dealing with the writing of literature reviews. Many of them give step-by-step instructions. However, there is the problem that different research areas choose a different procedure, which can lead to confusion.

This fact made us realize the need for a literature review for researchers who plan to write a literature review, interdisciplinary and so unrelated to the area of research. The target audience is especially young researchers and students. The focus is on presenting and explaining typical components that a high-quality literature review requires, taking into account the methodological approaches of different authors.

We focus on answering the following research question:

RQ: What components should a literature review contain and what should they include to make the literature review of high quality?

A. Contributions

We make the following contributions in this survey:

1. We provide a brief overview of the main types of literature reviews and discuss how they differ.
2. We describe the important components that compose a literature review. Here we bring in the methodological approaches of different authors.
3. For individual components, we additionally explain goal-oriented procedures to achieve a high-quality literature review.

The paper is organized as follows: In Section 2 we present the research methodology. Section 3 contains related work, motivating our work. In Section 4 we define the term literature review, look at the reason for doing it, the goals, and give an overview of the main different types of literature reviews. Section 5 presents our results and describes the important components that a high-quality literature review should contain. In Section 6, the discussion, the research question is answered based on the results. Finally, the conclusion including research limitations and future work is found in Section 7.

II. Methodology

A. Search Strategy

In order to extract relevant research from the published literature, a literature search capturing the state-of-the-art on writing a literature review was undertaken. The two meta-databases Scopus (using the default search within article title, abstract, keywords) and Google Scholar were searched till 11-16-2021 using the following logical keyword combination with the corresponding syntax of the individual search databases:

literature review OR literature survey AND writing OR crafting AND overview OR guideline OR components

In addition, a backward search was performed.

B. Inclusion and exclusion criteria

To ensure including only substantial scientific work in this review, we only considered international peer-reviewed publications (journal articles and conference papers). Poster sessions, editorials, interviews, and commentaries were not included. Literature reviews dealing with a different topic area were excluded. Furthermore, papers discussing citation, the review process or the publication of papers were excluded as these are not components of this work.

C. Search results

The initial search result were 348 articles. Having applied the described exclusion criteria, we identified 40 articles as relevant for this paper. The identification was based on a manual decision by the authors.

III. Related Work

This section provides an overview of related work on writing literature reviews and contrasts it with the present work.

Many authors provide detailed tips and instructions for each stage of the writing process from input to output in their papers, providing a guide to help readers write their own literature review [5–11]. Gregory and Denniss [6] as well as Green, Johnson and Adams [8] focus on writing narrative literature reviews, while Randolph [7] deals with writing qualitative and quantitative surveys. The authors of [11] describe the process of systematic literature reviews.

Since there are different types of literature reviews, some authors give an overview of them, compare them with each other and highlight differences [12–14]. All these papers also give a guideline for writing a general literature review [14] or specifically for the systematic literature review [12, 13].

A third form of related work is the description of the individual sections within the literature review [15, 16]. The author of [16] describes which content belongs in the sections introduction, literature review, discussion and conclusion. In [15] the sections abstract, results and recommendations are additionally explained.

In contrast to the related work, we do not write a step-by-step guide, but introduce the main types of literature reviews and describe important aspects of preparing a literature review, such as the topic selection and literature search. Our work also gives an overview of necessary components for a literature review of high quality, with methodological approaches from different authors.

IV. Literature Review

The literature review is a detailed overview of previous research including scientific sources on a specific topic, research area or theory. It summarizes previous, relevant literature usually limited to a specific time period [3, 10, 14, 17–20].

By surveying sources a literature review can illustrate to the reader what is known and unknown on the topic [3, 18]. The author of a literature review should clearly communicate the topic, summarize the state of the art, structure core knowledge, interpret data and answer a research question [3, 14, 19]. For identified areas where research is still needed, justify the need to formulate further questions [3, 17–19, 21].

Looking at the reasons for doing a literature review, the main focus is to gain information and progress in the research process [10]. For the author, literature reviews also add benefits to the learning process, as the preparation requires the author to acquire a lot of information about the chosen topic in order to write the literature review as solidly as possible [18].

Types of Literature Reviews

There are many different types of literature reviews and various ways to categorize these types. In this work, the categorization from [1, 8, 9, 13, 22] is used, i.e., the most commonly mentioned types of literature reviews are discussed as follows: Systematic Review, Quantitative Systematic Review (including Narrative Review), and Integrative Review.

However, it should be noted that there are many other forms of literature reviews. For a detailed description of the different types of reviews, we refer to Grant and Booth [23].

All of these literature reviews can be the right tool to answer a research question posed. However, it should be noted that there are many other forms of literature reviews. It is not uncommon for components from different formats to be combined [1].

A. Systematic Review

The systematic review summarizes results of several papers quantitatively into one paper [7]. They are usually found in research reports, case reports and expert reviews [24].

As a research method, it is used to identify relevant research, collect data from that research, analyse it and critically evaluate it [5]. Through predetermined inclusion and exclusion criteria and structured methods in reviewing articles, systematic literature reviews have the purpose of answering specific research questions [5, 24]. This research method therefore allows a high level of informativeness and precision [7], which summarizes existing literature in an unbiased manner [24]. This leads to reliable results from which decisions can be made [5].

The systematic literature review therefore also brings great benefits for practice. For clinicians, it eliminates the need to search and then read multiple long articles. What remains is the systematic review, a shorter document with large amounts of summarized information [7].

It should be noted that bias can occur with systematic literature reviews. These biases can come from the studies personally selected by the authors. For example, if only the studies that are most consistent with the research findings or personal opinion are considered [24].

The systematic review is related to the research method of quantitative systematic review [7].

B. Quantitative Systematic Review

The quantitative systematic review is also known as *meta-analysis* and was introduced in 1976. It statistically combines the results of different studies and critically evaluates them [8].

Both systematic review and meta-analysis are concerned with examining the quantity of previous research, but meta-analysis focuses on the statistical evaluation of available data from previous quantitative studies that are combined [8].

Meta-analysis is a popular form used by researchers to draw a conclusion from clinical trials that have small sample sizes [2, 8]. To obtain more precise results, results from quantitative studies are combined [23]. All included studies should be similar in their characteristics, such as the comparison made [23], in order to make meaningful conclusions [8]. However, the strength of meta-analysis is also its weakness, because it can be very difficult to find studies with comparable variables [8].

Randolph [7] states that prior to the advent of the meta-analysis review method, these kinds of reviews were mostly narrative quantitative reviews.

Narrative reviews summarize the content of each article and report an author's findings in a condensed format. In doing so, the author decides whether to critique each included study. Researchers disagree about this characteristic [8].

It should be noted that this type of review is often influenced by the subjectivity of the reviewer in mind. That is why even if the same topic is reviewed, completely different conclusions can be drawn [7].

C. Integrative Review

If a research question requires a creative approach to data collection, then the integrative review, another form of systematic research that generates new knowledge on a particular topic, can be used [1, 25, 26]. For this purpose, representative literature is reviewed and criticized in order to be able to form new frameworks and perspectives on the topic and eliminate inconsistencies [25].

The majority of these literature reviews deal with either established or recently emerging topics [27]. For established topics, the integrative review serves as an overview. The theoretical foundations and models of the topic are critically discussed, expanded, and finally developed. On the other hand, for new topics, initial theoretical models can be created [1].

The goal of the review is to summarize the collected state of knowledge, to create new theoretical models by combining perspectives and to illustrate open research questions [27, 28]. It is not important to review all previously published articles [27]. If possible, the integrative literature review should produce a new theory and not be descriptive or historical, in order to replace work that is behind the state of the art [1, 28].

V. Results

A substantial literature review is usually divided into the following sections: Abstract, Introduction, Method, Related Work, Results, Discussion and Conclusion with the associated Limitation and Future Work. It should be underlined that the components and their structure are not prescriptive and can be arranged differently.

Table 1 presents an overview of the sources reviewed in this literature review. The columns include all the components presented in this paper. It can be seen which sources have already reported on which components of a literature review in their work. It is noticeable that of the sources used, no paper includes discussions on all the typical components mentioned in this paper.

In the following sections, a detailed insight into the content and development of the individual components is given, considering the recommendations of different authors.

In this context, the results apply to all previously mentioned types of literature reviews (Section 3, Types of Literature Reviews), differences in the approach in the individual sections for the respective types are highlighted.

Finding and refining the topic

The first step in writing a literature review is to decide on a topic [10]. In doing so, it should be looked for general topics within the own field [10] that are of interest to both the author and the reader [2, 8, 10, 22], otherwise motivation can be lost during writing and reading [8]. Questions should be asked about the reason for conducting the review [1], whether there is a real need and whether it can be used to make a significant contribution to research and science [1, 29]. Therefore, a preliminary literature search must be conducted to determine what work has already been published in this area of research [1, 2, 8, 13, 29, 30].

This existing knowledge must then be analysed to ensure that there is enough data to fill the paper [22, 30]. A need exists if (1) the topic has been included in various conferences over a long period of time, (2) has been published in several papers, (3) or has had few papers published to date even though there is a large body of literature [8, 29].

In addition, relevant topics can be found in the Future Work section of other articles and papers. There, numerous opportunities for future research and investigation are highlighted by scholars, symbolising existing research gaps and needs [30]. These needs also become visible through discussions with other experts [10, 22].

If there is already a lot of work on a specific topic, it can be helpful to change the focus [8]. Moreover, different questions could be asked to present a novel contribution with a different research agenda [2] or choose a different topic [8].

During the search for a topic, the target audience that will read the paper [1, 31] should be kept in mind. The broader the audience, the more comprehensive the work must be [16].

Finding a title

The title of the literature review is intended to create a "frame of reference for the work" [16, p. 43] and to focus on the purpose of the work [16]. It should be short [2], interesting [8] and highlight that it is both a review of the literature and an outlook for future research [2], thus clearly describing the topic [2, 8]. This is also clarified by using the words "literature review", "review of the literature" [8] or the type of literature review, such as systematic literature review [32]. In addition, it should be formulated generally to allow subtopics, otherwise the choice of sources is severely limited [18], but there should also be a focus, as the paper may turn into an unsolvable task instead [8, 16].

Writing the Abstract

The abstract is a structured [8], short [22] and detailed summary [9] of the paper and offers the reader the most important information transparently at a look [9],

TABLE I. OVERVIEW OF REVIEWED PAPERS WITH THE COMPONENTS DESCRIBED IN THESE PAPERS, ALLOWING READERS TO REFER TO THE ORIGINAL PAPER FOR MORE DETAILS ON SPECIFIC COMPONENTS.

Paper		Typical components of a literature review									
	Topic Search	*Title*	*Abstract*	*Introduction*	*Research Question*	*Methodology*	*Literature Search*	*Related Work*	*Results*	*Discussion*	*Conclusion (Limitations, Future Work)*
[1]	■			■		■	■	■			
[2]	■	■									■
[3]	■			■		■	■		■		■
[4]			■	■		■	■	■	■		■
[5]				■			■				
[7]					■	■	■		■		
[8]	■	■	■	■		■			■		■
[9]			■	■	■	■			■		■
[10]	■			■					■		■
[12]									■		
[13]	■				■		■				
[15]			■	■		■			■	■	■
[16]	■	■		■				■		■	■
[17]				■			■	■			■
[18]	■	■		■					■		■
[19]							■				
[25]				■		■					■
[27]				■		■					
[28]									■		
[22]	■		■	■		■	■		■		■
[29]	■			■		■	■	■	■		■
[30]	■			■	■	■	■		■		■
[31]	■			■	■		■		■		
[32]		■	■	■						■	■
[33]				■		■			■	■	
[34]				■							
[35]					■						
[36]							■				
[37]							■				
[38]							■				
[39]							■				
[40]							■	■			■

including the most important conclusions and the added value of the paper [4].

The aim is to enable the audience to decide whether the paper can provide them with the information they are looking for and to create an understanding of the work [8, 15]. Usually this section is finalized as the last step of the work [22]. It follows a structured format [8] and is typically no longer than 300 words [15], where the exact length is often specified by the journal or conference. In principle, the abstract should include an introduction to the topic, the research question or aim and the methodology [4, 8, 9, 32].

Green [8] additionally describes that in narrative reviews the discussion, a conclusion and the keywords are part of the abstract. In systematic reviews, a conclusion should also be included in the abstract, as well as data sources, limitations and key findings [9, 32].

Writing the Introduction

The introduction is used to show that the current work can contribute something new to the current state of science and the research area [5, 29, 30]. It also helps the author to concentrate on a selection of key points and to provide an overview of what is covered in the work and what is not [29, 33]. It should catch the reader's interest [30, 33] and also serves as a framework and orientation for them and shows whether the paper is relevant to their own work [3]. At the beginning, the research purpose [1, 10, 13, 16, 22, 33] and focus [8] should be mentioned so that this is clear to the reader [31]. The aim of the paper [4, 8, 9, 15, 29, 33], for example in the form of a statement of purpose in the first sentence of the introduction [16] and the research question(s) should also be described [1, 4, 33]. There should then be a general introduction to the background of the topic [4, 10, 15, 16, 18, 22], what is already known [9, 25, 27], general trends [10], the history and importance of the topic and support this

with facts, figures [16] and literature [15, 34]. This should be followed by a statement of reasons [9, 33] and motivation [1, 4, 8, 29, 30] why this work is important in the light of current knowledge [8, 9, 18, 30, 32] and what is unique about it compared to work from the same field [29]. The existing gaps [4, 10, 25, 27] and conflicts in the literature should be presented and how the own work will solve them [10] in the form of a guiding perspective [18, 27]. Motivations can be (1) that the topic is to be considered from a new perspective with new theoretical understanding [17, 29], (2) that there is little comparable work on it to date, (3) that there is a known scientific need or that new [17] or (4) unresolved research questions are to be clarified [29]. Specialist terms that are relevant to the work should also be defined within the introduction [8].

At the end of the introduction, a brief overview of the paper's structure should be given in the form of a preview of the following chapters [4, 15, 16, 18, 29, 33]. Overall, the introduction should be concise [15], clear [17], short and engaging [16, 17] on no more than one page [33]. Furthermore, from the introduction section it should also be recognisable for which target group the work was written [4, 15].

A. Research question

The research question is basically the conclusion of the introduction after looking at what is known and what is not known about a certain topic [13] and serves to determine the research purpose [13, 31], the target group and the aim of the work [31]. Accordingly, the research question is influenced by the focus and aim established with the choice of topic [7]. The entire paper is then built around the research question and attempts to answer it [13]. Thus, it has an impact on the entire paper [9]. It also guides the criteria for the entire review (Section 5, Literature search) and thus the author has a structure for the entire writing of the literature review. The research question also indicates to readers whether the paper could be relevant to their own work [35]. The more readers are addressed by the research question, the higher the interest in the entire work [30]. The question itself should be formulated clearly, precisely, unambiguously [9] and concisely in one to two sentences [31] and can also have sub-topics that deal with certain features during the development [35].

Writing the Methodology section

In the methodology section, the entire process of conducting the study is described, as well as how the results are obtained and what is to be concluded from them [8, 9, 33]. Since this is a very important chapter, a separate section on methodology is useful, but can also be included in the introduction [4, 33].The process of how the author identified, analysed, summarized and presented the literature is described as well as a possible structure of the literature review is given [1, 27, 29]. Starting with the search strategy, the search terms used are provided, to be followed by a clear description of the inclusion and exclusion criteria established before conducting the literature review to select studies [3, 7, 9, 22, 25, 30]. It describes which literature databases were used and how many sources were finally selected for the literature review [29].The methodology should be described as clearly and transparently as possible to reduce bias and improve the overall outcome [1, 9, 15]. A detailed description of the methodology allows readers and other researchers to replicate the study [15, 25]. By providing an insight into the literature found, it is easier for the reader to evaluate the quality of the literature found [1, 15, 22]. Furthermore, it may be important for the reader to know about the sourcing of the literature to know why their own literature was included or not [27].

A. Literature search

The literature search includes database searching, planning and identifying the search strategy and forward and backward searching [37]. To ensure complete coverage of all relevant studies, the search process should be as neutral and comprehensive as possible [30]. The goal of the literature search is to collect a representative set of relevant articles for the topic under review [7]. It is beyond the scope of this article to provide more than a brief overview of this process. For detailed information on the literature search, we refer to Brocke et al. [36]. The process of literature search starts with searching electronic databases [1, 7, 22, 29, 38], which is the main place to start collecting sources for a literature search [31].
Badger et al. [39] mention in their work that there may also be relevant literature that cannot be found in electronic databases. Here, magazines and books are meant, which are among the traditional literature sources [31]. However, Brocke et al. [37] recommend searching electronic databases as this method provides access to top quality journals. Kraus, Breier and Dasí-Rodríguez [13] also encourage readers of their paper to search mainly in online databases. To cover many articles, searching more than one database is important [13]. The choice of the databases depends on the research field, examples are meta-databases such as Google Scholar or Scopus and specific databases such as IEEE Xplore, ACM Digital Library, ProQuest and EBSCO [31].Once the databases are selected, the next step is to define the search terms carefully, thus identifying relevant literature [13, 22, 29, 30, 37]. Words or phrases that are directly related to the research question and the goal of the paper are used in this process [1]. Depending on the precision of the search terms and different combinations, papers can therefore be excluded [30, 37]. Many databases use Boolean operators (AND, OR and NOT) to make the best use of such combinations [19, 22, 30, 31]. Additionally, inclusion and exclusion criteria can be specified [1, 38]. If relevant literature has been identified by the search, a forward and backward search can be performed to supplement it. The backward search represents the review of citations in the identified literature [17, 37, 40], while the forward search represents a review of those from additional sources that have cited the article [37, 40].

The end of the search is reached when the repeated search returns the same results [5, 7, 30, 31]. However, it should be noted that according to Okoli [31], it should be screened until the time of publication.

As stated by [4] a literature review typically consists of 30 to 100 references, whereas more than 100 references are unusual. Throughout the search process, it is important to document the databases, search terms, keyword combinations and results used to guarantee transparency and reproducibility later [7, 30, 38]. Finally, the process is described in the methodology [29].

Writing the Related Work section

Regardless of the type of literature review and the area of expertise for which the review is written, the summary of

previous research and publications in the related work section is essential [1, 16, 29].To evaluate the research area and motivate the goal of the work [1], this analysis can be very useful for understanding and evaluating the research [40].

In the related work section, previous research in the same area is considered [1, 17] and distinctions are made from the author's own literature review [4].

Writing the Results section

After conducting the research and explaining the methodological approach previously, the main part and thus the core of the report follows [8, 33], which can be imagined as a big picture of the current state of research on the topic being studied [18]. This process is very time consuming, however, [12] points out that it can be done systematically as long as the preparation, method, literature search and related work have been done properly. This component of a literature search includes a presentation and discussion of the results and findings from the literature [10, 22, 31, 33] and is almost always written under the heading "Results" [18]. The goal of results is to write a logically structured and valid concept [30] "describe[s] the essence of the phenomenon as seen through the eyes of the researchers who investigated that phenomenon" [7, p. 11]. This can ensure that meaningful integration is achieved [8], thereby increasing the level of a high-quality literature review outcome.

The structuring of the section to summarize the available information depends on the objective of the paper [4, 8]. There are different possibilities here [4, 8, 10, 22, 29]. In the body of the paper, one should assign the various research papers to thematic categories to ensure that the literature is brought together in a meaningful way [3, 10, 29]. Examples of possible common denominators include research area, research period, methods, objectives, theories, focus, results, or conclusions [4, 10]. The organization of topics into an order may differ depending on the study, but the focus should be delimited by the use of headings on topics [18]. To maintain continuity in a thematic approach, the report should flow logically from one topic to the next [22]. Schryen [29] describes in his paper that there is widespread agreement that the summary of information should be presented conceptually rather than chronologically. In [3], on the other hand, a chronological outline is also recommended depending on the focus of the study. The results section should highlight all the important information from the sources, compare them and critically evaluate them in the process [3, 22]. In doing so, each section should be comprehensive and cited by as many findings as possible while establishing a correlation among the sources [3, 8, 10, 18]. By synthesizing individual collections of data into unified statements about the research problem [28], consistencies and contradictions in the literature used can be discussed and unanswered questions and dissenting opinions can be considered [3, 22]. In analysing the individual data, questions posed can be addressed and the meaning of the work can be restated [3]. In doing so, the description of the results should be objective and clearly stated and no personal opinion should be introduced [8, 22]. In many cases, results are presented using text [4]. A graph, chart, or table form of presentation may also be used to present extensive information [4, 9, 15]. Tables highlight important points in the text and are used primarily to illustrate synthesis with the references used to illustrate the distribution of items considered [3, 10, 30]. Clustering of such tables can be done by subject, title, year of publication, or even total number of citations [30].

Writing the Discussion section

After the results have been presented in the paper, a discussion follows. In some papers, this chapter is also omitted, and all statements are summarised in the section "Conclusion". However, we view this part as important and therefore look at it in more detail. The discussion serves to link the results of the studies with reality, to summarise them briefly [16] and to help the reader draw his or her own conclusions [15]. In the course of this, the research question from the introduction must also be answered and justified with the results [15]. Basically, in this section the results should be discussed, compared with those of other researchers and relationships and generalisations presented to prove the validity and correctness of the paper and to show the contribution that the work makes [15, 33]. Missing relationships and exceptions should also be mentioned and justified [15]. Concrete consequences for practice should be mentioned and best summarised in the form of bullet points [16]. By interpreting the results, an implication for future research can also be generated [16, 32].

Writing the Conclusion section

The conclusion forms the last section within the literature review and is intended to return to the aims [4] and purpose [8, 16] of the work and to assess whether or not these have been achieved [4], symbolising the author's view of the results also in the context of the results of other authors [9]. It also aims to outline what the reader should take away from the literature review [3, 9, 16]. In doing so, the conclusions must be based on the reviewed work and no new material may be introduced [8, 15]. The content of this section thus repeats previous sections but should look back and highlight implications for future work [16].

A one- to two-phrase paragraph [30] should summarise the findings clearly, concisely [15] and succinctly [3, 8, 10, 16, 18, 22, 25, 29] and provide a link to the main conclusions and findings [8], thus providing a bridge to the current study [18]. The conclusions in this section can also be formulated as numbered statements, as in the discussion [15]. The now current state of knowledge should be described [22] as well as what is now known that was unknown before the study as a research gap and thus has expanded the research [3, 8, 10, 17]. Weaknesses in the work of other authors are now explicitly mentioned in this section [18]. Also, recommendations and applications for practice and future research should be provided [3, 8, 16, 17, 22, 25, 29] and how the own work can impact on this should be discussed [9, 15].

A. Formulating Limitations and Future Work

The limitations and future work are positioned in different parts of the paper by different authors, either in the discussion section or the conclusion section.

The limitations section should identify the limitations [9], restrictions [9, 32], weaknesses [8] and risks of all kinds [9] that emerged during the review process. In addition, the general quality and evidence of the paper should be assessed [9]. Possibilities for improvement should then also be derived from these negative points and described [8]. It should always be kept

in mind that this procedure does not reduce the quality of the paper, but rather increases its credibility [29].

The authors of [8] suggest that there are two ways to proceed: (1) writing the limitations in the course of the work and note points throughout that can be improved and leave them in the section that have not been remedied, or (2) writing the limitations at the end of the entire process after, for example, after a fellow researcher with experience has read the paper and made comments.

The future work section should assess the current state of research [30] and use this to create a research agenda for future research [30, 40], which states what future research reviews need to do and what questions should be considered and explored in the process [9, 16, 29, 40]. This should include some brief suggestions for specific guidelines and research designs that emerge from the literature review [8, 29, 40]. Research gaps should also be mentioned, as well as under-researched theories or potential new methods [2, 17, 40].

Brief comparison of proposed structure with existing literature reviews

In this section, a small number of existing literature reviews from different fields are briefly discussed with respect to the proposed structure in this paper. As an example, the systematic literature review [41] in the field of medicine contains an extra section "Objectives" in which only the research question is mentioned. Furthermore, within the Discussion section, an extra subsection deals with research implications and after the Conclusion a summary of the key points is given. The highly cited and ground-breaking survey paper in the field of explainable artificial intelligence (XAI) [42] did not specify search terms. We view this paper as an integrative review, since in addition to surveying it structures the emerging field of XAI. Prior to that paper this field lacked common terminology which would have made a search term-driven survey impossible. In the review [43] in the field of social science, the structure is similar to the proposal in our paper, yet, some of the typical components (e.g. limitations) are not directly visible at first glance.

VI. Discussion

In this section we will discuss our findings in relation to our overriding research question of:

What components should a literature review contain and what should they include to make the literature review of high quality?

In order to achieve high-quality within the literature review, we concluded through our findings that these typical components should be included: Abstract, Introduction, Method, Related Work, Results, Discussion and Conclusion with the associated Limitations and Future Work. While these are the typical components of a literature review, it is not mandatory to include and name these exactly as suggested. We believe that particularly young researchers and students will benefit the most from agreed structural components and guidelines as discussed in this paper. More experienced researchers, who typically have strong experience in reviewing papers themselves, will find it easier to write precise and comprehensible papers either following commonly used structures or adapting them to fit their needs. Scientific writing is still a creative process that, depending on the research topic and research domain, might make it necessary to adapt the commonly used structure or deviate from it. However, it is highly likely that most of the discussed issues will be present in some form in those papers as well.

During our research, we noticed that many authors use these components in their own literature review, but then do not describe them for readers, or only describe them in part and thus we could not find a paper that explained the most typical components in detail.

We have tried to unify or contrast the ideas and suggestions of a variety of different authors and findings in our work aiming to give an overview that is as comprehensive as possible considering the components of a literature review. By providing additional information, such as how to find a scientifically relevant and interesting title or how to search the literature, we also enable readers to obtain information on the most relevant steps within the literature review in the shortest possible time.

VII. Conclusion, Limitations, Future Work

In this paper we reviewed all the existing "substantial" scientific work concerning on how to write a literature review and built up a literature review for this purpose.

At the beginning, we first discussed the general definition of literature review and elaborated its benefits and objectives. Then, the three main types and their corresponding subtypes were presented with their respective definitions and distinguishing characteristics.

The results section of this paper includes an overview of the typical components of a literature review and also shows which methodological approaches different authors' mention.

In addition to the components of a literature review, the paper also discusses the topic and literature search, each of which explains the process involved in the procedure.

To achieve the goal of a high-quality literature review, these individual components must be worked out systematically and argumentatively and should be part of a literature review.

Limitations

The results of the literature search are limited by the used databases and by the selection of the search terms. While we are confident that we presented a representative selection of papers, researching other databases and enhancing the search terms could be future work. Furthermore, this paper deals exclusively with the general structure of a literature review and does not contain guidelines for writing a review in a specific field, such as medicine or computer science. Therefore, the individual typical components were described considering different methodological approaches of authors, but it is not possible to explain all details relevant for the creation of a literature review in a single paper. Further components could be added here.

Future work

Since this work is not subject-specific but provides a general overview, future work could apply and expand this topic to specific areas, such as medicine, information systems or other topics. Furthermore, positive, and negative writing examples could be added or a direct comparison between the different types of literature reviews could be made in terms of components.

Moreover, this topic will never lose its relevance, as the methodology is in constant change and an update of the components should therefore take place in the course of time. It will be interesting to see how machine learning methods can support the process of reviewing literature, approaches to automatically summarize papers have been proposed in literature.

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