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How to write a machine learning related scientific article

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Abstract

Traditionally, a significant number of scientists prefer experimenting and implementing their ideas instead of putting them on paper.

As such, the aim of this paper is to act as a simple introductory guide into the world of research paper writing. The goal is to help novice machine learning engineers to put their ideas in a structured form that can build up to a research paper.

We try to describe as easy as possible the main points that need to be covered in writing a research paper in the field of machine learning, starting from the introduction all the way to references and dissemination.

We hope that these steps might be helpful not only, but especially for bachelor or master students, that are interested in publishing their ideas as a scientific article. We focus on machine learning, but we believe that most insights can be extended to other domains.

1. Introduction

Writing a scientific article in the domain of machine learning can be a challenging but rewarding task. It involves organizing, and communicating complex ideas and concepts in a clear and concise manner. It also requires a strong understanding of the topic, as well as the ability to conduct research, organize and analyze data, and communicate effectively. As such, the main benefit is that it provides a very good way to share knowledge acquired in a very specific domain such as machine learning.

Given all of these benefits, it is very tempting for a beginner researcher in machine learning to get into putting his or hers new ideas into this form. Even though for someone accustomed to this kind of approach of expressing ideas, writing a scientific paper may seem like second nature, for the first timers, it might seem like a more challenging task than it actually is, or more challenging than the actual research subject. This problem might be especially worse in the case of machine learning research, because the people involved into this field are most likely stronger with numbers and code, rather than expressing an idea in a format that is to be ideally understood by other fellow researchers.

It is important to note that there are several alternatives to writing a traditional scientific paper that can be used to communicate research findings and share information with the scientific community. Some researchers create online resources or databases to share their research findings and make them more widely accessible to others. These resources can be helpful for researchers who are looking for specific data or information on a particular topic. Many scientists use social media or other online platforms to share their research findings and engage with the scientific

community. This can be an effective way to get feedback on ongoing work and to communicate research findings to a wider audience.

But these methods usually are not rigorous enough compared to a scientific paper, and can easily fade away in time and be forgotten, as opposed to scientific papers which can be continuously cited.

Having all of these arguments in mind, the aim of this paper is to give a concise and easy to understand guide for writing a research paper on a machine learning related topic. The target audience is composed of especially researchers that are looking to write their first paper. Therefore, we aim to cover aspects from the structure and contents of the paper, to dissemination of the paper. We also believe that the approach we present can be extended very easily to other domains also or to bachelor or masters thesis.

2. Placement in the general field

Machine learning is a field of artificial intelligence (AI) that involves the development of algorithms and models that can learn from data without being explicitly programmed. Machine learning algorithms can be trained on large datasets and can automatically improve their performance over time by learning from the data.

There are two main categories of machine learning: supervised learning and unsupervised learning. In supervised learning, the algorithm is trained on labeled data, which includes both input data and the corresponding correct output. The algorithm uses this data to learn how to map the input data to the correct output. In unsupervised learning, the algorithm is not given any labeled data and must discover patterns and relationships in the data on its own.

Machine learning has a wide range of applications, including image and speech recognition, natural language processing, fraud detection, and predictive modeling. It is an active area of research and has the potential to revolutionize many industries and fields.

3. Structure of a research article

To write a scientific paper, researchers typically follow a standard format and structure that includes an introduction, a literature review, a methods section, a results section, and a discussion section. The goal of a scientific paper is to communicate the results of a research study and contribute new knowledge to the field. The content and focus of a scientific paper will depend on the specific topic and research question being studied, as well as the discipline and field in which the research is being conducted.

In Fig. 1 we present a high overview of the structure of a scientific paper. The hourglass model is a framework for organizing the content of a scientific paper that is often used to help writers structure their papers in a logical and effective way. The model is called the hourglass because it starts with a broad introduction that sets the stage for the research, and then narrows down to focus on the specific research question and methods, before expanding again to discuss the results and implications of the research. Another point is that if the body is removed, the contents should still make sense and be continuous.

Overall, the hourglass model is intended to help writers structure their scientific papers in a way that is logical and easy for readers to follow. It provides a framework for organizing the content of a scientific paper in a way that clearly communicates the research question, methods, results, and implications of the study.

If the hourglass model represents the backbone of the paper, the king model gives the whole picture. As such, the hourglass model is wrapped with the title, abstract and references.

3.1. Title

The title of a research paper is an important element of the paper and plays a number of important roles. First of all, it should provide a clear and concise summary of the research: The title should clearly and concisely summarize the main focus and key findings of the research.

A good title should be interesting and attention-grabbing, and should encourage the reader to want to read more about the research. Also, the title should clearly identify the research area and the specific research question or problem being addressed.

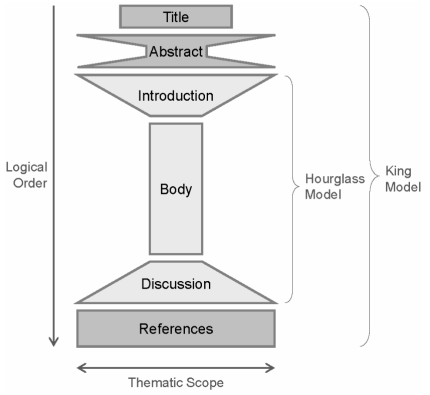

Fig. 1. General structure of a scientific paper, also known as the king model [1]

Research paper titles should generally be concise and should not be too long. A title that is too long may be truncated when it is published or indexed, which can make it difficult for readers to understand the main focus of the paper. Ideally, the title should be no more than 12-15 words long.

The title should include key terms that are relevant to the research area and that will help readers to understand the focus of the paper. These key terms should be carefully chosen to accurately reflect the content of the paper and should be used consistently throughout the paper.

While it is important to use key terms in the title, it is also important to avoid using jargon or technical terms that may be unfamiliar to many readers. The title should be written in plain language that is accessible to a broad audience.

A title that is too general or vague may not accurately reflect the content of the paper and may not be engaging for readers. It is best to choose a title that is specific and focused, and that clearly conveys the research question or problem being addressed.

Also, the title should be written with the intended audience in mind. It should be written in a way that is appropriate for the target audience and should be written in language that they will understand.

Finally, the title should accurately reflect the content of the paper and should not be misleading or overly general. In general, a good research paper title should be informative, concise, and engaging, and should help to convey the key points of the paper to the reader. It is important to spend some time considering the title of a research paper, as it can have a significant impact on the reader's impression of the paper and their willingness to read it.

3.2. Abstract

An abstract is a brief summary of a research paper that is typically presented at the beginning of the document. We can also see in in Fig. 1 that the abstract is simply a compressed version of the hourglass model, meaning that it covers a little bit from each part, going from general to specific and back to general. It is typically a single paragraph that provides an overview of the main points and findings of the paper. The abstract should be concise and should clearly and concisely describe the purpose, methods, results, and conclusions of the research and it should be self-contained so that readers can understand the main points of the paper without having to read the full paper. It should also include relevant keywords and phrases that will help readers find and understand the paper. The abstract is important because it gives readers an idea of the content and scope of the paper, and it can help them decide whether they want to read the full paper or not.

The abstract should include the purpose of the research, the methods used to conduct the research, the main results or findings of the research, and the conclusions or implications of the research. It should also include relevant keywords and phrases that will help readers find and understand the paper.

The length of an abstract can vary depending on the specific guidelines of the journal or conference, but it is usually around 200-300 words in length. It is important to write the abstract after the rest of the paper has been completed, so that the main points and findings of the research can be accurately summarized. Although, it is interesting to note that some researchers prefer starting with the abstract so that they have a good idea about what they want to explain in the

rest of the paper, and later come and refine the contents of the abstract. In the end is a matter of preference, but the abstract should be reviewed at the end anyways and it might be helpful to ask someone else for an opinion about it.

The abstract should be written in a clear and concise manner, using simple language that is easy to understand. Technical terms or jargon should be avoided unless they are necessary. Also, the abstract should be written in present tense, as it is a summary of the current state of the research and It is generally best to avoid using abbreviations in the abstract, as they can be confusing for readers who are not familiar with them.

It is also important to note that the abstract should be formatted according to the guidelines of the journal or conference where the paper will be published. This may include specific font, font size, and margin requirements.

In summary, the abstract is a crucial part of a research paper because it provides a brief overview of the main points and findings of the paper, and it helps readers decide whether they want to read the full paper or not. The first sentence of the abstract should be attention-grabbing and clearly state the purpose of the research and using transitional phrases, such as ”the aim of this study is to”, ”the results show that”, or ”the conclusion was is that” can help to clearly connect the different sections of the abstract.

3.3. Introduction

The introduction of a research paper is the section that comes at the beginning of the paper and provides an overview of the main points and purpose of the study. The introduction serves several important purposes. It should provide background information about the topic being studied, including any relevant theories or previous research that have been conducted on the subject. This helps to establish the importance and relevance of the research.

The introduction should clearly state the research question or hypothesis that the study is attempting to address. This helps to focus the study and guide the reader’s understanding of the rest of the paper.

It should also provide an overview of the structure of the paper, including the main sections or chapters and their purpose. This helps to guide the reader through the paper and helps them understand the organization of the information.

Finally, the introduction should be interesting and engaging, and it should make the reader want to read the rest of the paper. As such, the introduction of a research paper is an important section that provides context, states the research question or hypothesis, outlines the structure of the paper, and entices the reader to read on.

3.4. Body

The body of a research paper is the section that comes after the introduction and presents the main points and findings of the study. It is the longest section of the paper and is typically divided into several chapters or sections, depending on the specific requirements of the paper. The body of the paper should present the research in a logical and organized manner, and it should include several elements such as a literature review, or placement in the general field, methodology together with it’s results and how it compares to other approaches existent in the literature.

As it was the case up until this point, the body of the paper should be written in a clear and concise manner, and it should be well-organized and easy to follow. Each section should be clearly labeled and should be structured in a logical way, with subheadings and bullet points used as needed to break up the text and make it easier to read.

Another good practice is to use tables and figures which are useful tools for presenting and organizing data in a research paper. They can help to clarify and simplify complex information, making it easier for readers to understand and interpret the results of the study on which the paper is based.

While it is very good to use them, they should be used sparingly, by only including them if they are necessary to understand some results or help in clarifying or highlighting some important points.

Usually, the body itself is organized in several sections, each with its own role that we will describe in what follows.

3.4.1. Literature review

This section usually comes right after the introduction and it is meant to give some context about the field of interest for the research. Essentially, a literature review is a critical summary of what the scientific literature says about the specific research field of interest. It is a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of recorded knowledge on a topic. It should be thorough, covering all of the important and relevant studies on the topic.

The purpose of the literature review is to provide context and background information for the research being conducted. It should give the reader a sense of what has been done in the field, what the key findings are, and what gaps in the literature exist that the research paper aims to fill.

As such, a literature review is not just a list of studies, but rather a critical evaluation of the research that has been done on a topic. It should provide a balanced view of the literature and should not simply present one side of the argument.

Besides the key findings of the research, the literature review should also cover any limitations or weaknesses in the reviewed studies. Other important insights should be included such as patterns or trends in the research. This could help in figuring out which gaps should be filled by the research paper.

For instance, if the focus of the research is to introduce a new neural network architecture, the literature review should cover other similar neural network architectures. If the new neural network is a convolutional one, it might be a good idea to compare it with the well known and established architectures such as MobileNets [3, 4] or residual networks [2].

Finally, it is important to keep in mind that a literature review is an ongoing process. During the actual research, new findings or other methods might arise that need to be addressed and included in the literature review.

3.5. Method or learning algorithm

This section should describe the used method or learning algorithm. As before, if the focus is to propose a new neural network architecture, this section should give all the necessary details to understand its structure and why it makes sense.

It is important that the method is detailed enough in order for other researchers to be able to replicate the results by following the same methodology, which we describe next.

3.5.1. Methodology

The methodology section is arguably the core and most important section of the paper. Here are described the particular steps took into developing and testing the proposed machine learning model. If the other sections can be somewhat extended to other topics as well, this one is the most specific to machine learning.

First of all, data is essential to any machine learning algorithm, therefore it should be clearly stated how was the data used for training and testing collected. Its quality is crucial because it determines what the learning algorithm can actually learn. This may include information about the sources of the data, any preprocessing or cleaning that was done, and any sampling techniques.

Machine learning itself is a complex domain, comprising of several subdomains, each with its particularities and type of data. For instance, the most popular type of learning is supervised learning.

The dataset must have a special structure in order to satisfy the supervised learning algorithms. Basically, such a dataset must contain pairs of inputs and outputs from which a function that correlates them is learned.

These pairs must contain meaningful information. For example, it is a good idea to have the inputs to be samples from the same distribution in order to have some patterns. These inputs can be anything ranging from simple feature vectors to images or sequences of words and usually it is relatively easy to find lots of samples for input.

The tricky part is finding the correct output. Obviously, the outputs must be representative for the input and must describe what it should be learned. This part of gathering the outputs is especially hard because it means that each input must be processed and labeled. These labels can be quite costly, especially if expensive hardware or expert people are used in the labeling process. For instance, medical data could be such an example. Also, cheap labels can be quite costly in the end if there are a lot of inputs. And in this era of deep learning, a lot of data is required for an algorithm to learn, which is a big problem from the labeling point of view. This need for an extensive amount of good labels is one of the main pitfalls of supervised learning. As such, a lot of interest has been invested in unsupervised methods, that do not require any labels, also in semi-supervised methods that learns from samples with and without labels.

For instance, in the case of object detection, the inputs are images, and the output represent a set of bounding boxes corresponding to the target objects in the image. They need to contain information about the class of the object and about the location of the object in the image. A common way to describe the location is to give the coordinates of the upper left and bottom right corners in the image scale.

In order to have a qualitative dataset, it is important to have labeling conventions. For instance, it is important to clearly describe what is considered to be an object of interest. Otherwise, the learning algorithm might be confused. Also, the input needs to be clear, at least for humans, because if a human can't tell what is there, it would be difficult for the learning algorithm.

The next step is to describe the training process. Here the information about the scheduler, optimizer, loss and dataset splits should be included. Also, other relevant aspects such as data augmentation or other tricks such as regularization should be mentioned. The idea is that it should be fully reproducible.

3.5.2. Results and comparison

The next step is to evaluate the machine learning algorithm. Firstly, it is important to describe the performance metrics used on the test set so that the reader may know the significance of the presented numbers.

It is important to evaluate the machine learning model firstly to choose from a variety of versions resulted from hyperparameter fine-tuning for example. Evaluating and comparing these models can help in selecting the one that performs the best.

Another key point is that by evaluating the algorithm, it can then be compared with other existing models in the literature, such as the ones described in the earlier section of literature review. As such, comparing the performance of different models can help in understanding the strengths and weaknesses of each model and how they might perform on different types of data. In this way the performance of the model can be improved by working on the weaknesses observed by comparison.

Also, comparing the performance of a model on different datasets can be a good indicator of how well the model will generalize to new and unseen data. This is particularly important when deploying machine learning models in real-world settings.

Overall, evaluating and comparing machine learning models is an important step in the model development process, as it allows to select the best model and understand how it is likely to perform in different situations. It is also crucial to know where the proposed solution stands compared to what is already existent in the literature.

3.6. Discussion or conclusions

The conclusions of a research paper provide a summary of the main findings of the study and discuss their implications. It is important to be clear and concise in this section, as the goal is to highlight the key takeaways from the research without going in too much detail.

The conclusions should begin by summarizing the main findings of the study. This should include a brief overview of the research question, the method used, and the key results of the analysis. It is important to be specific and to provide enough detail so that the reader can understand the main points of the study.

Next, the conclusions should discuss the implications of the findings. This is where the authors interpret the meaning of the results and consider what they might mean in the broader context of the field. It is important to be thoughtful and reflective in this section, as the implications of the study may have broader implications for theory, practice, or policy.

The conclusions should also address any limitations of the study. It is important to be honest about the limitations of the research and to consider how these limitations might have affected the results. This can help the reader understand the limitations of the study and the potential implications of these limitations.

Finally, the conclusions should suggest directions for future research. Based on the findings of the study and any gaps in the literature, the authors should suggest areas for further research and provide recommendations for future studies. This can help to build on the current research and to advance the field in new directions.

Overall, the conclusions of a research paper provide a summary of the main findings of the study and discuss their implications. It is an important section that helps the reader understand the significance of the research and its potential impact on the field.

3.7. References

The references section of a research paper is a list of the sources that the authors have used in their study. It is important to include a complete and accurate list of references in a research paper, as this allows the reader to locate the sources and verify the information presented in the paper.

There are many different citation styles that can be used in a research paper, and the specific style used will depend on the discipline and the journal the paper is being submitted to.

The references section should include all of the sources that the authors have cited in the paper, as well as any sources that have influenced the research but were not specifically mentioned in the text. The sources should be listed in alphabetical order by the authors last names, and should be formatted according to the specific citation style being used.

In addition to the full bibliographic information for each source, the references section may also include notes about the sources. These can provide additional information about how to find the respective source such as the journal or conference in case of research papers.

Finally, the references section of a research paper is an important part of the paper that allows the reader to locate the sources used in the study and verify the information presented. It is important to include a complete and accurate list of references and to follow the specific citation style being used. This is because the quality of the references can reflect the quality of the research study.

4. Dissemination of a research paper

The dissemination of a research paper refers to the process of sharing the results of a study with the broader scientific community and the public. There are many ways that research can be disseminated, including through publication in academic journals, presentation at conferences, and sharing on social media or online repositories.

One common way to disseminate research is through publication in academic journals. This typically involves submitting the paper to a journal for review, and if the paper is accepted, it will be published in a print or online issue of the journal. There are many different types of journals, ranging from general interest to highly specialized, and the specific journal that a paper is published in will depend on the nature of the research and the audience it is intended for.

Another way to disseminate research is through presentation at conferences. These can be local, regional, or international conferences, and they provide an opportunity for researchers to present their work to a live audience and receive feedback from other researchers. Conferences can also be a good way to network and to learn about new developments in the field.

Research can also be disseminated through sharing on social media or online repositories. Many researchers use platforms like Twitter, Facebook, or LinkedIn to share their work with a wider audience, and there are also many online repositories, such as arXiv , where researchers can share their papers for free.

As such, each channel of communication has its pros and cons. Journals are traditionally seen as the most serious and prestigious way of presenting research works, but they require a long time to process the findings, which need to be more substantial also. This is not really suited for machine learning related papers, nor for computer science papers in general, because the state of the art in this field is quickly changing and by the time the findings are published in a journal, they might become obsolete. This is why in this domain conferences are preferred because they are quicker and more accessible. The main problem with social media or online repositories is that they are not verified or validated in any way therefore it is not a good idea to only disseminate in this way, but rather use it as an auxiliary way, paired with a journal or conference.

Overall, the dissemination of a research paper is an important part of the research process, as it allows the results of the study to be shared with the broader scientific community and the public. There are many different ways to disseminate research, and the specific approach will depend on the nature of the study and the audience it is intended for.

5. Conclusions

In conclusion, we hope that we highlighted the main steps in writing a machine learning related scientific article in a concise and easy to understand way. We also think that this work could be useful for research beginners that are looking to improve their writing skills, and that most of it can be extended to other domains as well.

References

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