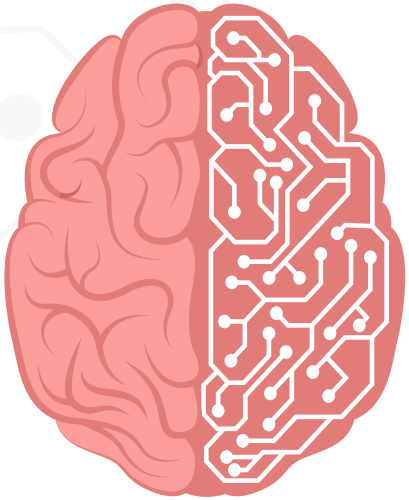


How to read a scientific paper

By Guillaume GUERARD

Why

Most ideas don‘t materialize out of nowhere. They build upon theories, methods, or findings found or developed in previous work.

“Nous sommes comme des nains juchés sur des épaules de géants (les Anciens), de telle sorte que nous puissions voir plus de choses et de plus éloignées que n’en voyaient ces derniers. Et cela, non point parce que notre vue serait puissante ou notre taille avantageuse, mais parce que nous sommes portés et exhaussés par la haute stature des géants”
XIIème, Bernard de Chartres

Why

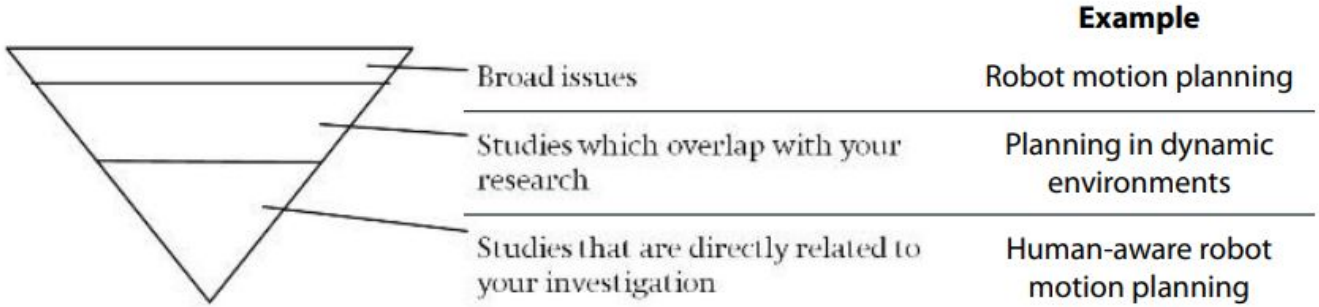
- A literature review is a selection and analysis of existing research which is relevant to your topic
- It shows how your work relates to previous research
- You demonstrate the ability to understand and critically analyze the background research
- ... and to select and source the information that is necessary to develop a context for your work. Concretely: Am I the first one to have this idea? Which aspect of my discovery is new and which one is not? Did someone else have a similar idea? What are the results and conclusions from other similar ideas? Etc.
- Only a literature survey allows you to convince people of the contribution of your new idea/finding/theory/method to the field. E.g. solve a problem that was unsolved before, fill a gap, generalize an existing theory

How to structure it

- A literature review is not a straightforward summary of everything you have read on the topic
- Neither is it a chronological description of what was discovered in your field
- A common way to approach a literature review is to start out broad and then become more specific
- To deal with a large body of related work, group similar works together according to e.g. commonly used theories, methods, system properties, etc.
- This will help to compare and contrast their approaches and facilitates the discussion with the literature in view of your new idea
- Be careful and exact in dismissing related work when promoting your idea

How to structure it

A common way to approach a literature review is to start out broad and then become more specific.



1. First briefly explain the broad issues related to your work. You don't need to write much about this, just demonstrate that you are aware of the breadth of your subject
2. Then narrow your focus to deal with the papers that overlap with your research
3. Finally, concentrate on the research which is closely related to your specific work. Proportionally you spend most time discussing those papers

Before you start

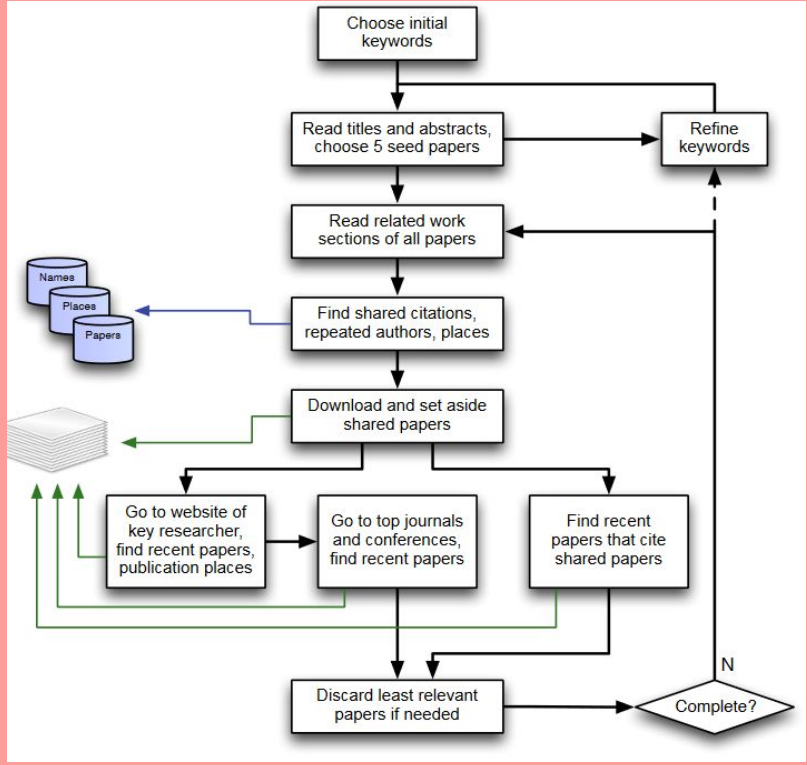
1. Identify what you need to know:
    - What research has already been done on my topic?
    - What are the relevant subareas of my topic?
    - What are the key papers on my topic?
    - What are the key issues, types of research questions and common approaches?
    - What other research (perhaps not directly on the topic) or other research communities might be relevant?
2. Moreover
    - Which research community is relevant for my topic?
    - What are the relevant places for publication (top conferences and journals) in this community?
    - Who are the important authors?

Where to find paper ?

- Google Scholar, Microsoft Academics, CiteSeer, OpenEdition
- With subscription: Web of Science, ACM Digital Library, IEEE Digital Library
- Local ressources: https://livres.devinci.fr/
- Attention aux sites illégaux comme Sci-Hub !

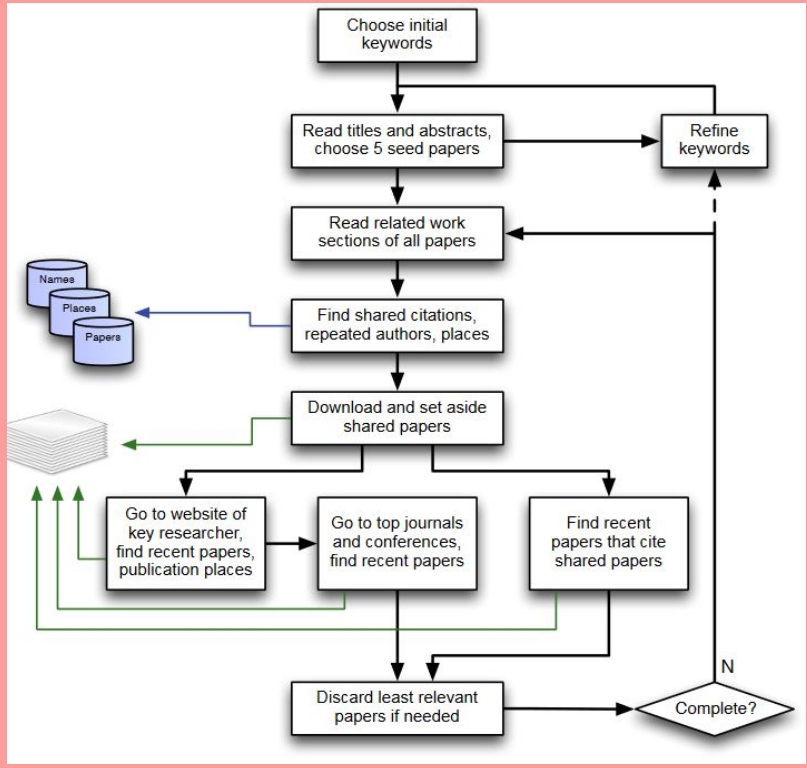
Follow this algorithm

1. Go to an academic search engine
2. Find some well-chosen keywords to find five recent papers in the area („seed“ papers)
   a. Select the five papers according to abstract and keyword match
   b. Prefer journal articles, then conference papers. Skip textbooks
   c. While you read abstracts and titles, refine your keywords and re-iterate
3. Read the related work section of each paper
   a. You will find a summary of the recent work in your area
   b. If you are lucky you find pointers to a recent survey paper



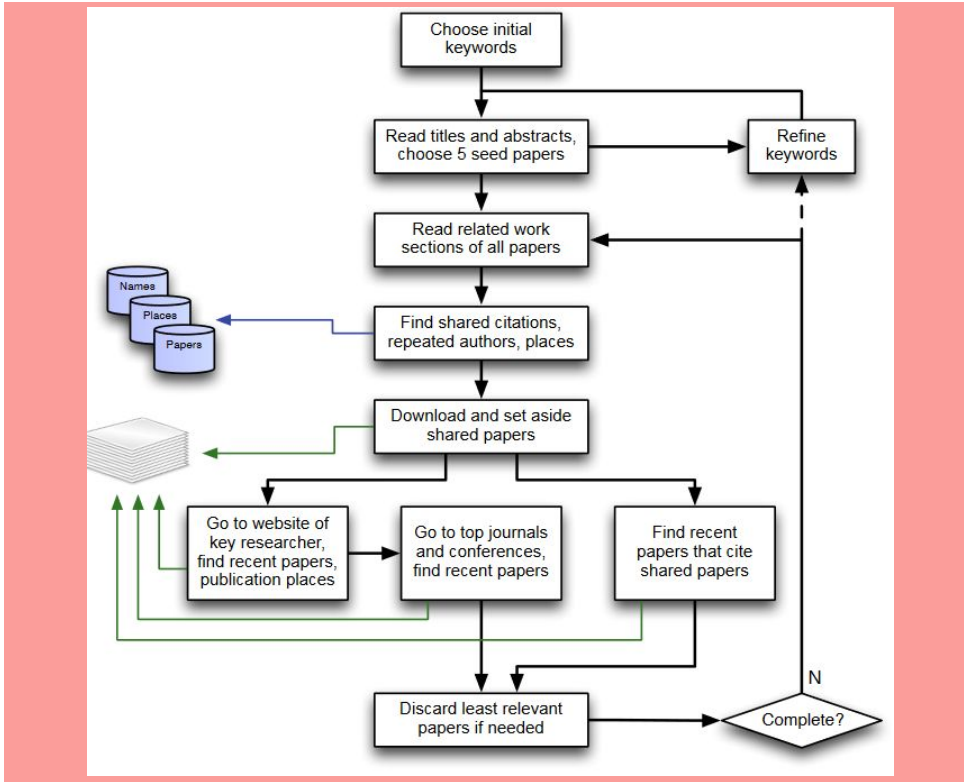
Follow this algorithm

4. Find shared citations, repeated author names and publication places in the bibliographies
    a. These are likely the important papers, authors and places in that area
    b. Maintain a statistics of their occurrences
    c. Download those papers and set them aside
5. Go to the website or Google scholar profile of the key researchers and see what and where they have published recently
    a. That will help you identify the top journals and conferences in that field because the best researchers usually publish in the top places
    b. This will also give you more recent high-quality related work
    c. Download and set aside the most relevant papers



Follow this algorithm

6. Go to the websites of those journals and conferences and look through their recent issues/proceedings
    a. This will give you more recent high-quality related work
    b. Download and set aside the most relevant papers
7. Use an academic search engine to find recent articles that cite the important papers found in step 4 (click on the citation count numbers)
    a. Download and set aside the most relevant papers
8. All papers that you have set aside constitute the first version of your survey
9. Go to step 3, re-iterate as necessary
    a. A good criterion to stop is when the statistics on important author names, publication places and papers has roughly converged



Quality of the selection

- The number of citations is an important measure to quantify the importance of a paper
- The accumulated number of citations of an author measures the impact of his/her work
- However, the number is not robust against one-hit wonders, does not measure durable academic performance
- Hirsch‘s h-index aims to provide a robust single-number metric of a researcher’s impact
- Note that numbers of citations and h-indices scale with the size of a community. In large communities, it is easy to receive many citations
- Rules of thumb: papers with >1000 citations are seminal papers, papers with >100 citations are important papers. Of course, this depends strongly on the paper’s age

Quality of the selection

- When you conduct a literature survey, the number of citations of a paper or an author is a good heuristic to find important papers and authors
- However:
  - Very recent papers had no time to accumulate many citations
  - Young (but promising) researchers have rarely many citations
  - Sometimes, a great paper is not cited because it is ahead of its time, proposes an uncommon idea against the current mainstream, or other reasons of human error

Before reading

Identify what you need to know:

- What is the research problem addressed in the paper?
- Why is this problem important?
- What are the novel ideas and key concepts proposed by the authors?
- How does the paper relate to other papers?
- What is the main contribution of the paper?
- Are there concepts or methods in the paper that are unclear?
- What are the flaws or limitations of this paper?
- How would you extend this work?

Thinking about your review

The structure of a literature review should include the following:

- An overview of the subject, issue, or theory under consideration, along with the objectives of the literature review,
- Division of works under review into themes or categories [e.g. works that support a particular position, those against, and those offering alternative approaches entirely],
- An explanation of how each work is similar to and how it varies from the others,
- Conclusions as to which pieces are best considered in their argument, are most convincing of their opinions, and make the greatest contribution to the understanding and development of their area of research.

Four Stages of Development

1. Problem formulation: which topic or field is being examined and what are its component issues?
2. Literature search: finding materials relevant to the subject being explored.
3. Data evaluation: determining which literature makes a significant contribution to the understanding of the topic.
4. Analysis and interpretation: discussing the findings and conclusions of pertinent literature.

Narrow the topic

The narrower your topic, the easier it will be to limit the number of sources you need to read in order to obtain a good survey of relevant resources. Your professor will probably not expect you to read everything that's available about the topic, but you'll make your job easier if you first limit scope of the research problem.

If your assignment is not very specific about what form your literature review should take, seek clarification from your professor by asking these questions:

1. Roughly how many sources should I include?
2. What types of sources should I review (books, journal articles, websites; scholarly versus popular sources)?
3. Should I summarize, synthesize, or critique sources by discussing a common theme or issue?
4. Should I evaluate the sources?
5. Should I provide subheadings and other background information, such as definitions and/or a history?

Three-pass approach by S.Keshav

The first pass: Bird's-eye view

The second pass: Grasp the content.

The third pass: Virtually re-implement the paper.

Methodology:

- Little boxes
- Highlighters
- Mindmaps
- Pomodoro sessions
- The Feynman technique
- Rubber duck debugging

Procrastination? Pomodoro session

The Pomodoro technique is a great tool if you are lacking motivation.

Get a timer and set it to 25 minutes. Do not expect any results. Eliminate any distractions and follow the three-pass approach until the 25 minutes are up.

By using this timeboxing approach you gain momentum and can follow the three-pass approach more easily. The nice thing is: you can apply the Pomodoro technique to any task.

The first pass: the bird's-eye view

The goal of the first pass is to get the big picture of the paper and should not take longer than 10 minutes. You don't have to get into the details or even read the paper in its entirety.

- Structure
- Abstract
- Title
- Introduction
- Conclusions

→ Is it worth reading any further?

The first pass: answer to

Category: The category describes the type of the paper. Is this paper about a prototype? About a new optimization method? Is it a literature survey?

Context: The context puts the paper into perspective to other papers. What other papers are related to this one? Can you connect it to something else? You could also see the context as a semantic tree where you assign specific importance to the paper. Is it an important branch or an uninteresting leaf? Maybe you do not have any prior knowledge in this field and therefore you still have to build your semantic tree from the ground up. This can be demotivating in the beginning but it is normal.

Correctness: Correctness is, just as the name suggests, a validity measurement. Are the assumptions valid? Most of the time the first pass won't give you enough information to answer this question with certainty but you probably have a hunch which is enough in the beginning.

Contributions: Most papers have a list of their contributions right in the introduction section. Are these contributions meaningful? Are they useful? Which problems do they solve? Are these contributions novel?

Clarity: Based on the sections you just read, do you think that the paper is well written? Did you spot any grammar mistakes? Any typos?

The first pass: first filter

This pass should serve as a quick, first filter. When you are done with the first pass you can decide to read further and continue with the second pass or you decide not to read further because:

- You are lacking background information
- You don't know enough about this topic
- The paper does not interest you or is not beneficial to you
- The paper is poorly written
- The authors make false assumptions

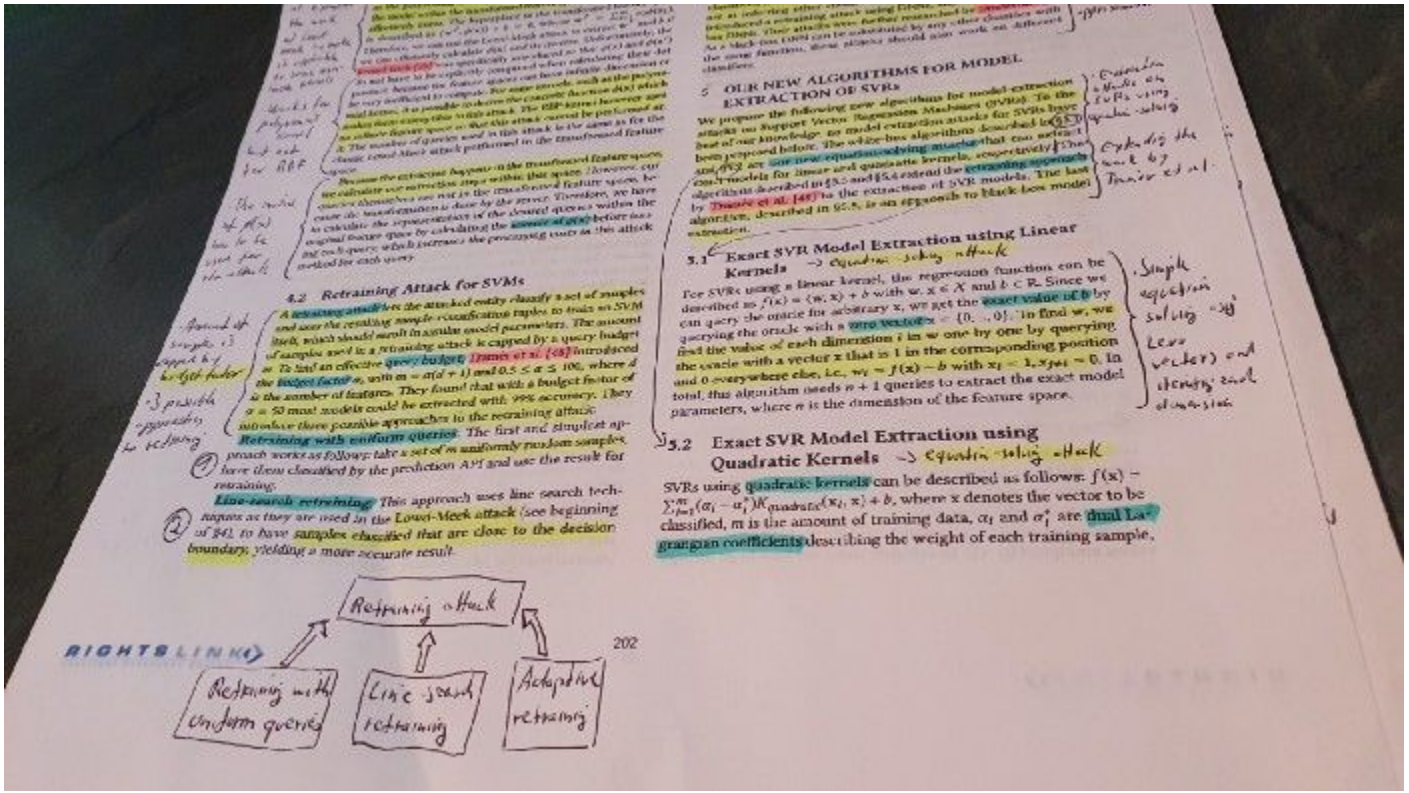
If that paper lies not in your area of expertise but may become relevant to you at a later point then this first pass is sufficient and you probably do not have to continue reading. If that's not the case then you can continue with the second pass.

The second pass: grasp the content

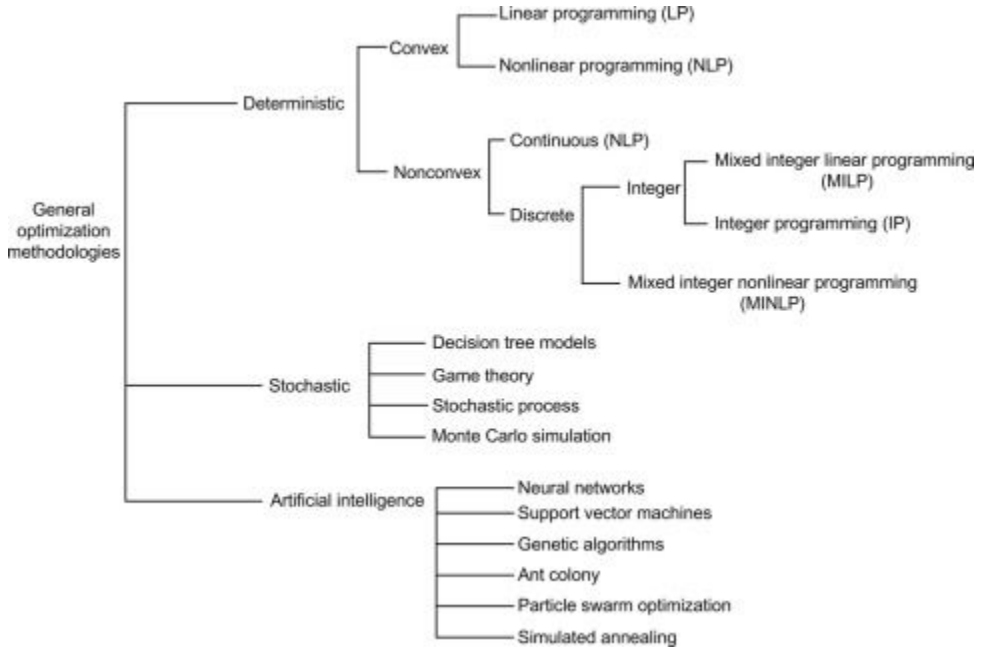
The second pass can last up to 1 hour and here you should read the complete paper. Ignore details such as proofs or equations because most of the time you won't need that specific knowledge anyway and it costs you valuable time.

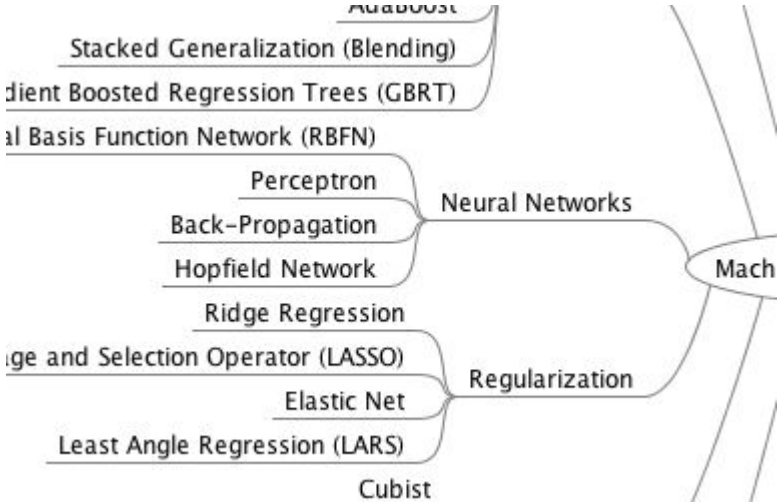
Writing down little summaries or key points at the margins in your own words is a great way to see if you really understand what you've just read; and you will remember it way longer.

The second pass: notes

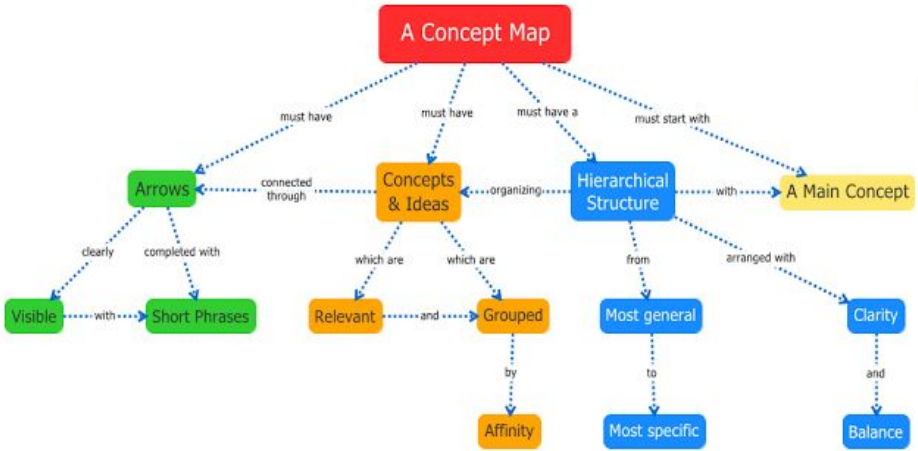


The second pass: enhance the semantic tree

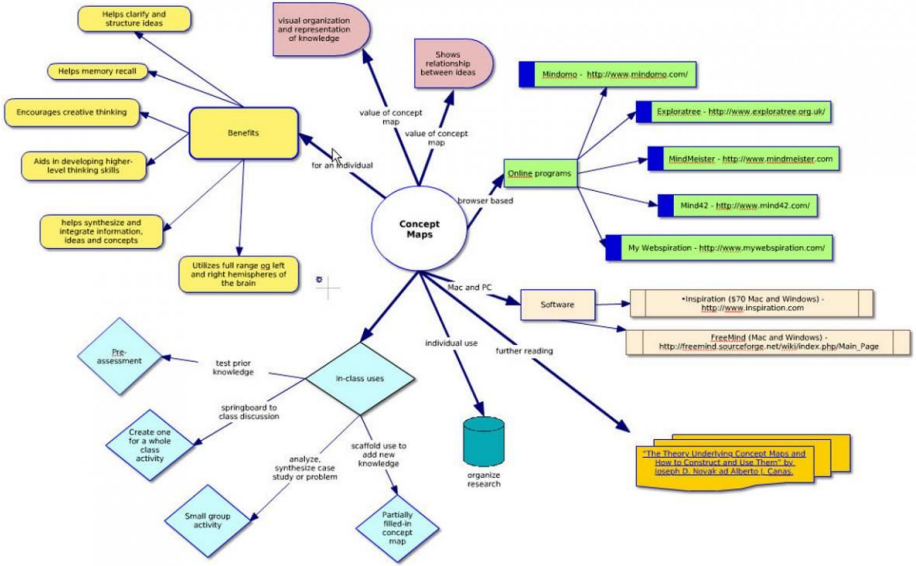




The second pass: enhance the concept map



2013 Philippe Boukobza
Based on Rémi Bachelet "How to assess a concept map"



The second pass: enhance your knowledge

At the end of the second pass it can happen that you still don't understand what you've just read. This could be due to many reasons. Maybe this is not your field of expertise or you are lacking background information.

You can already mark relevant unread references for further reading which is a good way to learn more about the background.

→ You can stop reading any further because the paper is not beneficial to you out of several reasons

→ Put the paper aside and continue reading after you read some background material

→ Continue with the third pass

The third pass: in-depth analysis

If you are a beginner then this pass probably takes 4 to 5 hours. This is a lot of work and you should carefully consider if this step is worth your time.

This step is mandatory if you are a designated reviewer or you already know for sure that you have to understand the paper with all its details.

Read the paper in its entirety and question every detail. Now it's time to get into the nitty-gritty math equations and trying to comprehend what is going on. Make the same assumptions as the authors and re-create the work from scratch.

Summarize: Feynman technique

1. Identify the subject

Write down everything you know about the topic. Each time you run into new sources of information, add them to the note.

Ex. An optimization method → An metaheuristic → Swarm optimization → Ant colony

The use of ant colony in energy optimization (microgrid)

Summarize: Feynman technique

2. Teach it to a child

Start with a blank note / slide and write the topic or subject you want to teach.

Speaking in plain terms: Children don't understand jargon or a lexicon of dense vocabulary.

Brevity: The attention span of a child requires you to deliver concepts as if you were pitching a business idea during one short elevator ride.

Summarize: Feynman technique

3. Identify your knowledge gaps

This is the point where the real learning happens. What are you missing? What don't you know? What do you need to complete your slides?

Ex. An optimization method (def. Of decision-making) → An metaheuristic (among what ?) → Swarm optimization → Ant colony (which one? How to compare them?)

The use of ant colony in energy optimization (microgrid)

Other similar papers and the difference in parameters? Paper with swarm optimization?

Summarize: Feynman technique

4. Organize + simplify + Tell a story

Start to tell your story. Piece together your notes and begin to spin a tale using concise explanations. Bring the most vital pieces of your knowledge about the topic together.

To create a good presentation is like a puzzle.

Use analogies and simple sentences to strengthen your understanding of the story.

“All things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another.”

How to efficiently summarize

- Basics : Authors, #quote, Journal rank, etc.
- Key ideas : Title, Keywords, Abstract, Section's names
- Issue/problem : Abstract, Introduction
- Context : Introduction
- Methods : Materials and Methods, Methods
- Results/Discussions : main contributions in Abstract, Introduction, Discussion

- Literature review overview (resume in a concept map what you learn)

Others useful information (depends of the type of scientific paper).

Organize your literature review

Chronology of Events

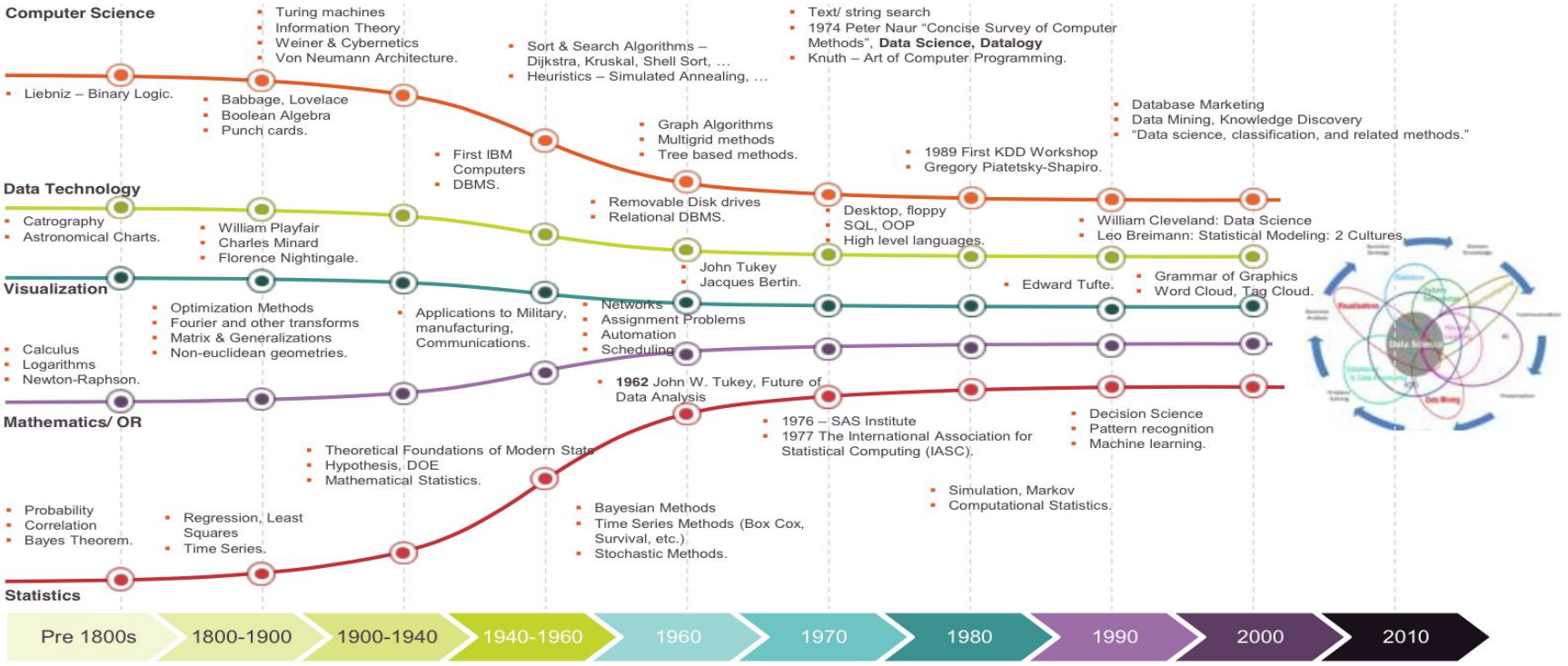
If your review follows the chronological method, you could write about the materials according to when they were published. This approach should only be followed if a clear path of research building on previous research can be identified and that these trends follow a clear chronological order of development.

By Publication

Order your sources by publication chronology, then, only if the order demonstrates a more important trend.

→ Trends; Enhancement, New Methods

Organize your literature review



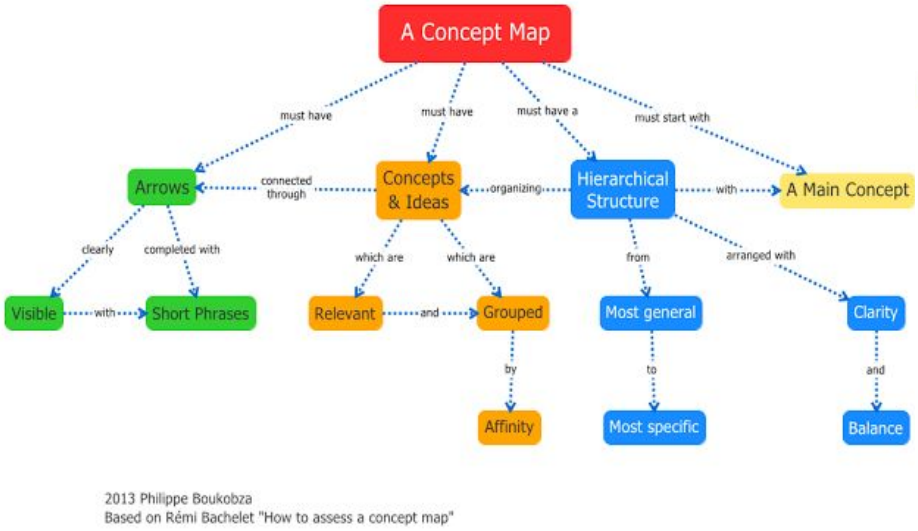
Organize your literature review

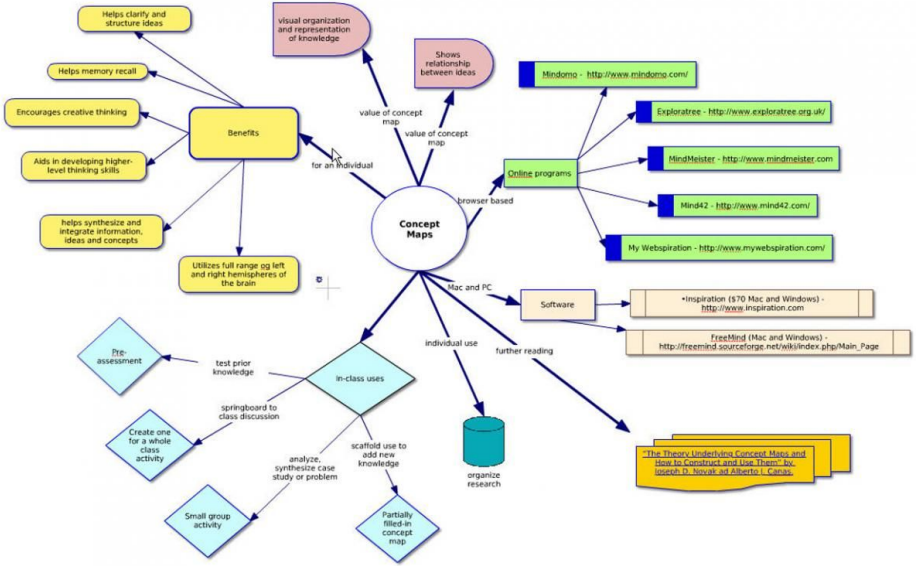
Thematic [“conceptual categories”]

Thematic reviews of literature are organized around a topic or issue, rather than the progression of time. However, progression of time may still be an important factor in a thematic review. The only difference here between a "chronological" and a "thematic" approach is what is emphasized the most. Note however that more authentic thematic reviews tend to break away from chronological order. A review organized in this manner would shift between time periods within each section according to the point made.

→ Concept Map

Organize your literature review





→ Concept Map

Organize your literature review

Methodological

A methodological approach focuses on the methods utilized by the researcher. A methodological scope will influence either the types of documents in the review or the way in which these documents are discussed.

→ Table of concept

Type	Advantage(s)	Disadvantage	Application(s)	Guidelines
Systematic Review	1. Minimized bias 2. A-priori protocol 3. Defined search and evaluation methods 4. Reproducible 5. High validity of review conclusions	1. Must adhere to established guidelines 2. Valid literature base required 3. Robust (enough) literature to review 4. Variation in study methods within reviewed literature may affect results	1. Identify relevant evidence 2. Assess quality of evidence 3. Non-biased synthesis of literature 4. Interpret evidence in an impartial manner 5. Applicable for establishing standards and health policy	PRISMA Guidelines[2]
Meta-Analyses - Quantitative	1. Same as systematic review 2. Determine a single estimate of the effect of treatment or management of an illness or event	1. Data in literature must be homogeneous and available for pooled analysis 2. Reliability of literature designs may affect results	1. Same as systematic review 2. Determine best practice for defined topic or event. 3. Narrow variations in known data sets.	PRISMA Guidelines[2]
Meta-Analyses - Qualitative	1. Same as systematic review 2. Determine major themes or experiences for an event or issue	1. Variable sampling errors in original literature leads to bias 2. Variation in qualitative tools used for original research	1. Same as systematic review 2. Define primary themes and priorities 3. Refine future research objectives	PRISMA Guidelines[2]
Cochrane Review	1. Form of systematic review method 2. Well defined methodology 3. Indexed in the Cochrane Library (open source)	1. Same as for Systematic Reviews	1. Same as systematic review 2. Determine support for specific treatment 3. Determine if evidence exists for defined concept	Cochrane Manual[5]
Scoping Review	1. Use of fluid literature search strategy 2. Broader review topics 3. May include literature of varied methodologies	1. Risk of bias due to lack of defined evaluation methods 2. Non-specific objectives 3. Heterogeneity in literature included	1. Map available literature in a review field or area 2. Literature gap analysis 3. Clarification of concept or theory	PRISMA SrR[7]
Narrative Review	1. Researcher determines literature to include 2. Less time intensive 3. May include literature of varied methodologies 4. Interpretive objectives (not structured analysis)	1. Risk of multiple forms of bias and error 2. Unstructured, not reproducible 3. May not include all appropriate literature 4. Lacks systematic synthesis of literature	1. Identify theory and frames of thought on a topic 2. Summarize a particular study topic 3. Justify a research topic	
Critical Review	Same as Narrative Review	Same as Narrative Review	1. Develop perspectives on a topic	
Conceptual Review	Same as Narrative Review	Same as Narrative Review	1. Evaluate general consensus on a topic 2. Show gaps of knowledge in literature	
State-of-the Art Review	Same as Narrative Review	Same as Narrative Review	1. Describe current beliefs on a topic	

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Write your literature review

Once you've settled on how to organize your literature review, you're ready to write each section. When writing your review, keep in mind these issues.

Use Evidence

A literature review section is, in this sense, just like any other academic research paper. Your interpretation of the available sources must be backed up with evidence [citations] that demonstrates that what you are saying is valid.

Be Selective

Select only the most important points in each source to highlight in the review. The type of information you choose to mention should relate directly to the research problem, whether it is thematic, methodological, or chronological. Related items that provide additional information but that are not key to understanding the research problem can be included in a list of further readings.

Use Quotes Sparingly

Some short quotes are okay if you want to emphasize a point, or if what an author stated cannot be easily paraphrased. Sometimes you may need to quote certain terminology that was coined by the author, not common knowledge, or taken directly from the study. Do not use extensive quotes as a substitute for your own summary and interpretation of the literature.

Write your literature review

Once you've settled on how to organize your literature review, you're ready to write each section. When writing your review, keep in mind these issues.

Summarize and Synthesize

Remember to summarize and synthesize your sources within each thematic paragraph as well as throughout the review. Recapitulate important features of a research study, but then synthesize it by rephrasing the study's significance and relating it to your own work.

Keep Your Own Voice

While the literature review presents others' ideas, your voice [the writer's] should remain front and center. For example, weave references to other sources into what you are writing but maintain your own voice by starting and ending the paragraph with your own ideas and wording.

Use Caution When Paraphrasing

When paraphrasing a source that is not your own, be sure to represent the author's information or opinions accurately and in your own words. Even when paraphrasing an author’s work, you still must provide a citation to that work.