Master’s Programme in Automation and Electrical Engineering

Equipment identification through image recognition

Master’s thesis

**Saidnassimov Darkhan**

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|  | **Master’s Thesis 2022** |

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| **Abstract**  The abstract is a short description of the essential contents of the thesis: what was studied and how, and what were the main findings.  For a Finnish thesis, the abstract should be written in both Finnish and English; for a Swedish thesis, in Swedish and English. The abstracts for English theses written by Finnish or Swedish speakers should be written in English and either in Finnish or in Swedish, depending on the student’s language of basic education. Students educated in languages other than Finnish or Swedish write the abstract only in English. Students may include a second or third abstract in their native language, if they wish. | | |
| **Keywords** computer vision, object detection, domain adaptation | | |

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Preface

I want to thank Professor Susan Supervisor and my instructors Dr Alan Advisor and Ms Elsa Expert for their guidance.

I also want to thank my partner for keeping me sane and alive.

Otaniemi, 23 March 2020

Eddie Engineer

Symbols and abbreviations

Symbols

|  |  |
| --- | --- |
| B | magnetic flux density |
| c | speed of light in vacuum ≈ 3×108 [m/s] |
| ωD | Debye frequency |
| ωlatt | average phonon frequency of lattice |
| ↑ | electron spin direction up |
| ↓ | electron spin direction down |

Operators

|  |  |
| --- | --- |
| ∇ × **A** | curl of vector **A** |
|  | derivative with respect to variable *t* |
|  | partial derivative with respect to variable *t* |
| Σ*i* | sum over index *i* |
| **A**・**B** | dot product of vectors **A** and **B** |

Abbreviations

|  |  |
| --- | --- |
| AC | alternating current |
| APLAC | an object-oriented analog circuit simulator and design tool (originally Analysis Program for Linear Active Circuits) |
| BCS | Bardeen-Cooper-Schrieffer |
| DC | direct current |
| TEM | transverse electromagnetic |

1. Introduction

This is the template file for writing your bachelor’s or master’s thesis. The template contains parts and text to accommodate two different degree lev-els, bachelor’s and master’s, and so it may contain parts that may not be relevant to your thesis. If so, simply delete those parts in the thesis that you do not need. This applies particularly to the abstract pages, the list of symbols, the list of abreviations, and appendices. You may also want to adjust the template section titles to better suit your work.

The text in this template advises you how to use the template, gives gen-eral pointers on how to write your thesis (you must still refer to writing guides and converse with your advisor and/or supervisor in this regard), and provides the technical specifications for the layout and style of the template.

* 1. Typical content in the introduction

In principle, the introduction is like the abstract, only broader in scope, and more detailed. The introduction generally describes the following:

* a description of the background of the field of study, what similar work others have already done, as well as an overview of the study,
* the goals of the study,
* the primary research question and the sub-problems in the line of inquiry, and
* the scope and constraints of the study along with the main concepts involved.

Although the introduction is a general description of the study, be concise and avoid writing a lengthy introduction. A concise introduction need not have any subsections.

1. Literature review
   1. Structure of the thesis

The thesis comprises the front matter, the main matter and possible appendices. The front matter in the required order is:

* a cover page,
* a page containing copyright information,
* the abstract page(s),
* an optional preface, and
* a table of contents.

If the thesis contains mathematical equations, give the list of symbols used to represent various quantities along with the mathematical operators used. The list must contain all the abbreviations used as well. Note that lists of figures and tables are not required.

The main matter, i.e. the actual thesis, begins after the list of symbols and abreviations. Its structure follows the standard structure used in scientific writing. A typical division of the content is

1. Introduction (research objectives and questions)
2. Literature review (research made earlier in this area)
3. Research material and methods
4. Results / Findings
5. Discussion
6. Summary / Conclusions
7. References

Often the discussion and summary (or conclusions) are combined in one chapter. The wording of the titles suggested above may differ. As a matter of fact, the titles above refer more to the type of content rather than being title suggestions. For example, the literature review of a thesis on electromagnetics could be under the title ‘Electromagnetic theory and FDTD’. The background to the methodology used—FDTD here—could also be in this chapter. Note that the chapters and sections within the main matter are numbered, and that they appear in the table of contents. The references, or the bibliography, is also shown in the table of contents, but without a number labelling it.

The appendix or appendices, when necessary, are presented in the last part of the thesis. They contain things like questionnaires used in the study, [selected parts of] data, derivations of mathematical results, a more detailed exposition of some aspect in the thesis, or code listings. Number them in the table of contents as follows:

1. The first appendix
2. The second appendix

Refer to a suitable guide on writing a thesis for a comprehensive description; there are plenty of them around. The instructions here are not exhaustive, and they concentrate more on how to use this template.

A bachelor’s thesis is ideally about 20 pages long, excluding the appendices, whereas a master’s thesis is about 60 pages long, again, not counting the pages in the appendices. The numbers pertaining to the length of your thesis given here are mere rules of thumb. Consult your school’s thesis guidelines and your thesis advisor and/or supervisor for the appropriate length in your case.

* 1. Page numbering

Number the pages using Arabic numerals, placed in the centre of the page footer. The numbering begins from the cover page and runs continuously to the end of the thesis. Enter the total number of pages in the thesis—front matter, main matter and appendices, if present—in the appropriate field on the abstract page. Enter also the number of pages in the appendices, if present, in the same field on the abstract page as follows: total number of thesis pages + number of pages in the appendices.

Do not print the page numbers on the cover and the copyright pages; number all the other pages. Thus, the first page with a page number printed on it—the first abstract page—is ‘3’. The page numbering of appendices continues from that on the previous page.

* 1. Referencing parts in the thesis
     1. Tables and figures

Theses generally contain figures and tables, which have captions describing them. For figures, the convention is to place the caption after (below) the figure, but for tables place the caption before (above). In order to refer to Note that ‘table’ in the cross-reference is not capitalised here. Often, you see the label capitalised, as in ‘Table’. In such cases, ‘**Error! Not a valid bookmark self-reference.**’ is considered a proper noun, hence the capitalisation. Although this templace uses the lowercase form, you can choose how you typeset cross-referencing labels like ‘table’ or ‘Table’—you might do well to consult your advisor and below, use Word’s built-in mechanism for cross-referring tables. Your menu path may look like this: References->Cross-reference->Reference type: Table; Insert reference to: Only label and number. The exact terms and menu options may depend on the Word version. Look on the internet for more help on cross-referencing. Depending on the Word version, you may have to manually change[[1]](#footnote-1) the font in the text body back to Georgia and undo the bold emphasis.

Note that ‘table’ in the cross-reference is not capitalised here. Often, you see the label capitalised, as in ‘Table’. In such cases, ‘**Error! Not a valid bookmark self-reference.**’ is considered a proper noun, hence the capitalisation. Although this templace uses the lowercase form, you can choose how you typeset cross-referencing labels like ‘table’ or ‘Table’—you might do well to consult your advisor and supervisor about this; they might have strong opinions on the matter. However you decide to typeset cross-referencing labels—table, figure, section or equation—be consistent.

Table 1: An example table. Common animals are classified into their classes.

|  |  |  |
| --- | --- | --- |
| Mammals | Birds | Insects |
| dog | crow | ladybird |
| cat | sparrow | ant |
| rat | tit | cockroach |

Figures have their captions below them, as shown in **Error! Reference source not found.** and Figure 2. Use Word’s mechanism to insert pictures from external files; *do not copy and paste* the picture, because this can break the automised structure of the template. Add the caption by right clicking on the inserted picture and choosing ‘Insert caption’ from the menu.

Again, use the cross-referencing mechanism to reference a figure. Just as for a table, use the label ‘figure’ when cross-referencing a figure in your text. Do not abbreviate the word to ‘fig.’ or ‘Fig.’ Journals do this because the amount of available space for an article is limited; space is not an issue in your thesis. You can refer to more than one figure, for example, by saying figures 1, 2 and 3… Note that the labels in the table and figure captions are typeset in a grotesque, or sans serif, font—Arial in this case (see appendix A).



Figure 1: A coil terminated in two LEDs, and a magnet placed at the centre of the coil.

Strive to place the referenced figure or table on the same page as where it is referenced. If this is difficult, place it on the following page, but not very much further. Placing figures (and tables) close to where they are referred to may be impossible when you have many pictures.



Figure 2: This is an example of a MATLAB graph.

Avoid placing figures and tables such that they are preceded or followed by just a line or two, because the reader can have difficulties in finding the line(s) of text and might even accidentally miss the text completely. Consider, for example, a page beginning with one line of text that ends a paragraph on the preceding page and that is followed by a figure, then a short three-line paragraph, then yet another figure, followed by more text, which Word positions such that only two lines of text are on the page and the remainder is placed on the following page. The layout of this page is fragmented, and as a result, the reader might initially miss the top line of text. Consider using one of the following three layout possibilities: place the figures in the top part of the page followed by the text, or place the text in the top followed by the figures, or place all the text in the middle with one figure on the top and the other at the bottom. Base your choice on considering how easily the reader can follow your text (the content of the figures affects this), and whether the page as a whole looks ordered and pleasing to the eye.

* 1. Structuring the text in the main matter
     1. Sections

You can structure your text by dividing it into sections with a suitable title. Well-devised sectioning clarifies your text, but beware of overusing them, since that will fragment and confuse your text. Do not use more than three levels of hierarchy in your sections. Notice that the section titles, just as the figure and table labels, are in the sans serif font Arial.

Use the sectioning mechanism (Header 1–Header 3, Appendix) in Word’s style ribbon (Home -> Styles) (this again may depend on the version of Word) to format the section title. The formatting specifications are in Appendix A. At least in technical texts, refraining from using the articles ‘a’ and ‘the’ as the first word in the title is common practice. Appendices are enumerated using capital letters. Begin every section on a new page. Begin a subsection on a new page only if the previous page is full. Similarly, begin every appendix on a new page.

* + 1. Paragraphs

Do not indent the paragraph that follows the section title. Simply remove the indentation with the backspace key. Indent the paragraphs that follow with ‘Normal’ in the style ribbon. Often, the body text is typeset as ragged-right to avoid unnecessarily large white spaces between words. On the other hand, in many technical fields, the text is justified on both sides, but in such cases, activate automatic hyphenation to maintain reasonable separation between words. This template uses justified text with automatic hyphenation. The line spacing is set to 1.0 in the text.

Write paragraphs so that they span more than three lines. Rethink your text, if you end up having one-line paragraphs; avoid them in your thesis—this includes appendices. In addition, you may need to reconstruct your text if your paragraphs are too long. Avoid emphasising text using italics. Italicised text poses additional problems for dyslexic readers.

When a number has a unit associated with it, ensure two things: the space between the number and the unit is smaller than the regular space (for example, 1 Hz) and the the number and unit are not split over lines (use a non-breaking space between the number and the unit and condense the font space).

* + 1. Equations

Equations are numbered using Arabic numerals, typically enclosed in parentheses, but not always. This template encloses equation numbers in parentheses. An example equation is

(1)

Referring to equation 1 follows the same pattern as in figures, tables and sections. Favour the uncapitalised label ‘equation’. If you do choose to capitalise one of the labels, capitalise them all. Be consistent with the choices you make. Do not abbreviate ‘equation’ to ‘eq.’ or ‘Eq.’; space is not an issue in your thesis.

Remember punctuation after the equation; an equation is an integral part of your sentence and may need to be followed by punctuation marks. Many scientific journals do not use them after equations; then again, many do. Punctuate the equations in your thesis.

Equations in appendices have the respective appendix letter as part of the equation number. So, one would refer to equation A1, the first numbered equation in appendix A, or to equations A1–A2, the first two equations there. Note the length of the dash between the equation numbers; it is the en dash, which is a little longer than the hyphen you type directly from the keyboard. Again, depending on your version of Word, you can produce the en dash by pressing Ctrl and the minus sign on the numeric pad ­­­or in the Symbol ribbon (Insert -> Symbol) under More Symbols in the tab Special characters. Use the en dash when specifying a range, be it equations, page numbers or any other quantity: for example, frequencies 3–30 GHz or the age group 16–70 years.

1. Research material and methods

This part is the core of your work, where you explain the methodological choices you made, its limitations, how you pick your research material or subjects, the implementation of your study and the methods used. This section determines the methodological strengths and weaknesses of your thesis. Any earlier description of the method should limit itself to work done earlier by others. Here you tell your reader what you have done.

1. Results

Present the results of your study here and answer the research questions, asked earlier in the thesis (in the introduction, perhaps), this study strives to answer. The scientific value of your work is measured by the results you obtain along with the arguments you give to back the answers to your research questions.

Be critical of the significance of your results. You may critically scrutinise the results and your interpretation of the results here, or you may do so later in the chapter with the discussion of your work or in the conclusions part.

This part should discuss how reliable the data used in the study are. You may discuss the reliability of the conclusions drawn from the study either in this chapter or later in the discussions part. You may have the discussion in a chapter of its own, separate from the summary or conclusions.

1. Summary/Conclusions

This is where you tie up any loose ends. Tell your reader briefly and clearly what you have done, what you have discovered, and the value of your discovery in the context of similar work done earlier. Draw clear conclusions regarding the research problem, sub-problems or hypotheses. You also discuss future lines of study and new questions your study might have posed.

As the author of the thesis, you alone are responsible for ensuring that the layout, form and structure of your thesis adheres to the guidelines outlined by your school. This template aims to help you meet these requirements.

References

n.d. *Leading.* Accessed November 29, 2019.   
https://en.wikipedia.org/wiki/Leading.

n.d. *Line length.* Accessed November 29, 2019.   
https://en.wikipedia.org/wiki/Line\_length.

n.d. *Visual elements.* Accessed November 29, 2019. https://www.aalto.fi/en/visual-library#/  
visual-elements/typography.

See Appendix B for a detailed discussion on reference lists and citing other people’s work.

1. Page layout and typographical design

Layout choices

Designing a visually pleasing, balanced and easily readable document requires setting several typographic parameters, one of the most important ones being the line length. If too wide, the reader’s eyes have trouble focusing on the text because the line length makes it difficult to gauge when the line begins and where it ends; too narrow, and the reader’s eyes have to travel back too often, breaking their reading rhythm and often causing them to begin the next line before finishing the current one.

Studies (Line length n.d.) on the effect of line length on readability of printed text have found that 45–75 characters per line (cpl) is an acceptable range, with 66 cpl being the ideal. This number includes letters, numbers and spaces. The line length in conventional books tends to be 30 times the type size, but anything between 20 and 40 times is considered acceptable. For example, for a 10 pt font, an acceptable line length is 300 points (30x10), or about 10,58 cm.

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Pellentesque et urna posuere, aliquam risus et, ullamcorper quam. Pellentesque sed dignissim metus. Etiam turpis dui, suscipit sed libero vel, vulputate imperdiet risus. Sed rutrum magna nec neque ornare, at imperdiet sapien porttitor. Sed fringilla, enim nec sollicitudin laoreet, arcu leo convallis nisl, eget rhoncus ligula libero malesuada justo.

Figure A3: Text typeset in a 300-pt-wide box using a font size of 10 pt. The resulting average number of characters per line is about 60. The text is framed to make the box size evident.

The reader’s experience as a reader also affects the preferred line length; an experienced reader can handle between 45 and 80 cpl for a comfortable reading experience, whereas a novice prefers a line length of between 34 and 600 cpl (Line length n.d.).

Reading text from a screen poses challenges absent in paper: glare, flicker and scrolling. Research seems to indicate that longer lines are better for scanning through the text whereas shorter lines are preferred for accurate reading. One study says that reading speed at a certain level of comprehension seems to be better for longer lines (100 cpl) than for shorter lines (25 cpl). Another study (Line length n.d.) indicates that subjective preferences for longer or shorter line lengths appear to be contradictory. About 60% of the test subjects preferred the presented shortest (35 cpl) or longest (95 cpl) lines, and at the same time all of them (100%) disliked either the shortest or the longest lines.

Another important typographical parameter is line leading or leading, which refers to the distance between adjacent lines of text. Double spacing is a practice from the era of typewriters particularly in academia to allow making handwritten comments in documents. Typewriters had a limited number of options for leading, and double spacing was chosen as a default. Studies show that too much leading can cause continuity problems, since the reader’s eyes must travel a greater distance between lines of text. The amount of leading is a compromise between ease of reading, desired efficiency in the use of vertical space, weight and type (serif or sans serif) of the typeface used, and visual aesthetics. Naturally, whether a document is printed or published online affects the leading, but even the language of the text must be considered when deciding on the required leading. (Leading n.d.)

Aalto University’s visual guideline for writing documents

Of Aalto University’s visual guidelines (Visual elements n.d.), the one that applies to document writing is related to the use of fonts. This guideline specifies that the body of the text be in the serif font Sentinel and the section titles in boldface of the sans serif font Nimbus Sans. These fonts should be available on all Aalto computers. However, being a commercial product, Sentinel can be replaced with Georgia and Nimbus Sans with Arial, both of which come installed in all Windows machines. Thus, Georgia and Arial are the fonts used in this template.

Layout and typographical specifications

Page layout in the thesis

The thesis is typeset on A4-sized paper. The text width is set to an average of about 75 cpl as a compromise between having to read the thesis on a computer screen and on paper, as discussed above. For the font size of 12 pt to be used in the body text, the text width works out to 14,2 cm. For the online version of the document, the text column is centred, implying that the left and right margins are both 3,4 cm. If you want to print the document and bind it, the binding margin must be 4,8 cm. The text height is set to 23 cm by setting the top margin to 3,7 cm and the bottom margin to 3 cm. The layout dimensions are summarised in **Error! Reference source not found.**.

Sectioning and text body

The font for the body text is Georgia 12 pt, as mentioned above, and Arial bold for the section titles. Use at most three levels of hierarchy in your text: section, subsection and subsubsection. The size of the section font is 16 pt, with a space of 20,2 pt before and 13,3 pt after the title. For subsection titles, the font size is 14 pt, with space of 18,75 pt and 8,65 pt before and after, respectively. The subsubsection font size is 12 pt and the space before and after the title is the same as for the subsection. The lower section numbering must use the section number of the higher section. For example, section number 2.1.3 refers to section 2, subsection 1 and subsubsection 3. The font and sizes for the three section hierarchies as well as the body text are given in **Error! Reference source not found.**.

Table A1:Page layout dimensions.

|  |  |
| --- | --- |
| Paper size | A4 |
| Text width | 14,2 cm |
| Top margin | 3,7 cm |
| Bottom margin | 3,0 cm |
| Online document |  |
| Left margin | 3,4 cm |
| Right margin | 3,4 cm |
| Printed document | **(for binding)** |
| Left margin | 4,8 cm |
| Right margin | 2,0 cm |

Table A2: Fonts and font sizes to be used in the title, section titles and the body text.

|  |  |  |
| --- | --- | --- |
| Text | Font | Size (pt) |
| Title | Arial bold | 18 |
| Section | Arial bold | 16 |
| Subsection | Arial bold | 14 |
| Subsubsection | Arial bold | 12 |
| Body text | Georgia | 12 |

The font size used for the text on the abstract page(s) is 11 pt both for the field labels as well as for the normal text.

Additional section to show equation numbering

This section is written only to show how any equations in the appendix are numbered. Section 2.4.3 refers to these equations.

(A1)

(A2)

1. Reference and in-text citation guidelines

With regard to standard practice across academic disciplines, it is important to use an in-text citation to indicate when your work borrows or refers to words or ideas from a specific source. A full reference of this source should be included in your ‘References’ / ‘Bibliography’ / ‘Works Cited’ section as well.

There are two major referencing styles: the Harvard style and the Vancouver style. The former was first introduced in a journal article by Professor of Zoology Edward Marks in 1881 during his tenure at Harvard University (Chernin, 1988, 1062). It has since become an umbrella term to refer to styles which utilise author-date (e.g., APA style) or author-page (e.g., MLA style) within parentheses (). It still remains in use to some degree in the natural sciences (e.g., American Chemical Society, 2006) and has become the predominant style within the social sciences (e.g., American Psychological Association, 2010), and the arts and humanities (e.g., Modern Languages Association, 2016; University of Chicago Press, 2017). In contrast, the latter Vancouver style has become a very common style within the fields of engineering, technology and science. The name is derived from the inaugural meeting in Vancouver, Canada in 1978 of a committee later referred to as the International Committee of Medical Journal Editors (ICMJE) (BMA, 2012). The style is typified by its use of numbers for in-text citations; as such, it is also known as the author-number system. One of the most common versions of the Vancouver Style is the IEEE Reference Guide (IEEE 2018). The numbers used for in-text citations correspond to a numbered reference list at the end of the text. Typically, the numbers refer to the order in which the referenced authors first appear in the text. Thereafter, they continue to be referred to by this number. A lesser utilised variation of this style can feature the numbers corresponding to an alphabetical list of authors.

There is a third system of notes and bibliography. This is one of the two styles in the Chicago Manual of Style; the other is an author-date style. Notes and bibliography is mostly used by the fields of literature and history. It is occasionally utilised in the field of arts, but it is considerably less common than the Harvard style. Among the 97 English doctoral dissertations available online in AaltoDoc as of 5 March 2020, only 14 utilised this method. As it is relatively rare within Aalto University, it is recommended to visit the Chicago Manual of Style online for the reference style guide for it.

The two key considerations in adopting a particular style are that you agree with your supervisor on the particular style at the start of your thesis writing process and that you remain consistent in the use of the style throughout your thesis. Your supervisor can provide recommendations for you on the common style guides generally used in your field.

Below, you will find general guidelines to these two major styles with reference to the specific style guides in use. Corresponding examples are provided in the boxes below. Please note that the use of boxes here is only to visually separate the examples for clarity’s sake and that boxes should not be used when quoting or paraphrasing in your own thesis.

Direct quotes

If you are using the exact wording from a source, you should place this in double quotation marks (“ ”) followed by the author, date, and page number in parentheses (if using the Harvard style) or a number in square brackets [if using the Vancouver style]. The citation should be on the same line and inside the punctuation. This citation should correspond to a full reference in the References / Bibliography / Works Cited section of your thesis. The punctuation used between the author, date, and page number may vary depending on which style guide you are using (compare, for example, The Chicago Manual of Style (University of Chicago Press, 2017), The Publication Manual of the American Psychological Association (APA, 2018), The MLA Handbook (MLA, 2016) and The New Oxford Style Manual (OUP, 2016)). However, it should be noted that the frequency of direct quote usage varies significantly between academic fields. While it is a fairly common practice to utilise quotes within art, design, architecture and business, it is rare in the science and engineering fields. Therefore, it is recommended that you ask your supervisor or check well-known journals in your field to gauge the frequency of quoting preferred by experts in your field.

Quoting in Harvard style

**Example 1:** Quote, information-prominent, American Sociological Association (2019) style

|  |
| --- |
| Attending to these breakdowns not only result in an on-going re-constitution of relations between people and things but are also hotbeds for unleashing everyday “creativity, invention, imagination, and artfulness” (Jackson, 2014: 226). |

*Source:* Durrani, M. 2018. Designers by any other name: exploring the sociomaterial practices of vernacular garment menders. *Design Research Society International Conference: Catalyst. DRS International Conference Series.* 4: 1731-1746. ISBN 978-1-912294-19-0 (electronic). DOI: 10.21606/dma.2018.495. *© 2018 Design Research Society. This work is licensed under a Creative Commons Attribution-NonCommercial-Share Alike 4.0 International License.*<https://creativecommons.org/licenses/by-nc-sa/4.0/>*.*

**Example 2:** Quote, author-prominent, American Psychological Association (2010) style

|  |
| --- |
| Philosopher Mark Johnson (2007) argued that meanings emerge from “deeper explorations into the qualities, feelings, emotions, and bodily processes” (p. x). |

*Source:* Aktaş, B. & Mäkelä, M. (2019). Negotiation between the maker and material: Observations on material interactions in felting studio. *International Journal of Design*, 13(2): 55-67. *© 2019 Aktaş & Mäkelä. Copyright for this article is retained by the authors, with first publication rights granted to the International Journal of Design. All journal content, except where otherwise noted, is licensed under a Creative Commons Attribution-NonCommercial-NoDerivs 2.5 License.*

Block Quoting

Block quotes are used for longer quotes. Note the line indentation on each line of the block quote below, starting from “There was …”, and the absence of quotation marks. Each style guide recommends its own minimum text length before using block quoting. [Compare: AMA - four lines of text or more; APA - 40 words or more; or Chicago - 100 words or more.]

**Example 3:** Block quote, Harvard style, as recommended by journal

|  |
| --- |
| When the Center for Bits and Atoms won the National Science Foundation Grant in 2003, MIT engineers began to look for local communities around the world they could help via digital fabrication: “Instead of bringing information technology to the masses, the fab labs bring information technology development to the masses,” explained Gershenfeld, in the official press release (NSF 2004). Karlsen had a more colourful version:  There was an innovation competition launched by MIT globally to develop local projects. MIT sent some of its best teachers to Norway to find a suitable cooperation project. They found us through Telenor, who told them: ‘There is this crazy guy lost in the fjord who devised sensors for his animals.’ We enjoyed a great year of cooperation with MIT in 2001 and we were invited to Boston to present and develop this project. |

*Source:* Kohtala, C & Bosqué, C. (2014). The Story of MIT-Fablab Norway: Community Embedding of Peer Production. *Journal of Peer Production*, 5 (8): 1-8. ISSN 2213-5316 (electronic). © 2014 public domain. http://peerproduction.net/issues/issue-5-shared-  
machine-shops/peer-reviewed-articles/the-story-of-  
mit-fablab-norway-community-embedding-of-peer-production/

Paraphrasing

Paraphrasing a more prevalent citation practice in many academic fields. In engineering and science, paraphrasing tends to dominate with quotations used only sparingly. In other fields, such as art and design, the ratio of quoting to paraphrasing varies significantly. Again, it is best to ask your supervisor or review journals from your field to see how common the practice is amongst your academic peers.

The intent behind paraphrasing is that you write the ideas or arguments of a source in your own words. This citation practice can allow for better integration of ideas, argumentation, and flow within the text. A good rule of thumb for paraphrasing is to have more than 80% of the paraphrased text in your own words. If you only change a few words from the original, you can run the risk of plagiarism, even if you cite the source. Words matter. If you use the exact combination of words from another author, these must be in quotes.

Paraphrasing in Harvard style

**Example 4:** Paraphrase, author prominent, Chicago Manual of Style (2017) style

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| von Hippel (1986) suggested a four-step process for working with lead users: first identifying important trends and key customer needs, then identifying lead users and understanding their needs and possible solutions and finally working with lead users in order to improve or generate product/service concepts. |

*Source*: Hyysalo, S., Kohtala, C., Helminen, P., Mäkinen, S., Miettinen, V., & Muurinen, L. (2014). Collaborative futuring with and by makers. *CoDesign*, 10(3–4), 209–228. DOI: 10.1080/15710882.2014.983937. *© 2014 The Authors. This is an Open Access article. Non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly attributed, cited, and is not altered, transformed, or built upon in any way, is permitted.*

**Example 5:** Paraphrase, information-prominent, Harvard style as recommended by journal

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| Obviously digital technologies will not destroy comics as we know them, but they may change their underlying decorum. In reality, these changes have continuously shaped the lives of the industry’s amateurs and semi-professionals, who have to organize their time around a bricolage of fragmented schedules and poorly paid work (Woo 2015): from daily feeding a Patreon account while filling a scanlation request, to selling a print in Deviantart while reviewing the latest Doujinshi on a not-so-free-of-ads-blog are some of the patchwork tasks of the comics networked precariat in the age of semio-capitalism. |

*Source:* Manouach, I. (2019). Peanuts minus Schulz: Distributed Labor as a Compositional Practice. *The Comics Grid: Journal of comics scholarship*, 9(16), 1–21. <https://doi.org/10.16995/cg.139> *© 2019 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See* http://creativecommons.org/licenses/by/4.0/.

Paraphrasing in Vancouver style

**Example 6:** Paraphrase, information prominent, IEEE (2018) style

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| When a laser beam is scattered by a dielectric microparticle, resulting in light refraction on entering and leaving the particle, a small amount of momentum is transferred from the photons to the matter. This change in momentum, known as the gradient force, results in the attraction of the particle to the high intensity part of the beam (usually the centre). Optical trapping of microscale particles via this mechanism was first reported in the 1970s [1] and duly led to the initial observation of a single beam optical trap in 1986 [2]. These preliminary experiments, and many of the methodologies that developed from them, utilized the gradient force exerted by a single, tightly focused Gaussian laser beam to trap particles in solution through what has become known as the “optical tweezer” effect. Since these initial findings, optical technology has evolved significantly, and traps that facilitate three dimensional manipulation of particles are now readily available. While originally limited to the controlled manipulation of individual particles, multitrap setups involving either splitting [3,4] or time sharing [5,6] with a single laser beam are now also commonly utilized. As a more advanced form of the former, holographic optical tweezers that employ diffractive optical elements such as spatial light modulators now allow computer controlled, independent manipulation of multiple particles [7−9]. A number of multitrap devices have also been developed based on the application of laser beams with more complex phase and intensity profiles, as for example Bessel or higher order Laguerre Gaussian beams [10−12]. |

*Source:* “Chirality in Optical Trapping and Optical Binding” by David S. Bradshaw, Kayn A. Forbes, Jamie M. Leeder, and David L. Andrews in *Photonics* 2015, available under a Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>) at <https://doi.org/10.3390/photonics2020483>.

If you would like to emphasise the inventor, you could rephrase the first in-text citation as “was first reported by Ashkin in 1970 [1]” or “was first reported by Ashkin [1]” if the year is less important. (Ashkin is the sole author of the paper. It was published in 1970.)

Tips for paraphrasing

1. Identify the important points from the source text. Then, try to identify the relationship between these different parts. Is the relationship sequential, causal, contrasting, or conditional? Can these be replaced by synonyms? For example, the contrasting conjunction, *but,* can be replaced by *however, although, nevertheless, yet* or *on the other hand.* In many cases, these synonyms may require that you change the structure of the sentence, which in turn may help you to formulate the ideas in your own words.
2. Synonyms - A word such as *give* can be replaced with *provide*, *supply* or *contribute*. Refer to a thesaurus for more examples. You can find these online or at the Learning Centre. If you are unsure of how a new word might be used, check a dictionary or search the word in Google Scholar for examples of its use in context.
3. Common phrases - There are often multiple ways of expressing a given phrase in academic writing. For example, compare “Previous studies have not dealt with…” with “Researchers have not treated X in much detail” or “Most studies in the field of X have only focused on…” These examples were drawn from the University of Manchester’s (2018) Academic Phrasebank (<http://www.phrasebank.manchester.ac.uk/>). This corpus of common phrases includes hundreds of examples, categorised according to their functions.
4. Additions or deletions - Can you add a missing item? Can you leave something out?
5. Change the structure of the sentence - There are many ways to change the structure. Can you change the sentence from passive voice to active voice, or vice versa? Can you rewrite the sentence with “It is” or “There is”? Can you switch to the inanimate agent, e.g. “This thesis discovered”? Refer to the Aalto University Language Centre site (<http://sana.aalto.fi/awe/>) in the “Cohesion” section for more ways to change the structure of a sentence.

**Example 7:** Before and After Paraphrase

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| **Before Paraphrase**  “Significant progress has been made in the use of smart textiles in wearable technology, especially in the sport and well-being sector. However, the medical sector still lacks commercial and viable solutions” (Ilen et al., 2019, p. 2).  **After Paraphrase**  While some industries have taken advantage of smart textiles in wearable technology, Ilen et al. (2019, p. 2) contend that the medical industry has yet to produce any viable products. |

*Source*: Ilen, E., Groth, G., Ahola, M., & Niinimäki, K. (2019). *Empathy in a Technology Driven Design Process: Designing for Users without a Voice of their Own*. Paper presented at 8th biannual Nordic Design Research Conference: Nordes 2019: Who Cares?, Espoo, Finland. Open Access paper.

Avoiding the pitfalls of the Finnish paragraph-length paraphrase (FPP)

In Finland, there exists a method of citation that is not permitted or recognised by many international style guides, including IEEE Reference Guide (IEEE 2018); Information and documentation – Guidelines for bibliographic references and citations to information resources (ISO 690:2010(E)) (ISO 2010); New Oxford Style Manual (OUP 2012); Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers (CSE 2012); The Chicago Manual of Style (University of Chicago Press 2017); The Publication Manual of the APA (APA 2018). Due to this and the reasons discussed below, it is not recommended that his method be used when writing in English. Interestingly, the Finnish Standards Association (Suomen Standardisoimisliitto SFS ry) which emulates the ISO standard, does not recognise this either (FSA 2010). In the Finnish style of citation, writers can write an entire paragraph where every sentence comes from a single source. Then, at the bottom of the paragraph, they provide a citation in brackets outside the final punctuation (see example below). Generally, the Finnish method suggests that by putting the citation after the period, the citation then refers to all the sentences preceding it in the paragraph.

**Example 7:** Paraphrase, Finnish style, not recommended in English

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| Additive manufacturing was originally developed to guide product design by providing a way to create prototypes directly from digital designs. This method called rapid prototyping (RP), as the name implies, consumes less time and resources than most preceding techniques. For instance, the manufacturing of an injection mold for prototyping purposes would be extremely expensive. However, the part can be created with additive manufacturing for a fraction of the cost. Moreover, rapid prototyping is cost and time effective when it can substitute handcrafting, CNC manufacturing, or silicon molding. The downside when compared to these methods is often poor surface quality and inferior dimensional accuracy. However, RP enables fast iterative testing of products with a low threshold of prototypes failing expectations. This makes it a superior tool in product development and explains why prototyping has been the leading application of AM. (Wohlers 2013) |

*Source:* Anonymous. (2015). Bachelor Thesis. Adapted from Anonymous, Bachelor thesis, School of Engineering, Aalto University, Espoo Finland, 2015. This work is licensed under an Attribution-NonCommercialNoDerivatives 4.0 International license.

This style has several inherent problems. To begin with, it significantly limits the writer from utilising what the noted academic writing scholar Ken Hyland (2005) has called stance and engagement within the actual paragraph. This is where the writer adds their own authorial voice to the text by interacting with the source material and with the readership in order to situate themselves in their community of academic peers. This interaction is achieved in the context of stance and engagement by the use of attitudinal markers, boosting, hedging, self-mentioning, directives, personal asides, questions, reader pronouns, and shared knowledge (Hyland 2005, 177). Within this long form Finnish paraphrase, the stance and engagement can logically be attributed only to the original cited source, not the current writer summarising the ideas of the source, for there is no meaningful way to discern ownership of ideas beyond the citation attribution. In example 8 above, it is possible to identify at least 10 separate statements made in the paragraph. Some of these are representative of stance, including claims (e.g., ‘The downside when compared to these methods is...’ and ‘This makes it a superior tool…and explains why prototyping has been the leading application in AM’) and logical connections (‘Moreover’, and ‘However’). Moreover, there are clear attempts at engagement with asides (e.g., ‘as the names implies’) and creating interpersonal solidarity with experts in the field through boosting (e.g., ‘extremely’ and ‘superior’). While some of these may have been the thesis writer’s own arguments, it would, for the reader, appear that these have all been paraphrased from the source (Wohlers 2013). From a larger perspective, this Finnish paraphrase style tends to promote a less critical style of writing where writers tend to summarise the work of others and avoid critically discussing individual ideas from sources as they are introduced.

Similarly, this Finnish paraphrase style can lead fledgling writers quite easily into practices that constitute plagiarism. For instance, when students write their bachelor’s thesis, it can often take the form of a literature review. When the perceived goal is to summarise others’ ideas, it can readily lead to an overuse of this FPP style. According to the Chicago Manual of Style, this could constitute plagiarism: ‘(u)se that is not fair will not be excused by paraphrasing. Traditional copyright doctrine treats extensive paraphrase as merely disguised copying’ (University of Chicago Press 2017, 212). It is similar to the problem of overuse of block quotes in the arts, humanities, and social sciences.

Worse yet, the logic of the FPP style has led some students to the practice of summarising two or more sources into a single paragraph with the citations provided only at the end of the paragraph. This would certainly constitute plagiarism as there is no meaningful way for the reader to discern which idea or argument belongs to which author. Unfortunately, this logical leap does not appear to be a rare occurrence. In a recent survey of 41 theses written in English at Aalto University between 2008 and 2018, 85% (35 samples) used the FPP style, while the multiple citation problem occurred in 41% (17 samples) (Forget and Paloposki 2019).

While it is generally better to introduce a citation and immediately contextualise it (i.e. integrate it into your argumentation; explain its significance; agree/disagree with it; or contrast it), it is possible to continue discussing a single source without using the same citation at the end of every sentence.

For instance, the Publication Manual of the APA (APA 2018) recommends maintaining a clear progression of the topic at the start of the next sentence.

**Example 9:** APA-recommended method of paraphrasing same source across consecutive sentences

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| Chen and Liu (2004) studied the effect of aggregate size distributions and the volume fraction of aggregate on the fracture parameters of concretes with strength 50 – 89 MPa under three-point bending test. For this purpose three various maximum aggregate sizes of 10, 15 and 20 mm were employed. |

*Source:* Rashad, A. and Seleem, H. (2014). A Study of High Strength Concrete with Moderate Cement Content Incorporating Limestone Powder. *Building Research Journal*, 61(1): 43 – 58. DOI <https://doi.org/10.2478/brj-2014-0004>. This work is licensed under a Creative Commons Attribution-NonCommercialNoDerivatives 3.0 International license.

In example 9, it is clear the Rashad and Seleem are still referring to Chen and Liu’s article in the second sentence by starting with ‘For this purpose…aggregate sizes…’ Although one would suffice, both noun phrases are clearly connected by topical progression to the narrative of the first sentence.

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References in the Harvard Style

The reference list below contains examples of a scholarly article, book, chapter in a book with editors, conference publication, doctoral dissertation, interview, master’s thesis, motion picture, painting, photograph, standard and webpage. These have been formatted in the American Psychological Association (APA) style, one variation of the Harvard Style. Please note that the APA recommends including the digital object identifier (DOI) for sources found online. When the DOI is missing, they recommend including the home page URL. Although the APA guidelines do not require a date of retrieval, it is good practice to note the date retrieved as online sources can change over time.

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The reference list below contains examples of scholarly articles [1, 2], a book [3], a chapter in a book with editors [4], a conference publication [5], a master’s thesis [6], a doctoral dissertation [7], a standard [8] and a webpage [9]. Note that the IEEE style allows DOIs, but does not require them. For online references, you should specify the ‘accessed date’ if it is a webpage that might change. Scholarly articles and theses should not change, and thus the access date is not important for such references. Today, some periodicals use article numbers [2] instead of ordinary page numbers [1]. Please see [10] for more details.

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1. A note on English grammar: Split infinitives are still shunned sometimes in many circles. Use them; they are not wrong. They often improve clarity. P.S. The use of footnotes in your thesis is not recommended. The present note is a classic case of ‘do as we say, not as we do’. [↑](#footnote-ref-1)