University of Zurich[UZH]

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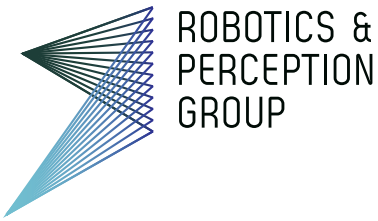

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RPG Thesis Template

Semester Thesis

Robotics and Perception Group
University of Zurich

Supervision

First Supervisor
Second Supervisor
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Contents

Abstract

Compress the introduction in a few key sentences. No more than half a page. The abstract should motivate your work, outline the work that you did, and give some insights into its results.

Nomenclature

Notation

$\mathbf{J}$	Jacobian
$\mathbf{H}$	Hessian
$\mathbf{T}_{WB}$	coordinate transformation from frame B to frame W
$\mathbf{R}_{WB}$	orientation of B with respect to W
${}_W\mathbf{t}_{WB}$	translation of B with respect to W, expressed in coordinate system W

Scalars are written in lower case letters (a), vectors in lower case bold letters ($\mathbf{a}$) and matrices in upper case bold letters ($\mathbf{A}$).

Acronyms and Abbreviations

RPG	Robotics and Perception Group
DoF	Degree of Freedom
IMU	Inertial Measurement Unit
MAV	Micro Aerial Vehicle
ROS	Robot Operating System

Chapter 1

Introduction

Describe the problem and the motivation for this research.

1.1 Related Work

Describe the current state of the art. Provide all necessary citations.

Chapter 2

Scientific Writing

This chapter gives you some tips on how to write scientifically. It should prevent you from making the most common mistakes people do and help you with creating a well written report.

2.1 General Style

- A report/paper is not a short-story. There is no build-up to a climax. The climax should be in the abstract. Even better, in the title.
- Hierarchical exposition, not linear: this goes in hand with the previous point. A hierarchical exposition means that you start with the core of your work (The main thing your project was about) and then go into details in following sections. Do not build up to the core of your work with too much background/preliminaries as it would be the case in a linear exposition.
- At the beginning of every chapter/major section, you should summarize what the content of the section will be. A person should get a good sense of the report by reading the first paragraph of each section.
- Express your thoughts succinctly. Avoid unnecessary words or phrases and be precise and specific.
- Definitions are useful if they are used often. Do not define something if it is only used once.
- Be generous with your references. Do not compare your results with others by pointing the deficiencies of their work; rather, state how your results are adding to the body of knowledge others have created.
- Notation is extremely important. Good notation facilitates understanding. You do not want the reader to mentally perform translations every time they see a symbol.

2.2 Important Stuff

- Use active verb tense whenever possible: instead of *An analysis of the signal noise is performed using a discrete Fourier transform.* write **We perform an analysis of the signal noise using a discrete Fourier transform.**
- Make short sentences with one statement. Long sentences with multiple statements are complicated and hard to understand. Write to be understood, not to impress!
- Be concrete/specific: instead of *We use a model to predict the state* write **We use a linear model of the attitude dynamics to predict the quadrotor's state at time** $t + \Delta t$.
- Be precise: instead of *We assume the model to be linear*, say **We design a linear model of the system dynamics**. (You assume the *system dynamics* to be linear and hence you create a linear model.)
- Be consistent: this basically applies to every level. Denote the same thing always with the same word, create figures with a similar style, etc.
- Do not make unsubstantiated statements. Do not use *It is common knowledge* or *Several researchers have shown.* Instead use constructs like **Recently, several researchers [?, ?] have shown**.

2.3 Small Things

- Do not use *don't*, *aren't*, etc., use **do not** and **are not**.
- Do not use words like *simply*, *highly*, *just*, *very*, *a lot*, etc.
- Use **because** instead of *due to the fact that*, **to** instead of *in order to*, etc.
- When referencing to figures, sections, etc., use capital letters: see Figure 3.1, see Section 2.
- Every figure, table, and algorithm must be referenced in the text.
- Put punctuation marks after each formula as if they were text. Separate multiple consecutive formulas by commas and put a period if you start a new sentence after the formula. For more details, see Section 3.4.
- Avoid brackets. If something is important enough to be mentioned it does not need brackets; if not, it does not need to be mentioned at all.
- In English, after a colon (:) you continue with small letters.
- Use *we* to refer to yourself: **We** developed an algorithm to ...
- Do not use *ours*.
- Use the "Oxford comma" when you list three or more items, e.g., we used red, green, and blue balls.

- Put a hyphen for multi-word adjectives, e.g., high-speed robotics, state-of-the-art research.
- Put details in an appendix.
- Avoid single-sentence paragraphs.
- Do **not** start sentences with a citation (*[**?**] proposed a similar approach.*) or a variable (*f is the focal length.*).
- Number all equations.
- Do not use the word "equation" before a reference to an equation, unless it is at the beginning of a sentence. Example: Equation (12) is a simplification of (4).

Chapter 3

LaTeX Tips and Tricks

In this chapter, we show some useful tips and tricks when working with LaTeX.

3.1 Using Git

We recommend you to use *Git* also for your LaTeX files such as this report. If you do so, we suggest to write every sentence in your TeX file on a new line. This will make it easier to keep track of changes since *Git* tracks them line by line. So if you change one sentence, *Git* will tell you that only that sentence has changed instead of the entire paragraph otherwise. Furthermore, if you are using the PDF viewer of *texmaker*, you can jump from the PDF directly to the sentence in the TeX file by clicking on it (instead of just jumping to the corresponding paragraph).

3.2 Headings

Your report can be structured using several different types of headings. Use the commands `\chapter{.}`, `\section{.}`, `\subsection{.}`, and `\subsubsection{.}`. Use the asterisk symbol `*` to suppress numbering of a certain heading if necessary, for example, `\section*{.}`.

3.3 References

References to literature are included using the command `\cite{·}`. For example [**?**, **?**]. Your references must be entered in the file `bibliography.bib`. Making changes or adding new references in the bibliography file can be done manually or by using specialized software such as *JabRef* which is free of charge. Most references you will need are already available in the `rpg_bib` repository.

Cross-referencing within the text is easily done using `\label{·}` and `\ref{·}`. For example, this paragraph is part of Chapter 3; more specifically on page 5. Use ~ to make spaces which LaTeX must not separate: `Figure~\ref{fig:bla}`, `in~\cite{KleinMurray2007}`, `focal length~$f$`. This avoids having the word and the number on different lines.

3.4 Writing Equations

The most common way to include equations is using the `equation` environment. Use `\eqref{·}` to reference an equation, e.g., (3.1).

Use `\left(` and `\right)` when you have mathematical expressions that are higher than normal brackets, e.g., $\left(\frac{pV}{RT}\right)$ instead of $(\frac{pV}{RT})$.

Embed equations in the text. Thus you must use proper punctuation. You must introduce all symbols that you use. You should define these before you use them. However, they must be introduced in the same sentence at the latest.

Example 1

For n detections and m LEDs on the object, we will obtain N pose candidates,

$$N = 4\alpha \binom{n}{3} \frac{m!}{(m-3)!}, \tag{3.1}$$

where $\alpha \in \{1, 2\}$ is a magic factor.

Example 2

The transformation matrix in homogeneous coordinates, `T`, is composed of the rotation matrix $\mathbf{R}$ and translation vector $\mathbf{p}$,

$$\mathtt{T} = \begin{bmatrix} \mathbf{R} & \mathbf{p} \\ 0 & 1 \end{bmatrix}, \qquad \text{with} \quad \mathbf{R} \in SO(3), \quad \mathbf{p} \in \mathbb{R}^3. \tag{3.2}$$

3.5 Including Graphics

The easiest way to include figures in your document is to use PDF figures if you use `pdflatex` to compile. Figure 3.1 was created with the use of the open-source program `ipe`.

3.6 Including Matlab Figures

When including figures into your report you want them as a vector graphic such that you can zoom into the figure without getting blurry. Furthermore

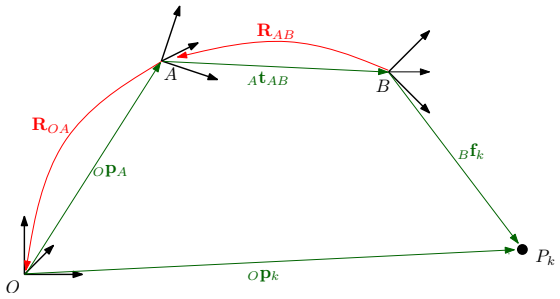


Figure 3.1: Example of a figure.

it is nice when the text in the figure gets substituted by LaTeX such that you have the same font and the same font size. Figure 3.2 shows an example of such an imported matlab figure. An easy way of achieving this is by using the `matlab2tikz` script. You can find a short example on how to use this script in the `matlab_figures` folder. The `create_figures.m` script creates a plot and then the tikz file which you can include in your document. For using tikz, you need to make use of the `pgfplots` package in your TeX document. More information on using `matlab2tikz` can be found on Matlab Central where you can also download the necessary files (`matlab2tikz.m`, `matlab2tikzInputParser.m`, `updater.m`).

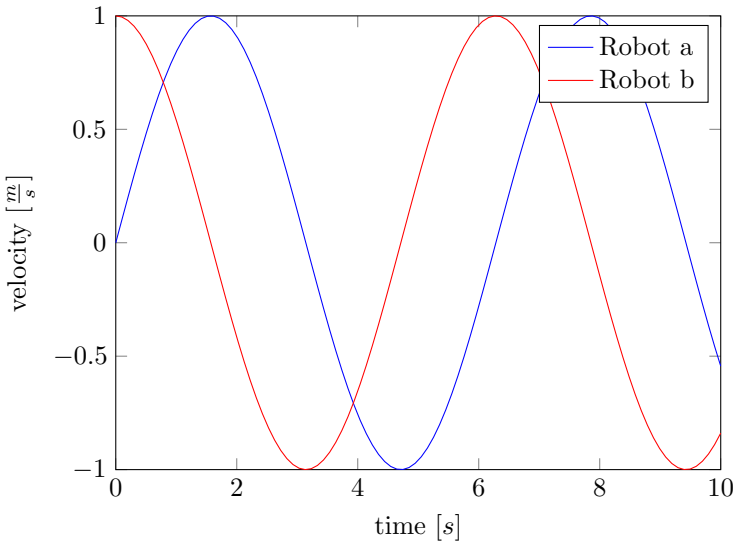


Figure 3.2: Example figure created with `matlab2tikz`.

An alternative which you might want to consider is `matlabfrag` and `mlf2pdf`. Especially when there are many data points in your figure you might run into problems when using tikz. Again, you can find a short example on how to use `mlf2pdf` in the `create_figures.m` scriptin in the `matlab_figures` folder. This script makes use of the two functions `matlabfrag.m` and `mlf2pdf.m` to

create a PDF which you can then include into matlab. These two files can be downloaded here and here.

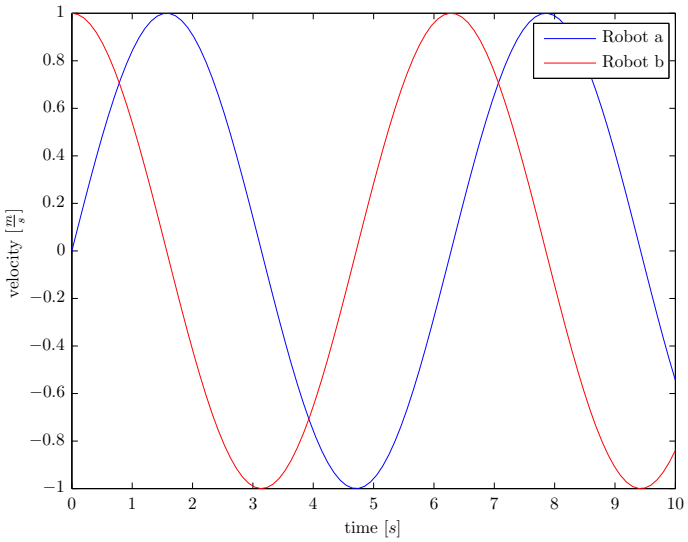


Figure 3.3: Example figure created with `mlf2pdf`.

3.7 Including Code in your Document

You may include samples from your Matlab code using the `lstlistings` environment, for example:

Listing 3.1: Matlab Example

```
% Evaluate y = 2x
for i = 1:length(x)

  y(i) = 2*x(i);

end
```

Listing 3.2: C++ Example

```
// sum all elements in a list
int sum=0;
for(list<int>::iterator it=mylist.begin(); it!=mylist.end(); ++it)
  sum += *it;
```

Chapter 4

RPG Notation Style

This chapter presents some conventions on notation that we use at the Robotics and Perception Group. Try to stick to those conventions since a unique style makes it easier to review the report.

4.1 Variable styles in LaTeX

Use lowercase and bold letters for vectors, e.g. $\mathbf{x}$, uppercase and bold letters for matrices, e.g. $\mathbf{R}$, and lowercase letters with normal weight for scalars, e.g. s.

4.2 Coordinate Systems and Rotations

We use the notation introduced by Prof. Glocker in the course "Mechanik 3" at ETHZ to express coordinate frames, rotations and vectors. Refer to Chapter 5 "Kinematik" in the lecture script for more details [1]. Figure 4.1 gives an overview of how coordinate transformations and vectors are specified. Observe that the coordinate system in which a vector is expressed is always written as index before the variable, e.g. ${}_B\mathbf{t}_{AB}$ is the vector from A to B expressed the coordinate system B. For the ease of reading, the index for the origin coordinate frame can be omitted: ${}_O\mathbf{t}_k := \mathbf{t}_k$.

[1] http://mitschriften.amiv.ethz.ch/main.php?page=3&scrid=1&pid=87&eid=1

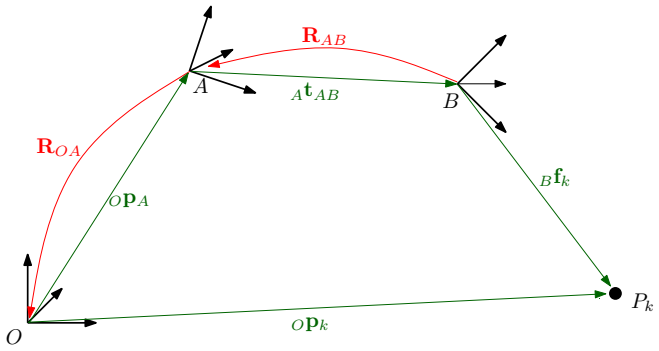


Figure 4.1: Notation overview.

A and B are two adjacent coordinate frames and O is the frame of origin. $\mathbf{R}_{AB}$ describes the coordinate transformation from frame B to frame A, thus it holds that

$$
\begin{aligned}
{}_O\mathbf{t}_k &= \mathbf{R}_{OB}\ {}_B\mathbf{f}_k, \\
\mathbf{R}_{OB} &= \mathbf{R}_{OA}\ \mathbf{R}_{AB}.
\end{aligned}
$$

4.3 Measured, estimated and target values

For controllers and estimators please specify the variables as follows in the report:

true value:	$\mathbf{x}$
estimated value:	$\hat{\mathbf{x}}$
measured value:	$\tilde{\mathbf{x}}$
desired value:	$\mathbf{x}_{\text{des}}$
error value:	$\mathbf{x}_{\text{e}}$
equilibrium value:	$\mathbf{x}^*$

Chapter 5

Experiments

Provide numerical results, plots, and timings. Interpret the data.

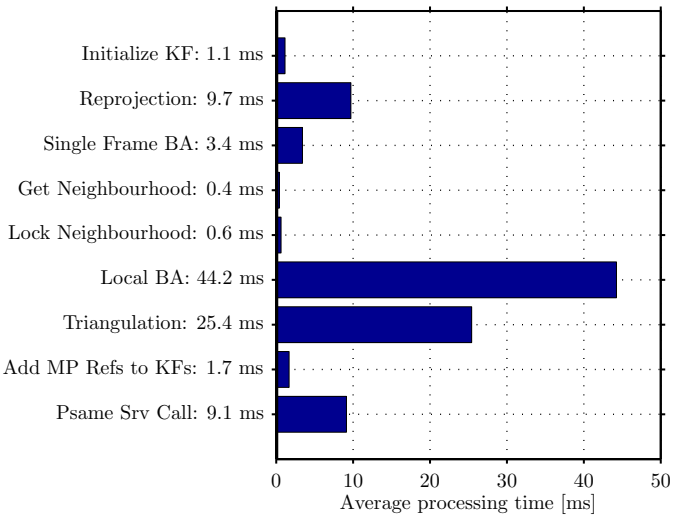


Figure 5.1: Example of a figure.

Chapter 6

Discussion

Explain both the advantages and limitations of your approach.

6.1 Conclusion

Summarize your work and what came out of it.

6.2 Future Work

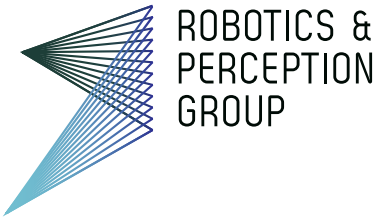
How would you extend the work? Can you propose another approach?

Appendix A

Something

In the appendix, you can provide some more data, a tutorial on how to run your code, a detailed proof, etc.

It is, however, not a requirement to have an appendix.



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