Advanced AUV Motion Control and Terrain Following for Automatic Seabed Inspection

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Declaration of Originality

I, Fabio Guelfi, hereby declare that this thesis is my own work and all sources of information and ideas have been acknowledged appropriately. This work has not been submitted for any other degree or academic qualification. I understand that any act of plagiarism, reproduction, or use of the whole or any part of this thesis without proper acknowledgment may result in severe academic penalties.

Acknowledgements

This is an optional section, where you can write acknowledgments. Don't forget to acknowledge your supervisor!

This is a short, optional, dedication. To all the Master and PhD students of Robotics Engineering at the University of Genova.

Abstract

The abstract should be a concise report of what the thesis is about. Do not use citations here, and avoid the use of abbreviations. It should not exceed one page of length.

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Chapter 1

Introduction

1.1 Content

In the introduction, please state clearly the context your work is framed within, and the motivations of your work. Furthermore, it is important to clarify your contribution (and not those of the group you work in - it is still an exam after all). Provide an outline of the thesis.

1.2 Basic commands

This is a citation: Caccia *et al.* (1999). Make sure to correctly enter all the bibliographic details. It is important that you double check them when retrieving the bibtex file from a source such as Google Scholar. Consistency in the references is valued by the Committee.

This is an emphasized word: *global*.

This is a reference to another part of the thesis: Chapter **??**.

This is an enumerated list:

1. first item.

2. second item.

This is an in-line equation: $x-$.

This is a word in quotes: "regular".

1.3 Equation

This is an equation:

$$\mathcal{U}_k(s_k) = \frac{P_k}{C_k}. \tag{1.1}$$

Equations follow the punctuation rules, as if they were inline with the text. This is an equation split over multiple lines:

$$\begin{aligned} x_k &= \mathcal{F}(x_{k-1}, u_k, w_{k-1}), \\ z_k &= \mathcal{H}(x_k, v_k). \end{aligned} \tag{1.2}$$

This is an example of equation with matrices:

$$\mathcal{Q}_l = \frac{d_l^2 \sigma_\phi^2}{2} \begin{bmatrix} 2\sin^2\phi_l & -\sin 2\phi_l \\ -\sin 2\phi_l & 2\cos^2\phi_l \end{bmatrix} \begin{bmatrix} cc\frac{\sigma_d^2}{2} & 2\cos^2\phi_l & \sin 2\phi_l \\ & \sin 2\phi_l & 2\sin^2\phi_l \end{bmatrix}. \tag{1.3}$$

This is a reference to the Equation 1.2. Avoid using unnumbered equations as it makes it difficult to reference them during a discussion. Also, be consistent in the use of matrix or vector notation. For example, $\dot{\boldsymbol{x}} = \boldsymbol{A}\boldsymbol{x} + \boldsymbol{B}\boldsymbol{u}$ or $\boldsymbol{y} = \alpha\boldsymbol{x}$, where the α is a scalar. You can change the corresponding definitions in the class file, as long as you remain consistent.

1.4 Figure

I add a figure.

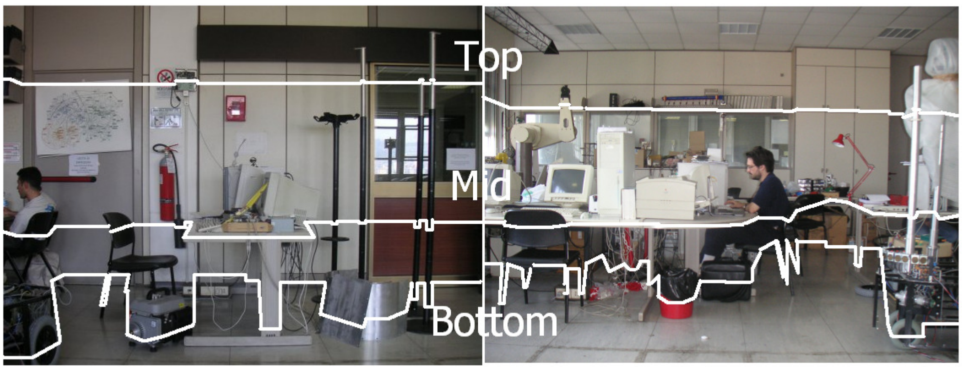

Figure 1.1: Scan profiles: *bottom*, *mid* and *top view*.

Make sure that figures axis are readable. Make sure to label all the units on both axes. The width of the lines should be also crosschecked for readability (the typical MATLAB plot might need higher line width). Double check that legends are present. Figures' captions should allow the reader to fully understand the figure.

This is a reference to Figure 1.1.

1.5 Table

The suggested packages for tables is tabular. There are many examples on the Internet. In general, avoid vertical lines, and use horizontal lines sparingly. Here S allows to align to the decimal point.

m	$\Re\{\underline{\mathfrak{X}}(m)\}$	$-\Im\{\underline{\mathfrak{X}}(m)\}$	$\mathfrak{X}(m)$	$\frac{\mathfrak{X}(m)}{23}$	A_m	$\varphi(m)$ / °	φ_m / °
1	16.128	8.872	16.128	1.402	1.373	−146.6	−137.6
2	3.442	−2.509	3.442	0.299	0.343	133.2	152.4
3	1.826	−0.363	1.826	0.159	0.119	168.5	−161.1
4	0.993	−0.429	0.993	0.086	0.08	25.6	90
5	1.29	0.099	1.29	0.112	0.097	−175.6	−114.7
6	0.483	−0.183	0.483	0.042	0.063	22.3	122.5
7	0.766	−0.475	0.766	0.067	0.039	141.6	−122
8	0.624	0.365	0.624	0.054	0.04	−35.7	90
9	0.641	−0.466	0.641	0.056	0.045	133.3	−106.3
10	0.45	0.421	0.45	0.039	0.034	−69.4	110.9
11	0.598	−0.597	0.598	0.052	0.025	92.3	−109.3

1.6 Algorithm

This is an algorithm:

1.7 Historical background

The first real underwater explorations date back to the Phoenicians, Greeks, and Romans, who, through diving and free diving, recovered corals, sponges, and objects from the seabed, in addition to defenses Erodoto (V sec. a.C.). Many years later, in 1535, Guglielmo de Lorena designed the first underwater bell for underwater inspections, but only at shallow depths Eliav (2015). It was not until 1934 that the first real exploratory expedition took place with William Beebe and Otis Barton's bathyscaphe to a depth of about 923 meters, and in 1960, Auguste Piccard's bathyscaphe, the Trieste, reached a depth of 10,916 meters in the Mariana Trench Jacques Piccard.

Algorithm 1 Split & Merge [& Split]

Require: A scan s. A stack $\mathcal{L}$. A counter j. A threshold τ
Ensure: $\lambda \leftarrow \mathcal{M}(s)$, $j = 1, ..., |\lambda|$

$\mathcal{L} = \texttt{push}(s)$
$j \leftarrow 1$
while $\mathcal{L} \neq \varnothing$ **do**
  $\mathcal{L} = \texttt{pop}(s_{top})$
  $l_j \leftarrow \texttt{fitting}(s_{top})$
  $q_k = \text{argmax}_q \, \texttt{dist}(\texttt{l}_j, \texttt{q})$
  if $\texttt{dist}(\texttt{l}_j, q_k) < \tau$ **then**
    $j \leftarrow j + 1$
    `continue`
  else
    $s_a \leftarrow \texttt{sub}(s_{top}, 1, k)$
    $s_b \leftarrow \texttt{sub}(s_{top}, k+1, |s|)$
    $\mathcal{L} = \texttt{push}(s_a)$
    $\mathcal{L} = \texttt{push}(s_b)$
  end if
end while
$\{l_j\} \leftarrow \texttt{merge}(\{l_j\})$
$\{l_j\} \leftarrow \texttt{split}(\{l_j\})$

1.7.1 Marine robotics

With the advent of technology, remotely operated vehicles (ROVs) emerged, allowing for deeper and more complex underwater exploration without putting human divers at risk. The most complex challenge was the communication between the ROV and the surface vessels. The solution was to build tethered systems that could maintain a constant connection. The CURV, Cable Controlled Undersea Recovery Vehicle, was the first ROV to be used in underwater missions.

1.7.2 Autonomous navigation

1.7.3 Underwater mission in seabed inspection

1.8 Motivation

1.9 Problem statement

1.10 Previous work and main contribution

1.10.1 Motion control of vehicles

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Terrain Tracking

Chapter 7

Controller

Chapter 8

Results and Simulations

Write the results here...

Chapter 9

Conclusions

Write the conclusions here...

Appendix A

Extra

Write here...

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