NTNU – Trondheim
Norwegian University of
Science and Technology

Visual Sensing in Mobile Robots

Vegard S. Lindrup

Submission date: December 2015
Responsible professor: Firstname Lastname, Affiliation
Supervisor: Firstname Lastname, Affiliation

Norwegian University of Science and Technology
Department of Telematics

Abstract

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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And after the second paragraph follows the third paragraph. Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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Preface

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. If you read this text, you will get no information. Really? Is there no information? Is there a difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. This text should contain all letters of the alphabet and it should be written in of the original language. There is no need for special content, but the length of words should match the language.

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Chapter 1
Introduction

This section is intended to provide an overview of the contents and context of this report. The first part of this section gives a brief introduction to the field of mobile autonomous robotics and computer vision, as well as the benifits and potential applications for this technology. The robot system and tools used in the project is presented in subsection **??**. Lastly, each of the following sections will given short introductions.

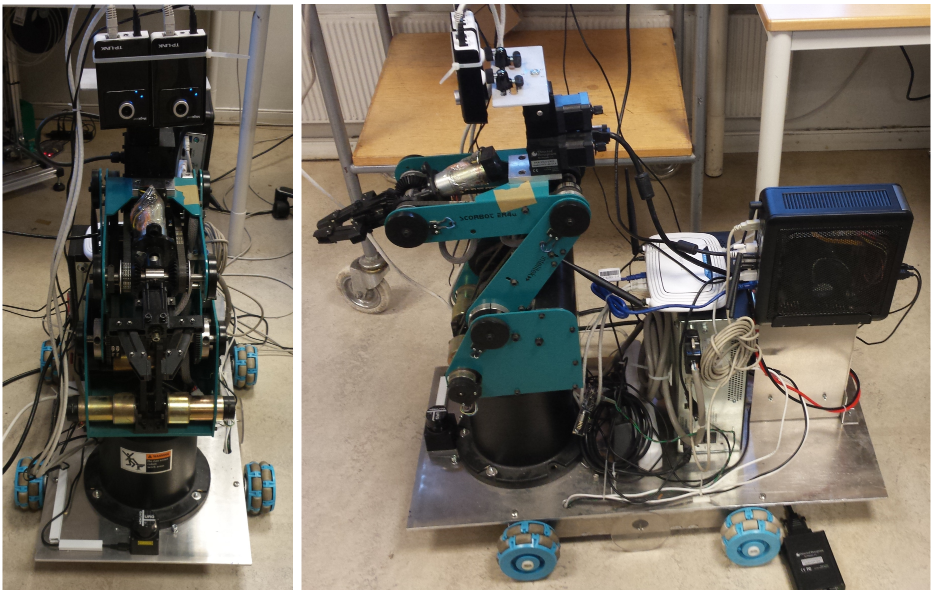
1.1 Mobile Autonomous Robotics and Computer Vision

Put the task into a larger context. Bring in some points on the societal impact of autonomous robotics and the increased potential of mobile robotics.

The field of computer vision has seen an enormous growth over the last few decades - not only in scale, but in accessibility and capability as well. As a consequence of this recent growth, tapping into the field of computer vision is bound to reveal applications that are useful for a mobile autonomous maintenance robot. Recent discoveries within computer vision includes robust feature recognition and object detection, face detection and video processing. The latest great additions to the field are Big Data and Artificial Intelligence.

1.2 System Overview

The mobile robot being worked on in this project is shown in figure 1.1a. The manipulator arm has been used in previous projects on robotic maintenance, and it was placed on the mobile platform during the master thesis of (Aspunvik og siter). This section provides a short description of the hardware. If a more detailed description of the robot and it's equipment is required, consult the thesis of Aspunvik[cite].



(a) Front view. (b) Side view.

Figure 1.1: The robot used in the project.

1.2.1 Propulsion

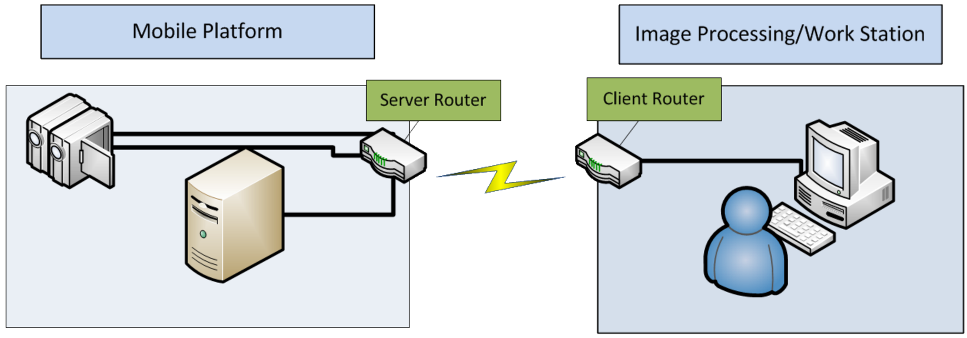
The steel chassis of the robot stands upon four omni-wheels. The wheel pairs are placed in parallel, making the vehicle uncontrollable along the lateral axis. Each wheel is powered by an electrical motor and motor driver. The motor drivers are controlled with pulse width modulation by an evaluation board from Atmel,(atmel kort).

1.2.2 Sensors

The robot was outfitted with several sensors during previous projects. These are:

- Two odometer wheels with encoders. One on each side.
- Two infrared distance sensors.
- A LIDAR (Light Detection and Ranging).
- Two IP-cameras.

Only the cameras were used in this projects.



1.2.3 The Manipulator

1.3 Report Structure

How the report is structured, and a very brief description of the contents in each section.

Chapter 2

Background Theory

2.1 Introduction to Computer Vision

2.1.1 Introduction

nanana

2.1.2 How it's Done

nanana

2.1.3 OpenCV

OpenCV started... 1999 Intel. Today, it is a fully open source library with a vast number of advanced computer vision algorithms. The pre-build library can quickly be plugged into an IDE such as Qt Creator or Visual Studio 2013 (not tested for compatibility with Visual Studio 2015 at the time of writing), thus giving the programmer access to all basic OpenCV features. A steb-by-step guide for using both the pre-built and a custom-built library can be found in Appendix **??**.

2.2 Stereo Vision and Depth Perception

Stereo vision and depth perception is one of the core topics within this report. Here, the theory behind a method using two cameras is presented, while some additional methods are mentioned to provide context.

2.2.1 Various Methods

Methods for computer vision can be separated into two main categories, i.e. active and passive. Active sensors will usually project a light pattern onto the scene to be perceived, before sensing how this pattern is displaced by the topology of the scene. The Kinect sensor and 3d-scanners using laser light are typical examples of active

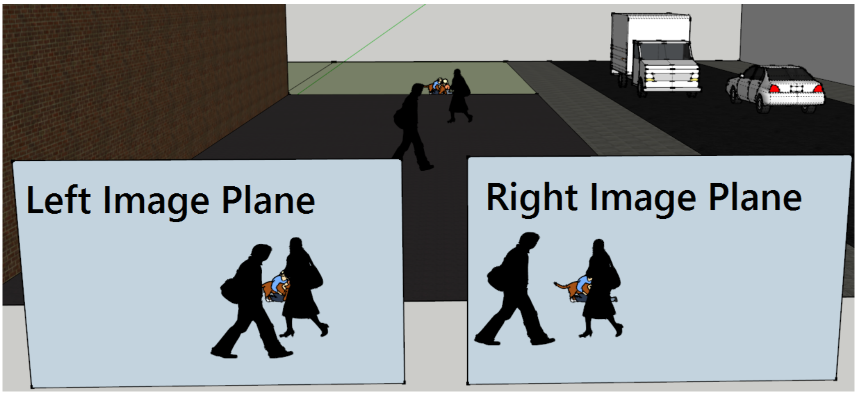


Figure 2.1: Left to right displacement on the image plane based on distance.

sensors. Passive depth perception makes use of many of the same cues we use to perceive depth. The most common passive sensors extract the depth information by observing observing a scene from at least two different positions.

Optical flow is another important method for depth perception. Optical flow may be either active or passive. The passive variant requires only one camera, but depends on motion and a stream of images to extract depth information. Observing how much some chosen features in a scene has moved in the image frame at $t = 1$ compared to the frame at $t = 0$ is the basis of depth sensing from optical flow. In a scene where all objects are stationary, objects that are far away will naturally have an optical flow field with a smaller magnitude than objects that are close.

2.2.2 Stereoscopic Vision in General

In this project, passive stereoscopic vision is achieved by using two identical (in theory) cameras placed on the same plane. The cameras are placed a few centimetres apart. The gist of passive stereoscopic vision is based on the fact that objects close to the cameras will have a large displacement from the left to the right camera compared to objects that are further away. This is illustrated in figure 2.1.

Figure 2.2 illustrates the epipolar geometry of stereo vision based on two pinhole camera models. The illustration shows an ideal stereo camera set-up where The image planes are parallel and are related by a horizontal translation B, which is called the baseline. This implies that the projection X_L of the object X on the left image plane, relates to the projection X_R on the right image plane through B: $O_R = O_L + B$.

Cite [Ein05].

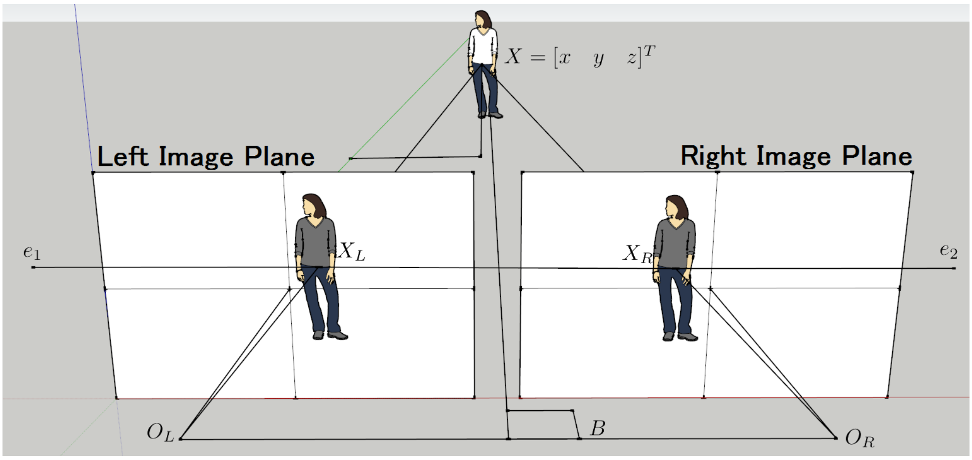


Figure 2.2: Geometry of stereo vision.

2.2.3 Stereoscopic Vision in OpenCV

The prebuilt version of OpenCV 3.0.0 comes with two stereo matching algorithms: Block Matching and Semi Global Block Matching. Additional algorithms are available if OpenCV is built with, e.g. CUDA.

Chapter 3
Example

Here is an example of how to use acronyms such as Norwegian University of Science and Technology (NTNU). The second time only NTNU is shown and if there were several you would write NTNUs. And here is an example[1] of citation [NN00].

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[1] A footnote

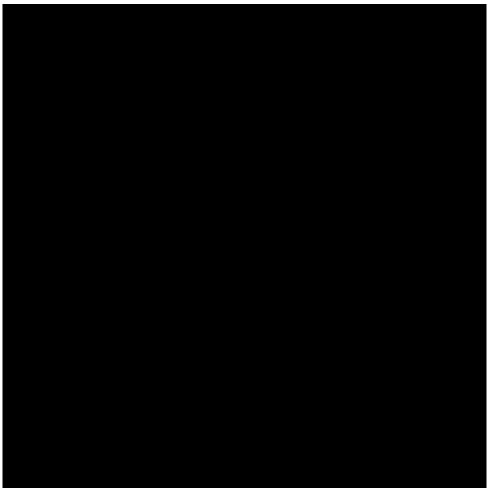

Figure 3.1: A figure

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3.1 First section

3.1.1 First subsection with some $\mathcal{M}ath$ symbol

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- item1
- item2
- ...

3.1.2 Mathematics

Hello, here is some text without a meaning. This text should show what a printed text will look like at this place. $\sin^2(\alpha) + \cos^2(\beta) = 1$. If you read this text, you will get no information $E = mc^2$. Really? Is there no information? Is there a

Table 3.1: A table

a	b	c	d	e
f	g	h	i	j
k	l	m	n	o
p	q	r	s	t
u	v	w	x	y
z	æ	ø	å	

difference between this text and some nonsense like "Huardest gefburn"? Kjift – not at all! A blind text like this gives you information about the selected font, how the letters are written and an impression of the look. $\sqrt[n]{a} \cdot \sqrt[n]{b} = \sqrt[n]{ab}$. This text should contain all letters of the alphabet and it should be written in of the original language. $\frac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\frac{a}{b}}$. There is no need for special content, but the length of words should match the language. $a\sqrt[n]{b} = \sqrt[n]{a^n b}$.

B
X_L
X_R
e_1
e_2
O_R
O_L
$X = [x \quad y \quad z]^T$

Proposition 3.1. *A proposition... (similar environments include: theorem, corrolary, conjecture, lemma)*

Proof. And its proof. □

3.1.3 Source code example

Algorithm 3.1 The Hello World! program in Java.

```
class HelloWorldApp {
  public static void main(String[] args) {
    //Display the string
    System.out.println("Hello World!");
  }
}
```

You can refer to figures using the predefined command like Figure 3.1, to pages like page 10, to tables like Table 3.1, to chapters like Chapter 3 and to sections like Section 3.1 and you may define similar commands to refer to proposition, algorithms etc.

Chapter 4

Implementation

4.1 Vanishing Point Detection

4.1.1 Overview

4.1.2 Line Detection

4.1.3 Line Filtering

4.1.4 Vanishing Point Detection

4.1.5 Graphical User Interface

4.1.6 Where it Fails

4.2 Depth Perception and Obstruction Detection

4.2.1 Overview

4.2.2 Stereo Matching

4.2.3 Finding Obstructions

4.2.4 Distance Measurment

4.2.5 Problems Encountered During Implementation

References

[Ein05] Albert Einstein. Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921, 1905.

[NN00] Firstname 1 Name1 and Firstname2 Name2. A dummy title. *A Fake Journal*, 1(1):000–000, June 2000.