# High Quality Depth Refinement with Color Photometric Stereo

**Songyou Peng**

Supervised by:

Dr. Yvain Quéau Prof. Daniel Cremers

Computer Vision Group

Department of Computer Science

Technical University of Munich

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**Abstract**

The abstract will go here....

*Research is what I'm doing when I don't know what I'm doing. . . .*

Werner von Braun

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# Acknowledgments

Leave this part until I finish the whole thesis

# Chapter 1

# Introduction

## 1.1 Research Goal

## 1.2 Outline

### 1.2.1 References

You can reference other authors by using the *citecommand* [1] [2]. You are encouraged to use bib files and let bibtex do the job for you.

# Chapter 2

# Background

Joint estimation of depth, reflectance and illumination for depth refinement

## 2.1 RGB-D Cameras

### 2.1.1 General

### 2.1.2 ASUS Xtion PRO LIVE

## 2.2 Shape from Shading & Photometric Stereo

## 2.3 Intrinsic Image Decomposition

## 2.4 Depth Map Refinement

## 2.5 Super-resolution Imaging

# Chapter 3

# Methodology

Describe the structure of this chapter.

## 3.1 Pre-Processing

The first step for most of the image processing tasks is to pre-process the initial input image. Due to the hardware limitation of modern inexpensive RGBD sensors, there usually exist holes with missing values on the depth images. Also, the depth data is often noisy so we need to do denoising and acquire a relative smooth surface.

In this section, we will describe respectively the basic depth inpainting and denoising algorithm that we use for our pre-processing.

### 3.1.1 Depth inpainting

Image inpainting itself is a very mutual area and has been widely applied as a useful tool for many modern computer vision applications, e.g, restore the damaged parts of ancient paintings, or remove unwanted texts or objects in a photography [3]. Since the idea of image inpainting is to automatically replace the lost or undesired parts of an image with the neighbouring information by interpolating, we were inspired to apply it to fill in the missing depth information.

It should be noted that, the depth inpainting is applied to the input noisy image so there is no need to use some powerful algorithms. The only request is to fill the missing areas with inexpensive computational time.

The general mathematical form of a typical inpainting algorithm [3] can be written as follows

$$I^{t+1}(i,j) = I^{t}(i,j) + \mu U^{t}(i,j), \forall (i,j) \in \Omega \tag{3.1}$$

where $I(i,j)$ is the pixel value in image $I$, $t$ is the artificial time step, $\mu$ is the updating rate, $U$ is the update information and $\Omega$ are the area with missing information.

To build the update map $U$ in each time step, there are two principles that we need to follow. One is the inpainted values inside $\Omega$ should be as smooth as possible. The other is the line reaching the edge of $\Omega$ should be continued and cross the missing area, while the values in $\Omega$ should be propagated from the nearest neighbours of $\Omega$ along the line.

Based on these two principles, w can model $U$ as

$$U = \tag{3.2}$$

### 3.1.2 Depth denoising

## 3.2 RGBD-Fusion method

### 3.2.1 ddd

## 3.3 Proposed method 1: RGB Ratio Model

### 3.3.1 Limitations

- *LEDs have to be set up far away from each other.*
- *Natural illumination is a problem.*
- *Only feasible for the simple albedo cases*

## 3.4 Proposed method 2: Robust Lighting Variation Model without Regularization

### 3.4.1 Depth super-resolution

# Chapter 4

# Results and Evaluation

## 4.1 RGB-D Cameras

### 4.1.1 General

### 4.1.2 ASUS Xtion PRO LIVE

## 4.2 Shape from Shading & Photometric Stereo

## 4.3 Intrinsic Image Decomposition

## 4.4 Super-resolution Imaging

# Chapter 5

# Conclusion

## 5.1 RGB-D Cameras

### 5.1.1 General

### 5.1.2 ASUS Xtion PRO LIVE

## 5.2 Shape from Shading & Photometric Stereo

## 5.3 Intrinsic Image Decomposition

## 5.4 Super-resolution Imaging

# Appendix A

# The first appendix

If you need to add any appendix, do it here... Etc.

# Bibliography

[1] Witold Pokorski and Graham G. Ross. Flat directions, string compactification and three generation models. 1998.

[2] Dumitru Ghilencea and Graham G. Ross. Unification and extra space-time dimensions. 1998.

[3] Marcelo Bertalmio, Guillermo Sapiro, Vincent Caselles, and Coloma Ballester. Image inpainting. In *Proceedings of the 27th annual conference on Computer graphics and interactive techniques*, pages 417–424. ACM Press/Addison-Wesley Publishing Co., 2000.