Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

IGP
Institute of Geodesy and Photogrammetry

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Title

Subtitle

Interdisciplinary Project

Institute of Geodesy and Photogrammetry
Swiss Federal Institute of Technology (ETH) Zurich

Supervision

Prof. Konrad Schindler

31st of May, 2019

IGP-XX-YY-ZZ

Abstract

Keywords: photometric stereo, Plan of St Gall, feature detection, image stitching.

Acknowledgement

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Chapter 1

Introduction

1.1 Plan of St Gall

The Plan of St Gall is one of the only remaining major architectural drawings from the period between the fall of the Western Roman empire until the 13th century (Reference wikipedia...). At nearly 1200 years of age and consisting of 5 pieces of parchment stitched together, significant care has to be taken to ensure that it is preserved into the future. For this reason, there has been expressed interested in capturing 3D information about the surface of the plan at a fine scale that may not have been readily visible by the human eye. By capturing this information digitally, it enables researchers, historians or other interested parties unrestricted access to the plan from wherever they are in the world. Furthermore, in the mission to preserve the plan, this will reduce the need for physical inspection of the plan and decrease the amount it is exposed to environmental conditions that will hasten the deterioration process of the plan.

1.2 Project Overview/goals

Previously, a high resolution photogrammetric stereo 3D model has been generated of the Plan of St Gall, but similarly to the Nyquist-Shannon sampling theorem for signal processing, the resolution of the 3D model has to be higher than that of the features one seeks to identify within it. The 3D model acquired, although of a high resolution, was not quite high enough to discern fine features in the parchment, such as needle holes, without having the physical parchment for comparison or a prior knowledge of the existing feature.

Because of this, it was proposed and accepted to perform an extremely high resolution photometric stereo capture of the full plan.

1.3 Photometric Stereo

Although photometric stereo does not natively provide a 3D model in the typical sense, but what it does capture is a set of 3D vectors representing the surface of the object projected onto an image plane. Thus the output is in the form of an image where the typical RGB colour channels representing a 3D normal vector for the area of the object that each pixel projected onto. This leads to the common reference of this being referred to as 2.5D data as the image only has 2 dimensions but the normal maps provide a discretised approximation of the normal vectors for the objects surface within the region each pixel covered.

In addition to the 3D properties of the plan that can be obtained through the normal maps from the photometric stereo, ambient and albedo images can also be generated which can also be used

to provide additional information about the surface of the objects reflectance properties which is not captured in a photogrammetric stereo model.

The resulting project of the collaboration between the Stiftsbibliothek and the group behind the Minidome from Leuven University (check names) can be described in three parts. The first part consists of the preparation and data capture of the Plan of St Gall largely performed by the staff from Leuven. The last two sections represent the individual works of the two authors regarding the specific works each author performed on the Plan of St Gall.

Chapter 2

Photometric Stereo Survey

2.1 Introduction

This section will describe the main physical processes and considerations regarding the data acquisition of the Plan of St Gall using the Minidome. This chapter will not provide an in depth explanation of photometric stereo, nor some of the finer details associated to the Minidome that as volunteered and controlled by the group from Leuven as the major part of this project was focussed on utilising the post-processed outputs from the Minidome provided by them.

2.2 Location

As the Stiftsbezirk St.Gallen are the custodians of the Plan and responsible for the safety and security of the Plan, the photometric stereo survey was performed within a secure room provided on the premises. This allowed allowed for not only the secure storage of the Plan and Minidome equipment overnight, but also the oversight of their staff for the handling of the Plan throughout the data acquisition.

2.3 Equipment

- Minidome - 270 LEDs Whitelight - 180 Multispectral

- Camera specs?

- 1 plan

- Tripods and rail setup for holding the minidome over the plan

- Trolley

- Tables which the trolley would be rolled along

- Tape to mark positions of trolley to ensure full coverage

- Measuring "tape"/"stick" (I'm not sure what the measuring things here are called... I'm used to the metal rolling ones

- Laptop and NES storage system for capture of all the data

2.4 Considerations

- Room selection

- White light / Multispectral
- Setup and movement of the plan
- overlap
- Room lighting
- Room temperature
- Moving of floor boards - During acquisition

2.5 Methodology

Acquisition - Geometric calibration
- Exposure calibration
- Acquisition
- White front
- White back
- Multispectral front
- Limitation of NUV / NIR exposure to plan - Cover

Processing - Camera calibration
- Exposure calibration
- Determine albedo / ambient / normal products
- Cluster processing for exposure correction

2.6 Results

2.7 Analysis

Chapter 3

Feature Extraction

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Chapter 4

Plan Stitching

4.1 Introduction

4.2 General Process

4.3 Photo Mosaicing

Hugin

Photoshop

OpenCV

ICE

Results

Discussion

4.4 3D Model Reconstruction

Normal Map to Point Cloud

Point Cloud Registration

Point Cloud Cleaning

Results

Discussion

Chapter 5

Analysis

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Appendix A

Example Appendix Chapter

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language = {english},
howpublished = {Version 1.6.0},
organization = {Institute for Dynamic Systems and Control ({IDSC})},
address = {ETH Z\"{u}rich, Switzerland},
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year = 2018
}
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Swiss Federal Institute of Technology Zurich

Institute for Dynamic Systems and Control

Prof. Dr. R. D'Andrea, Prof. Dr. E. Frazzoli, Prof. Dr. C. Onder, Prof. Dr. M. Zeilinger

Title of work:

Title

Subtitle

Thesis type and date:

Interdisciplinary Project, 31st of May, 2019

Supervision:

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