EUROGRAPHICS Workshop on Graphics and Cultural Heritage (2014)
R. Klein and P. Santos (Editors)

Poster

Facilitating Access to the Field of Geometry and Reflectance Acquisition

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Abstract

Documentation and presentation of cultural heritage can greatly benefit from photorealistic digitization. This field, however, is subject to ongoing research and very hard to enter for new researchers. This is mostly because a respective processing pipeline requires many steps that strongly depend on each other and thus must be fully implemented. Moreover, sophisticated acquisition hardware is expensive and usually difficult to construct due to its complexity. In this paper, we briefly summarize our ongoing work in this field. Our main contribution is a collection of datasets acquired with a state-of-the-art geometry and reflectance acquisition device. The datasets do not only include the raw scanner data, but also results of our individual processing stages. Other researchers can use this data to work on a specific task/stage without having to implement the full pipeline.

Categories and Subject Descriptors (according to ACM CCS): I.4.1 [Image Processing and Computer Vision]: Digitization and Image Capture—Scanning, I.4.1 [Image Processing and Computer Vision]: Digitization and Image Capture—Reflectance

1. Introduction

In the context of cultural heritage, object digitization methods have been used for many different tasks such as documentation/preservation [SBJB*14], virtual exhibition [SFKP09] and replication [Fow00]. Most of these applications use only 3D geometry, whose acquisition is supported by the easy availability of 3D scanners. However, it has been pointed out by several authors, that 3D geometry alone is often not sufficient, e.g. in the context of virtual museums. Digital exhibitions rely, among other things, on a realistic rendition and thus the object's appearance must be captured as well [NKRS13, SRWK13, SWRK11]. While acquisition of geometry and reflectance was treated independently in the past, research recently shifted towards methods for combined acquisition that allows to capture all data in a single pass. This is in general a challenging problem and strong subject to ongoing research. While the general approach is a very promising, we believe that it is very hard for new researchers to enter this field for two reasons. First, the required hardware for data acquisition is often complex and expensive, as it is required that sensors and light sources can be driven to positions around an object independently. [MMS*04] for example proposes a hemispherical dome with 151 cameras for this task, while in [HLZ10] two coaxial projector/camera units are driven around an object by robotic arms. [KNRS13] propose a full-spherical device that enables scanning in a single pass by using a glass carrier.

The second reason that prevents easy participation in this field is, that the processing pipeline from capturing the raw data to the final representation consists of many stages. Several of these stages are themselves subject to ongoing research, implementation thus requires significant domain knowledge. The processing of reflectance data e.g. requires calibration of all devices and reconstruction of the geometry beforehand. Without this information, it is for example not possible, to aggregate all available reflectance probes for a surface point. Research in this last step of the pipeline therefore requires substantial preparatory work because all previous pipeline stages such as geometric calibration, radiometric calibration, geometry processing and geometry parameterization need to be completely implemented before research can even begin.

We facilitate access to the field of geometry and reflectance acquisition by sketching our pipeline and providing datasets acquired with the device presented in [KNRS13]. Our datasets not only include the raw scanner data, but also the intermediate results of our individual, completely implemented processing stages. Other researchers can use this

DOI: 10.2312/gch.20141323

data to gain insight into our work. Moreover, they can focus on a specific task/stage without having to implement the full pipeline.

2. Datasets

We provide datasets of 6 different objects captured with the device proposed by [KNRS13]. The movable scanning unit of this device holds 7 cameras and one projector. Depending on the object, we use 14 to 20 scanner/object positions to cover the surface. Each dataset consists of the raw scanner output (i.e. the captured images) and all intermediate results of our processing pipeline. More detailed, we provide captured data of a porcelain vase, a brass teapot, two wooden figures, a gum figure and a plastic figure. We acquired three types of input data: Fringe images for geometry reconstruction, reflectance images for appearance reconstruction and a shadow-free color image that can aid in appearance or diffuse color reconstruction. In the following, we list the stages of our pipeline and the data we provide. Our pipeline is described in more detail in [NKRS13] and [KNRS13]. The data can be downloaded from http://av.dfki.de/orcam-dataset.

- **Phase computation:** We use phase shifted structured light [GZC07] with two phase functions per camera and level-based unwrapping [WNB10] to generate correspondences between all devices of a single scanner/object position. For each camera position, we provide 22 fringe images for each phase and the two unwrapped phase functions.
- **Device calibration:** We calibrate all cameras and projectors using the pinhole model and represent the light sources by point lights. We provide intrinsic/extrinsic parameters for each camera and light position and color for each light source used. Note that all parameters are computed in a single, global coordinate frame.
- **Point triangulation:** We triangulate a point cloud for each camera from the phase correspondences and use the projector for outlier removal as proposed in [KNRS12]. We thus provide, depending on the dataset, 98 to 140 individual point clouds and the corresponding filtered parts in a common frame.
- **Mesh extraction:** From all point clouds, we extract a mesh using the volumetric approach of [NKRS12]. We provide the mesh and an appropriate parameterization.
- **Reflectance estimation:** For each of the 98 to 140 cameras of a single dataset, we provide 19 reflectance images that are illuminated by different, individual light sources. Reflectace estimation is, in general, strong subject to ongoing research. In our datasets we aggregate all available reflectance probes per surface point and fit a parametric Ward reflectance model [War92] to this data. We provide three maps for storing the Ward model's parameters: A diffuse and specular color of the respective surface point and the surface roughness.

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