Single-Shot Analysis of Refractive Shape Using Convolutional Neural Networks

The appearance of a transparent object is determined by a combination of refraction and reflection, as governed by a complex function of its shape as well as the surrounding environment. Prior works on 3D reconstruction have largely ignored transparent objects due to this challenge, yet they occur frequently in real-world scenes. This paper presents an approach to estimate depths and normals for transparent objects using a single image acquired under a distant but otherwise arbitrary environment map. In particular, we use a deep convolutional neural network (CNN) for this task. Unlike opaque objects, it is challenging to acquire ground truth training data for refractive objects, thus, we propose to use a large-scale synthetic dataset. To accurately capture the image formation process, we use a physically-based renderer. We demonstrate that a CNN trained on our dataset learns to reconstruct shape and estimate segmentation boundaries for transparent objects using a single image, while also achieving generalization to real images at test time. In experiments, we extensively study the properties of our dataset and compare to baselines demonstrating its utility.

Visual Human-Computer Interaction

Technologies such as Virtual and Augmented Reality has gained extensive popularity in the recent years. Simultaneously, vision systems and computing power have reached a point, where it is possible to acquire and process geometric and appearance data to produce photorealistic renderings that can appear indistinguishable from real photographs. This enables new ways for Human-Computer Interaction (HCI) methods and applications, which should be further evaluated to explore their full potential. This thesis addresses a set of vision based challenges concerning HCI. The presented contributions fall into the overall themes of geometric acquisition of refractive objects, photorealistic rendering for computer graphics applications, and demonstration of systems for advanced and realistic applications for HCI. Accordingly, the work of this thesis is presented in a four-element taxonomy: Geometry and appearance digitization, tracking, visualization and
interaction, and datasets. The work contributes to state of the art methods and prepares the ground for future research within the above-mentioned topics and generally the field of visual HCI.

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Contributors: Stets, J. D.
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A variational study on BRDF reconstruction in a structured light scanner
Time-efficient acquisition of reflectance behavior together with surface geometry is a challenging problem. In this study, we investigate the impact of system parameter uncertainties when incorporating a data-driven BRDF reconstruction approach into the standard pipeline of a structured light scanning system. The parameters investigated include geometric detail of scanned objects; vertex positions and normals; and position and intensity of light sources. To have full control of uncertainties, experiments are carried out in a simulated environment, mimicking an actual structured light scanning setup. Results show that while uncertainties in vertex positions and normals have a high impact on the quality of reconstructed BRDFs, object geometry and light source properties have very little influence on the reconstructed BRDFs. With this analysis, practitioners now have insight in the tolerances required for accurate BRDF acquisition to work.

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Scene reassembly after multimodal digitization and pipeline evaluation using photorealistic rendering
Transparent objects require acquisition modalities that are very different from the ones used for objects with more diffuse reflectance properties. Digitizing a scene where objects must be acquired with different modalities requires scene reassembly after reconstruction of the object surfaces. This reassembly of a scene that was picked apart for scanning seems unexplored. We contribute with a multimodal digitization pipeline for scenes that require this step of reassembly. Our pipeline includes measurement of bidirectional reflectance distribution functions and high dynamic range imaging of the lighting environment. This enables pixelwise comparison of photographs of the real scene with renderings of the digital version of the scene. Such quantitative evaluation is useful for verifying acquired material appearance and reconstructed surface geometry, which is an important aspect of digital content creation. It is also useful for identifying and improving issues in the different steps of the pipeline. In this work, we use it to improve reconstruction, apply analysis by synthesis to estimate optical properties, and to develop our method for scene reassembly.

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Virtual reality inspection and painting with measured BRDFs

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics
Contributors: Dal Corso, A., Stets, J. D., Luongo, A., Nielsen, J. B., Frisvad, J. R., Aanæs, H.
Number of pages: 2
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Visualization and labeling of point clouds in virtual reality

We present a Virtual Reality (VR) application for labeling and handling point cloud data sets. A series of room-scale point clouds are recorded as a video sequence using a Microsoft Kinect. The data can be played and paused, and frames can be skipped just like in a video player. The user can walk around and inspect the data while it is playing or paused. Using the tracked hand-held controller, the user can select and label individual parts of the point cloud. The points are highlighted with a color when they are labeled. With a tracking algorithm, the labeled points can be tracked from frame to frame to ease the labeling process. Our sample data is an RGB point cloud recording of two people juggling with pins. Here, the user can select and label, for example, the juggler pins as shown in Figure 1. Each juggler pin is labeled with various colors to indicate different labels.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Image Analysis & Computer Graphics, Massachusetts Institute of Technology
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Number of pages: 2
Publication date: 2017
Wearable Gaze Trackers: Mapping Visual Attention in 3D
The study of visual attention in humans relates to a wide range of areas such as: psychology, cognition, usability, and marketing. These studies have been limited to fixed setups with respondents sitting in front of a monitor mounted with a gaze tracking device. The introduction of wearable mobile gaze trackers allows respondents to move freely in any real world 3D environment, removing the previous restrictions. In this paper we propose a novel approach for processing visual attention of respondents using mobile wearable gaze trackers in a 3D environment. The pipeline consists of 3 steps: modeling the 3D area-of-interest, positioning the gaze tracker in 3D space, and 3D mapping of visual attention. The approach is general, but as a case study we created 3D heat maps of respondents visiting supermarket shelves as well as finding their in-store movement relative to these shelves. The method allows for analysis across multiple respondents and to distinguish between phases of in-store orientation (far away) and product recognition/selection (up close) based on distance to shelves.

Our 3D Vision Data-Sets in the Making

3D Surface Scanner Using Structured Light & Industrial Robot
Contributors: Stets, J. D., Dahl, A. L., Aanæs, H.
Publication date: 2011
Peer-reviewed: Yes
Event: Poster session presented at Visionday: Industrial, Lyngby, Denmark.
Electronic versions: 13107d01.pdf
URLs: http://www.visiondays.dk/
Source: orbit
Source-ID: 284224
Research output: Research - peer-review → Poster – Annual report year: 2011

Projects:

**ASAN: Autonomous Situation Awareness for Navigation**
The purpose of this project is to develop techniques to let a computer obtain reliable situation awareness for a vessel at sea. Based on state of art sensor technology, algorithms will interpret information about surroundings and predict behaviours of other vessels. When information confirms deviations from anticipated normal behaviours, algorithms shall predict imminent risks and provide decision support for safe manoeuvring. One aim is that results of risk assessment and risk avoidance can be presented as advice to a human navigator. Another aim is that this information can be presented to an autonomous manoeuvring system that can respond with a plan for immediate manoeuvring to avoid risk of collision or grounding. The project aims to demonstrate the technology at a proof of concept level, first against simulated scenarios at SIMAC, then using live data from one or more vessels in Danish waters.

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01/12/2018 → 31/03/2021
Collaborators: Svendborg International Maritime Academy, Wärtsila-Lyngsø Marine

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Project: PhD