Vertex based color correction to remove fixed highlights in 3D scans

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Many cultural heritage objects are cataloged using 3D-scanning techniques which simultaneously record space coordinates and color values. One shortfall of these techniques is due to changes in the illumination of the object during the scanning process. Surfaces that reflect light produce highlights, which then are recorded by the scanner and therefore are present at a fixed location in the resulting 3D model. At worst a 3D-scanner is incapable to record any information about regions that reflect the incoming signal. For the most part the lacking information is merged from several scans but with different lighting situations causing a stained coloring. One example of where this effect occurs is black-figure pottery (antique Greek vases). The black material of the paintings is very likely to cause reflections of surrounding light sources.

We introduce an algorithm for color correction in 3D-scans that allows for removing such highlights. It operates on irregular vertex based 3D data, e.g. a triangular mesh or a point cloud. Color information of the objects' surface is assumed to be present for each vertex. The deployed methods base upon a virtual light model and the clustering of color values to identify and to color-correct the highlighted regions. On the basis of a light model we virtually reconstruct the highlight and calculate material colors without a specular reflection. This provides an estimation of where highlighted regions can be found and how intense they are. Clustering the surface color values allows on the one hand for identifying colors of the occurring materials. On the second hand it permits a more detailed selection of regions for applying color correction. In detail we solve an inverse problem estimating the reflective material parameter from the recorded color value. To create a virtually illuminated scene three components are necessary: geometry of the object, positions and intensities of the light sources, and material properties. The geometry is available from the scanned 3D-data. The positions of light sources are either known or calculated from the overall setting of the scene. Material colors can be retrieved from the surface colors in the vicinity of the respective points but specular properties have to be estimated and/or defined by user input.

The result is a weighted color correction of the diffuse material color such that the objects appear properly lighted in any virtual setting with varying light sources. We demonstrate our algorithm on black-figure ceramics of the Kunsthistorisches Museum Wien (KHM). The presented algorithm can handle an arbitrary number of reflections on a homogeneous material. We give an outlook on how to deal with more than one reflective material when the information about which material was behind the reflection is eventually lost.

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Projects

Digitization of inscriptions of medieval gravestones on the Jewish Cemetery "Heiliger Sand" in Worms with 3D close range scanner; image filtering with 3D surface data for automated transscriptions of scripts (epigraphy) for ancient documents (Assyrian cuneiform, Greek inscriptions, Chinese sutras); anisotropic diffusion filtering for hatching and scripture in digital images (Vaugondy Globe (1751) and Giant Gottorf Globe/Blaeu Globe, 17^{th} century); scanning campaigns in Vienna and Graz involved with Corpus Vasorum Antiquorum (CVA); scanning campaigns in Cambodia with the Heidelberg Angkor Project Group in 2009, 2011, and 2013; German Ministry for Education and Research (BMBF) funded project for the mathematical and computer scientific treatment of Muqarnas plans (2002 – 2005);