Identifying and Visualizing Surface Detail on Michelangelo's David

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Figure 1: Michelangelo's David: (a) chisel marks, (b) graffiti initials, (c) thin fracture lines.

1 Introduction

We present the results of new experiments in which we have identified, characterized, and produced visualizations of selected fine surface detail on Michelangelo's David statue. Starting with available raw scan data [Levoy et al. 2000], we have applied a number of techniques, both developed and refined by us, including the calculation of *curvature maps*, *2.5D spatial noise filtering*, *texture projection merging* [Rugis 2006], and *image processing assisted physical measurement*.

Having never viewed the real statue, we specifically searched the scan data for features reported in Bracci et al. [2004], including chisel marks left on the statue by Michelangelo, graffiti, and thin stress fractures. Note that, with our surface visualization techniques, no photographic images of the statue were used. Challenging problems that needed to be solved included extracting fine detail from noisy scan data.

2 Processing Tools and Pipeline

We have produced software tools including a 3D point visualization tool (K-Scan) and a number of batch scriptable utilities. K-Scan was used for interactive exploration, analysis, import/export, and 3D stereo viewing. Scriptable access to modules within K-Scan is possible. Software utilities include file conversion, bounding box calculation, 3D point data searching, and directory tree walking.

Data processing began with the raw scan data which is held in 6540 *sweep* files organized in a hierarchical directory structure consisting of 9 *groups*, 30 *dates*, and 515 *scan* directories in which the individual sweep files can be found. After identifying bad sweeps, we created a collection of 6355 2D curvature map reference images, one for each good sweep file, using K-Scan in batch mode. An image browsing tool was used for initial visual identification of interesting sweeps. The 3D coordinates of the interesting features were then determined by viewing the sweeps in K-Scan. Our sweep search utility was used to produce a list of all sweeps containing each 3D point of interest. The sweep search tool makes use of bounding boxes associated with each sweep and each directory in the hierarchy. The bounding boxes were calculated and organized off-line by another of our utilities.

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3 Analysis and Results

Further analysis of identified sweeps was performed with K-Scan. Analysis included using a number of different curvature estimators [Klette and Rosenfeld 2004], along with 3D filtering and external 2D filtering. 3D distance measurements were taken. Both 2D curvature maps and distance maps were output for visualization of significant features. External processing of distance map files was used to produce visualizations and plots of distance measurements. We characterized a sample of the chisel marks left by Michelangelo (see the accompanying images).

Color shading coded triangle mesh files were output and externally rendered to produce perspective correct curvature texture images. We employed an existing simplified 3D triangle mesh model of the complete statue and projected the curvature texture images onto this simplified model for full 3D visualization (see Figure 1 and the accompanying video).

References

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