



“Projecting Surface Curvature Maps”

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Introduction

High resolution 3D range scan digitizations often produce datasets that, when directly converted to 3D models, are too large to be rendered quickly for display.

The usual solution to this problem is to sacrifice detail and reduce the model size by simplification.

In this research, we propose a method whereby high resolution detail can be merged with a simplified mesh model for visualization.

Introduction

To this end, we firstly introduce curvature maps which are calculated from the original scan data associated with each scan view point.

Then we project these curvature maps onto a simplified model in a way that is analogous to using slide projectors to project multiple photographs onto a 3D object.



Flat shading of triangle mesh.



Smooth shading of triangle mesh.



With a strip of projected surface curvature.

Some problems that needed to be solved...

- 1) Generally raw scan data contains noise, and this noise destroys the possibility of direct curvature calculation.
- 2) The standard 3D graphics lighting projection model is not appropriate because it does not handle the unavoidable projection overlap seamlessly.
- 3) Implementation issues (e.g. handling large datasets).

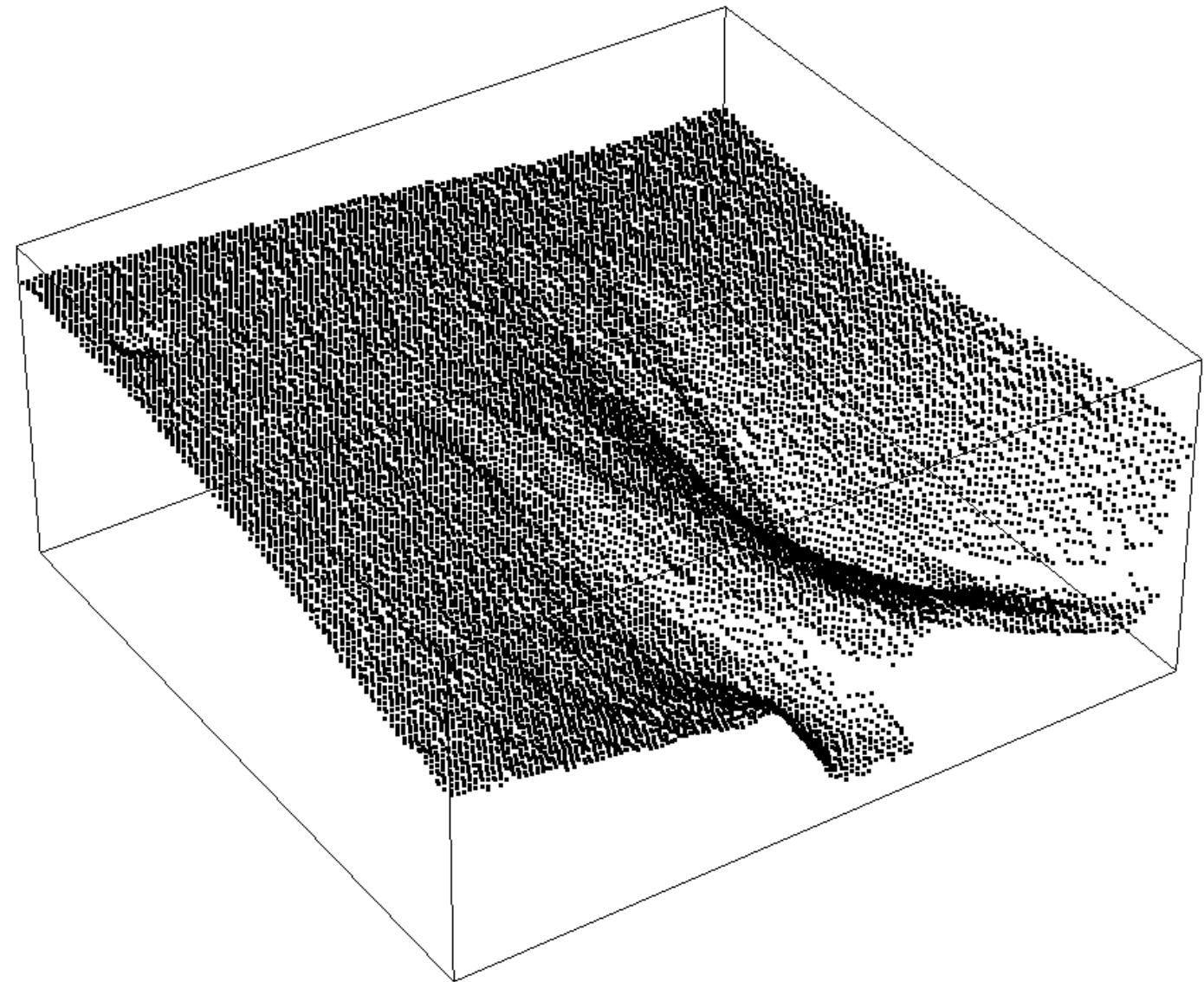
Curvature Maps

When working with point set data, surface curvature can only be estimated [Klette and Rosenfeld 2004].

In this research, we use an uncompensated orthogonal cut method to calculate a mean curvature [Rugis 2005].

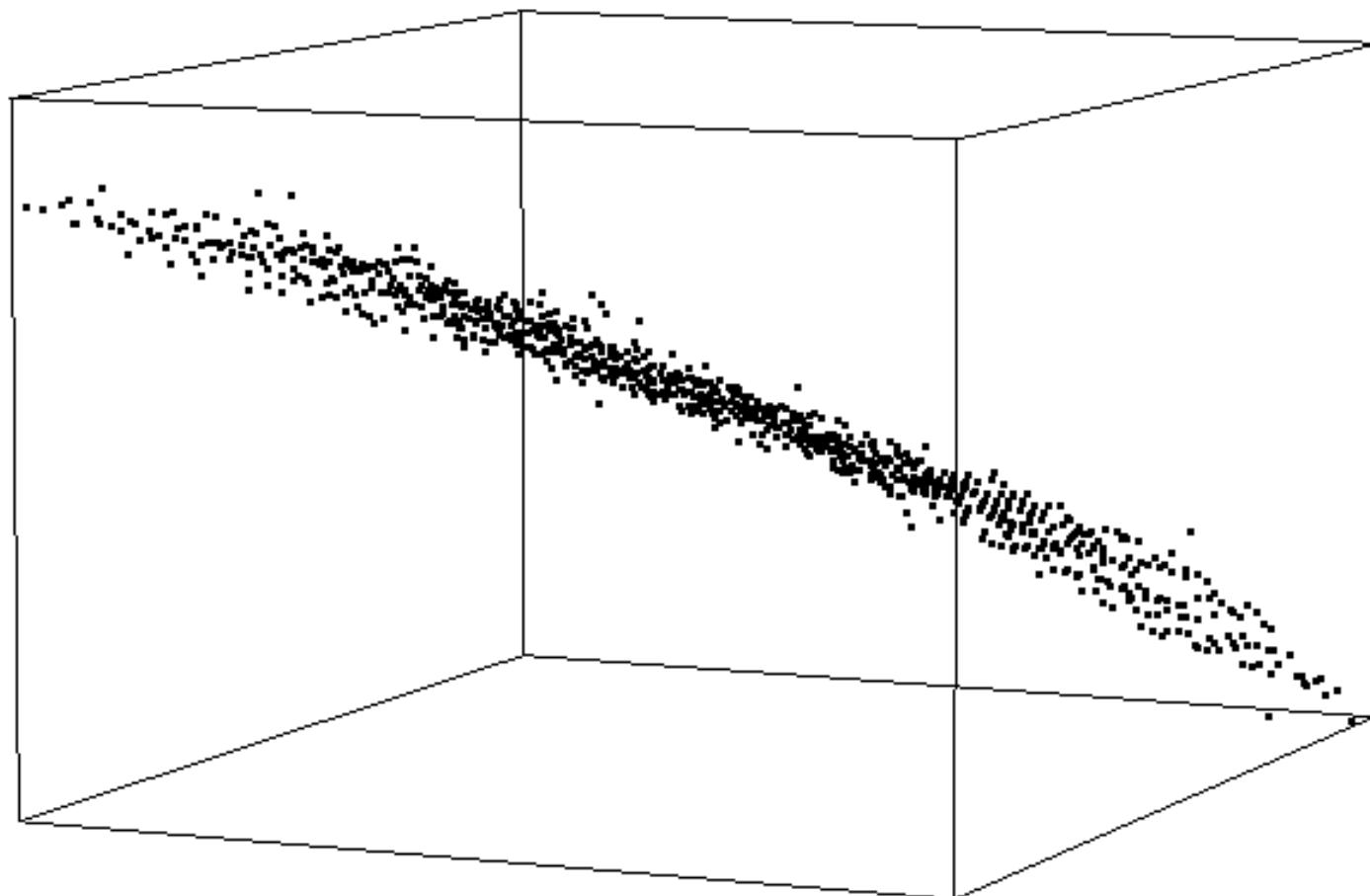
Curvature Maps

Raw data consists of 3D scan points.



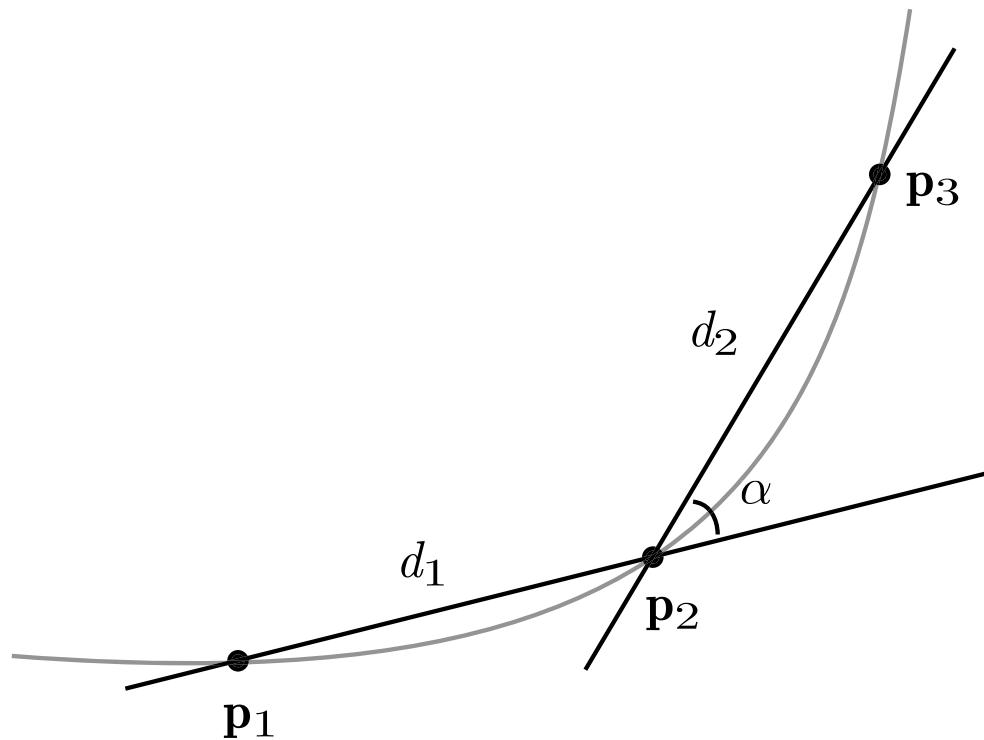
Curvature Maps

Closer viewing reveals that the scan points are noisy.



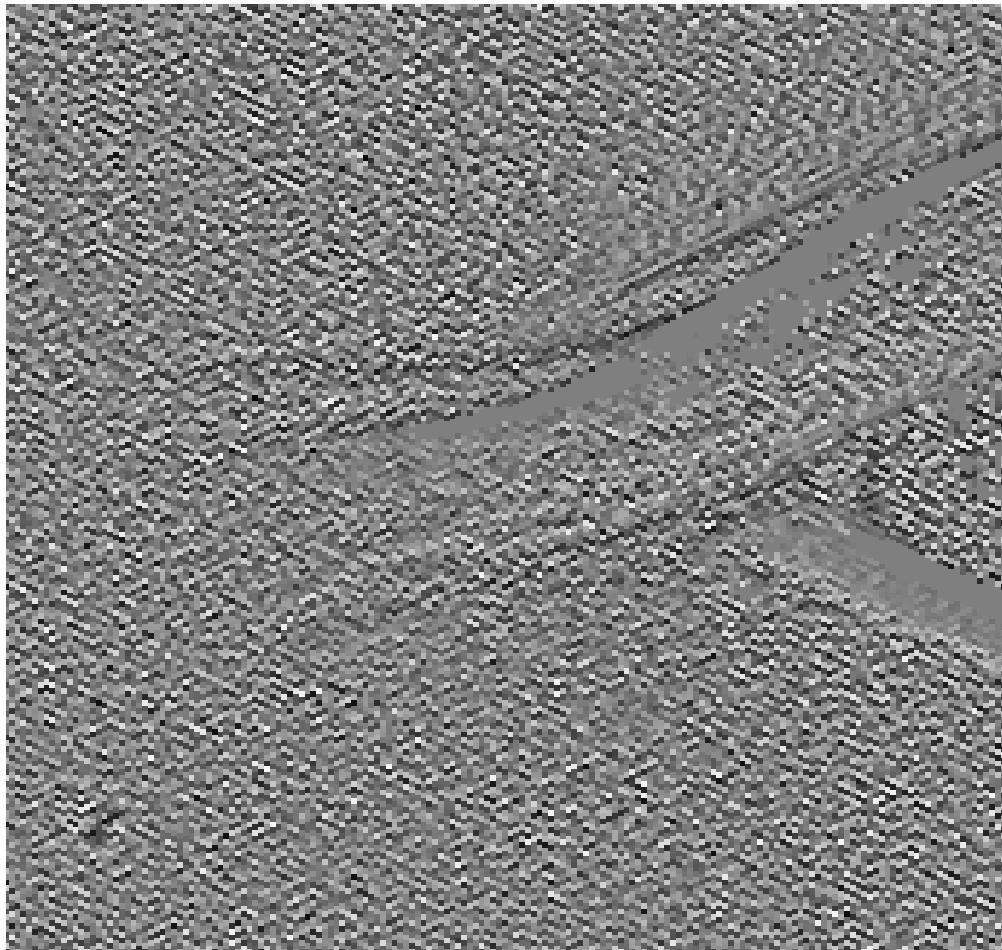
Curvature Maps

We handle the noisy data problem by firstly doing a noisy mean curvature calculation on the raw scan data and then mapping a shading encoded version of these noisy curvatures into the 2D domain.



Curvature Maps

Shading encoded noisy curvature map.



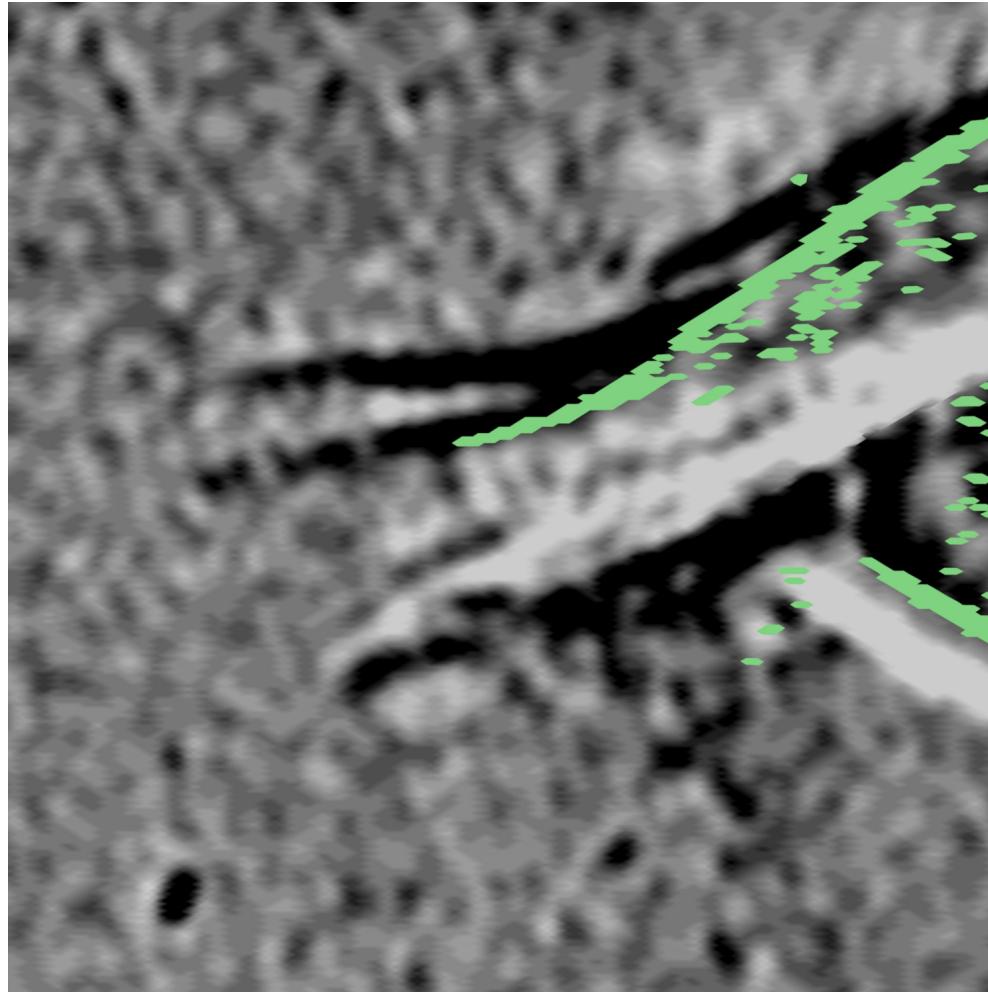
Curvature Maps

After applying 2D image filtering and segmentation.



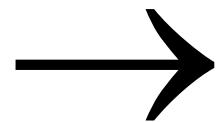
Curvature Maps

Results mapped back into vertex colors in the 3D domain.



Curvature Maps

Each perspective correct final projection map consists of a vertex colored single frame rendering of these results.



Projecting Curvature Maps

A goal from the outset was to, as much as possible, use existing 3D graphics techniques.

However, the standard lighting projection model is additive for multiple sources [Foley et al. 1996].

$$I_\lambda = Ambient + \sum Specular + \sum Diffuse$$

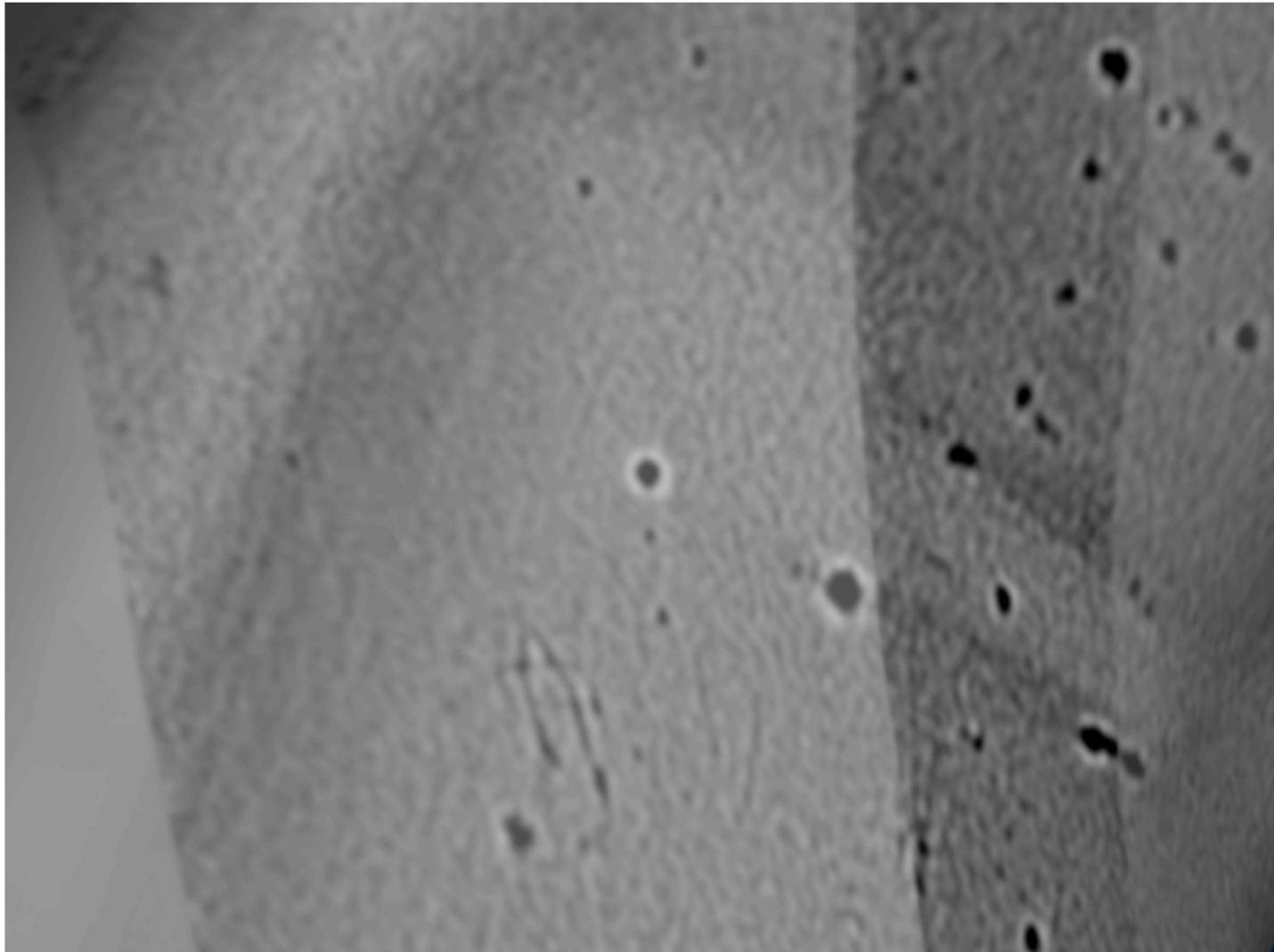
Projecting Curvature Maps

We introduce a multiple source averaging lighting model that overcomes this problem.

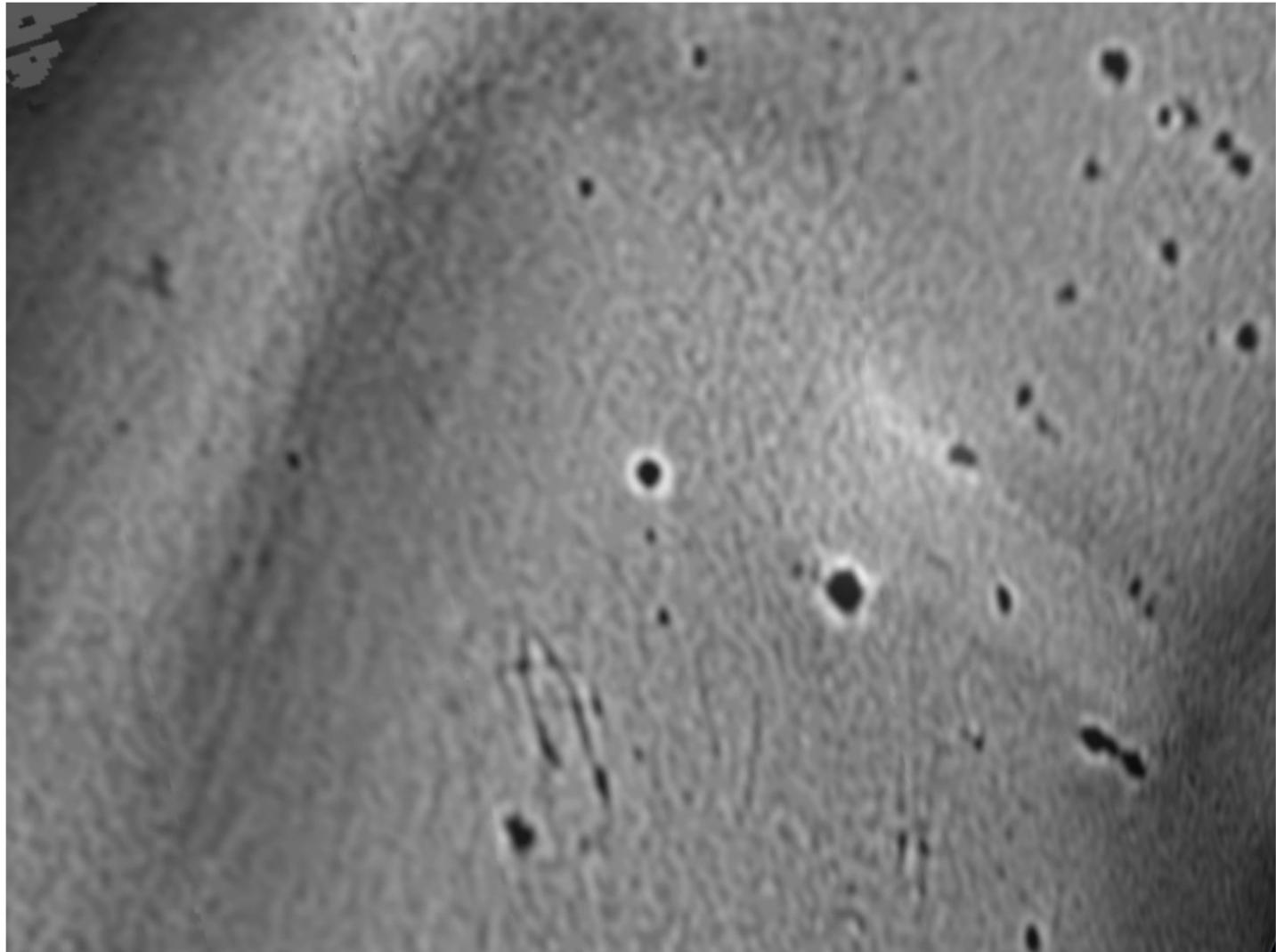
The diffuse component for each of the projection sources is averaged into a total value that is used to modulate the final standard lighting value.

$$I_{\lambda} = Ambient + \sum Specular + \left(\frac{\sum_{i=1}^n Projection}{n} \right) \sum Diffuse$$

Projecting Curvature Maps (onto the back of David's left leg)
The standard lighting model, two overlapping scans.



Projecting Curvature Maps (onto the back of David's left leg)
The new lighting model, seamless scan strip overlap.

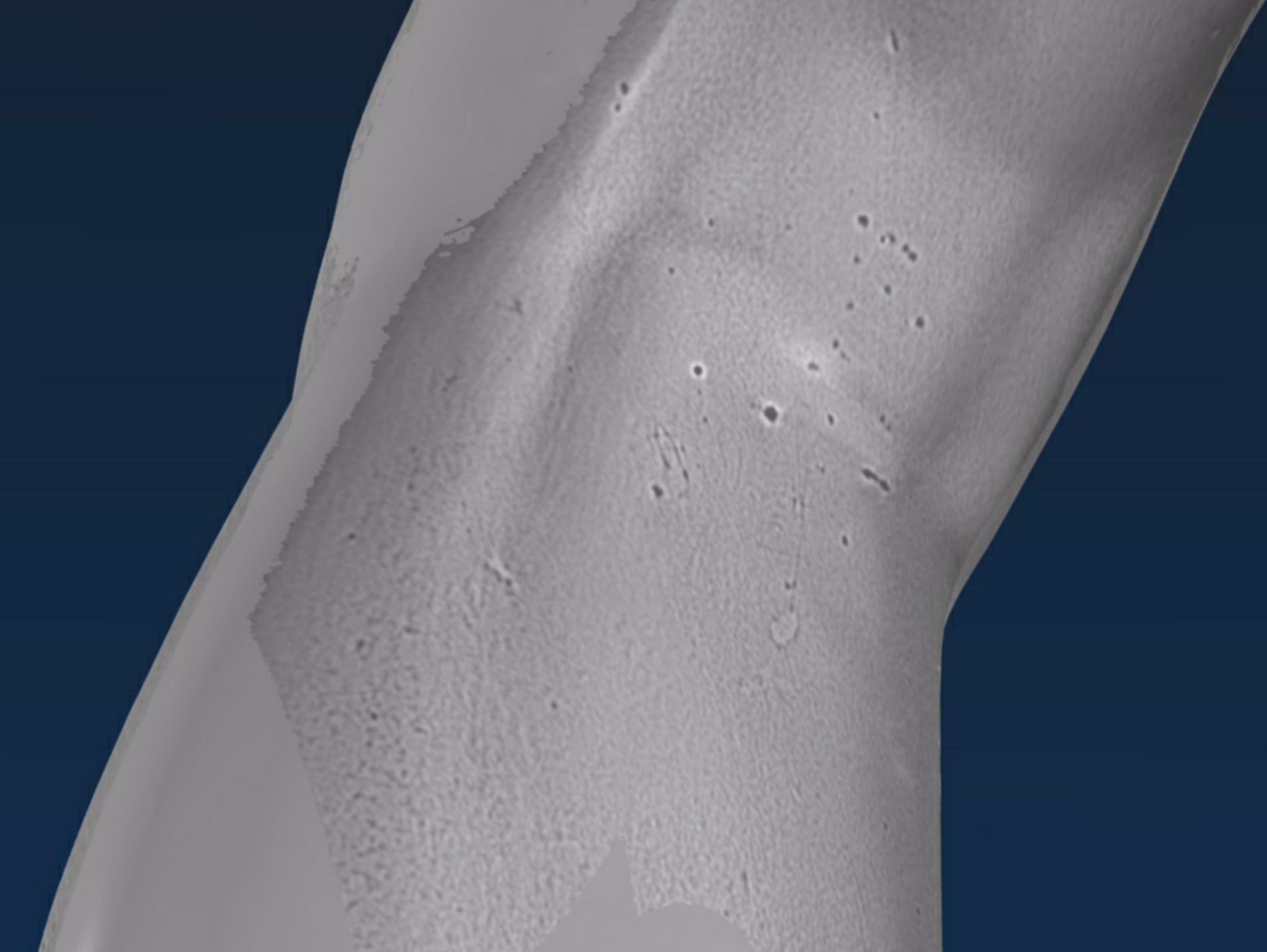


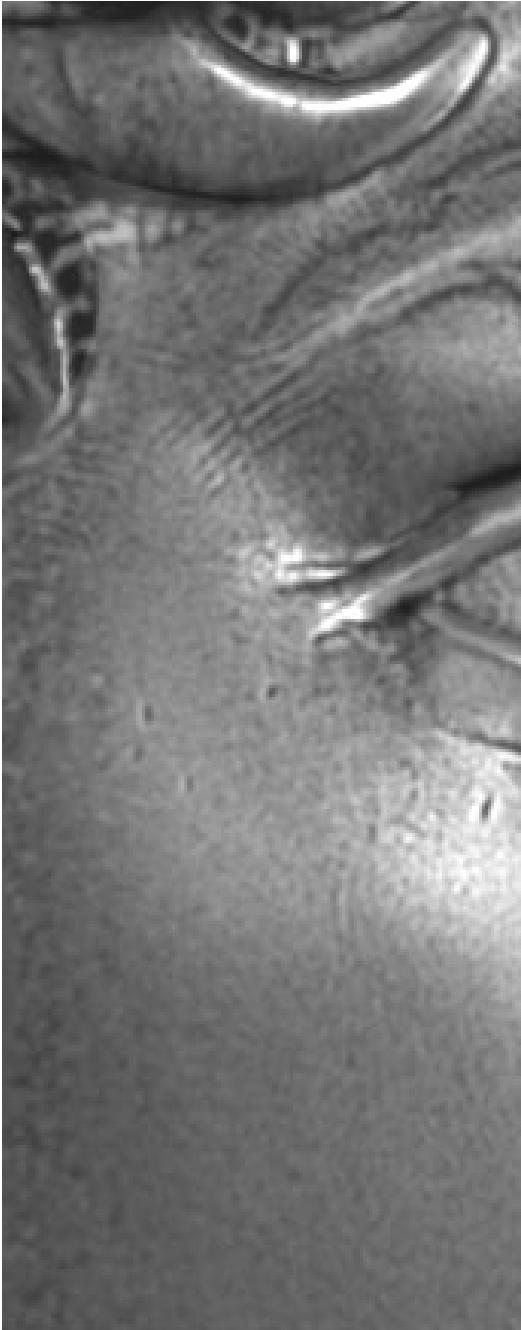
Conclusion

We have successfully merged surface detail, based on curvature maps from high resolution range scans, with a simplified 3D mesh model for visualization purposes.

Because the curvature maps were created outside any lighting model, and the fact that curvature itself is rotation and translation invariant, the projected surface curvature detail retains a unique clarity in animated visualization. (See the accompanying video.)







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References:

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