“Extracting Surface Curvature from Noisy Scan Data”

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Introduction

In general, the noise that is present in real-world 3D surface scan data prevents accurate curvature calculation.

A common approach towards solving this problem is to smooth the point data [Desbrun 99, Fleishman 03] prior to attempting curvature calculations.

Undesirable effect: Edges get smoothed!

The bilateral filter [Tomasi & Manduchi 98] employs an edge preserving term, seems promising, but is intended for 2D applications.
Introduction

In this paper we show how curvature can be extracted from noisy data by applying filtering after a noisy curvature calculation.

Prior method (IVCNZ05):
1) Noisy curvature calculation.
2) Conversion to 2D curvature map.
3) 2D Gaussian filtering, expansion segmentation.

New method:
1) Noisy curvature calculation.
2) 2.5D Gaussian filtering, range expansion.
3) Conversion to 2D curvature map.
Surface Curvature Estimators
A surface point and its adjacency neighborhood:

Mean curvature: \[ H(P) = \frac{3}{4} \sum \frac{\|e_n\| \beta_n}{A(f_n)} \]
2D Gaussian filter

The convolution kernel:

\[ h(n_1, n_2) = h_g(n_1, n_2) / \left( \sum_{n_1=-m}^{m} \sum_{n_2=-m}^{m} h_g \right) \]

with \( h_g(n_1, n_2) = e^{-(n_1^2 + n_2^2)/2\sigma^2} \)
2.5D Gaussian filter
Adjacency neighborhood:
2.5D Gaussian filter
Defining equation:

\[ \tilde{H}(P_{0,0}) = \sum_m \sum_n (w_{mn} H_{mn}) / \sum_m \sum_n w_{mn} \]

with \[ w_{mn} = e^{-(P_{mn}-P_{0,0})^2 / 2\sigma^2} \]
Experiments:
The Digital Michelangelo Project
A curl of hair over David’s right eye.

Surface cross-section.
2D Curvature maps

Noisy curvature values
2D Curvature maps

2D filter

2.5D filter
Pixels at AB cut:

2D filter

2.5D filter

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Graph showing pixel value against pixel position with two lines representing 2.5D and 2D filters.
Conclusion

In the experiment presented, 2.5D filtering results in more representative curvature at a fold edge than does 2D filtering.

Further work is anticipated to include additional noise models (such as highly impulsive), additional filtering methods, and additional visualization techniques.
Loading file: C:\Rugis\CS PhD\DMP_data\David\feb17\Face6.sd\2.ks
scan_width: 486
scan_height: 1705
scan_size: 828630
scan_points: 509362
loading indices.
loading vertices.
vert_bmin: 1024.58 -329.668 287.356
vert_bmax: 1224.94 -85.4637 929.874
vert_bmid: 1124.76 -207.566 608.616
loading intensities.
i_min: 8
i_max: 169
loading depth_values.
dv_min: -2939
dv_max: -60
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References:


