Adaptive View Dependent Tessellation of Displacement Maps

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Outline

- **Introduction**
- **Approach**
- **Midpoint Tests**
- **Hardware Architecture**
- **Results**
- **Conclusion**

Motivation

- **More realistic images without sending more triangles**
- **Address Bump Mapping issues**
  - **No Silhouette**
  - **No Occlusion**
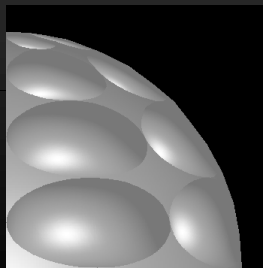
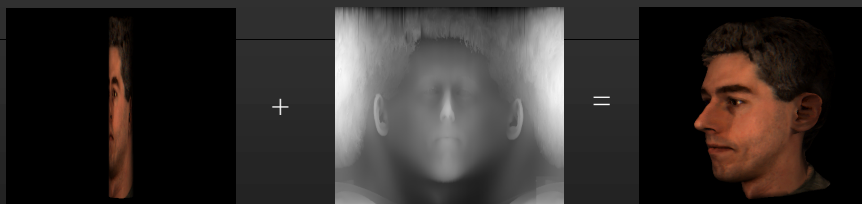Doggett, Hirche   Displacement Mapping   University of Tübingen

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Displacement Mapping

Base Mesh + Displacement   = Displaced
Map   Mesh

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Previous Work

- **Bump Mapping**
  - Blinn 1978
- **Displacement Mapping**
  - Cook 1984
  - Krishnamurthy, Levoy 1996
  - Lee, Moreton, Hoppe 2000
- **Hardware accelerated -** Rasterization
  - Doggett, Kugler 1999
  - Gumhold, Huettner 1999

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Approach

- **Hardware Pipeline**
  - Process triangles individually
  - Unordered
  - Computational Complexity
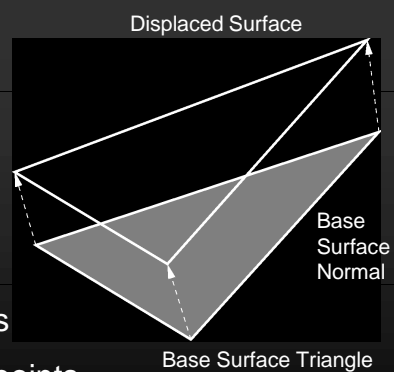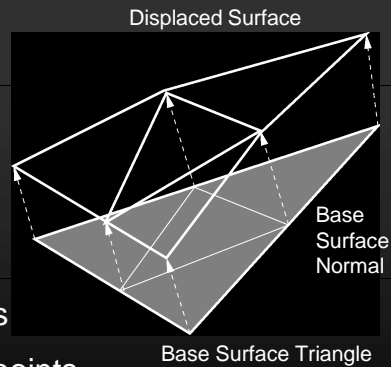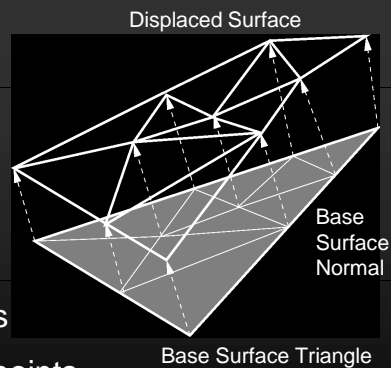- **Avoid cracks between triangles by only evaluating the edge**

Adaptive Tessellation

- **Recursive Tessellation**
  - Calculate edge midpoint
  - Displace midpoint
  - Transform midpoint
  - Calculate surface normal
  - Conditionally insert midpoints
  - Tessellate with selected midpoints

Displaced Surface

Base Surface Normal

Base Surface Triangle

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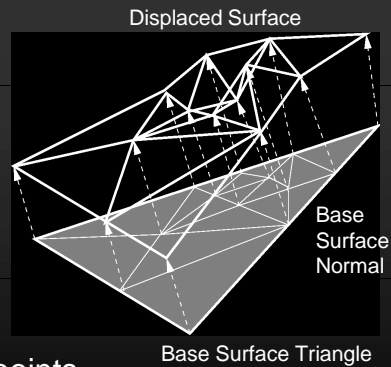
Displaced Surface

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Edge Tests

- **Surface detection**
  - Surface Normal Variance Test
  - Local Area Average Height Test
- **Recursion limits**
  - View Dependent Test
  - Refinement Limit Test

Surface Normal Variance Test

- **Check if any normal component differs more than a given threshold**
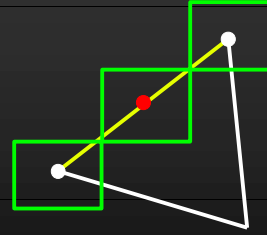- **Detects high frequency surface change**
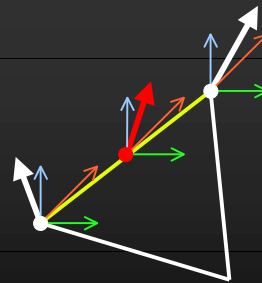
Local Area Average Height Test

- **Compute Average height at end and mid points**
- **Use precomputed Summed Area Table containing displacements**
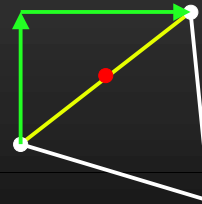- **Detects low frequency surface change**

View Dependent Test

- **Calculate Manhattan length of current edge**
  - Screen Space
- **Insert midpoint if greater than pixel or multiple of pixel resolution**
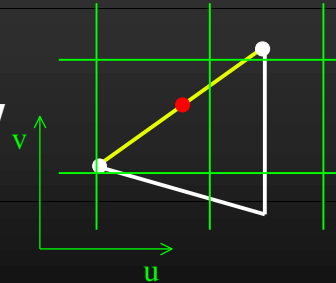- **Stops generation of invisible triangles**

Refinement Limit Test

- **Compare rounded texture coordinate**
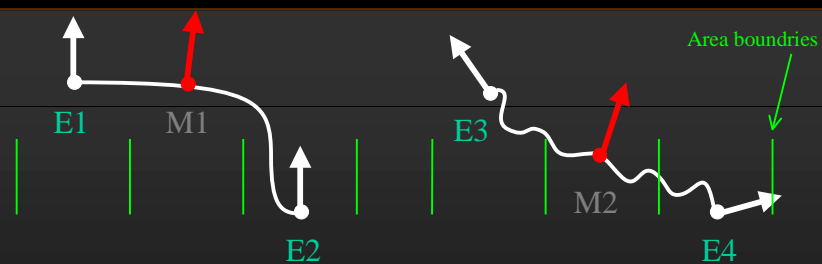- **Stops insertion of midpoints that add no new surface detail**

v

u

Combined Effect

Area boundries

E1   M1   E3

E2   M2   E4

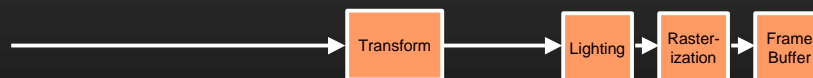| Effective	Area Test	Normal Test
Ineffective	Normal Test	Area Test

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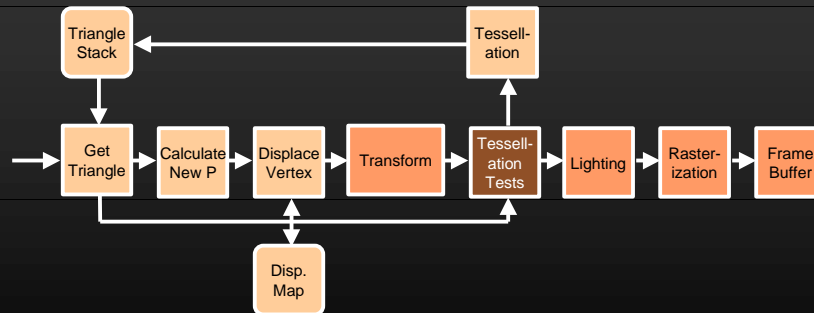- **Conclusion**

Hardware Architecture

- **Graphics Pipeline**

```
─────────────→ [Transform] ──→ [Lighting] → [Raster-ization] → [Frame Buffer]
```

Hardware Architecture

- **Displacement Mapping Pipeline**

Hardware Architecture

- **View dependent tests use transformed vertex information**
  - Vertices are only transformed once
- **Triangle stack size can be controlled by base mesh**
  - Need for on-chip/off-chip memory
- **Normals on displaced surface calculated using Bump Map operation**

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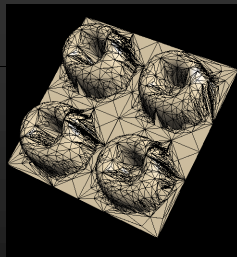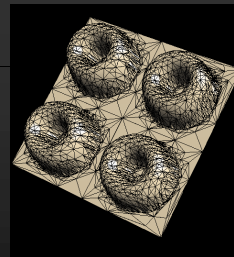Doggett, Hirche   Displacement Mapping   University of Tübingen

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Combined Test Results
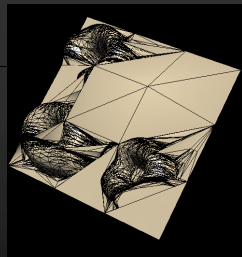
Normal Only   **Area Only**   **Combined**
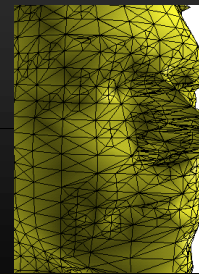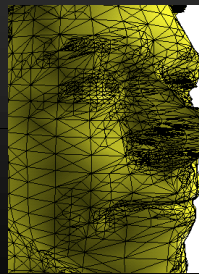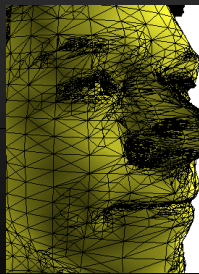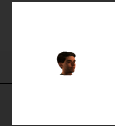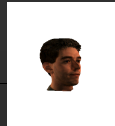
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View Dependent Results
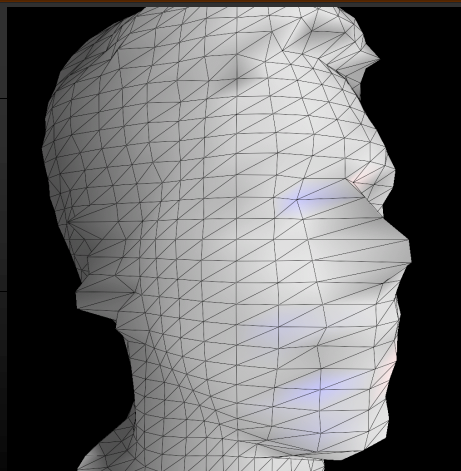
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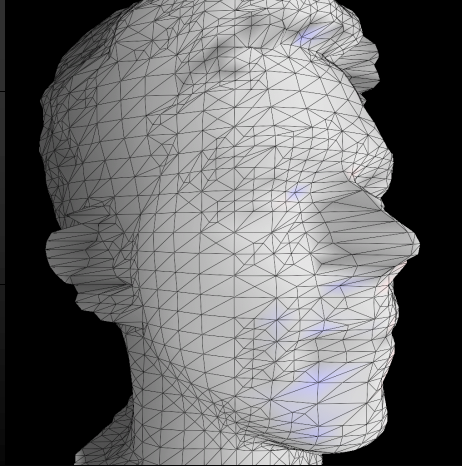# Tessellation Results

- **Level 0**

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Tessellation Results

- **Level 1**

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Tessellation Results

- **Level 2**

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Tessellation Results

- **Level 3**

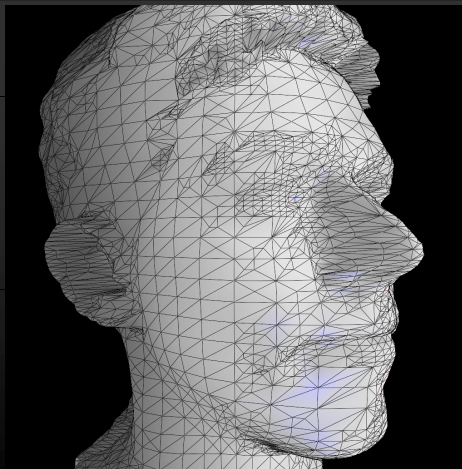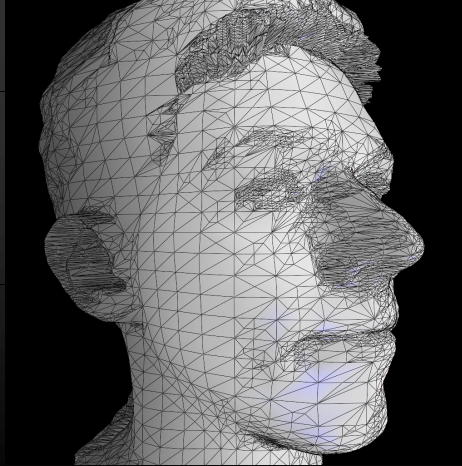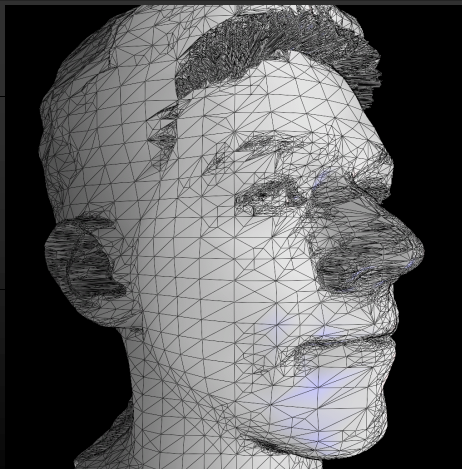Doggett, Hirche   Displacement Mapping   University of Tübingen

Tessellation Results

- **Level 4**

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Results

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Conclusion

- **A new hardware design for Displacement Map Rendering**
- **Lower triangle count using adaptive tessellation**
- **View dependent**
- **Simple representation**
- **Integrated hardware implementation**
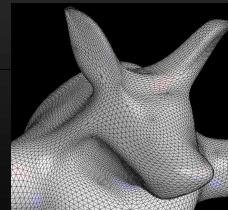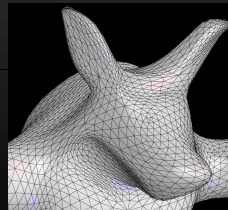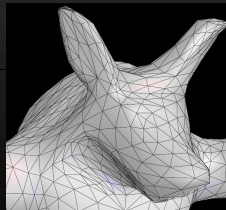
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Future Work

- **Automatic threshold calculation**
- **Improved subdivision**
  - Subdivision surfaces - Arbitrary point insertion

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**Thank You
and
Questions**

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