POINT NORMAL TRIANGLES

Rick van Veen Laura Baakman
December 14, 2015

Advanced Computer Graphics

2015-12-09

Point Normal triangles

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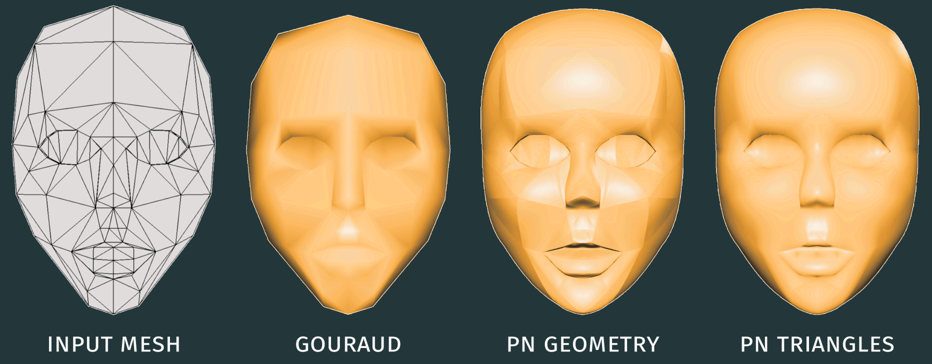
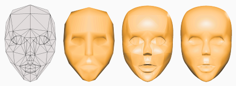
[Rick] Welcome everybody. Tell people that PN means Point Normal triangles.



Point Normal triangles



[Name] Why PN triangles? Look at the nice result it gives :-) and we will see that it easy to extend it to the 'existing' pipeline.

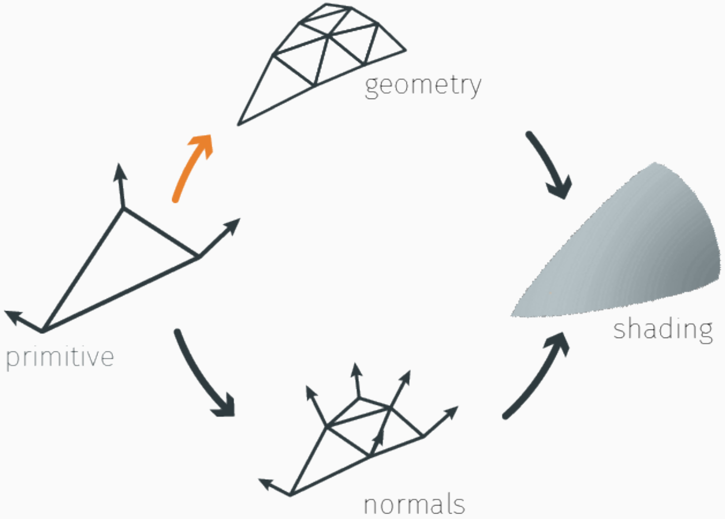
SINGLE PN TRIANGLE

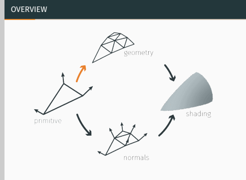
SINGLE PN TRIANGLE

[Name] How does one construct a single PN triangle?

Overview on the next slide

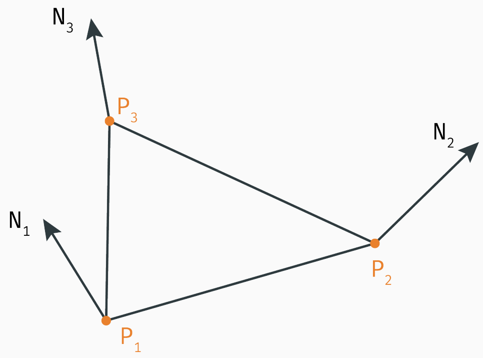
OVERVIEW



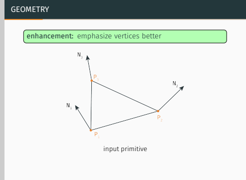


[Name] Why PN triangles? Look at the nice result it gives :-) and we will see that it easy to extend it to the 'existing' pipeline.

enhancement: emphasize vertices better



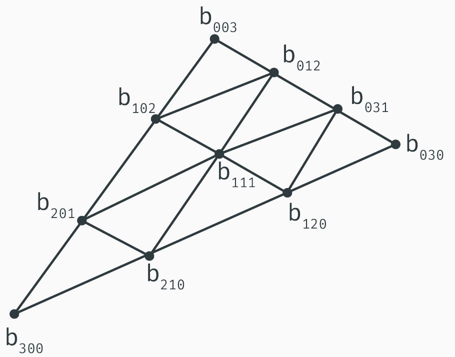
input primitive



[Name] This a standard triangle primitive, defined by its vertices and normals.

Focus on getting the different control primitives.

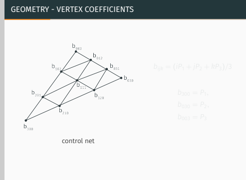
GEOMETRY - VERTEX COEFFICIENTS



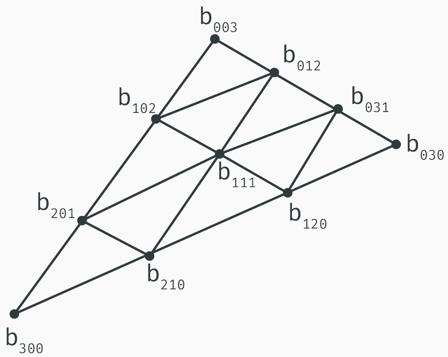
control net

$$b_{ijk} = (iP_1 + jP_2 + kP_3)/3$$

$$b_{300} = P_1,$$
$$b_{030} = P_2,$$
$$b_{003} = P_3$$



[Name] These are all the initial control point. Evenly divided on the triangle. -> formula



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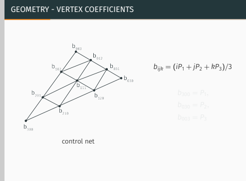
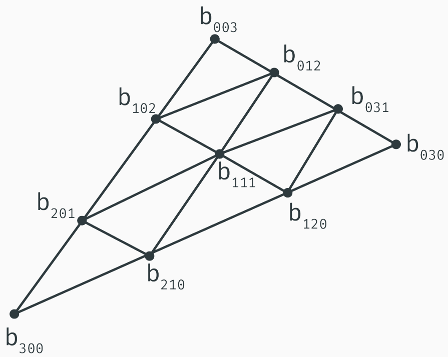
Point Normal triangles
└─Single PN Triangle
└─Geometry - Vertex Coefficients



[Name] Nice formula



control net

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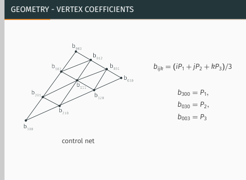
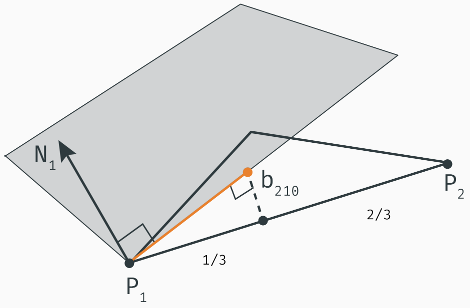


[Name] Stress that the vertex coefficients/control points are the one on the original vertices and that they do not move.

GEOMETRY - TANGENT COEFFICIENTS



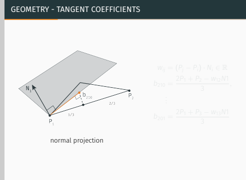
normal projection

$$w_{ij} = (P_j - P_i) \cdot N_i \in \mathbb{R}$$

$$b_{210} = \frac{2P_1 + P_2 - w_{12}N1}{3},$$

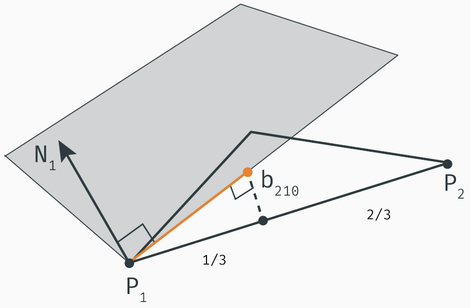
$$\vdots$$

$$b_{201} = \frac{2P_1 + P_3 - w_{13}N1}{3}$$



[Name] How to get the tangent coefficient (the ones on the edge but now curvy)

GEOMETRY - TANGENT COEFFICIENTS



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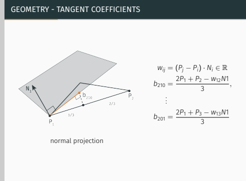
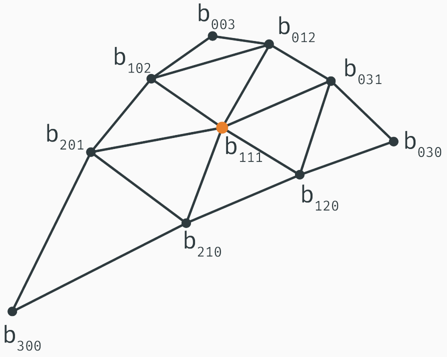
normal projection



[Name] Projection of the initial control points on the normal plane of a vertex.

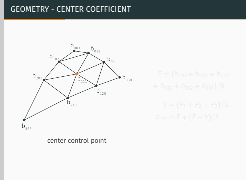
GEOMETRY - CENTER COEFFICIENT



$$E = (b_{210} + b_{120} + b_{021} + b_{012} + b_{102} + b_{201})/6,$$

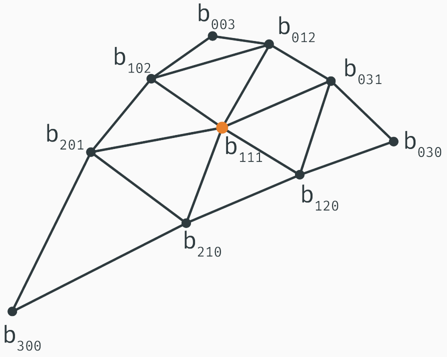
$$V = (P_1 + P_2 + P_3)/3,$$
$$b_{111} = E + (E - V)/2$$

center control point



[Name] Note that this is the result of the previous step -> now only center coefficient is left.

GEOMETRY - CENTER COEFFICIENT



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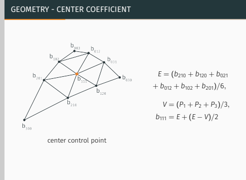
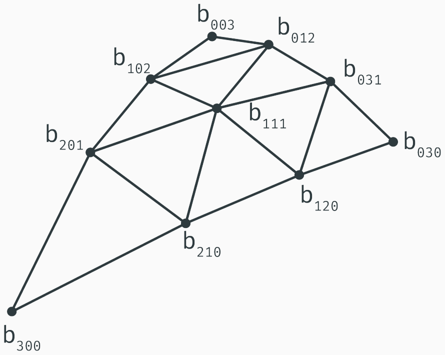


[Name] Average of the tangent coefficients plus half the difference between the tangent and vertex coefficients. -> why?

enhancement: Set result slide to plain



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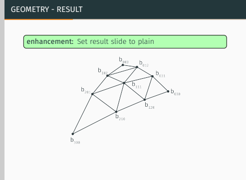
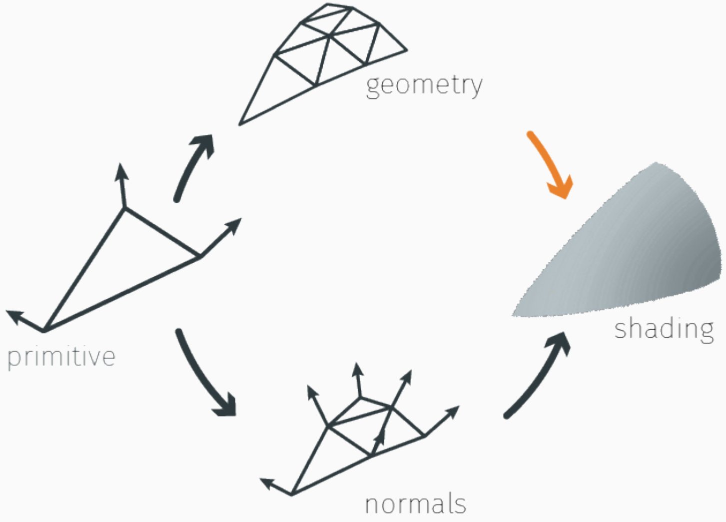
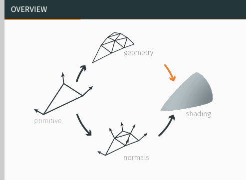
Point Normal triangles
└─Single PN Triangle
└─Geometry - Result



[Name] Results

OVERVIEW





[Name] Overview -> how to get from this to shading.
Sample/subdivide with formula on following slide.

CUBIC PATCH

Spacing van de for all

Plaatje?

$$b : \mathbb{R}^2 \to \mathbb{R}^3, \text{ for } w = 1 - u - v, u, v, w \geq 0$$

$$\begin{aligned} b(u,v) &= \sum_{i+j+k=3} b_{ijk} \frac{3!}{i!j!k!} u^i v^j w^k \\ &= b_{300}w^3 + b_{030}u^3 + b_{003}v^3 \\ &+ b_{210}3w^2u + b_{120}3wu^2 + b_{201}3w^2v \\ &+ b_{021}3u^2v + b_{102}3wv^2 + b_{012}3uv^2 \\ &+ b_{111}6wuv. \end{aligned}$$

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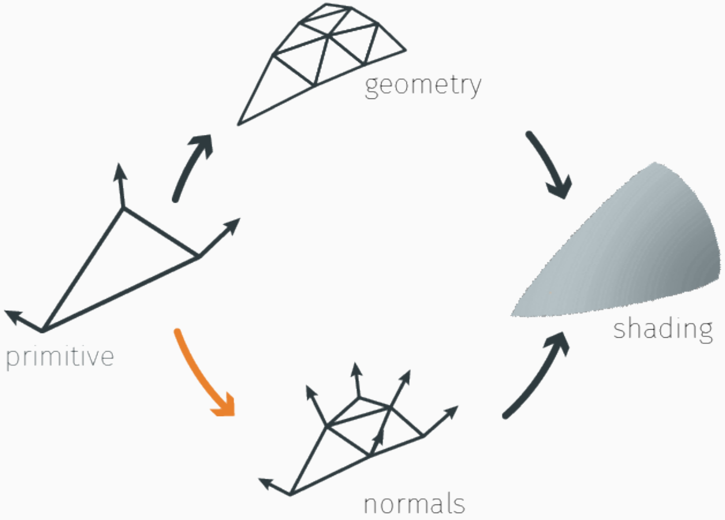
[Name] Very nice formula with a nice picture.



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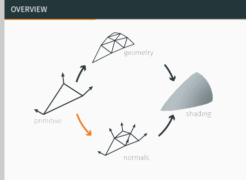
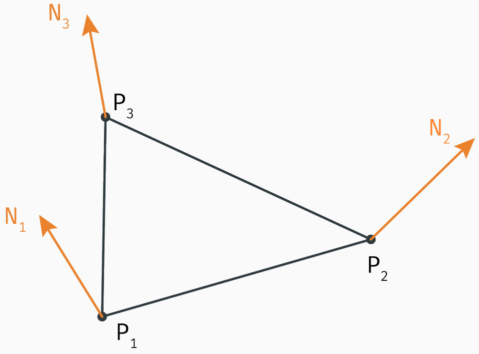
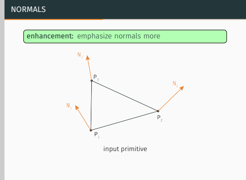
Point Normal triangles
└ Single PN Triangle
└ Overview



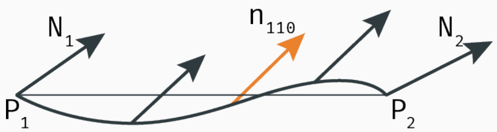
enhancement: emphasize normals more



input primitive

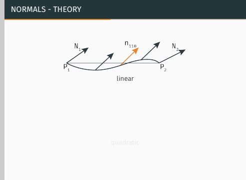


NORMALS - THEORY

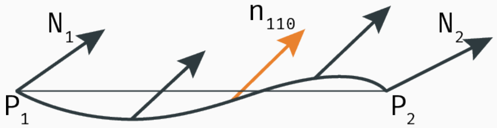


linear

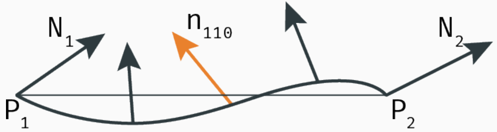
quadratic



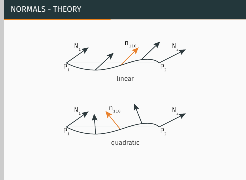
NORMALS - THEORY



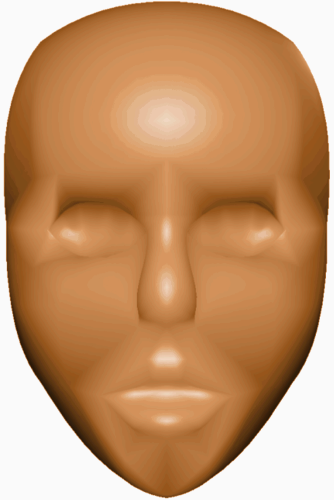
linear



quadratic

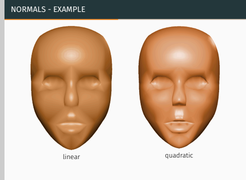


NORMALS - EXAMPLE

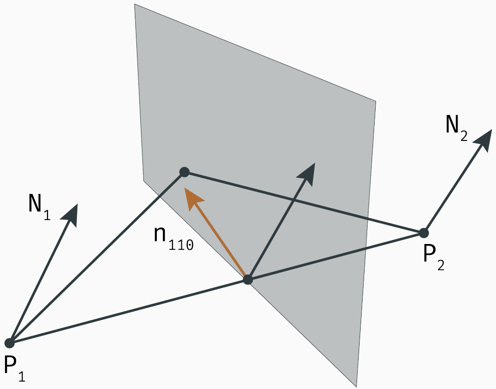


linear

quadratic



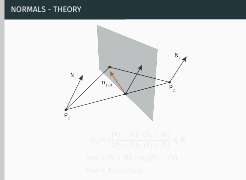
NORMALS - THEORY



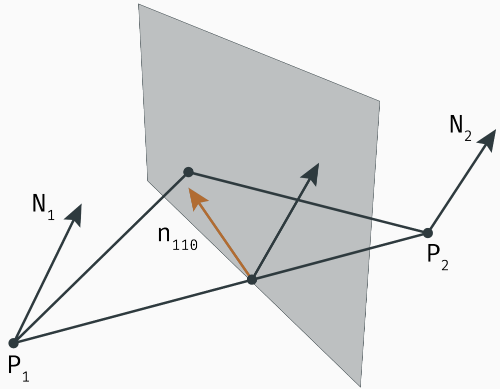
$$v_{ij} = 2\frac{(P_j - P_i) \cdot (N_i + N_j)}{(P_j - P_i) \cdot (P_j - P_i)} \in \mathbb{R}$$

$$h_{110} = N_1 + N2 - v_{12}(P_2 - P_1)$$

$$n_{110} = h_{110}/||h_{110}||$$



NORMALS - THEORY



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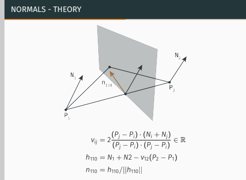
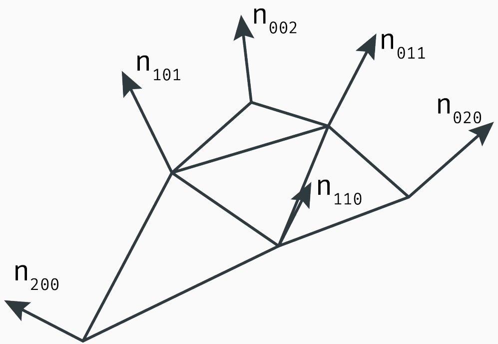


enhancement: Set result slide to plain



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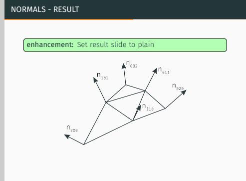
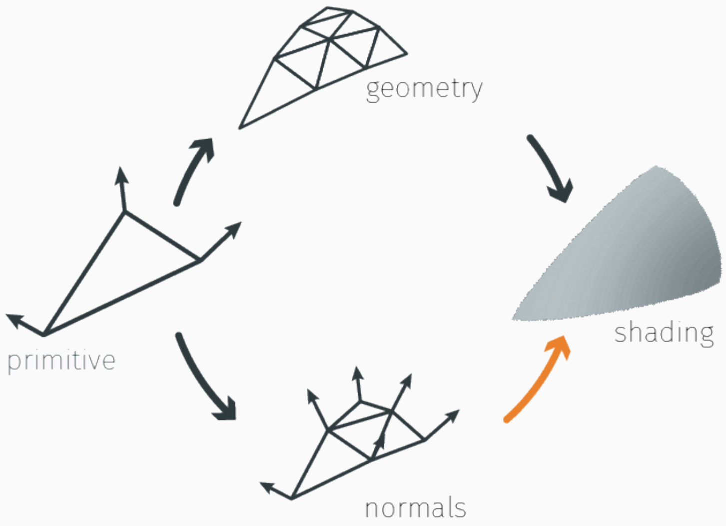
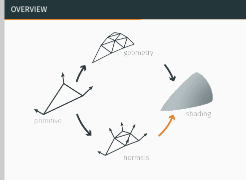
Point Normal triangles
└Single PN Triangle
└Normals - result



OVERVIEW





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QUADRATIC PATCH

Plaatje

$n : \mathbb{R}^2 \to \mathbb{R}^3$, for $w = 1 - u - v$, $u, v, w \geq 0$

$$\begin{aligned} n(u,v) &= \sum_{i+j+k=2} n_{ijk} u^i v^j w^k \\ &= n_{200} w^2 + n_{020} u^2 + n_{002} v^2 \\ &+ n_{110} wu + n_{011} uv + n_{101} wv \end{aligned}$$

QUADRATIC PATCH
Plaatje
$n : \mathbb{R}^2 \to \mathbb{R}^3$, for $w = 1 - u - v$, $u, v, w \geq 0$
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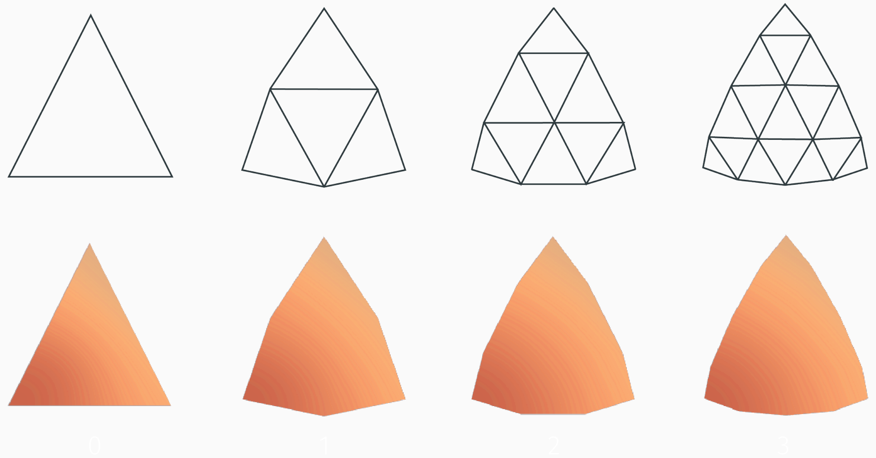
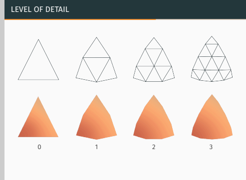
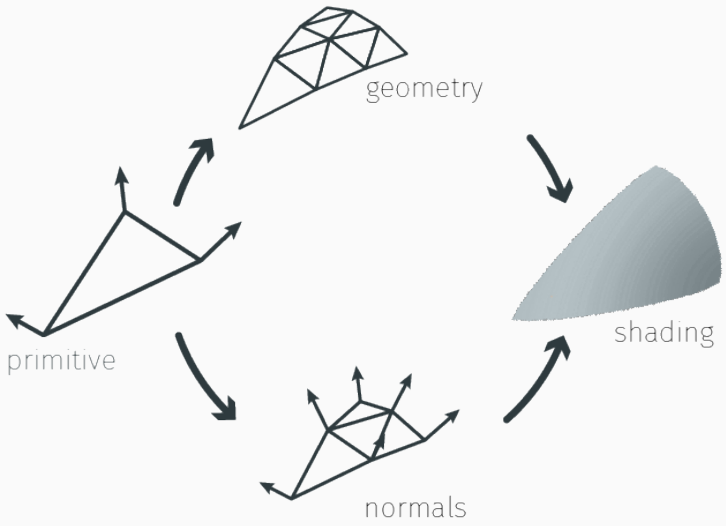
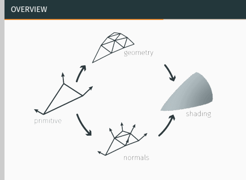
LEVEL OF DETAIL





OVERVIEW





A TRIANGLE MESH

A TRIANGLE MESH

PROPERTIES

"PN triangles should not deviate too much from the original triangle to preserve the shape and avoid interference with other curved triangles." [1]

[1] Vlachos et al.

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[1] Vlachos et al.

CONTINUITY

PN triangles have:[2]

- C^1 continuity in the vertex points
- C^0 continuity everywhere else

[2] Jiao and Alexander

CONTINUITY

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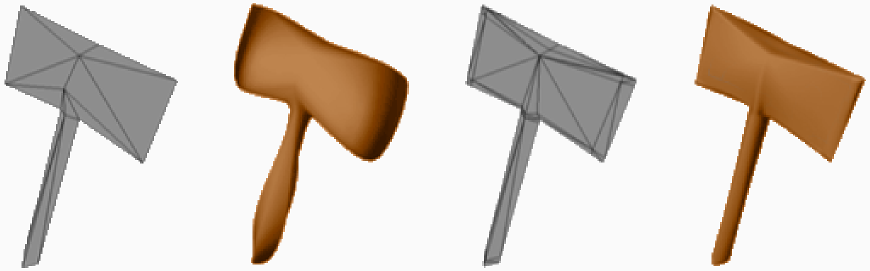
- C^1 continuity in the vertex points
- C^0 continuity everywhere else

[2] Jiao and Alexander

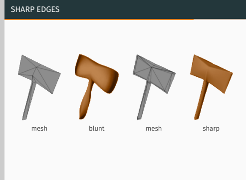
SHARP EDGES



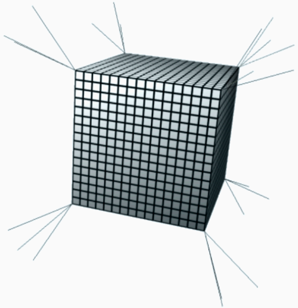
mesh blunt mesh sharp

2015-12-09

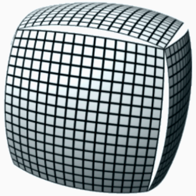
Point Normal triangles
└A Triangle Mesh
└Sharp Edges



SEPARATE NORMALS



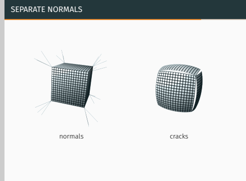
normals



cracks

Point Normal triangles
└A Triangle Mesh

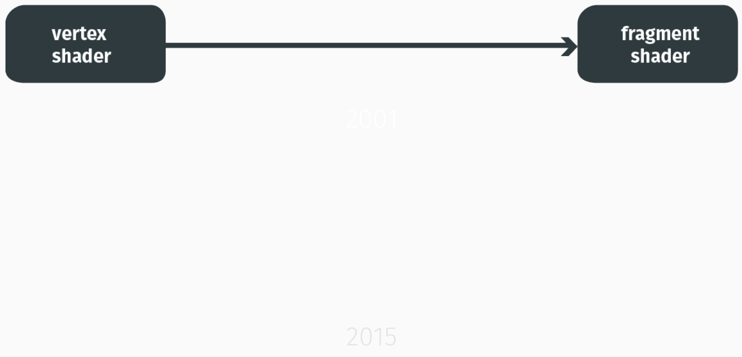
└Separate Normals

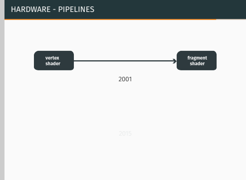


GRAPHICS PIPELINE

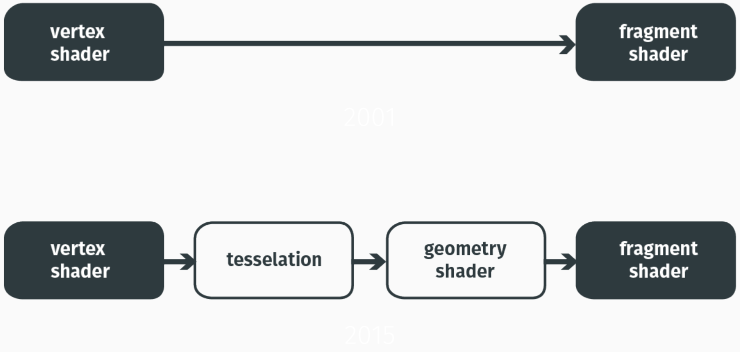
GRAPHICS PIPELINE

HARDWARE - PIPELINES

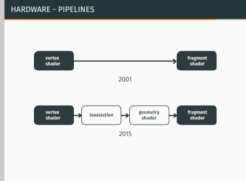




HARDWARE - PIPELINES



2015-12-09



CONCLUSION

CONCLUSION

Some conclusion?

Point Normal triangles
└─Conclusion

2015-12-09

└─conclusion

CONCLUSION

Some conclusion?

FIGUUR 13 UIT PAPER

QUESTIONS?

- Xiangmin Jiao and Phillip J Alexander. “Parallel feature-preserving mesh smoothing”. In: *Computational Science and Its Applications–ICCSA 2005*. Springer, 2005, pp. 1180–1189.
- J McDonald and M Kilgard. *Crack-free point-normal triangles using adjacent edge normals*. 2010.
- Alex Vlachos et al. “Curved PN triangles”. In: *Proceedings of the 2001 symposium on Interactive 3D graphics*. ACM. 2001, pp. 159–166.

REFERENCES

- Xiangmin Jiao and Phillip J Alexander. “Parallel feature-preserving mesh smoothing”. In: *Computational Science and Its Applications–ICCSA 2005*. Springer, 2005, pp. 1180–1189.
- J McDonald and M Kilgard. *Crack-free point-normal triangles using adjacent edge normals*. 2010.
- Alex Vlachos et al. “Curved PN triangles”. In: *Proceedings of the 2001 symposium on Interactive 3D graphics*. ACM. 2001, pp. 159–166.