POINT NORMAL TRIANGLES

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Advanced Computer Graphics

INPUT MESH

GOURAUD

PN GEOMETRY

PN TRIANGLES

SINGLE PN TRIANGLE

CUBIC BÉZIER TRIANGLES

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

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

GEOMETRY

img/1_single/inputPrimitive.png

Input primitive

GEOMETRY - STEP 1

img/1_single/geometry_1.png

Control net

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

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

GEOMETRY - STEP 1

img/1_single/geometry_1.png

Control net

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

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

GEOMETRY - STEP 2

img/1_single/geometry_2.png

Normal projection

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

$$b_{210} = (2P_1 + P_2 - w_{12}N1)/3,$$

$$b_{120} = (2P_2 + P_1 - w_{21}N2)/3,$$

$$b_{021} = (2P_2 + P_3 - w_{23}N2)/3,$$

$$b_{012} = (2P_3 + P_2 - w_{32}N3)/3,$$

$$b_{102} = (2P_3 + P_1 - w_{31}N3)/3,$$

$$b_{201} = (2P_1 + P_3 - w_{13}N1)/3$$

GEOMETRY - STEP 2

img/1_single/geometry_2.png

Normal projection

$$
\begin{aligned}
w_{ij} &= (P_j - P_i) \cdot N_i \in \mathbb{R} \\
b_{210} &= (2P_1 + P_2 - w_{12}N1)/3, \\
b_{120} &= (2P_2 + P_1 - w_{21}N2)/3, \\
b_{021} &= (2P_2 + P_3 - w_{23}N2)/3, \\
b_{012} &= (2P_3 + P_2 - w_{32}N3)/3, \\
b_{102} &= (2P_3 + P_1 - w_{31}N3)/3, \\
b_{201} &= (2P_1 + P_3 - w_{13}N1)/3
\end{aligned}
$$

GEOMETRY - STEP 3

img/1_single/geometry_3.png

Center control point

$$
\begin{aligned}
E &= (b_{210} + b_{120} + b_{021} \\
&\quad + b_{012} + b_{102} + b_{201})/6, \\
V &= (P_1 + P_2 + P_3)/3, \\
b_{111} &= E + (E - V)/2
\end{aligned}
$$

GEOMETRY - STEP 3

img/1_single/geometry_3.png

Center control point

$$
\begin{aligned}
E &= (b_{210} + b_{120} + b_{021} \\
&\quad + b_{012} + b_{102} + b_{201})/6, \\
V &= (P_1 + P_2 + P_3)/3, \\
b_{111} &= E + (E - V)/2
\end{aligned}
$$

GEOMETRY - RESULT

img/1_single/geometry_4.png

NORMALS

img/1_single/inputPrimitive.png

Input primitive

NORMALS

img/1_single/normals.png

$$A^2 + B^2 = C^2$$

NORMALS

img/1_single/normals.png

$$A^2 + B^2 = C^2$$

NORMALS - THEORY

img/1_single/linearVsQuadraticNormals_line

Linear

Quadratic

NORMALS - THEORY

img/1_single/linearVsQuadraticNormals_line

Linear

img/1_single/linearVsQuadraticNormals_quad

Quadratic

NORMALS - THEORY

img/1_single/computingNormals.png

$A^2 + B^2 = C^2$

NORMALS - THEORY

img/1_single/computingNormals.png $A^2 + B^2 = C^2$

NORMALS - RESULT

img/1_single/linearlyVaryingNormals.png

Linear

img/1_single/quadriticall

Quadratic

Barycentric coordinates recap

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

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

LEVEL OF DETAIL

LOD verhaal

./img/1_single/lod_lod0.png

./img/1_single/lod_lod1.png

./img/1_single/lod_lod2.png

./img/1_singl

0

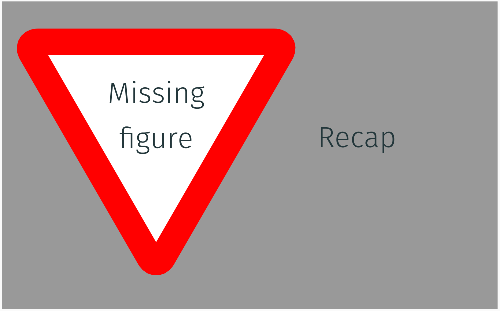
1

2

3

CONSTRUCTION

The steps. Recap of everything construct geometry and normals and evaluate less (low lod) or more points (high lod)



A TRIANGLE MESH

PROPERTIES

Shared normals + [Thales of Milet, 500 BC]?

Continuity recap?

SHARED NORMALS

Continuity

SHARP EDGES

Sharp edges

GRAPHICS PIPELINE

Waarom waren PN triangles hip in 2001? Plus pipeline

HARDWARE - PIPELINES

Hoe zou je het nu kunnen implementeren? Plus pipeline

CONCLUSION

FIN.

Questions?

REFERENCES

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beamericonarticle.pdf Alex Vlachos et al. “Curved PN triangles”. In: *Proceedings of the 2001 symposium on Interactive 3D graphics*. ACM. 2001, pp. 159–166.