Actions de Recherche Coopérative (ARC)

2 year INRIA research programs

CoSTIC: Curves and surfaces

3D Visibility: theory and applications (Visi3D)

Context:

Visibility computations in computer graphic applications

- limits of umbra and penumbra cast by a light source

- identifying sets of blockers between 2 polygons
- determining the view from a given point

Visibility queries in global illumination algorithms:

more than 50% of the total time spent

Ultimate objective

- Fast and effective rendering algorithms

  $\rightsquigarrow$ time, space, accuracy, reliability

Specific objectives

- Create an effective global data structure for answering efficiently 3D visibility queries.
- Bring together graphic and computational geometry communities
- Integrate theoretical and applied knowledge
- Identify problems arising in practice that theoreticians can help solve

People

Inria-Lorraine / Loria / Isa

H. Everett X. Goaoc
S. Lazard S. Petitjean
H.-S. Na (Postdoc 1 year)
A. Pant (ITT Kanpur - 3 month)

ENS Ulm / GéCoal

M. Pocchiola

Inria-Sophia / Reves

G. Drettakis
F. Duguet (DEA project - 6 month)

Inria-Sophia / Prisme

F. Cazals O. Devillers

Inria-Rhône-Alpes / iMAGIS

N. Holzschuch C. Puech

MIT

F. Durand

Université d'Utrecht

M. de Berg

Université de Groningue

G. Vegter

Meetings

March 1-4, 2000: meeting in Utrecht

March 27-28, 2000: days Visi3D at ENS Paris

Sept. 16-22 2000: Workshop in Bonifacio (20 pers.)

June 18-20, 2001: meeting Sophia-Antipolis

Sept. 20-21, 2001: Visi3D days at ENS Paris

Oct. 15-19, 2001: meeting during the Journées de géo algo

Now: Visi3D ending days at ENS Paris

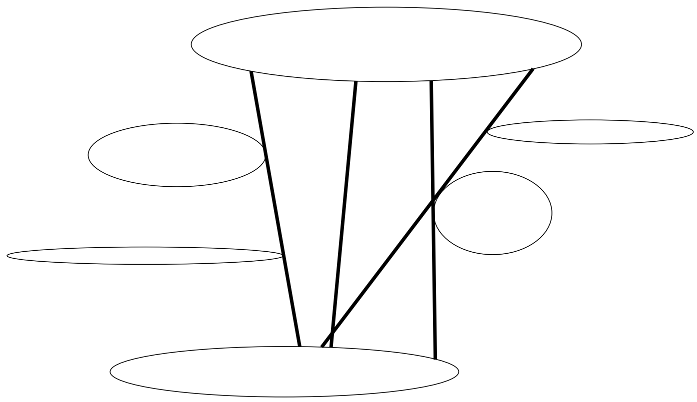
Data structure: the visibility complex

- 2D [Pocchiola,Vegter,96]

Decomposition of the set of maximal free line segments

into connected components of similar segments

$\leadsto$ encodes the visibility information of a scene



- 3D [Durand,Drettakis,Puech97], [Durand,99]

  $\leadsto$ visibility skeleton

  $\leadsto$ application to rendering

Short-comings

Size: Worst-case: $\Theta(n^4)$ Expected: $O(n^{\frac{8}{3}})$
Experimental $\sim \Theta(n^2)$

Robust implementation: no

Results

The visibility complex is usually quite small (Na)

Robust implementation of the visibility skeleton: ε-approx

(Duguet)

Optimal algorithm and implementation for the visibility complex of disks (Pocchiola)

Topology of the cells of the visibility complex of spheres (Goaoc)

New simple $\Omega(n^3)$ worst-case lower bound on the complex of spheres

[Devillers,Ramos,01]

Using graphics hardware to speed-up visibility queries

[Holzschuch, Alonso, 00]

Ongoing work

• Exact predicates for visibility queries:
Does a line through 4 segments intersect a fifth segment?

- Optimal computation of the (two) lines through 4 segments

(Devillers, Hall-Olt)

- Testing the intersection with the fifth segment

(Mourrain, Devillers, Isa)

- Implementation (Pant)

• Expected size of the silhouette of a polyhedron is $O(\sqrt{n})$ if

$$\lim_{i\to\infty} \sum_{e \text{ edge of } P_i} |\alpha_e| l_e = \int_S |\text{mean curvature}|$$

but problems of type "lampion de Schwarz" (Devillers et al)

• Discontinuity meshing with high order wavelet (Holzschuch)

Future work

- Robust exact implementation of the visibility complex

  - for triangles

  - for polyhedra

Fast output-sensitive algorithms

Validating theoretical results on complexity:
how big is the $O(n)$?

Dynamic visibility complex

Incorporating smooth surfaces, like, say, ... quadrics!
$\rightsquigarrow$ intersecting quadrics in $\mathbb{P}^5$

- Lazy discontinuity meshing

- Automatic identification of "scene type"

$\mathbf{\Omega(n^3)}$ worst-case lower bound on the complex of spheres
[Devillers,Ramos,01]

Quadratic view: