Robust Visibility Skeleton

Journées Visi3D

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Plan

- Introduction
- New Approach
- Algorithm
- Applications Results

Introduction

- New approach for visibility computation in image synthesis
- *Analytic* Visibility
- Handling general scenes
  - robust methods

Previous Work

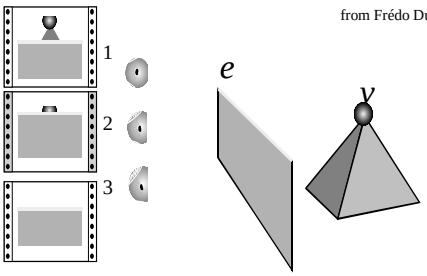
- The Visibility Complex (2D) : Pocchiola and Vegter [PV96]
- 3D Visibility Complex : Durand and Drettakis and Puech [DDP96]
- The Visibility Skeleton : Durand and Drettakis and Puech [DDP97]

Analytic Visibility

- Study the lines of the scene
  - Set of critical lines known as visibility events

Analytic Visibility

- Study the lines of the scene



from Frédo Durand's PhD thesis

Analytic Visibility

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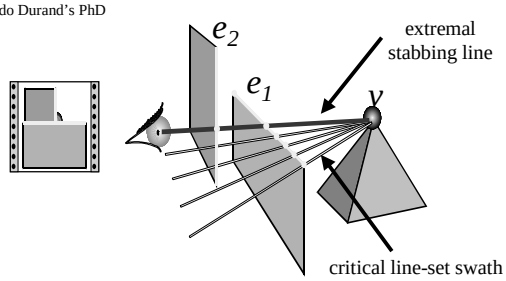


Visibility Skeleton [DDP97]

- Node :
  - Extremal stabbing line defined by elements of the scene
    - catalog of nodes
    - examples: VV, VEE
- Arc :
  - Critical line-set
    - node connection
    - Given by adjacencies of the catalog

Motivation

- The Skeleton by Durand et al.
  - catalog approach
  - generic scenes, known connectivity
- New method
  - generalized approach
  - all kind of scenes

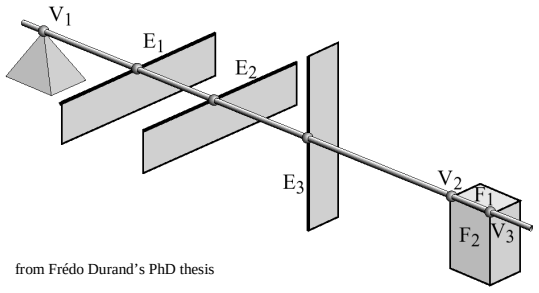
New approach

Theoretical results

New approach

- Limits of the previous model:
  - bound to the catalog
  - connectivity needed
- Proposed solutions:
  - general approach
  - scenes of any type (typical CG models)
  - degeneracies handled

Illustration of a degenerate node



from Frédo Durand's PhD thesis

New approach

- Generalized approach :
  - Generator
    - Element of the scene which can restrict line-space
      - Example : tangency to an edge, vertex contact
  - Node
    - Set of Generators which define an extremal stabbing line
  - Arc
    - Connected critical line-set of dimension 1 (swaths)

Construction - Nodes

- Enumeration of Nodes
  enumerate the critical zero-dimensional set of lines in line-space
- Validation of a Node
  check if the line is a maximal free segment
- ε-interactions
  Interactions are computed for data considered as approximations

Construction - Arcs

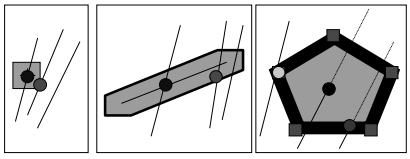
- Geometric computations in 3D
  1D critical line-sets - swaths
- Validation
  interaction with the set of potential interactors

Implemented Techniques

- Computation of line through four edges (from Teller [Tel92b])
- Progressive validation process
- On the fly computations for intersections in the mesh
- ε-interactions
- Test Blocker / Generator

Modelisation

- Vertex is a cube of size ε
- Edge is a shaft linking two vertices
- Faces are considered “as is”

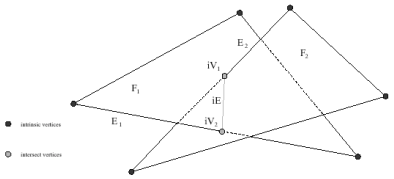


Edges through four lines

- Technique from Teller [Tel92b]
  - Gauss Reduction
  - Computation of two vectors of the kernel
  - Second degree equation on a parameter

Intersections

- Treatment of intersecting polygons
  - No geometric construction (tests only)
  - *Combinatorial* approach to the intersection



Progressive validation process

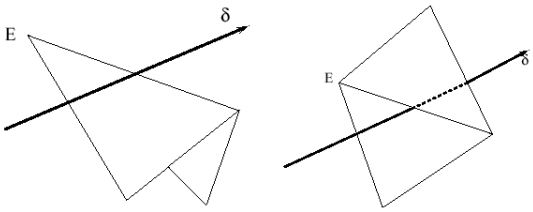
- Fat ray casting through the scene
  - interaction with elements of the scene (stored in a grid) along the line
  - test blocker / generator on the elements encountered

ε-interactions – contact

- Vertex
  - *min* distance to the vertex
- Edge
  - *min* distance from the nearest point of the edge

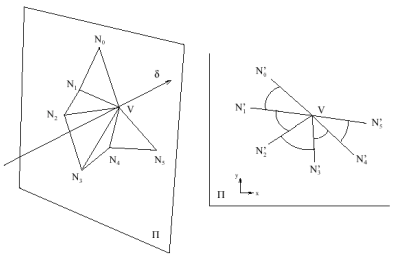
Test blocker / generator

- Edge



Test blocker / generator

- Vertex



Connection by arcs

- For two given nodes
  - they must share *a sufficient number* of generators
  - dimension of the associated algebraic variety for criterion
- List of touched faces (for validation)
  - interaction of these faces with the *midline* (as for nodes)

Application

Computation of the shadows cast by a directional source

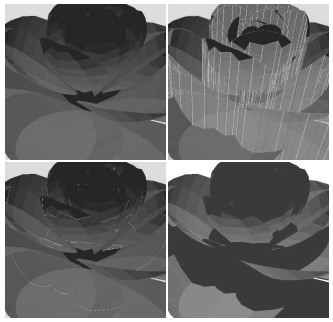
- Input :
  - polygonal scene
  - directional source
- Output :
  - *classified* polygonal scene: lit polygons and polygons in shadow

Pseudo-code of the method

- `Node enumeration/validation`
  - `enumeration of SV`
  - `enumeration of SEE`
- `Arcs enumeration/validation`
  - `enumeration of SE`
- `Projection of the arcs onto faces`
- `Constrained triangulation`

Algorithm

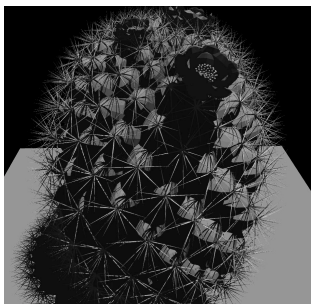
- Scene
  - Skeleton
- Limits
  - Result



Enumeration

- Nodes
  - intrinsic vertices
  - apparent vertices EE
    - computation of apparent intersections of two edges
- Arcs
  - edges
    - sorting nodes along the edge

Results



44k polygons, 1h

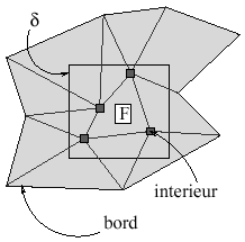
110k polygons, 8min

Multiface

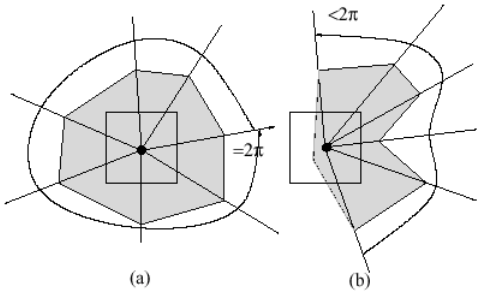
- Multiple interactions between the line and the face
  - face and line in the same plane
  - small face with respect to ε
- Group of connected faces
  - connectivity is needed for the Multiface
  - the group is considered as a whole
- Towards hierarchical visibility
  - the multiface is a representant for a set of elements while increasing the value of ε

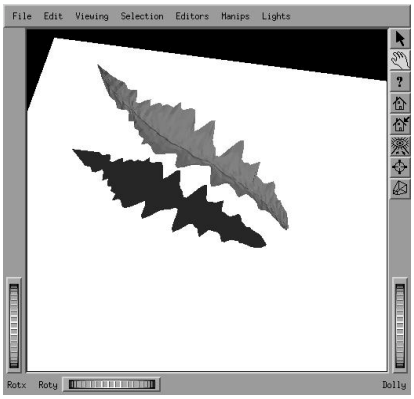
Construction

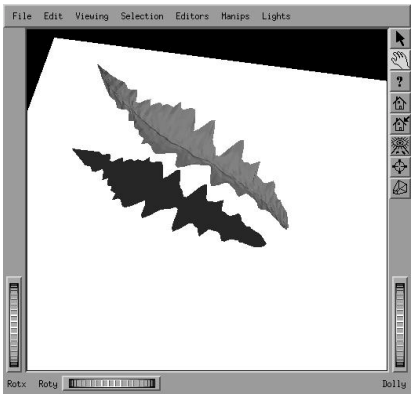
- Multiface
  - inner vertices
  - inner faces
  - boundary edges
- Inner edges
  - *touched* by δ
  - non-silhouette

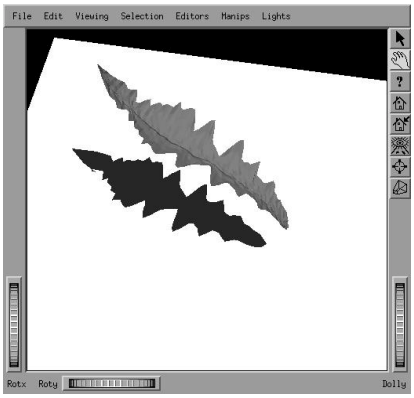


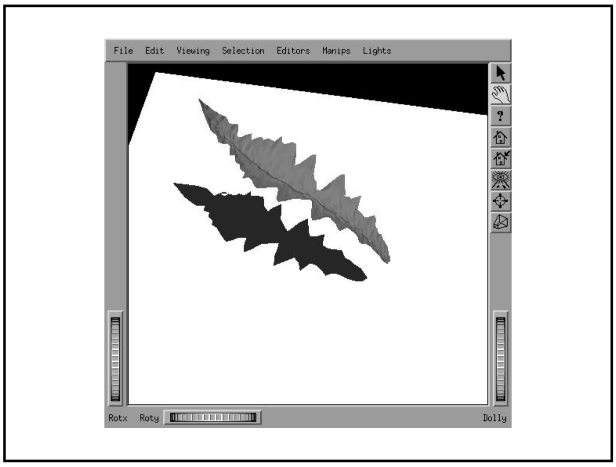
Interaction test







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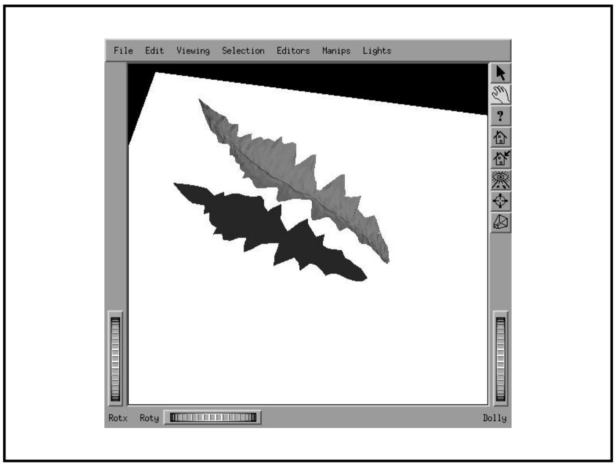
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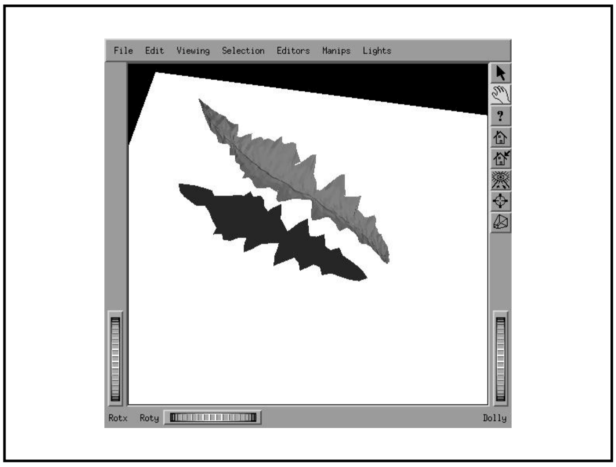
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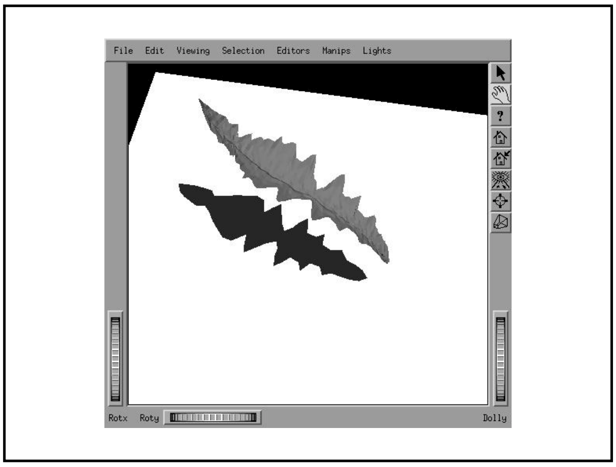
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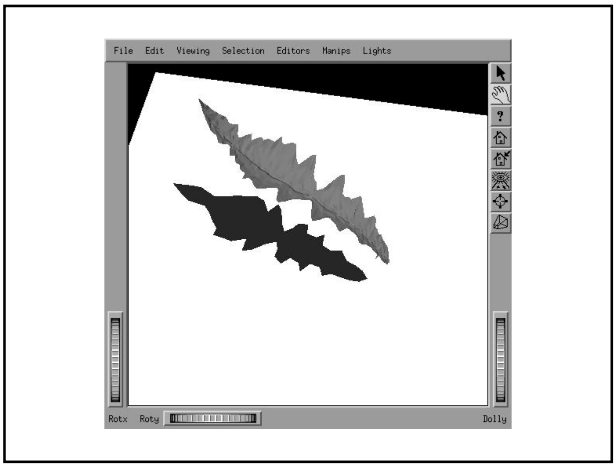
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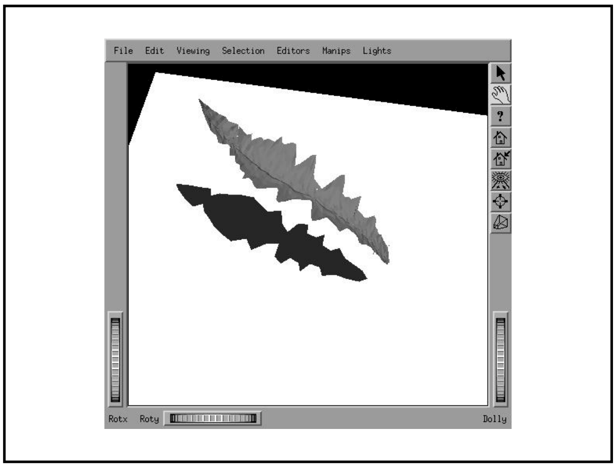
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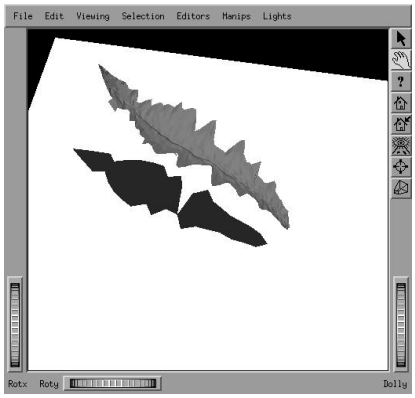


Conclusion

- Robust visibility for simple problems
- Towards hierarchical visibility
- Work in progress : discontinuity meshing (robust)

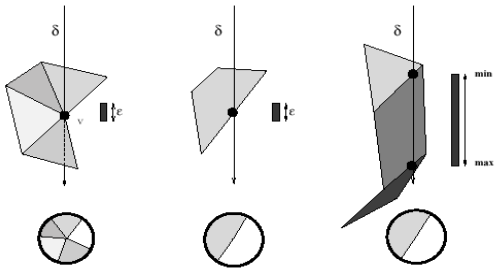
Lost connectivity – Blocker Fan

- Connectivity is not always available
  - Blocking predicates are no longer consistent
- Contacts
  - Contacts are treated on the fly, the input geometry is not modified

Blocker Fan

- A stack of thick slices
- Each element « touched » by a line generates a thick slice
  - each thick slice is pushed onto the stack of the blocker fan
  - we look for zones one the line in which the set of slices form a complete disk

Blocker Fan



Blocker Fan

- Merging thick slices