

Synthèse d'Images

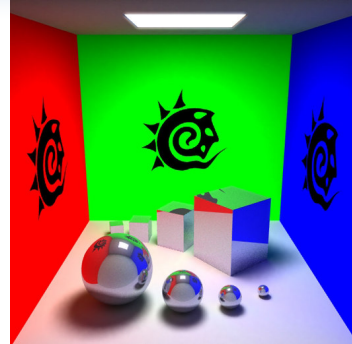
Elmar Eisemann

Elmar.Eisemann@inrialpes.fr

Basé sur les cours de
Frédo Durand, Barbara Cuttler, E. Boyer,
H. Briceno, N. Holzschuch

Rayon secondaire

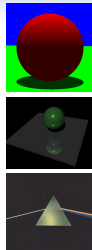
Ombres
Réflexions
Réfractions
Lumière
indirecte
...



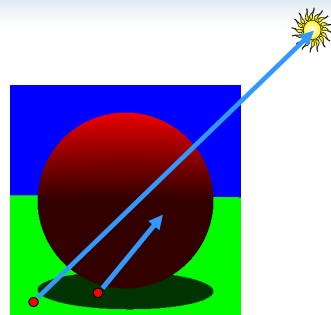
http://admin2.sudhian.com/images/review/cpu/amd/X2/Radiosity_Box.jpg

Maintenant

- Ombres
- Reflexions
- Réfractions

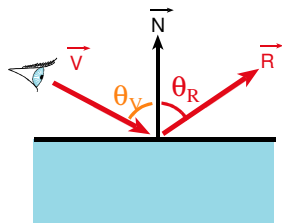


Ombres



Reflection

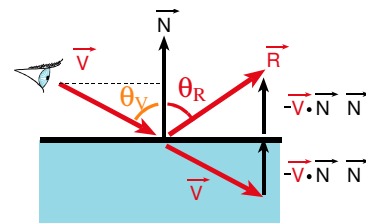
- angle de réflexion = angle de vue
À vous...



Reflection

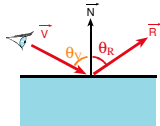
- angle de réflexion = angle de vue

$$R = V - 2(V \cdot N)N$$



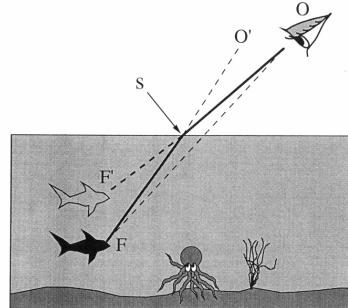
Montant de Réflexion

- ray tracing traditionnel
 - coefficient de reflection < 1
 - Multiplication composant par composant



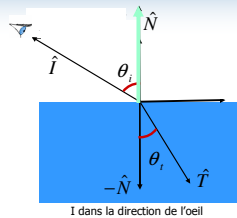
Qualitative refraction

- From "Color and Light in Nature" by Lynch and Livingston



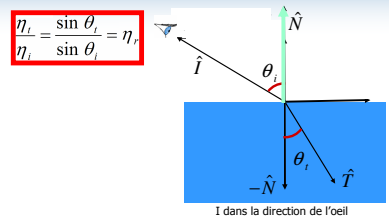
Refraction

Snell-Descartes Law



Refraction

Snell-Descartes Law



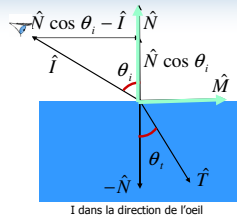
Refraction

Snell-Descartes Law

$$\frac{\eta_i}{\eta_r} = \frac{\sin \theta_i}{\sin \theta_r} = \eta_r$$

$$\hat{M} = \frac{(\hat{N} \cos \theta_i - \hat{I})}{\sin \theta_i}$$

$$\hat{T} = \sin \theta_i \hat{M} - \cos \theta_i \hat{N}$$



Refraction

Snell-Descartes Law

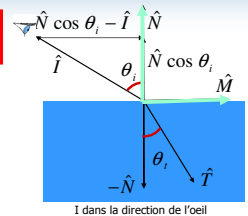
$$\frac{\eta_i}{\eta_r} = \frac{\sin \theta_i}{\sin \theta_r} = \eta_r$$

$$\hat{M} = \frac{(\hat{N} \cos \theta_i - \hat{I})}{\sin \theta_i}$$

$$\hat{T} = \sin \theta_i \hat{M} - \cos \theta_i \hat{N}$$

$$\hat{T} = \frac{\sin \theta_i}{\sin \theta_i} (\hat{N} \cos \theta_i - \hat{I}) - \cos \theta_i \hat{N}$$

$$\hat{T} = (\eta_r \cos \theta_i - \cos \theta_i) \hat{N} - \eta_r \hat{I}$$



Refraction

Snell-Descartes Law $\frac{\eta_t}{\eta_i} = \frac{\sin \theta_t}{\sin \theta_i} = \eta_r$

$$\hat{M} = \frac{(\hat{N} \cos \theta_i - \hat{I})}{\sin \theta_i}$$

$$\hat{T} = \sin \theta_i \hat{M} - \cos \theta_i \hat{N}$$

$$\hat{T} = \frac{\sin \theta_t}{\sin \theta_i} (\hat{N} \cos \theta_i - \hat{I}) - \cos \theta_i \hat{N}$$

$$\hat{T} = (\eta_r \cos \theta_i - \cos \theta_i) \hat{N} - \eta_r \hat{I}$$

$$\cos \theta_t = \hat{N} \cdot \hat{T}$$

$$\cos \theta_t = \sqrt{1 - \sin^2 \theta_t} = \sqrt{1 - \eta_r^2 \sin^2 \theta_i} = \sqrt{1 - \eta_r^2 (1 - (\hat{N} \cdot \hat{I})^2)}$$

Refraction

Snell-Descartes Law $\frac{\eta_t}{\eta_i} = \frac{\sin \theta_t}{\sin \theta_i} = \eta_r$

$$\hat{M} = \frac{(\hat{N} \cos \theta_i - \hat{I})}{\sin \theta_i}$$

$$\hat{T} = \sin \theta_i \hat{M} - \cos \theta_i \hat{N}$$

$$\hat{T} = \frac{\sin \theta_t}{\sin \theta_i} (\hat{N} \cos \theta_i - \hat{I}) - \cos \theta_i \hat{N}$$

$$\hat{T} = (\eta_r \cos \theta_i - \cos \theta_i) \hat{N} - \eta_r \hat{I}$$

$$\hat{T} = \left(\eta_r (\hat{N} \cdot \hat{I}) - \sqrt{1 - \eta_r^2 (1 - (\hat{N} \cdot \hat{I})^2)} \right) \hat{N} - \eta_r \hat{I}$$

Réflexion complète si racine est imaginaire

$$\cos \theta_t = \hat{N} \cdot \hat{T}$$

$$\cos \theta_t = \sqrt{1 - \sin^2 \theta_t} = \sqrt{1 - \eta_r^2 \sin^2 \theta_i} = \sqrt{1 - \eta_r^2 (1 - (\hat{N} \cdot \hat{I})^2)}$$

On a oublié un truc: NORMALISER

Montant de Refraction

- ray tracing traditionnel
 - coefficient de refraction < 1
 - Souvent combiner reflexion+refraction (Fresnel)

Sous l'eau

- "Color and Light in Nature" de Lynch and Livingstone

Fig. 3.7A The optical manhole. From under water, the entire celestial hemisphere is compressed into a circle only 97.2° across. The dark boundary defining the edges of the manhole is not sharp due to surface waves. The rays are analogous to the crepuscular type seen in hazy air, Section 1.9. (Photo by D. Granger)

Fig. 3.7B The optical manhole. Light from the horizon (angle of incidence = 90°) is refracted downward at an angle of 48.6°. This compresses the sky into a circle with a diameter of 97.2° instead of its usual 180°.

Exemple

- Enright, D., Marschner, S. and Fedkiw, R.,

Récursion réflexion

0 recursion 1 recursion 2 recursions

Eviter les récursions infinies

Criteria pour s'arrêter:

- Limiter la récursion
 - Nb répétitions
- Contribution rayon
 - Attenuation par transparence/transmittance

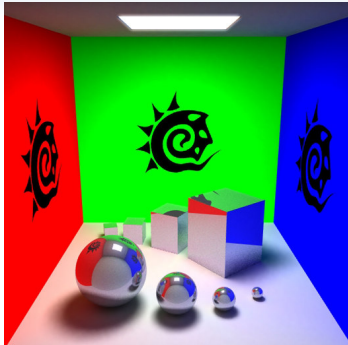
Pourquoi devient-il plus faible?

Ou bien les deux

Est-ce que un rayon secondaire suffit?

Rayon secondaire

Ombres
Réflexions
Réfractions
Lumière indirecte
...

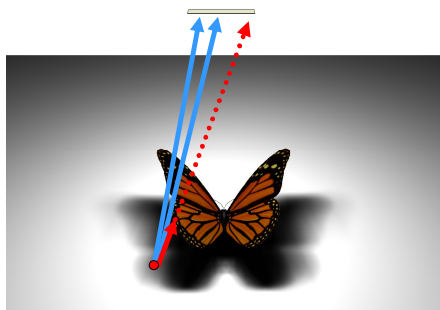


http://admin2.sudhian.com/images/review/cpu/amd/X2/Radiosity_Box.jpg

Plusieurs rayons nécessaire pour ceci:

- Distribution Ray Tracing
 - Ombres douces
 - Anti-aliasing (plus de "jaggies")
 - Glossy réflexion
 - Motion blur
 - Depth of field (focus)

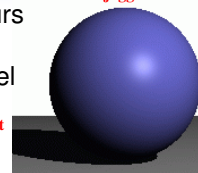
Sources surfacique



Antialiasing – Supersampling

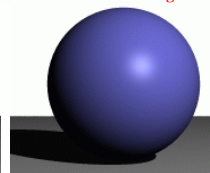
- Plusieurs rayons par pixel

point light

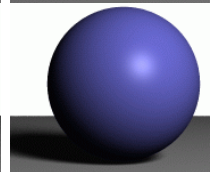
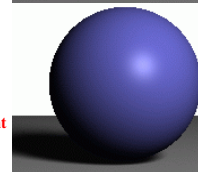


jaggies

w/ antialiasing



area light



Reflection

- Une réflexion par intersection

perfect mirror

Glossy

- réflexions multiples par rayon

polished surface

Motion Blur

- Echantillonnage temporelle

Rob Cook

Jolies images...
mais quelles sont les limitations?

Analyse

cost \leq height * width *
 num primitives *
 intersection cost *
 num shadow rays *
 supersampling *
 num glossy rays *
 num temporal samples *
 max recursion depth *
 ...

Comment réduire ceci????????????

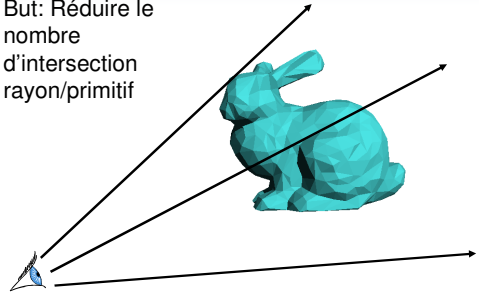
Questions?

Plan

- Review & Schedule
- Motivation – Distribution Ray Tracing
- **Bounding Boxes**
 - of each primitive
 - of groups
 - of transformed primitives
- Spatial Acceleration Data Structures

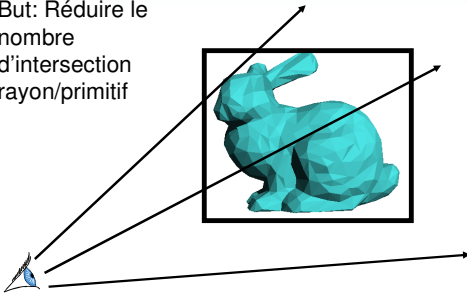
Acceleration of Ray Casting

- But: Réduire le nombre d'intersection rayon/primitif



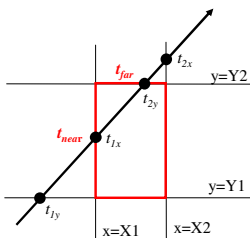
Acceleration of Ray Casting

- But: Réduire le nombre d'intersection rayon/primitif



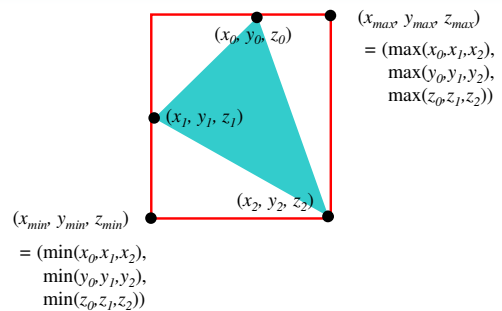
Les boîtes les plus simples: Axis-Aligned Box

Intersection with Axis-Aligned Box

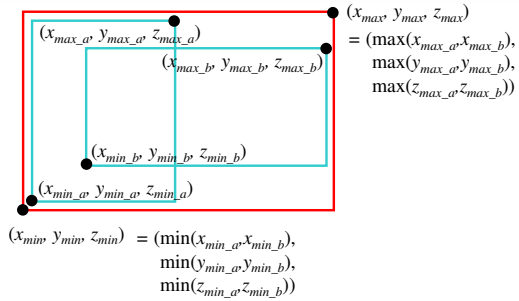


- Pour les 3 axes, calculer les distances d'intersection t_1 et t_2
- $t_{near} = \max(t_{1x}, t_{1y}, t_{1z})$
- $t_{far} = \min(t_{2x}, t_{2y}, t_{2z})$
- Si $t_{near} > t_{far}$ boîte ratée
- Si $t_{far} < t_{min}$ box derrière
- Sinon intersection à t_{near}

Bounding Box pour un triangle



Bounding Box pour un groupe

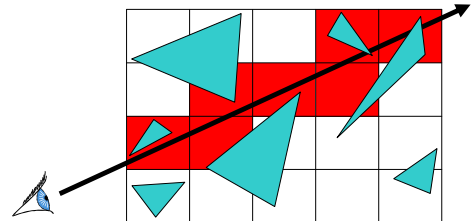


Questions?

Autres accélérations:

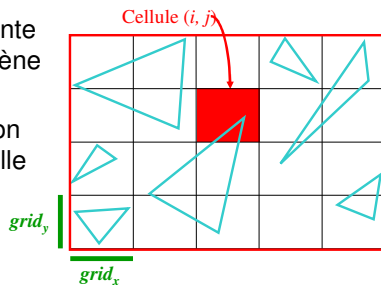
- Spatial Acceleration Data Structures
 - Regular Grid
 - Adaptive Grids
 - Hierarchical Bounding Volumes

Grille régulière



Créer la grille

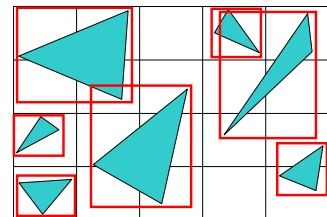
- Trouver boîte englobante de la scène
- Choisir résolution de la grille



Insérer les primitifs dans la grille

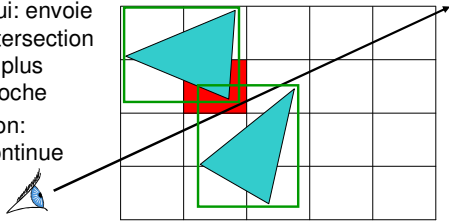
- Primitifs dans plusieurs cellules?

Utiliser pointeurs



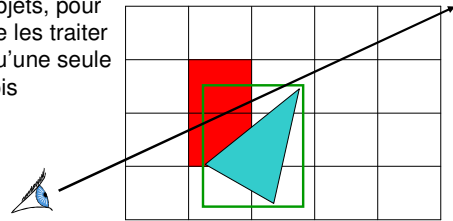
Traverser la grille

- Y-a-t-il une intersection?
- Oui: envoie intersection la plus proche
- Non: continue



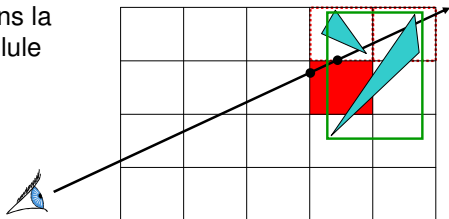
Preventing repeated computation

- Mettre un "tag" sur les objets, pour ne les traiter qu'une seule fois



Attention aux intersections distantes

- Intersection doit être dans la cellule



Discussion: Grille régulière

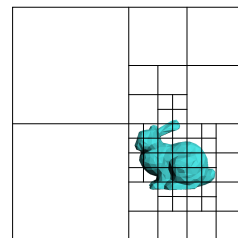
- Avantages?
 - Facile à construire
 - Facile à traverser
- Désavantages?
 - Peut contenir beaucoup de cellule vide
 - Géométrie peut être mal répartie

Autres accélérations:

- Spatial Acceleration Data Structures
 - Regular Grid
 - Adaptive Grids
 - Hierarchical Bounding Volumes

Grilles adaptatives

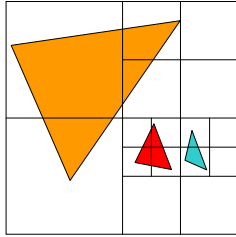
- Subdivision jusqu'à ce que la cellule ne contient plus que n éléments, où elle est à une profondeur d



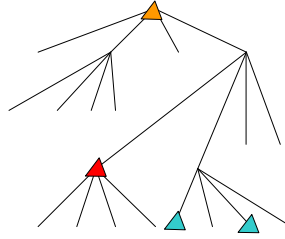
Octree/(Quadtree)

Grille adaptative

- Éléments aux niveaux intermédiaires



Octree/(Quadtree)



Discussion: Octree

- Avantages?
 - Facile à construire
 - Facile à traverser
- Désavantages?
 - Boîtes divisées par rapport à l'espace
 - Toujours alignées
- Autres possibilités: BVH...

Merci

C'est l'heure de se reveiller...

Slides

- Contributions de:
 - Briceno, H., Notes du cours SI, UFRIMA
 - Boyer, E., Notes du cours SI, UFRIMA
 - Holzschuch, N., « Notes du cours DEA-IVR, ENSIMAG, Création d'Images Virtuelles ». 2005-2006
 - Frédo Durand and Barbara Cottler, SI, MIT

- Images taken from various sources:
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