

## Chapitre 4

### Villes virtuelles 3D

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- 4.1 – Introduction
- 4.2 – CityGML
- 4.3 – Rappels de photogrammétrie
- 4.4 – Conclusions

### 4.1 – Introduction

- Visualisation des villes à 3D
- Nouveaux projets couvrant le globe terrestre
  - Google Earth (2D et 3D)
  - Bing (Virtual Earth de Microsoft)
- Vision globale et recherche locale
- Intégration de données provenant de sources multiples

### Composants

- Modélisation des bâtiments
- Modélisation des terrains
- Modélisation des objets urbains

## Berlin



## Heidelberg

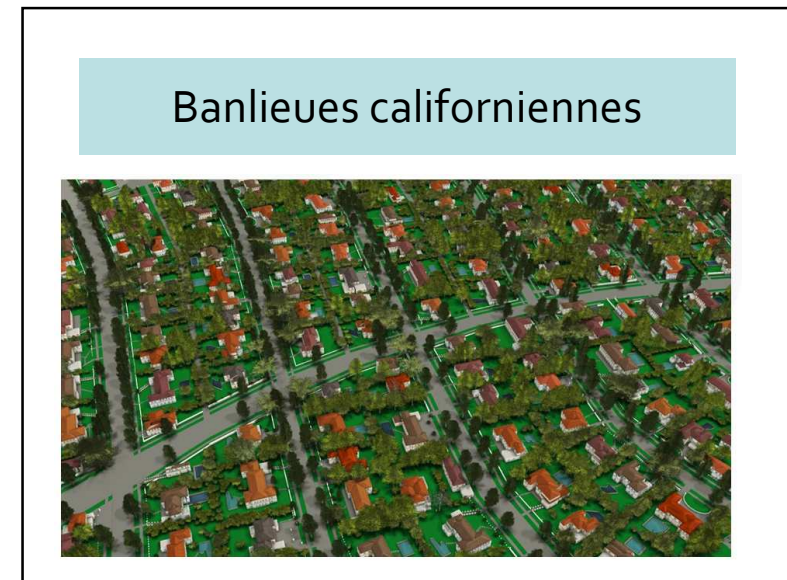
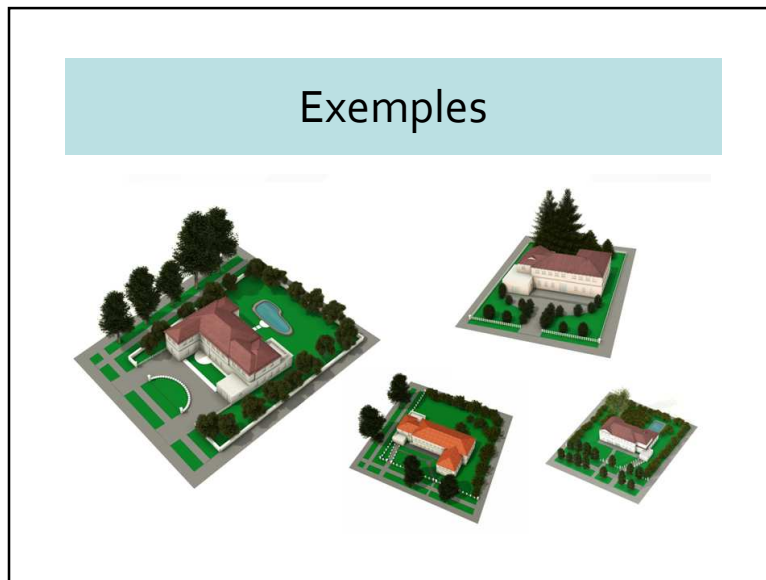
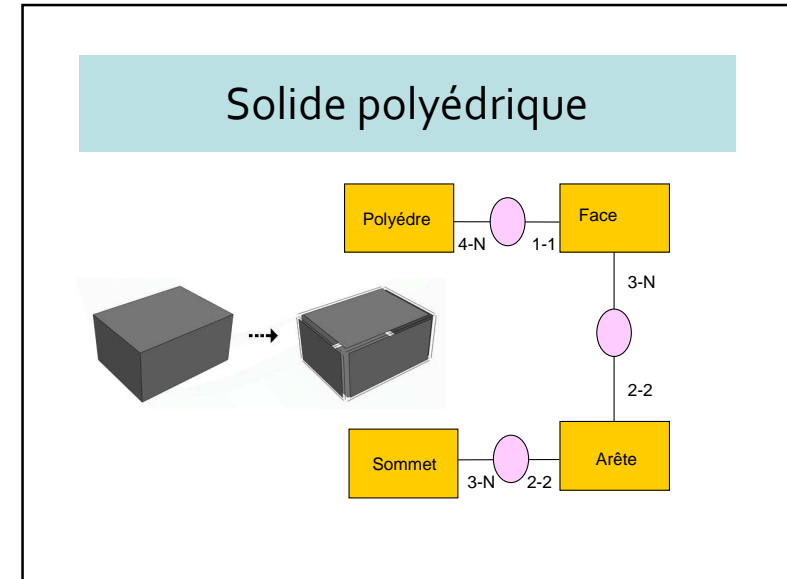
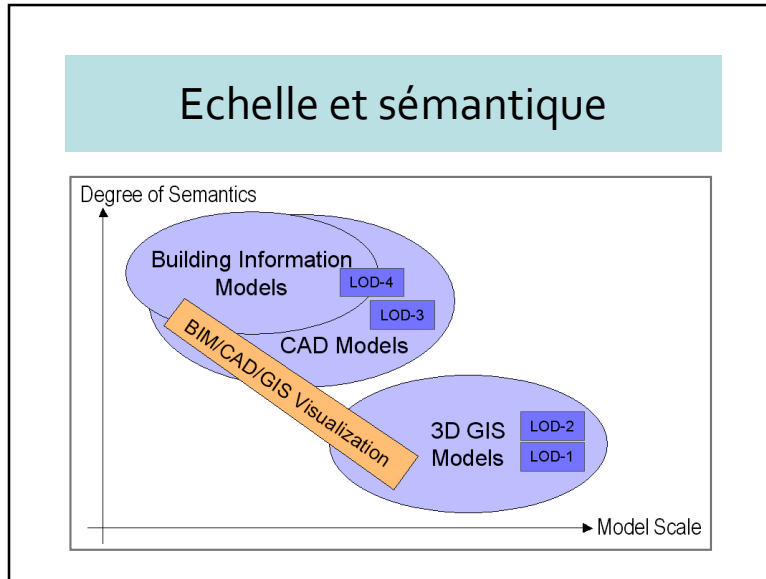


## Applications potentielles

- Simulation du bruit, de la pollution de l'air
- Simulation des inondations
- Simulation des risques naturels et technologiques
- Comparer les hauteurs des bâtiments et les hauteurs légales
- Impact visuel de nouveaux projets
- Vérification des déclarations pour les impôts locaux
- Etc.

## Autres applications

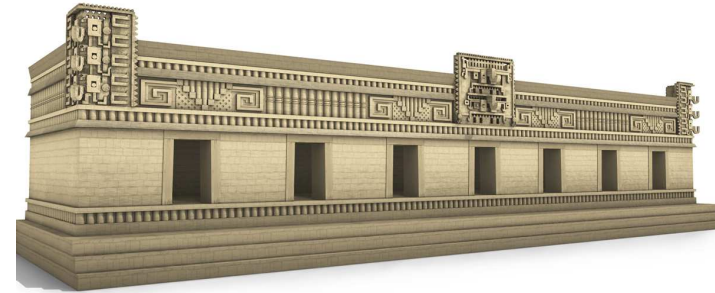
- Geomarketing : impact visuel de la publicité
- Agences immobilières : donner une idée du voisinage aux acquéreurs potentiels
- Tourisme : monuments et lieux à visiter
- Téléphones mobiles : positionnement des antennes (intervisibilité)
- Panneaux solaires : localisation optimale
- Hélicoptères : endroits pour atterrir
- Histoire et archéologie : modéliser une ville dans les siècles ou les millénaires précédents
- etc.



## Reconstitution de Pompéi



## Architecture maya



## Modélisation des toits



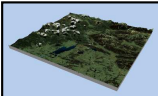
## 4.2 – CityGML

- Initiative allemande
- Extension de GML
- But : villes virtuelles à 3D

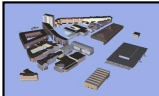
## Objets de CityGML

- Terrains nus
- Edifices, ponts, tunnels, murs
- Rues, transports, voies ferrées, eau, végétation
- Mobilier urbain

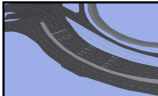
## Exemples d'objets CityGML




Terrain



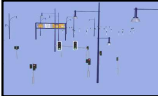
Bâtiment



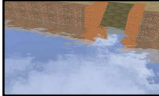
Réseau routier



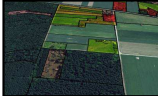
Végétation




Mobilier urbain



Eau



Sols

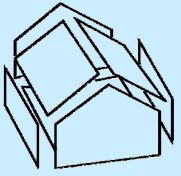


Regroupement

## Modélisation 3D des bâtiments

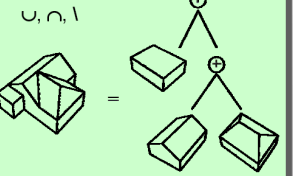
**GIS: accumulative**  
**Boundary Representation**

- Aggregation of all surfaces enclosing the object's volume



**CAD: generative**  
**Constructive Solid Geometry**

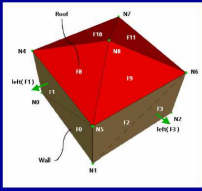
- Volumetric primitives
- Set theoretical operators for combination:  
∪, ∩, ∖



## Modèle simple

### 3D Data Model 1

- Define Geometry by point coordinates
- Example:  
x0 y0 z0, x1 y1 z1, x5 y5 z5, #F0  
x0 y0 z0, x5 y5 z5, x4 y4 z4, #F1  
x1 y1 z1, x6 y6 z6, x5 y5 z5, #F2
- Redundancy: Each Point coordinate is stored 6 times !!!
- Used in CityGML, Spatial DB



### Modèle plus sophistiqué

**3D Data Model 2**

Building Geometry

E-Edge (Arc), H Halfedge (E-Edge)

Edges and Halfedge dominate storage cost (E = T + V !)  
 3D-FDS, Molenaar (1990)

### Niveaux de détails

- LOD<sub>0</sub> – Modèle Régional
  - 2.5D Modèle de terrain
- LOD<sub>1</sub> – Ville/ Modèle de site
  - Modèle de bloc avec ou sans toits
- LOD<sub>2</sub> – Ville/ Modèle de site
  - Texture des toits et des façades
- LOD<sub>3</sub> – Ville/ Modèle de site
  - Modèle architectural détaillé
- LOD<sub>4</sub> – Modèle de l'intérieur
  - Navigation à l'intérieur des bâtiments

### Niveaux de détails

LOD0

LOD1

LOD2

LOD3

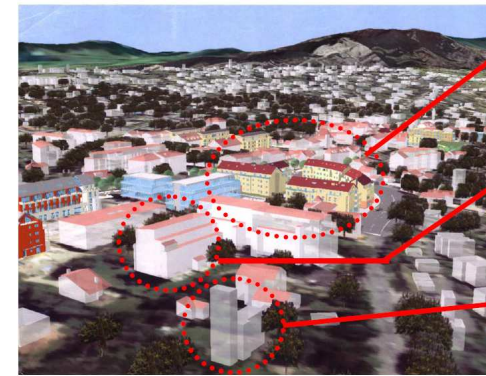
LOD4

<p>IFC Modell</p>	<p>CityGML LoD 1 Modell</p>
	<p>CityGML LoD 2 Modell</p>
	<p>CityGML LoD 3 Modell</p>
	<p>CityGML LoD 4 Modell</p>

### Niveaux de détails – exemple 1



### Niveaux de détails – exemple 2



LOD3 et LOD4 :  
pour mettre en  
évidence les  
nouveaux  
bâtiments

LOD 2 : pour les  
bâtiments au  
voisinage

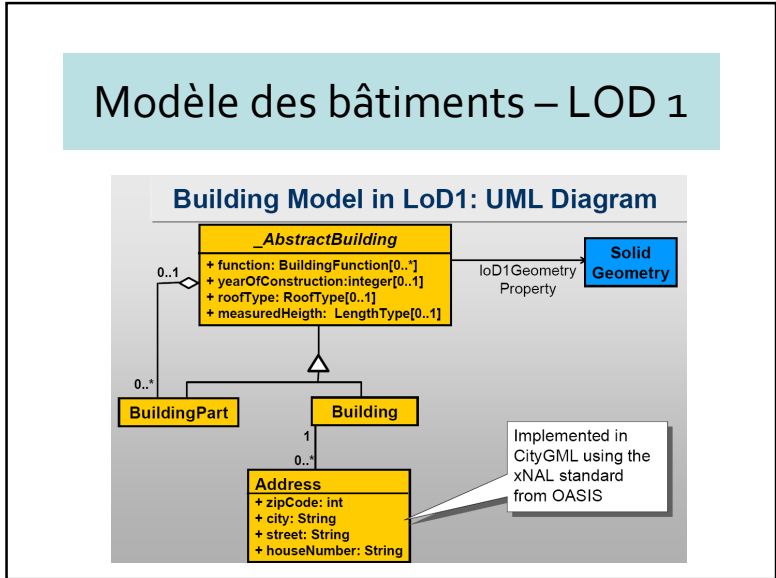
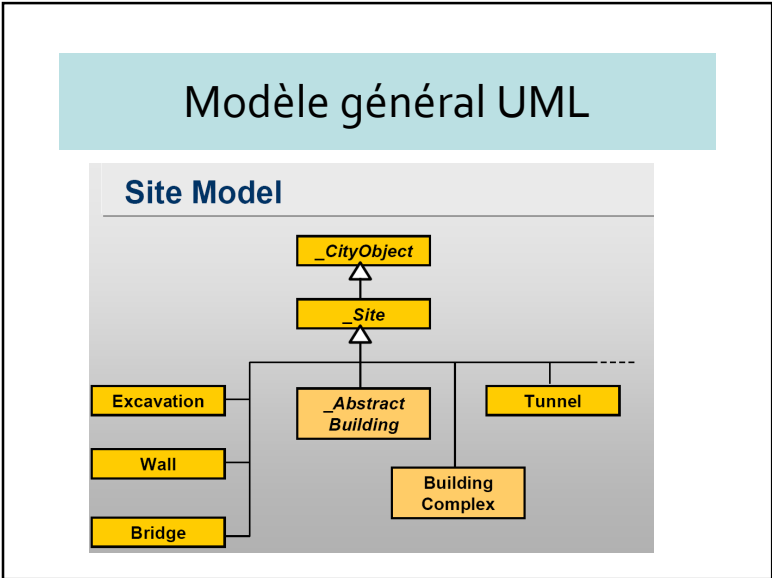
LOD 1 : pour les  
autres bâtiments

### Bonn



### Trento

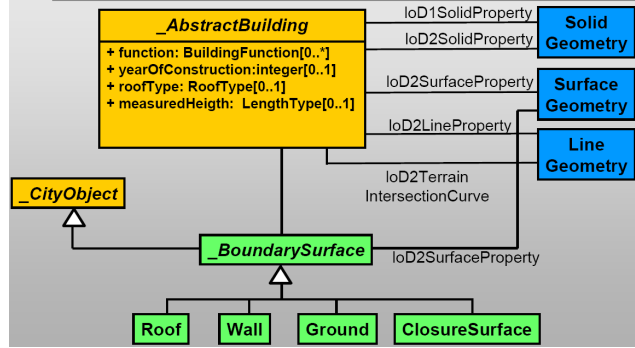






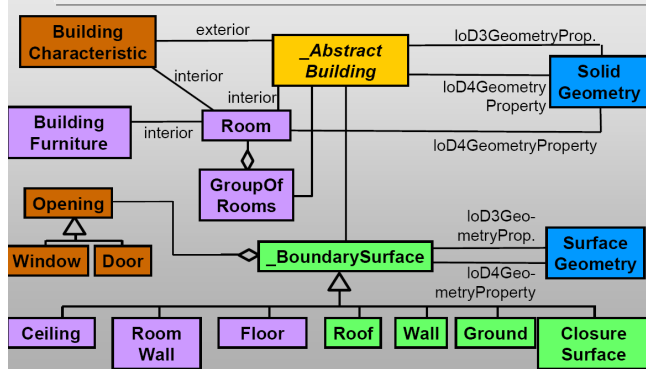
### Modèle des bâtiments – LOD 2

Building Model in LoD2



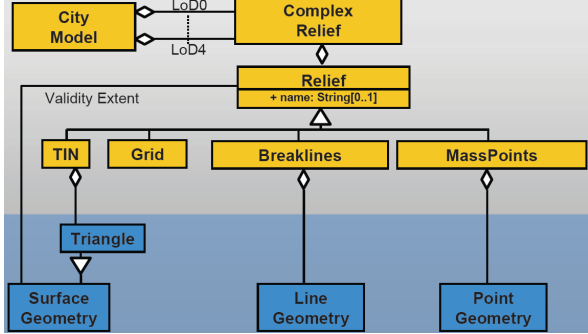
### Modèle des bâtiments – LOD 3 et 4

Building Model in LoD3 & LoD4



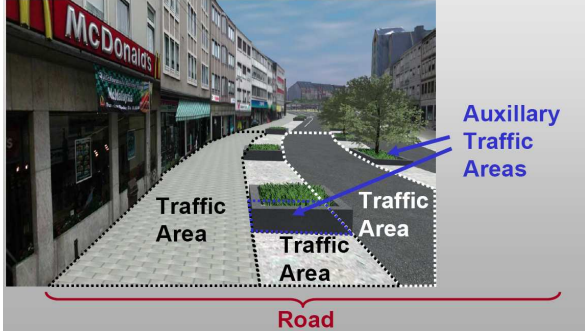
### Modèle de terrain

Digital Terrain Model: UML Diagram

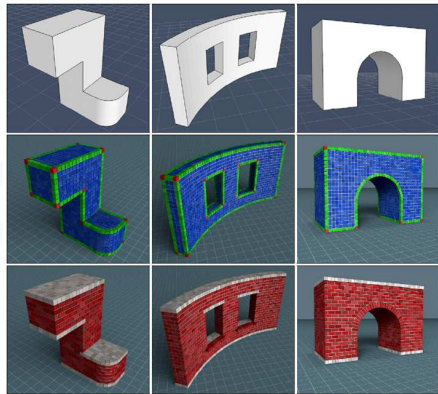


### Exemple modèle de transport

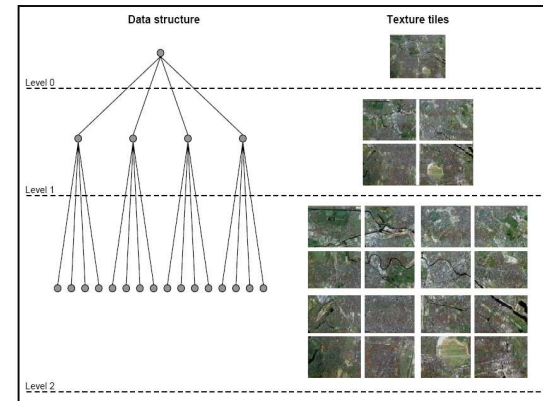
Example: Transportation Model in LoD2



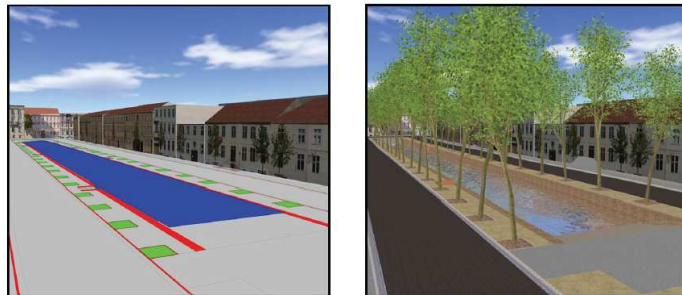
## Application des textures



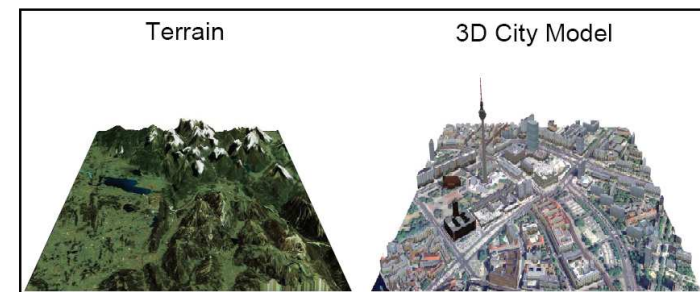
## Modèle multi-résolution pour les textures des terrains



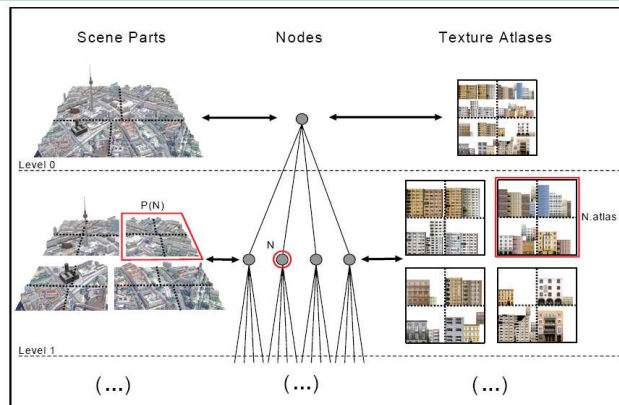
## Habillage



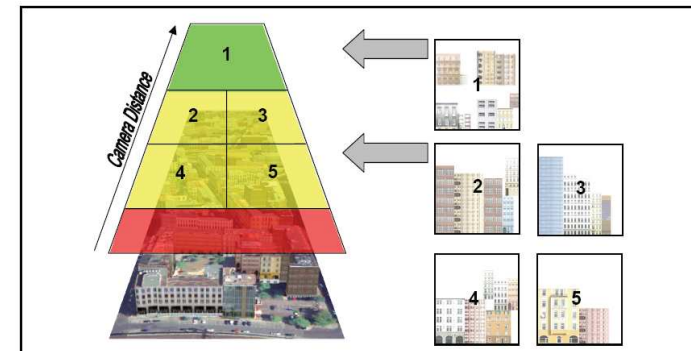
## Exemple



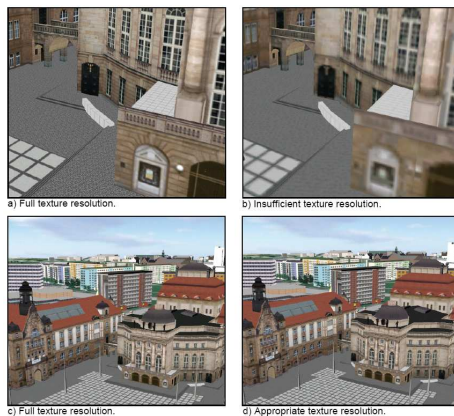
## Textures hiérarchiques des façades



## Textures et perspectives

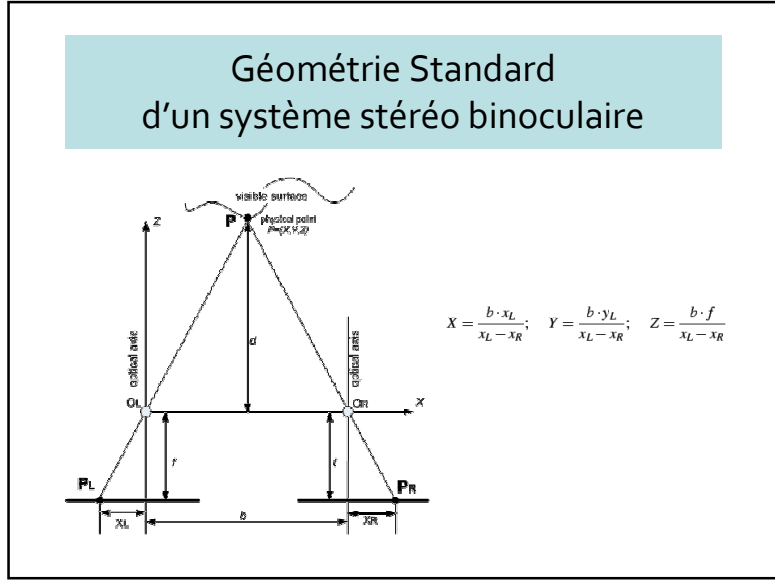
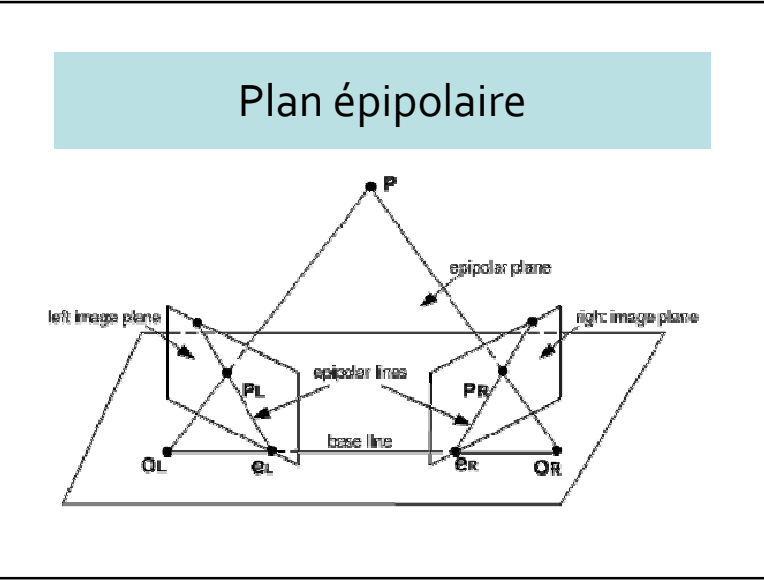
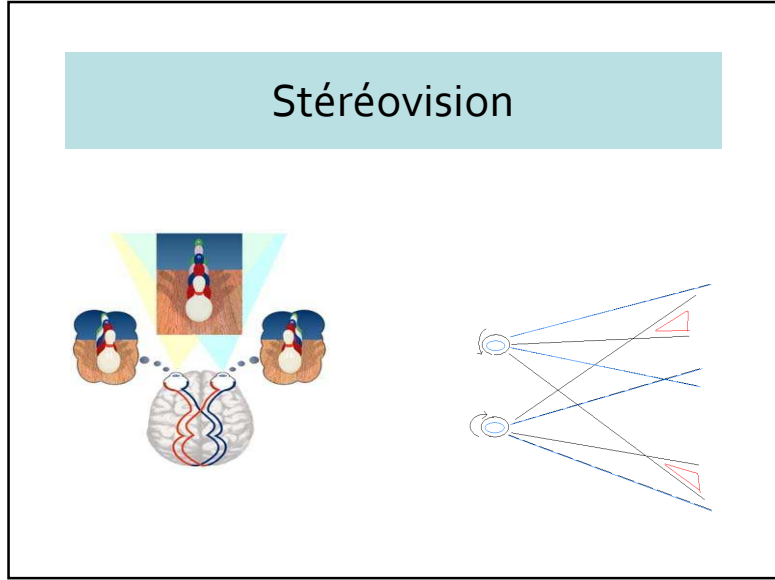
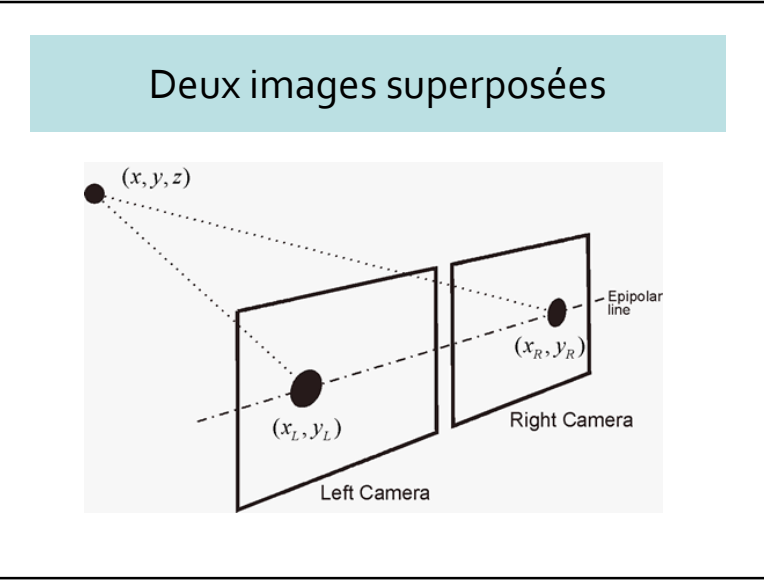


## Textures et résolution



## 4.3 – Rappels de photogrammétrie

- Œil et images
- Stéréovision
- Photos aériennes
- Reconstruction des édifices



## Vision et objets

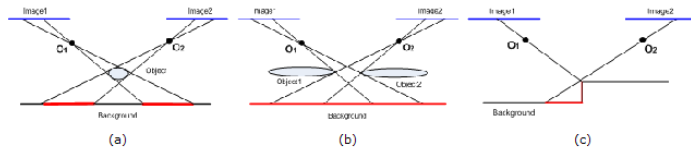
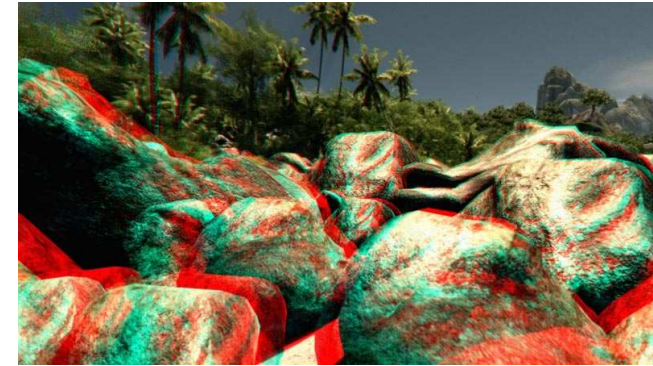
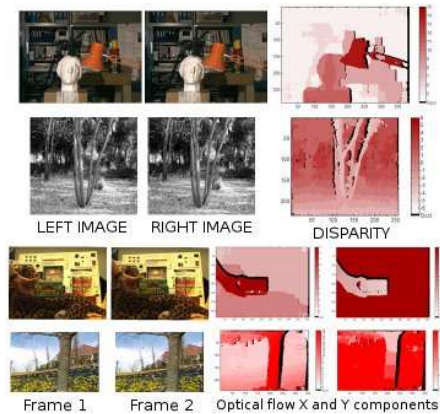


Figure: Variants of partial occlusions (Red Colour Regions): (a) due to a thin foreground object; (b) due to small foreground hole; (c) due to surface discontinuity.

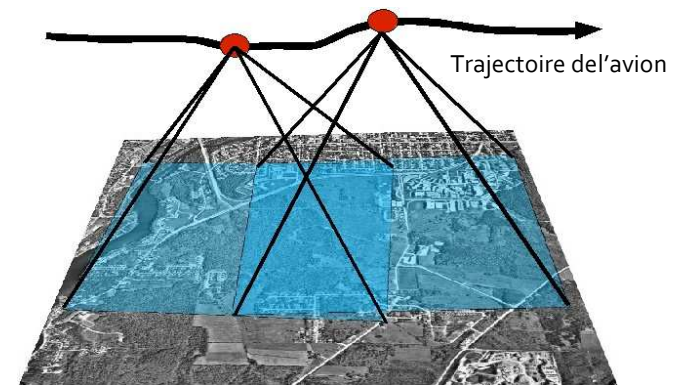
## Superposition



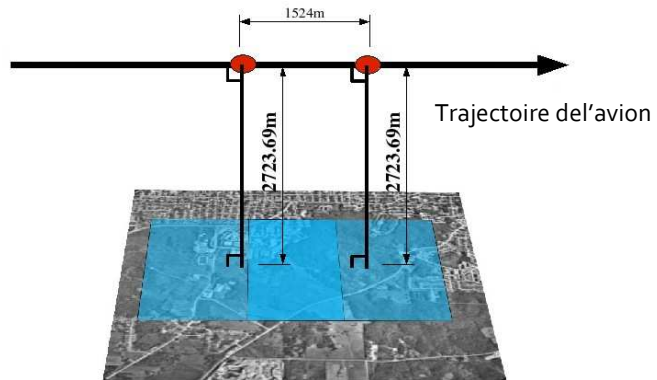
## Comparaison de deux images



## Principe des photos aériennes



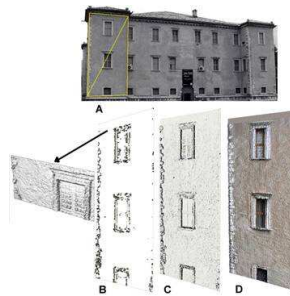
## Stabilisation de la trajectoire



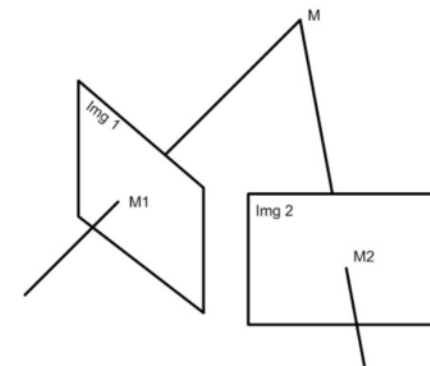
## Photos et points de référence



## Extraction des lignes



## Reconstruction d'un point 3D à partir de deux images 2D



### Etapes principales

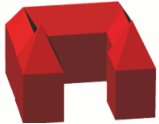
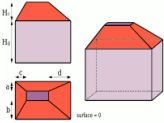
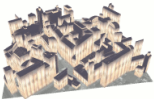


- Localisation des points homologues
- Extraction des lignes
- Génération modèle 3D
- Identification des textures
- Extraction des textures

### Deux vues d'un objet reconstruit



### Reconstruction de bâtiments



### UltraCamX



**UltraCamX Prime**

Image Format  
17,330 x 11,3100 Pixel  
196 Mega Pixel

6,600 Images per Removable Storage Unit

1.8 cm at 300m Flying Height above Ground



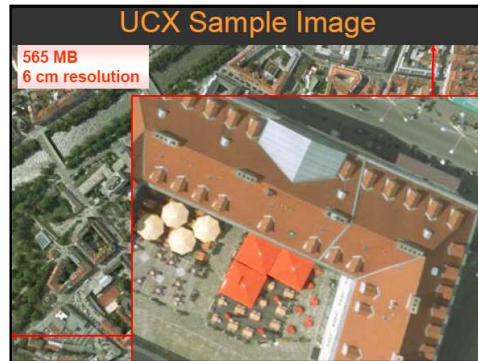
8 Gigs/bytes per Second  
955 MB per Trigger  
One Image per ~ 1 Second

± 2 μm Geometric Accuracy  
7,000 Gray Values

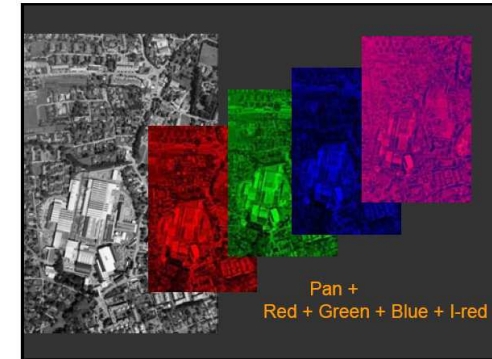
~ 4 Tera-Bytes per Data Unit  
Unlimited # of Images in One Aerial Sortie

Extreme Environmental Challenge

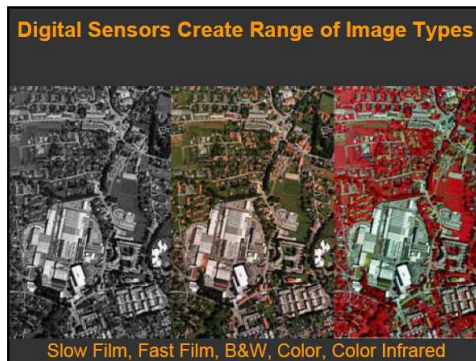
## Exemple



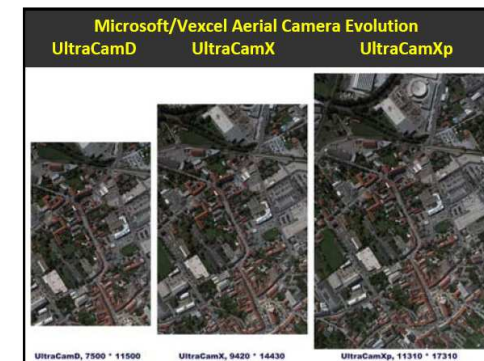
## Canaux



## Capteurs numériques

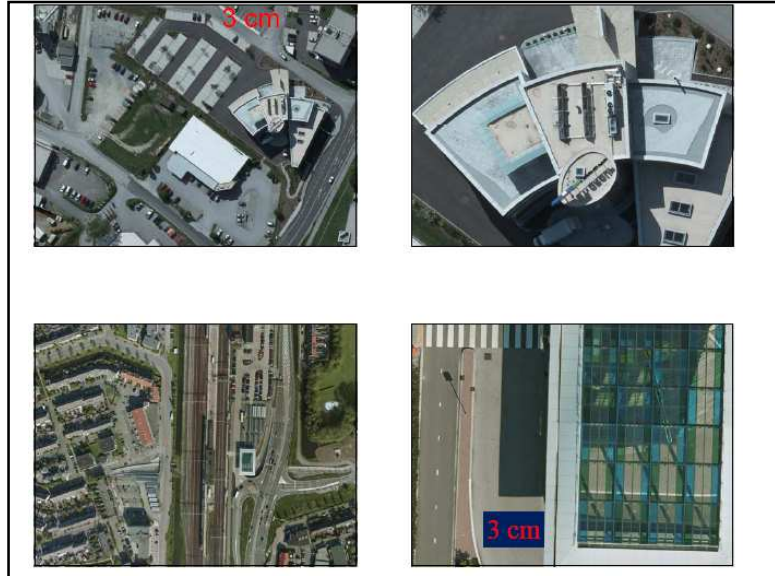


## Evolution

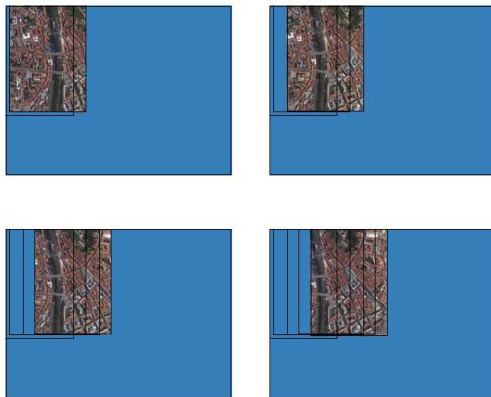




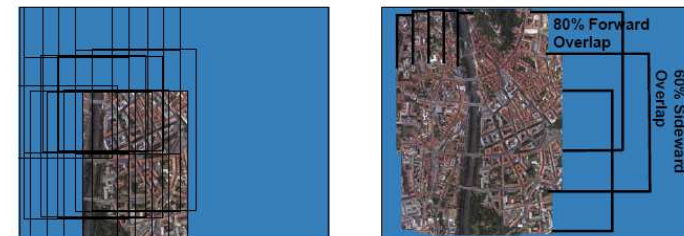
## Zooming - Exemple



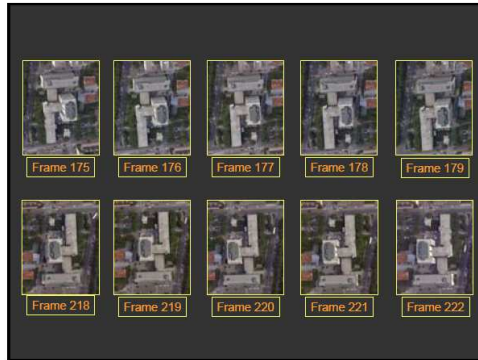
## Superposition d'images



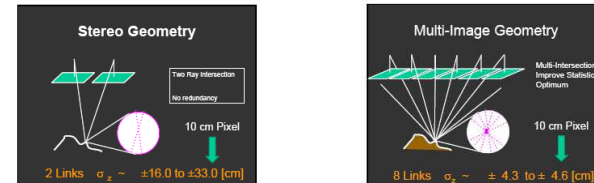
## Organisation



## Résultats



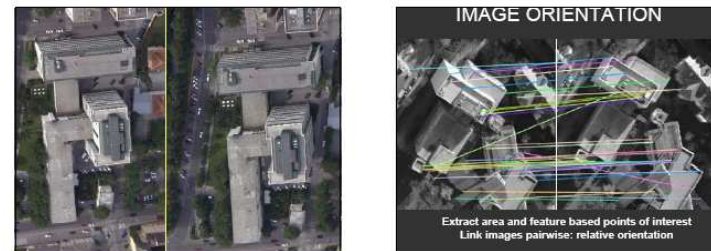
## Stéréovision



## Redondance - précision



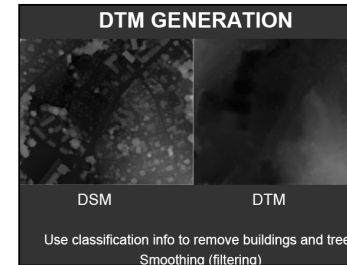
## Extraction des points semblables



## Analyse



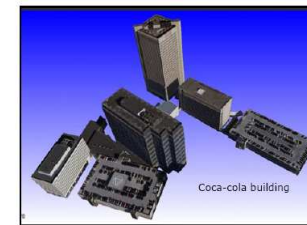
## Terrains



## Extraction des bâtiments



## Bâtiments reconstitués



### Ortophoto

The diagram illustrates the process of creating an orthophoto. On the left, under the heading "Input Multiple 'Raw' Aerial Photos", there are several small, overlapping aerial photographs. A yellow arrow points from these inputs to a single, larger, and geometrically corrected aerial photograph on the right, labeled "Output Single Ortho Photo".

### Projection des ortophotos

This diagram compares two methods of orthophoto projection. The left side, titled "TRADITIONAL ORTHOPHOTO", shows a "Bald Earth" surface (a simple curve) used as the projection surface, resulting in a "Bald Earth Ortho Projection" where buildings are distorted. The right side, titled "REFLECTIVE SURFACE ORTHOPHOTO", shows a "Digital Surface Model (DSM)" used as the projection surface, resulting in a "'TRUE' ORTHOPHOTO" where buildings are shown in their true shape and scale.

### Détection des lignes

The image shows two side-by-side aerial photographs of the same urban area. The left image is labeled "Frame 219 GSD 8 cm" and shows a raw, slightly tilted and distorted frame. The right image is labeled "RSO GSD 8 cm" and shows the same area after orthorectification, where the lines are straight and the geometry is corrected.

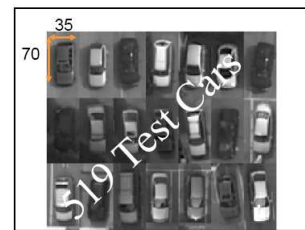
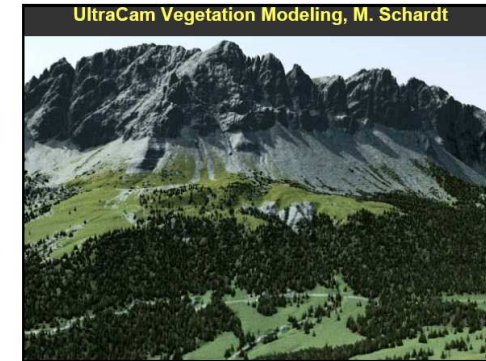
### Matching

The image compares two dense matching results for a building. The left side is labeled "DSM-QUALITY VS ORTHOPHOTO" and "Previous Dense Matching", showing a building with a jagged, irregular outline. The right side is labeled "Improved Dense Matching", showing the same building with a much smoother and more accurate outline. Both images are labeled "GSD 12 cm".

## Détection des arbres et des forêts



## Modèle 3D de la végétation



## Rue sans voitures



## Localisation et élimination



## 4.4 – Conclusions

- Importance de la visualisation 3D
- Il existe déjà des applications 3D
- CityGML
- Usage de la photogrammétrie
- Recherche du réalisme
- Base pour autre chose, simulations, histoire, etc.
- Enormes potentialités : Geobrowsers