Modeling 3D Urban Spaces Using Procedural and Simulation-Based Techniques

Procedural Urban Modeling in the Industry

Pascal Mueller
Industries

- Media & Entertainment Film, TV, Games ...
- Architecture Urban Design, Visualization ...
- GIS Urban Planning, Training & Sim, Navigation ...
- Others Cultural Heritage, Education ...
Tool Concepts

• **Scripting**  Maya, Softimage, CityEngine ...

• **Node-based**  Shader editors, Houdini, ArcGIS ...

• **Parametric modeling**  Maya, Construction History, Revit ...

• **Hard-coded use-cases**  Game editors, plugins ...
WORKFLOWS
Designing Cities from Scratch

- Sketch main streets
- Define land use, densities & building types
- Layout detailed street network
Cities based on Streetnetworks

- Real street data from GIS
- Extract blocks from streetnetwork
- Subdivide blocks into parcels

OpenStreetMap... Space Syntax... Skeleton, recursive...
Cities based on Footprint Data

• Often with attributes height, rooftop type, age ... 
• Procedural building generation using given, approximate or random attributes
Existing Cities based on Photos

3D models from groundbased/aerial imagery
Covered in previous section of this course

V-City: Combine aerial imagery with GIS data:
Parcels

General Patterns & Zoning Laws

- Max distances building-street, between buildings...
- Footprint layout orientation, min area, access...
Mass Models 1/2

“Cruciform Skyscraper” by Le Corbusier

Control attributes:

attr Building_height = 220
attr Wings_n = 4
attr Wing_length = 100
attr Wing_width = 16
attr Spine_width = 50
attr Tooth_projection = 10
attr Tooth_distance = 12 ...
Mass Models 2/2
Facades vs. Floors

Two split strategies:
- Facade surfaces
  non-complex models
- Floor volumes
  required for interiors

Refinement using subdivision schemes
covered in previous section of course
Levels of Detail 1/2

- Photo textures for photorealistic looks
Levels of Detail 2/2

- Multiresolution assets for rendering performance
Roofs

• Hipped roofs
  Gable, gambrel, mansards ...

• Flat roofs
  Complex asset distribution
PRODUCTION PIPELINES
Dataflow Example

Geospatial Data / Assets

- SHP: ESRI Shapefile
- DXF: Autodesk
- OSM: OpenStreetMap
- OBJ: Wavefront
- DAE: COLLADA
- Images: Maps, Textures

CityEngine®

Generated 3D Data

- DAE: COLLADA
- FBX: Autodesk
- OBJ: Wavefront
- RIB: Renderman
- MI: mental ray
- RealityServer
- MAS: Massive

PY: Python Scripting

- Reporting, Metadata
Production Requirements

- Generate reasonable polygon counts becomes less and less of a problem
- Support instances if possible instances in Collada/FBX often not supported
- Take high object counts into account hard to manage in traditional 3d editing tools
- Avoid high material counts affects performance in realtime rendering
Procedurally Generated Materials

- Complex materials using different UV sets
- Material exchange capabilities often limited
Game Development Pipeline

CityEngine

COLLADA FBX
3ds Max Softimage Maya

COLLADA FBX obj

Transformation info of instances (text/xml/proprietary)

COLLADA FBX obj
Modeled Assets

... and other game engines

CRYENGINE
Gamebryo
source
unity
idTech
UNREAL

Source
Procedural Content in Games

- Procedural map generation
- Procedurally distributed asset instances
- Pre-processed procedural models
  geometry by 3rd party tools or engine editor
- Realtime procedurally generated geometry
  usually hardcoded due to different requirements
Example: Instancing Assets 1/2

- Procedural creation of streets
- Positioning of buildings assets
Example: Instancing Assets 2/2

- Import assets & other elements as geometry
- Import positioning info of assets into engine
Urban Planning Pipelines

- **Design**  Parameterize & encode buildings
- **Analyse**  Shadow, energy, agent-based simulation...
- **Visualize**  For decision makers & public
Example: City of Rotterdam

• Data aggregation
  From various 2d and 3d sources

• Procedural new developments
  Encoding of designs for analysis & visualization
Analysis

- Shadowing impacts
- View sheds
- ...

Esri
ArcGIS 3D Analyst
Visualization

- Cloud-based rendering in web browser

Nvidia RealityServer