Progressive Streaming and massive rendering of 3D city model on Web

Quoc Dinh NGUYEN

Engineer at Valilab

Email : quoc-dinh.nguyen@ign.fr

Introduction

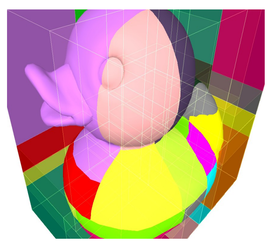
3D city model (ex. 3D building model), consisting of hundreds of millions of triangles and mesuring in tens or hundreds of terabytes. So accessing the entire dataset is an extremely time consuming process. These data largely overload the computational power and memory capacity of state of the art graphics and computational platforms ; and arises naturally difficulties for interactive visualization on Web.

Main issues [1]:

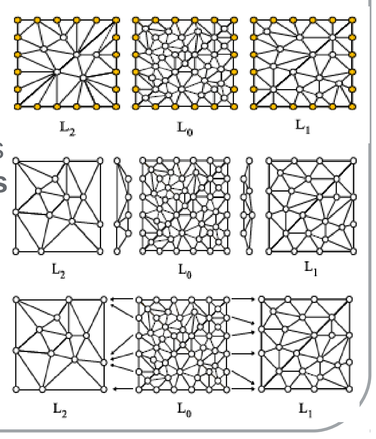
1. Most of existing systems suffer from network **latency** (due to the data downloading time and serve multiple users simultaneously).
2. Lack of adaptation to heterogeneous networks and client devices (i.e. the lack of **levels of details**)
3. Problems with **chunked multi-resolution model** (crackings, T -junctions)
4. Fast, **direct / zero copy GPU** uploads
5. Possibility for **progressive** transmission
6. Geometry **compression** methods (decompression with multi-threading)
7. **GPU-friendly** integration of (compressed) texture data
8. Downloads / rendering are **decoupled**.
9. Rendering artifacts (popping, z-fiting, jiterring, etc)

Chunked Multi Resolution Model

Mesh is spatially divided by Kd-tree into several manageable Chunks [2] :

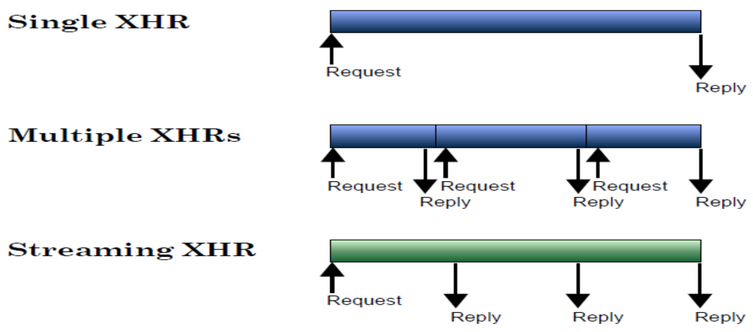


- Chunks as **Primitives** :
  - + naturally suited for **out-of-core** management
  - + allows for aggressive GPU optimization (local coherence, triangle strips)
- Chunked multi resolution model :
  - + reduce an **object's complexity** and the overall number of elements that must be handled when it contributes **less** to the scene.
- Chunk boundary Management :
  - + avoid **cracks** while assembling Chunks from different levels (**marking**, **stitches geomorphing**).
- Chunk geometry **compression** :
  - + reduces the size chunk which make it **valuable** at all levels of the cache hierarchy.



Progressive Streaming

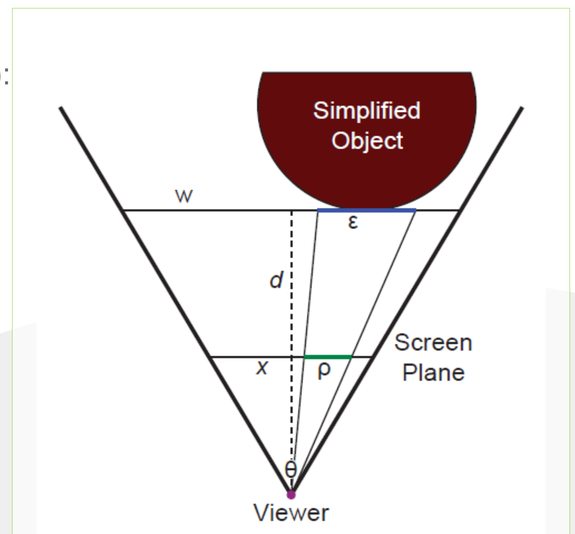
- Requesting a single file prevents processing until the transmission **has completed**.
- Partial requests allow early processing, but at the costs of additional **overhead** for each request.
- The Streams API provides **progress** events, **without** any additional request.

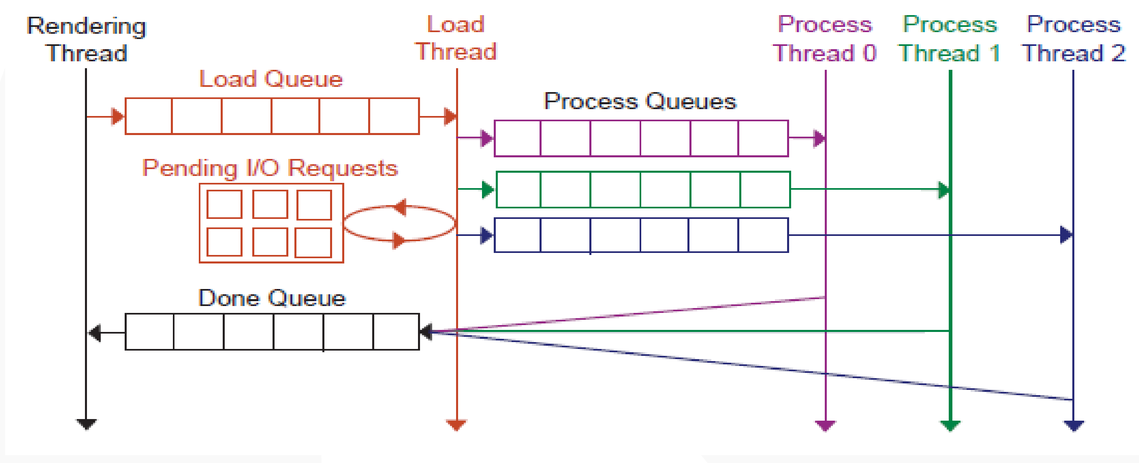


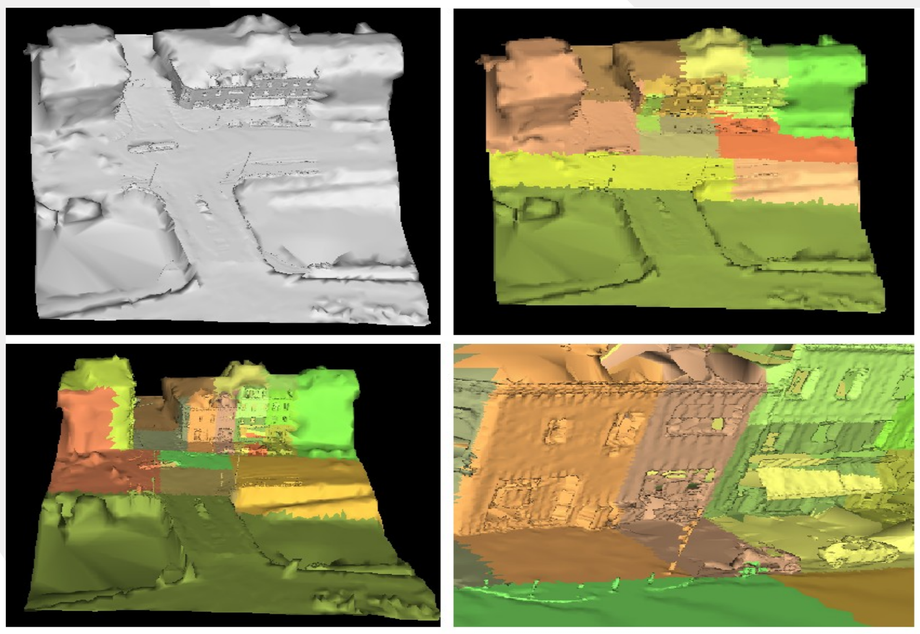
Massive Rendering

Visualisation massive quantities of 3D city model using **out-of-core** algorithms (ex. **ChunkedLOD**):

- The maximum accuracy in every part of the model is **not required** every time.
- For example : a chunk in the distance may be rendered with **less geometry** and **lower resolution textures** than the same chunk if it were close to the viewer.
- Only chunk in camera's frustum is selected to load **progressively** from sever.
- Chunk's LOD is selected with Screen Space Error (**SSE**).
- SSE is used as priority criterion in Binary Heap method to sort loading chunks.
- Parameters are **pre-computed** (ex. Bounding Box, Geometric Error, etc).
- Rendering, downloads and processing (ex. decompression) are **decoupled** and **outperformed** with multi-threading.
- Cache **hierarchy** (GPU memory → CPU memory → Server)







Original Model	Multi resolution without geometry compression	Multi resolution with geometry compression
3D Bulding Model (Faces : 307K, Vert : 256k, Size : 8110 KB)	Size : 9077 KB, Number of Level : 5	Size : 749 KB ; Number of Level: 5

Future works

- Manage data in large scale
- Support Texture (MegaTexture / Projective Texturing)

Bibliography

- Engineer at Valilab
- Working at MATIS, IGN

References

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[2] P. Cignoni, F. Ganovelli, E. Gobbetti, F. Marton, F. Ponchio, and R. Scopigno. Batched multi triangulation. In Proceedings IEEE Visualization, pages 207{214, Conference held in Minneapolis, MI, USA, October 2005. IEEE Computer Society Press.

[3] M. Limper, M. Thöner, J. Behr, D. W. Fellner: "SRC - a streamable format for generalized web-based 3D data transmission", Proceedings of ACM Web 3D 2014, pp. 35-43 .