# View dependent decompression for web-based gigantic triangle meshes visualisation

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## Abstract

We introduce a framework extending an existing progressive compression-decompression algorithm for 3D triangular meshes. First, a mesh is partitioned. Each resulting part is compressed, then joined with one of its neighbours. These steps are repeated following a binary tree of operations, until a single compressed mesh remains. Decompressing the mesh involves progressively performing those steps in reverse, per node, and locally, by selecting the branch of the tree to explore. This method creates a compact and lossless representation of the model that allows its progressive and local reconstruction. Previously unprocessable meshes can now be visualised on the web and mobile devices using this technique.

## Related work

- Triangle mesh compression with mesh traversal
- Out-of-core compression and visualisation
- View-dependent refinement

## Problem

With existing progressive lossless mesh traversal compression/decompression algorithm:

**Benefits**
- Progressive transfer and reconstruction
- Visualisation suitable for low performance devices

**Drawbacks**
- Unable to process gigantic models
- Reconstruction is independent from the view


Figure 2: Progressive decompression with a single view point on Marigny Aqueduct, provided by Air Marine

## Preprocessing

### Out-of-core partitioning

- Vertices clustered in 3D grid
- Grid is cut to satisfy a maximum vertex count per submesh
- Each submesh can then be processed in-core

### In-core parallel compression

Bottom up creation of binary tree by **recursive operations**:

1. **Progressive compression**
- capped by a vertex limit
- borders are locked

2. **Stitching two by two**
- shared border are unlocked

**1. & 2. until a single mesh remains**

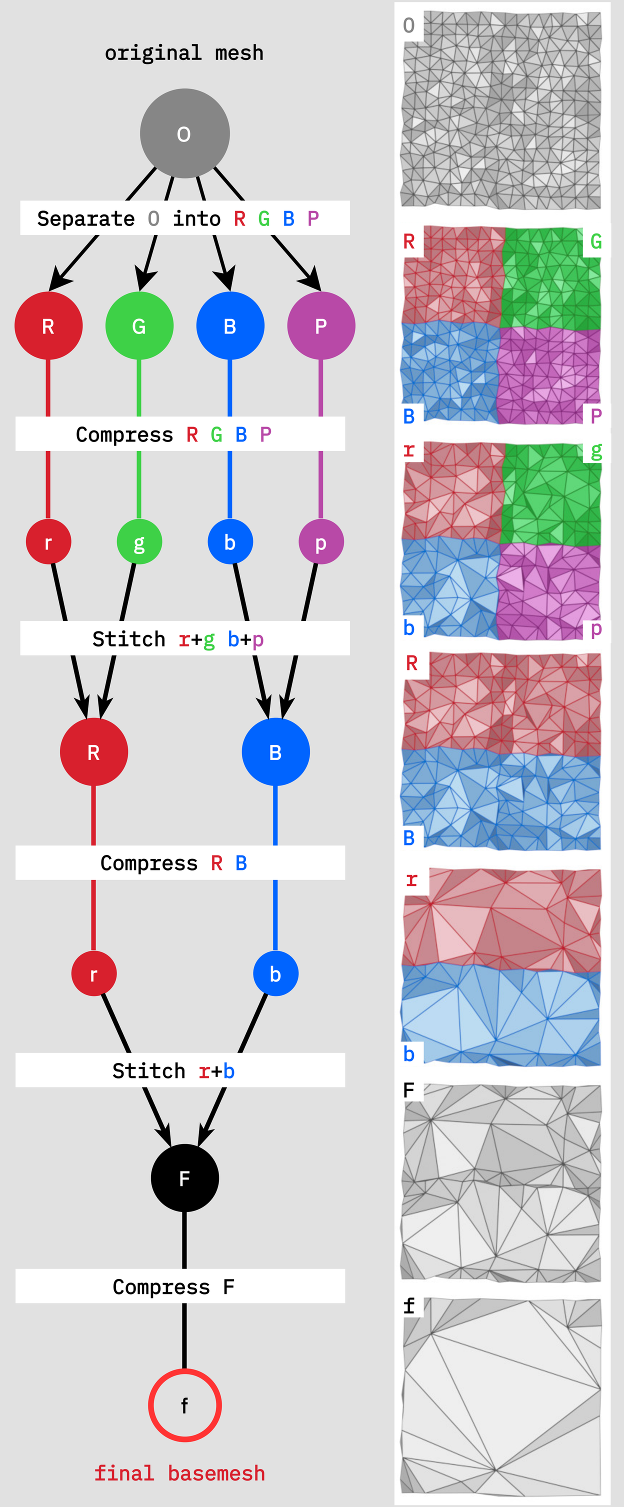
basemesh = remaining mesh

Progressive compression
=
Iterative valence driven decimation conquests

Simultaneous mesh simplification and connectivity encoding

Reversing operations to prepare for runtime

| Node | → | Node |
|---|---|---|
| Compression + Stitch | | Separation + Decompression |




## Transfer

### Data structure

| | Downloaded once | Downloaded per node |
|---|---|---|
| for the decompression | • Basemesh | • Seed edge of mesh traversal<br>• Encoded traversal attributes |
| for the framework | • Hierarchy structure<br>• Node bounding volumes<br>• Node quality criteria | • Separation attributes |

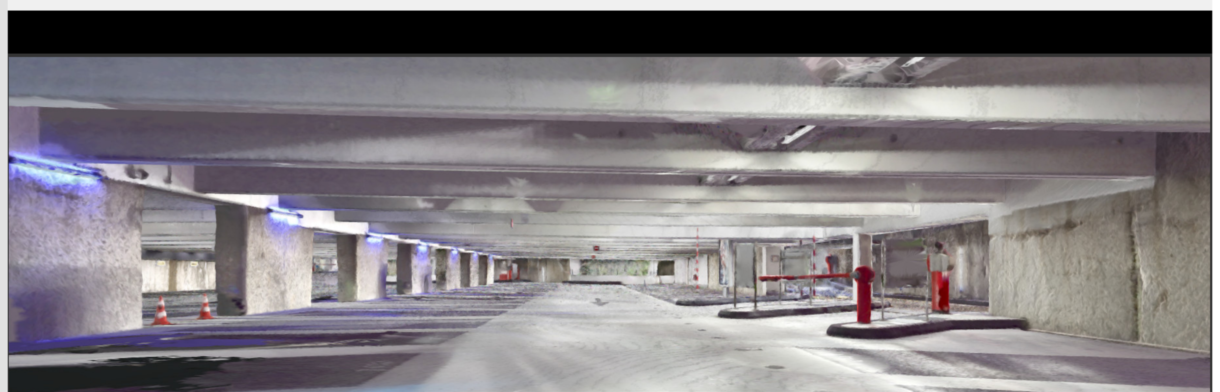


Figure 1: Underground Parking, provided by QPark

### Model presentation

Gigantic triangle mesh > 200M Vertices

| | Vertex count | Triangle count |
|---|---|---|
| Avignon Cathedral | 986,396,965 | 1,973,010,686 |
| Marigny Bridge | 499,722,772 | 999,342,292 |
| Underground Parking | 312,709,538 | 625,443,996 |

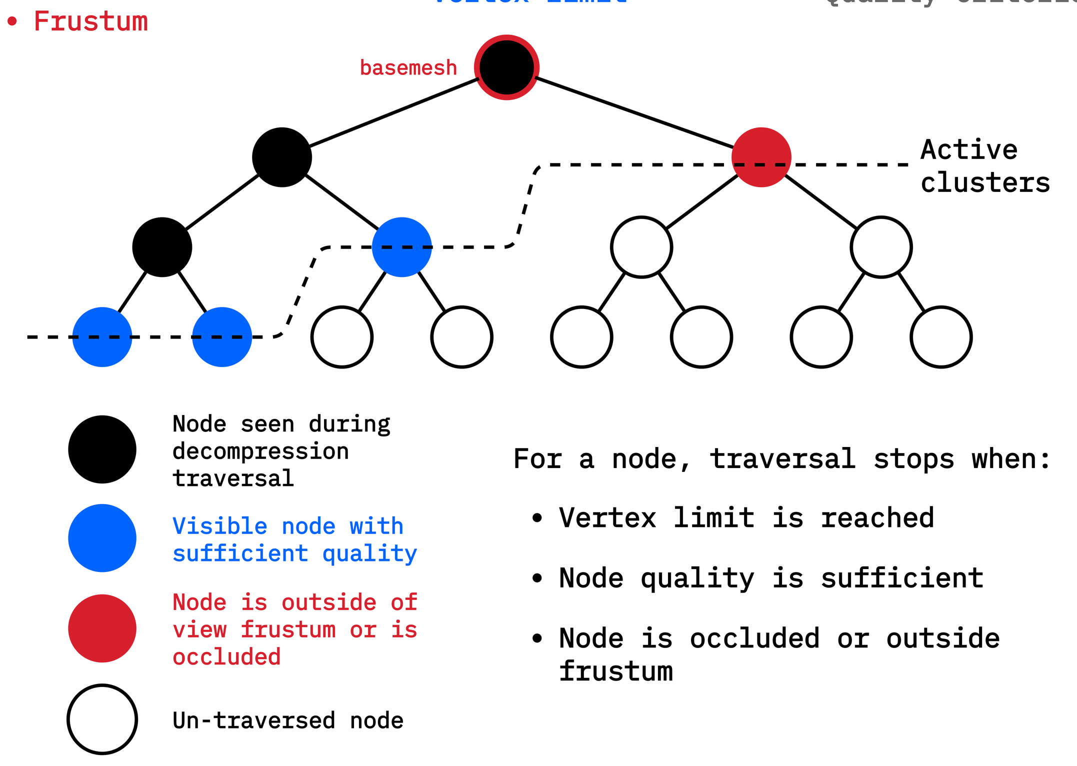
**Table 1:** Triangle meshes statistics

## Runtime

### Optimal view determination

reversed hierarchy traversal per frame

| View dependent | Device dependent | Mesh dependent |
|---|---|---|
| • Camera Transform<br>• Frustum | • Vertex limit | • Quality criterion |




For a node, traversal stops when:
- Vertex limit is reached
- Node quality is sufficient
- Node is occluded or outside frustum

### Progressive decompression

download and decompression on separate thread

- Reversed compression steps, top down from basemesh
- Start by downloading the global information, then for each selected node :

if parent is done separating : Download → Decompress progressively → Separate

Intermediary meshes are created during the progressive decompression and are re-used during visualisation.
For every frame, the closest decompressed nodes to the optimal view are rendered using WebGL.

## Preprocessing time

| | (H:MM:SS) |
|---|---|
| Avignon Cathedral | 1:37:24 |
| Marigny Aqueduct | 0:32:35 |
| Underground Parking | 0:22:54 |

Time includes:
- Out-of-core partitioning
- In-core recursive compression-merging
- computed on Intel® Core™ i7-10750H CPU @ 2.60GHz × 12

**Table 2:** Preprocessing time for the three test models

## Compression rate

| | Original file size (GB) | Compressed file size (GB) | Compression rate (bit/vertex) |
|---|---|---|---|
| Avignon Cathedral | 45 | 3.1 | 27 |
| Marigny Bridge | 24 | 1.8 | 30 |
| Underground Parking | 15 | 1.0 | 27 |

**Table 3:** File size comparison and compression rate
Compressed file size is the maximum size of data transferred to view the original file details

## Decompression speed

(s/1M vertices)

| | PC | high-end smartphone | low-end smartphone |
|---|---|---|---|
| Avignon Cathedral | 3.4 | 7.5 | 17.5 |
| Marigny Aqueduct | 3.0 | 7.3 | 16.1 |
| Underground Parking | 3.5 | 8.3 | 18.0 |

- **PC**: Intel® Core™ i7-10750H CPU @ 2.60GHz × 12
- **high-end smartphone**: OnePlus nord: Qualcomm SM7250 Snapdragon 765G 5G (7 nm)
- **low-end smartphone**: Samsung Galaxy S6: Exynos 7420 Octa (14 nm)

**Table 4:** Decompression speed per million vertices on three devices with WebAssembly

Figure 3: View dependent details on Avignon Cathedral, provided by Art Graphique & Patrimoine
(5M vertices per view point, visible partitions top-left)

## Conclusion

We have introduced a framework for the interactive visualisation of gigantic triangular meshes. Our representation is compact, transferring only a simplified basemesh and the necessary steps to refine it hierarchically. No intermediate mesh is downloaded during the visualisation: the information of a node is downloaded only once. This allows a lightweight transfer with no redundancy of even gigantic models. Thanks to the view dependent hierarchy traversal, only targeted nodes are downloaded and decompressed. The visualisation is maintained at a constant framerate of 60 frames per second thanks to our device dependant criteria, independently from the model. The progressive decompression provides a high granularity of levels of details to adapt as best as possible to the view.

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