CRYPTO-COMPRESSION OF 3D OBJETS

CONCEPTS

3D Crypto-Compression relies on an efficient data representation coupled with an encryption algorithm.

By implementing the Edgebreaker algorithm, which efficiently traverses the mesh to describe its connecivity, we can store the triangle/vertex incidence graph on 2 to 3 bits per triangle.

Positions are quantized and stored as coordinates on a regular grid. This step reduces the representation of a vertex from 224-248 bits (28 to 31 chars) to 30 bits with minimal loss. Compressing normals can be achieved by representing them as a 17 bits index to a dictionary (instead of 23 to 26 chars, 184-208 bits). By pre-computing 2^{17} normals, we can achieve perceptually lossless compressions of the data.

Encryption is done with a Geometry Preserving Algorithm capable of preserving the 3D nature of our data and its bounding box, while occluding any pertinent information.

KEY PAPERS

Michael Deering, “Geometry Compression”, sun Microsystems, 1995

Jarek Rossignac, “Edgebreaker: Connectivity compression for triangle meshes”, GVU Center, Georgia Institute of Technology, 1999

Jarek Rossignac, Alla Safonova, Andrzej Szymczak, "3D Compression Made Simple: Edgebreaker on a Corner-Table", College of Computing and GVU Center, Georgia institute of Technology, 2001

Jarek Rossignac, “3D mesh compression”, College of Computing and GVU Center, Georgia institute of Technology, January 2003

Marc Éluard, Yves Maetz, and Gwenaël Doërr, "Geometry-preserving Encryption for 3D Meshes", Technicolor R&D France, November 2013

First we load a 3D model.

Its vertices, positions and normals are represented by 3D points/vectors (3 floats, 96 bits).

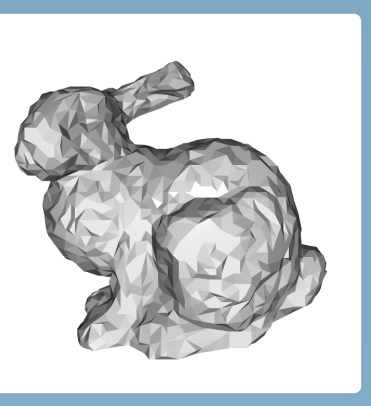
Each triangle is represented by 3 ints, 96 bits

3D MODEL

We quantize vertices positions on a discrete grid, and normals on a precalculated dictionary.

This step compresses data as positions are now represented on 30 bits and normals on 17 bits.

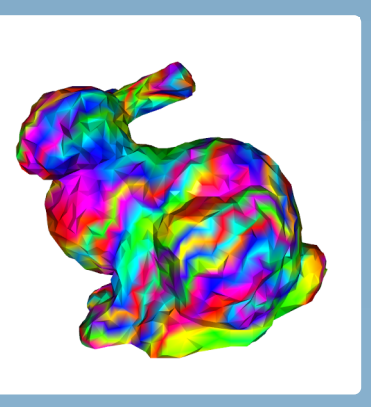
QUANTIZATION



Edgebreaker compresses the mesh by representing triangle strips on a low entropy format.

This step can squish a triangle in 1.5 bits, but 3 bits is a more realistic representation for worst case scenarios.

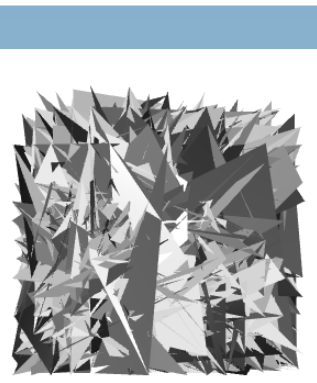
EDGEBREAKER



Then, we use a Geometry Preserving Encryption.

This is an encryption algorithm capable of preserving the 3D nature of our data while concealing its shape.

ENCRYPTION



Finally, an entropic compression can be done to further increase the compression ratio.

ENTROPIC COMPRESSION

Then, the data is decrypted using an encryption/decryption key.

As the algorithm is geometry preserving, it will always return inteligible data, even without the right key.

DECRYPTION

Finally, a 3D model is returned.

That 3D model could either be "scrambled" if the wrong key was used during the decryption step, or a quantized mesh if the correct key was chosen.

LOSSY 3D MODEL

The Edgebreaker decompression algorithm is then used to reconstruct the mesh.

EDGEBREAKER

First, the file is decompressed.

ENTROPIC DECOMPRESSION

Romain Fournier, Clément Potin, Master 2 IMAGINE, Université de Montpellier, 2021