Connectivity Compression for Irregular Quadrilateral Meshes

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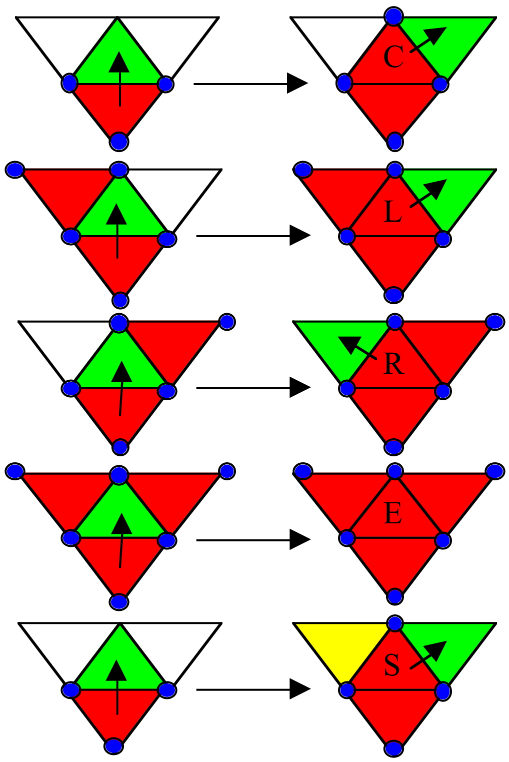
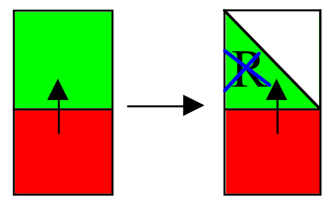
Many 3D models used in engineering, scientific, and visualization applications are represented by an irregular mesh of bounding quadrilaterals (quads). The simplest representation of such a mesh stores a table of the coordinates of its V vertices and a connectivity table of quads, each represented by four vertex indices of $\log_2(V)$ bits each. Vertex coordinates may be compressed down to 4 or 5 bits each using vertex quantization, geometric predictors, and variable length encoding of corrective vectors [1]. Connectivity information may be compressed down to 4 bits per vertex or less by splitting each quad into two triangles and by using one of the recently developed algorithms for compressing triangle meshes (see survey in [2]). We propose here a new strategy for splitting the quads. Our approach reduces the file size an additional 25-45% and preserves the original pairing of the triangles.

Our approach is an extension of the Edgebreaker compression approach [2] and of the Wrap&Zip decompression technique [3]. Edgebreaker visits the entire mesh by applying the following transformations:



where green identifies the current triangle, yellow identifies a triangle to be put on the stack of future current triangles popped after each E, red identifies previously processed triangles, white identifies triangles not yet processed, and blue identifies previously processed vertices. The resulting sequence of C, L, R, E, or S labels suffices to capture the connectivity of all triangle meshes that are homeomorphic to a sphere. Vertices are compressed in the order in which they are first encountered. A simple encoding of the labels guarantees 4 bits per vertex. A more elaborate encoding, which exploits the fact that CL and CE combinations are impossible, reduces the expected storage cost to 3.2 bits per vertex. For very large meshes, an entropy code reduces the cost to an average of 2.6 bits per vertex [3].

By splitting each quad as shown below, we ensure that the first label in each pair is not an R.



This observation may be exploited to develop a better encoding for the 13 possible combinations of labels possible in a pair: CR, CC, LE, CS, SC, LC, SE, LL, LR, LS, SL, SR, and SS, each corresponding to the two triangles of a quad. An entropy encoding of these restricted pairs yields compressed formats ranging from 0.26 to 1.7 bits per vertex, depending on the regularity of the mesh. Our experiments show that this format is consistently at least 45% more compact than the format obtained by the same label encoding technique, when applied to triangle meshes produced by randomly splitting quads.

Wrap&Zip decompression [3] decodes and uses these labels to decide where to append each new triangle to a previously reconstructed one. The result is a simply connected topological polygon. To correctly glue the corresponding pairs of its bounding edges, Wrap&Zip uses the labels to orient the bounding edges counter-clockwise for L, R, and E, and clockwise for C triangles. A recursive procedure restores the complete incidence information by gluing pairs of adjacent edges whose orientations point towards their common vertex. Vertices are decoded in the order in which they are first encountered.

Bibliography

[1] Geometric Compression through Topological Surgery, G. Taubin, J. Rossignac, ACM Transactions on Graphics, Volume 17, Number 2, pp. 84-115, April 1998.

[2] Edgebreaker: Connectivity compression for triangle meshes, J. Rossignac, IEEE Transactions on Visualization and Computer Graphics, Vol. 5, No. 1, January - March 1999.

[3] Wrap&zip: Linear decoding of planar triangle graphs, J. Rossignac, A. Szymczak, GVU Center, Georgia Institute of Technology, Tech Report: GIT-GVU-99-08, January 1999. http://www.cc.gatech.edu/~jarek/abstracts.html