Wang Cubes for Video Synthesis and Geometry Placement

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Abstract

We present an extension of Cohen's Wang Tiles to three dimensions: *Wang Cubes*. Cubes are filled with video or Poisson distributed points to perform realtime video synthesis or geometry placement.

1   Motivation

Video synthesis from a sample is useful for generating dynamic backgrounds for games or special effects but costly in terms of storage and runtime. Randomly positioning non-overlapping 3D geometry is useful for simulations and games but also costly. We propose Wang Cubes where we only store 32 cubes and generate, at runtime, large amounts of synthesized video, or Poisson distributed geometry.

2   Methods

Cohen et al. [2003] introduced a fast and simple stochastic algorithm to generate an aperiodic tiling of the plane with as few as eight Wang Tiles (oriented squares with color associated edges). Cohen et al. used these tilings for texture synthesis and 2D geometry placement.

We extend these applications to the 3D case, where cubes with colored faces replace tiles. 32 cubes are sufficient to tile space. The extended tiling algorithm iterates through the space, placing a cube at each point. To select a cube, we pick a random cube whose top, left, and front faces match the colors of the three neighbors (Figure 1a). The 32 cubes contain either Poisson ball distributed points or video data and are tiled at runtime to generate large stretches of 3D geometry or video sequences.
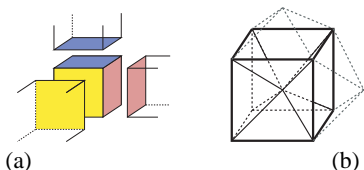

Figure 1: Wang Cubes. (a) Aligning face colors. (b) Assembling six octahedra to form a cube.

We use dart-throwing to fill each cube with Poisson distributed points. Several iterations of Lloyd's relaxation are applied to prevent points near boundaries from violating the minimum distance constraint in tiling. To fill the cubes with video data, we cut six octahedra from the video stream and stitch them together. Then, the result is trimmed into a cube (Figure 1b). Each original octahedron is associated with a face color. A *xy* plane in this cube corresponds to a frame of video and the *z* axis corresponds to time.

Stitching the octahedra together requires finding a minimal cutting surface between the two neighboring octahedra. We use the Kwa-

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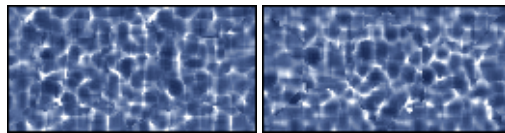‡e-mail: gem@cs.brown.edu

Figure 2: Vertical slices from two tiled Wang cubes. Note that the vertical middle seam of each frame is invisible.
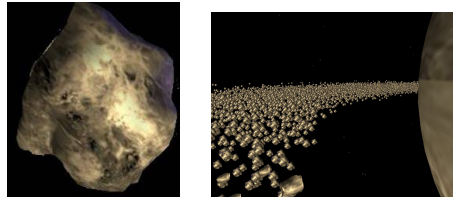

Figure 3: (a) Single asteroid model. (b)Saturn Asteroid Belt, 5959 asteroid instances placed using tiling of 3972 cubes each with 15 Poisson distributed points. Note, this took only seconds to generate.

tra et al. [2003] approach, by formulating this as a min-cut graph problem and solving it via the Ford-Fulkerson max flow algorithm.

3   Results

We constructed a cube set (64^3 voxels per cube) from a video of simulated shallow pool caustics. Two vertical slices through two cubes tiled horizontally are show in Figure 2. Note how the vertical seam in the middle of each frame is invisible. In order to keep our computation feasible, we constrained the cuts to lie near the intersecting triangles of the octahedra. We have noticed temporal artifacts in the videos, a growing and shrinking square-discontinuity. We believe these are caused by constrained cuts and small cube sizes.

As a geometry placement application, we modeled the asteroid belt of Saturn with 5958 astroids constructed from 3972 tiled cubes with 15 points in each cube. The asteroids are placed according to a Poisson distribution in this large area (Figure 3b). Using cubes only took 15 minutes to precompute, and under 20 seconds to tile. Note that filling the same region with dart throwing is simply infeasible. These tests were performed on an AMD Athlon XP 1800 with 512MB of memory.

4   Future Work

For video synthesis, we restricted the space searched for a min-cut surface, sacrificing quality of the cut for faster execution. Implementing known randomized max-flow algorithms to approximate the cut could yield much lower preprocessing, which would allow for less constrained cuts and eliminate temporal artifacts.

References

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KWATRA, V., SCHÖDL, A., ESSA, I., TURK, G., AND BOBICK, A. 2003. Graphcut textures: Image and video synthesis using graph cuts. *ACM Transactions on Graphics, SIGGRAPH 2003* *22*, 3 (July), 277–286.