Assignment D

- Give a detailed explanation about one of the following texture synthesis algorithm:
  - Image Quilting for Texture Synthesis and Transfer, SIGGRAPH2001 http://graphics.cs.cmu.edu/people/efros/research/quilting.html

Detail of image quilting algorithm:

Patch-based texture synthesis procedure:

Define S_B to be the set of all overlapping blocks in the input texture image.B_i to be a square block of S_B specified by the user, which is the unit of synthesis.

1) Taking blocks randomly from S_B to synthesize a simple new texture image.

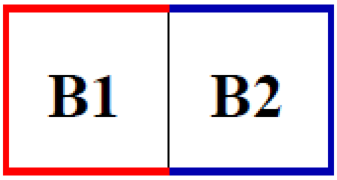

Figure 1 Random Placement of blocks without overlap

2) Neighboring blocks constrained by overlap. Search S_B for such a block that by some measure agrees with its neighbors along the region of overlap. The block has a clean edge as in Figure 2.

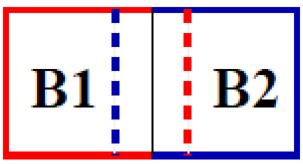

Figure 2 Neighboring blocks constrained by overlap with clean edge

3) Minimum Error Boundary Cut.

Let the blocks have ragged edges which will allow them to better approximate the features in the texture just as Figure 3 . This can easily be done with dynamic programming.

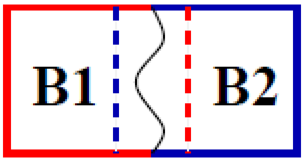

Figure 3 Minimum error boundary cut of overlap with ragged edge

Look at the error in the overlap region between the blocks. Find a minimum cost path through that error surface and declare that to be the boundary of the new block. The procedure of finding the minimum cost path is the core work of image quilting algorithm.

a) The compute of minimal cost path through the error surface

If B1 and B2 are two blocks that overlap along their vertical edge (Figure 3) with the regions of overlap $\mathrm{B1}^{ov}$and $\mathrm{B2}^{ov}$. Then the error surface is defined as $\mathrm{e} = (\mathrm{B1}^{ov} - \mathrm{B2}^{ov})^2$.To find the minimal vertical cut through this surface, we traverse e (i = 2..N) and compute the cumulative minimum error E for all paths:

$$\boldsymbol{E_{i,j} = e_{i,j} + min(E_{i-1,j-1}, E_{i-1,j}, E_{i,j-1})}$$

In the end, the minimum value of the last row in E will indicate the end of the minimal vertical path though the surface and one can trace back and find the path of the best cut.

Similarly, it can be applied to horizontal overlaps.

When there is both a vertical and a horizontal overlap, the minimal paths meet in the middle and the overall minimum is chosen for the cut.

b) The complete algorithm

- Go through the image in raster scan order in steps of one block.
- For every location, search the input texture for a set of blocks that satisfy the overlap constraints (above and left) within some error tolerance. Randomly pick one such block.
- Compute the error surface between the newly chosen block and the old blocks at the overlap region. Find the minimum cost path along this surface and make that the boundary of the new block. Paste the block onto the texture.
- Repeat.

The size of the block is the only parameter controlled by the user and it depends on the properties of a given texture. In all of their experiments, the width of the overlap edge (on one side) was 1/6 of the size of the block. The error was computed using the L2 norm on pixel values. The error tolerance was set to be within 0.1 times the error of the best matching block.

✧ Advantages

The algorithm is particularly effective for semi-structured textures. (which were always the hardest for statistical texture synthesis)

The performance is quite good on stochastic textures as well.

   

✧ Disadvantages

The two most typical problems are excessive repetition (e.g. the berries image), and mismatched or distorted boundaries (e.g. the milk power can). Both are mostly due to the input texture not containing enough variability.