Lecture 11: Texture

( unless otherwise stated slides are taken or adopted from Bob Woodham, Jim Little and Fred Tung )
Texture

What is texture?

Texture is widespread, easy to recognize, but hard to define.

Views of large numbers of small objects are often considered textures:
- e.g. grass, foliage, pebbles, hair

Patterned surface markings are considered textures:
- e.g. patterns on wood

Figure Credit: Alexei Efros and Thomas Leung
Definition of Texture

(Functional) Definition:

Texture is detail in an image that is at a scale too small to be resolved into its constituent elements and at a scale large enough to be apparent in the spatial distribution of image measurements.
Definition of **Texture**

*(Functional) Definition:*

**Texture** is detail in an image that is at a scale too small to be resolved into its constituent elements and at a scale large enough to be apparent in the spatial distribution of image measurements.

Sometimes, textures are thought of as patterns composed of repeated instances of one (or more) identifiable elements, called **textons**.

— e.g. bricks in a wall, spots on a cheetah
Uses of **Texture**

Texture can be a strong cue to **object identity** if the object has distinctive material properties.

Texture can be a strong cue to an **object’s shape** based on the deformation of the texture from point to point.

— Estimating surface orientation or shape from texture is known as “**shape from texture**”
Texture

We will look at two main questions:

1. How do we represent texture?
   → Texture analysis

2. How do we generate new examples of a texture?
   → Texture synthesis

We begin with texture synthesis to set up Assignment 3
Texture Synthesis

Why might we want to synthesize texture?

1. To fill holes in images (inpainting)
   - Art directors might want to remove telephone wires. Restorers might want to remove scratches or marks.
   - We need to find something to put in place of the pixels that were removed
   - We synthesize regions of texture that fit in and look convincing
Texture Synthesis

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   - We synthesize regions of texture that fit in and look convincing.

2. To produce large quantities of texture for computer graphics
   - Good textures make object models look more realistic.
Texture Synthesis

Szeliski, Fig. 10.49
Bush campaign digitally altered TV ad

President Bush's campaign acknowledged Thursday that it had digitally altered a photo that appeared in a national cable television commercial. In the photo, a handful of soldiers were multiplied many times.

This section shows a sampling of the duplication of soldiers.

Original photograph

Photo Credit: Associated Press
Texture Synthesis

Cover of “The Economist,” June 19, 2010

Photo Credit (right): Reuters/Larry Downing
Assignment 3 Preview: Texture Synthesis

Task: Make donkey vanish
Assignment 3 Preview: Texture Synthesis

Task: Make donkey vanish

Method: Fill-in regions using texture from the white box
Assignment 3 Preview: Texture Synthesis

Task: Make donkey vanish

Method: Fill-in regions using texture from the white box
Texture Synthesis

**Objective:** Generate new examples of a texture. We take a “data-driven” approach

**Idea:** Use an image of the texture as the source of a probability model
- Draw samples directly from the actual texture
- Can account for more types of structure
- Very simple to implement
- Success depends on choosing a correct “distance”
Texture Synthesis by Non-parametric Sampling

Alexei Efros and Thomas Leung
UC Berkeley

Slide Credit: http://graphics.cs.cmu.edu/people/efros/research/NPS/efros-iccv99.ppt
Efros and Leung

wood

granite
Efros and Leung

white bread

brick wall
Like **Copying**, But not Just Repetition
— What is **conditional** probability distribution of $p$, given the neighbourhood window?
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— Directly search the input image for all such neighbourhoods to produce a **histogram** for \( p \)
Efros and Leung: Synthesizing One Pixel
Efros and Leung: Synthesizing One Pixel

\[ p(\text{dark gray}) = 0.5 \]

\[ p(\text{light gray}) = 0.5 \]
Efros and Leung: Synthesizing One Pixel
Efros and Leung: Synthesizing One Pixel

$p(\text{dark gray}) = 0.75$

$p(\text{light gray}) = 0.25$
— What is **conditional** probability distribution of $p$, given the neighbourhood window?

— Directly search the input image for all such neighbourhoods to produce a **histogram** for $p$

— To **synthesize** $p$, pick one match at random
Efros and Leung: Synthesizing One Pixel

Infinite sample image

SAMPLE

— Since the sample image is finite, an exact neighbourhood match might not be present
Efros and Leung: Synthesizing One Pixel

— Since the sample image is finite, an exact neighbourhood match might not be present

— Find the **best match** using SSD error, weighted by Gaussian to emphasize local structure, and take all samples within some distance from that match
For multiple pixels, "grow" the texture in layers
   — In the case of hole-filling, start from the edges of the hole

For an interactive demo, see
(written by Julieta Martinez, a previous CPSC 425 TA)