CPSC 532E — Week 5: Lecture

Edge Detectors; Texture Perception

- Edge Detectors - Gabor filters
- Texture Segmentation
- Texture Coding

Texture vs. Colour

Colour is a surface property

- used a a means -> formation of groups
-> formation of boundaries

- used as an ends -> coding of categories

Texture is the spatial analog of colour…

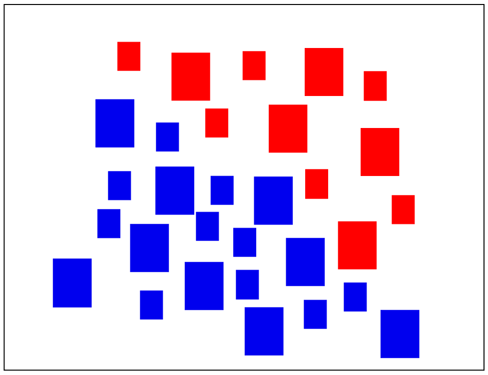
Texture is a surface property

- used a a means -> formation of groups
-> formation of boundaries

- used as an ends -> coding of categories

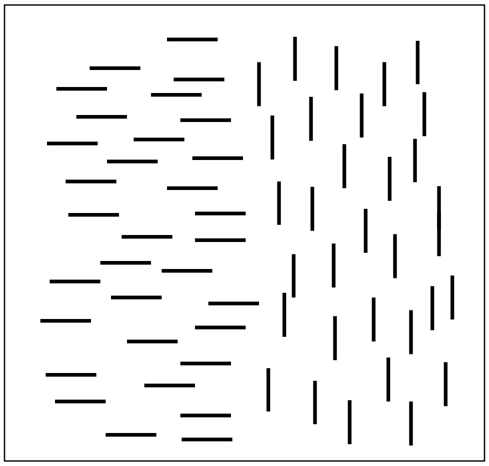
Texture perception

Some texture differences give rise to boundaries:



different colours

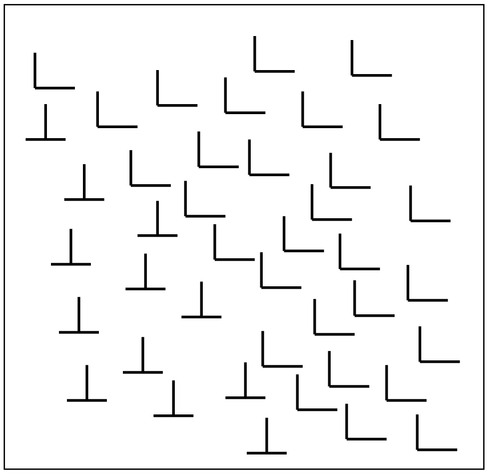
-> texture boundary



different orientations

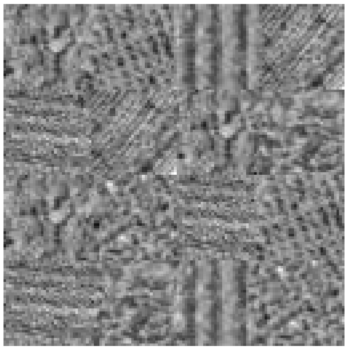
-> texture boundary

Others don’t…



Need a framework to handle these kinds of textures

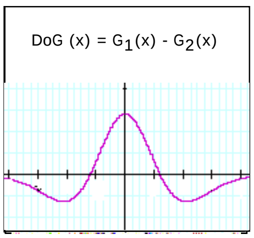
as well as more “natural” kinds



Edge Detection

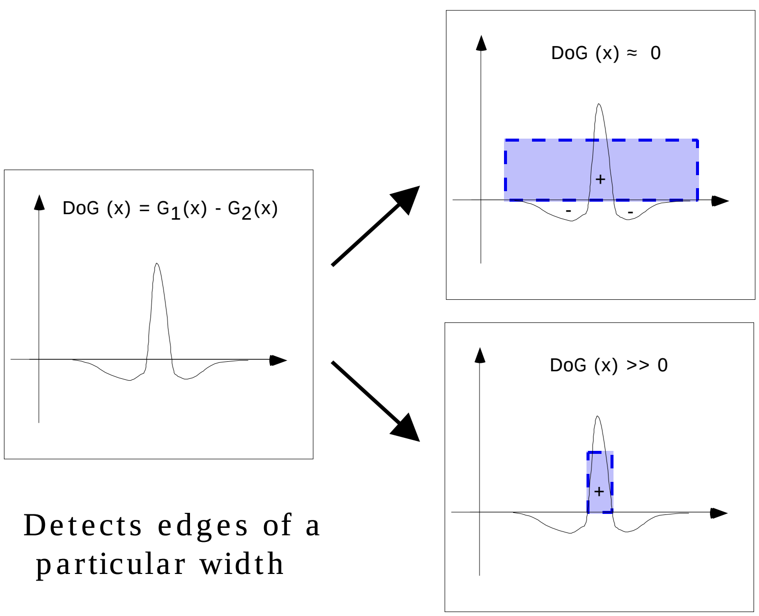
Just as colour is based on the input of cones
at early stages of vision (eye),

so is texture based on the input of edge detectors
at early stages of vision (eye + first cortical area)



Simplest case:

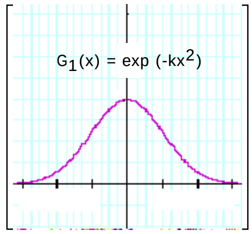
Circularly symmetric detector
(difference of Gaussians)



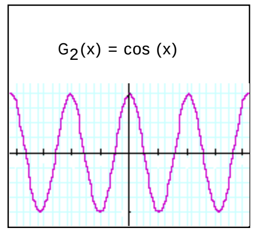
Detects edges of a particular width

Edge detectors usually have the form of a
<u>Gabor function</u> $G(x) = \cos(x)\exp(-kx^2)$

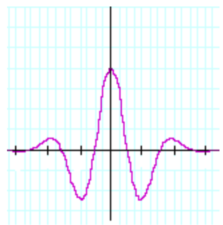
$G(x) =$



x

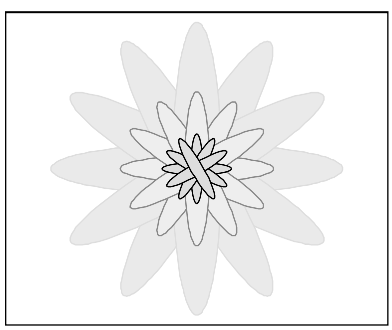


$G(x) =$



k - determines the width best responded to

In two dimensions, Gabor functions have both <u>width</u> and <u>orientation</u>



Provide a complete analysis of the geometric information <u>at each location</u> in the visual field

-> the basis of shape perception (features)

Spatial Frequency Channels

Since Gabor functions respond only to particular widths and orientations (cf. color photopigments),

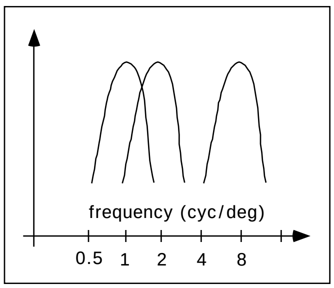
they form the basis of a categorization of geometric structure (cf. color categories)

-> <u>spatial frequency channels</u>

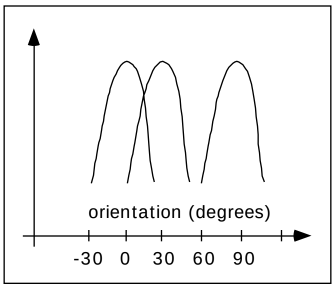
- spatial frequencies within factor of 3 are in same channel

- orientations within 30 degrees are in same channel

-spatial frequencies within factor of 3



- orientations within 30 degrees

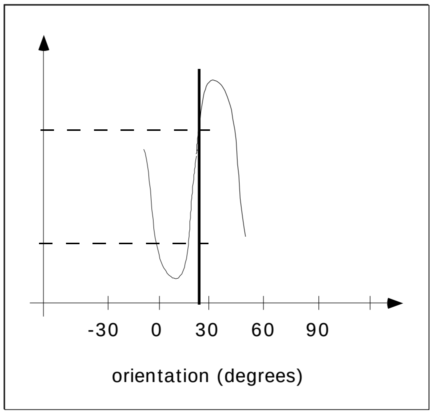


With this kind of resolution (in space and orientation), how is it possible to get information about details of geometric structure?

Answer: **Differences** in signals

E.g.

$F_1(\theta) - F_2(\theta)$

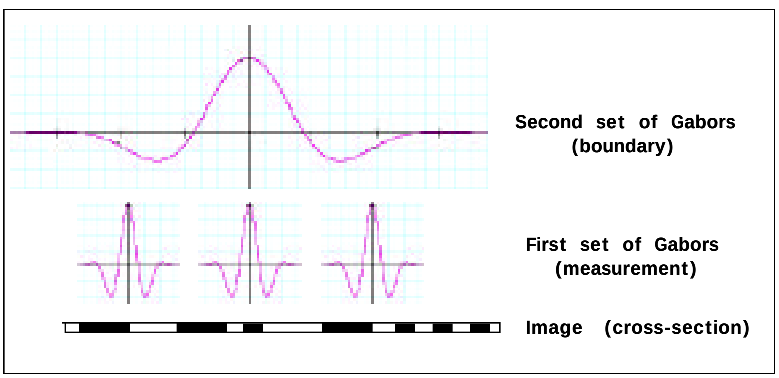


A **small** difference in orientation leads to a **large** difference in signal

Same idea for spatial frequency, colour, etc., …

Texture

Textures are based on outputs of Gabor functions at early levels…



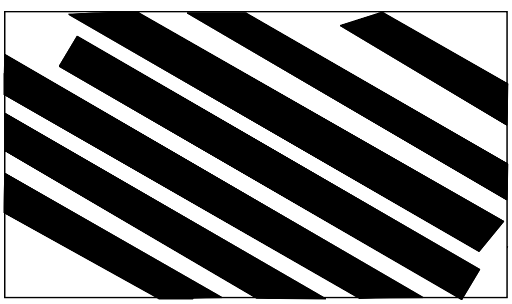
Since texture perception is based on Gabor functions, key properties of a texture include:

1. Lightness (true of all spatial patterns)
2. Contrast (true of all spatial patterns)
3. Dominant Width (spatial frequency content)

Note:

Dominant width cannot distinguish between

- small texture elements with large spaces between them, and
- large texture elements with small spaces between them



average lightness varies, though

Since texture perception is based on Gabor functions, key properties of a texture include:

1. Lightness (true of all spatial patterns)
2. Contrast (true of all spatial patterns)
3. Dominant Width (spatial frequency content)
4. Dominant Orientation
5. Distribution of Colours
6. Etc. (e.g. measure of randomness)

Texture Segmentation

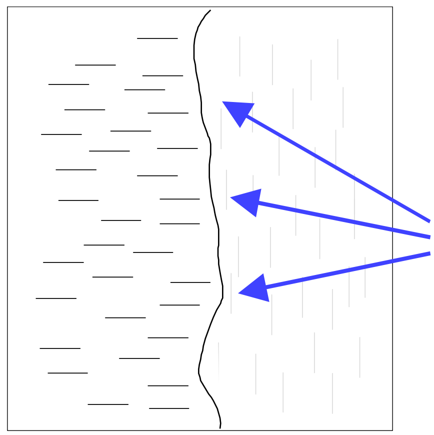
The most important aspects of texture are sometimes the **boundaries** between different regions

(cf. colours - act as a medium)

First set of Gabor functions act like photoreceptors

- each type provides a “map” of activity

e.g.
Horizontal filters
respond only to
horizontal items



Edge of activity
defines a border
for given texture

To get sharp border, need strong segmentation

-> activate different sets of Gabor functions

This requires activation of different spatial frequency channels:

- difference in frequency of factor ≥ 3
- difference in orientation of ≥ 30 deg

(This is for <u>immediate pickup</u> of texture differences)

Texture differences can be resolved that are smaller than this.

- difference in frequency of factor ≈ 0.1
- difference in orientation of ≈ 5 deg

This is based on the combination of signals from different spatial frequency channels

-> This requires more time

Using texture this way is similar to using colour.

If contrast and luminance are controlled, there are limits on how texture can be used:

- Borders have low spatial resolution
  - only useful for relatively large areas
- Borders poor for perception of motion
  - (factor of 10 worse)
- Areas cannot support perception of depth

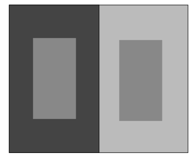
Colours and textures that have same luminance (and contrast) as surrounding areas cannot provide luminance system with information

This also includes patterns defined by
- motion
- binocular stereopsis

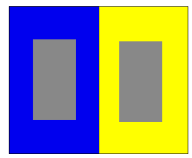
These are collectively called
second-order properties

Note: Second-order properties have a range of similar behaviours

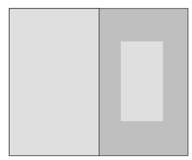
E.g., simultaneous brightness contrast



simultaneous colour contrast



simultaneous texture contrast



Texture Coding

Just as colours can be used as visual labels (e.g. to represent distinct categories), so can textures

Textures can be used independently of colours, and so can effectively expand dimensionality of the label space

-> Possibly have interactions with colour [i.e., coloured textures], but this hasn't been explored yet

Distinct texture categories involve activation of different sets of Gabor functions

1. If categories must be immediately obvious, this requires activation of different spatial frequency channels:
   - difference in frequency of factor ≥ 3
   - difference in orientation of ≥ 30 deg

   (cf distinct set of colour labels)

2. If categories only need to be obvious when scrutinized, this requires resolution of activity in the spatial frequency channels:
   - difference in frequency of factor ≈ 0.1
   - difference in orientation of ≈ 5 deg