LOG and DOG Filtering

- An Isotropic second derivative operator
- Does not respond to constant regions
- Does not respond to ramps
- Locates step edge by zero-crossings
- Model explains animal edge detection well
- Model explains blob detection
- Model explains line endpoint detection
Laplician of Gaussian

- Gaussian function
  \[ g(x) = ce^{-\frac{x^2}{2\sigma^2}} \]
  \[ \sigma = 2 \]
  \[ g(x, y) = ce^{-\frac{(x^2+y^2)}{2\sigma^2}} \]

Laplician of Gaussian

- 1\textsuperscript{st} derivative of Gaussian function
  - Zero crossing in the origin
  \[ g'(x) = \frac{-1}{\sqrt{2\pi} \sigma^3} xe^{-\frac{x^2}{2\sigma^2}} \]
  \[ = \frac{-x}{\sigma^2} g(x) \]
Laplacian of Gaussian

- 2nd derivative of Gaussian function
  - Laplacian of Gaussian (LoG)
  - Mexican hat

\[
g''(x) = \left(\frac{x^2}{\sqrt{2\pi}\sigma^5} - \frac{1}{\sqrt{2\pi}\sigma^3}\right) e^{-\frac{x^2}{2\sigma^2}}
\]
\[
= \frac{x^2}{\sigma^4} g(x) - \frac{1}{\sigma^2} g(x)
\]
\[
= \left(\frac{x^2}{\sigma^4} - \frac{1}{\sigma^2}\right) g(x)
\]

Detecting Edges with the LOG Filter

Input Image

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Cross correlation

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11 x 11 LOG approximation

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0  0  0  -1 -1  -2 -1  0  0  0
0  0  -2 -4  -8  -8  -4  -2  0  0
0  -2  -7 -15 -22 -22 -15 -7  -2  0
-1 -4 -15 -24 -14 -14 -24 -15 -4  -1
-1 -8 -22 -14  52  52 -14 -22 -8  -1
-2 -9 -23 -10  103 103 -1 -23 -9  -2
-1 -8 -22 -14  52  52 -14 -22 -8  -1
-1 -4 -15 -24 -14 -14 -24 -15 -4  -1
0  -2  -7 -15 -22 -22 -15 -7  -2  0
0  0  -2 -4  -8  -8  -4  -2  0  0
0  0  0  -1 -1  -2 -1  -1  0  0  0
```

- Choose mask size according to fineness of the edges
- Perhaps human visual system uses 4 or 5 sizes
- Parallel computing similar to animal visual systems

ANN architecture for Edge detection

- Mach band effect using an ANN architecture
- Implementing mask
  \[ M = [-1, 2, 1] \]
- Step edge of 10 levels is expanded to 20 levels
Experience the Mach Band Effect

- Seven constant stripes with grey levels $31 + 32k$, $k = 1, \ldots, 7$
- Human perceive concaved panel

Simple Model of a Neuron

- Simple models of a neuron
- Two possible output conditioning functions
3D ANN LOG Architecture

- Receptive field of neuron A: input
- There are different sizes of receptive field and different densities
  - Center: +
  - Surround: -
- Neurons A and B compute at the same time in centiseconds

Examples of using Gaussian

Input  σ = 4  σ = 1