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COST IC1102 STSM

Image restoration:

A Machine learning approach

from January 7, 2013 to February 22, 2013
PAMPLONA

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Brno University of Technology

The Public University of Navarre

Outline

- Deblurring problem - specialized
- Human vision - connectionist model
- Playing with neural nets
- Regularization and spatial density
- Limitations

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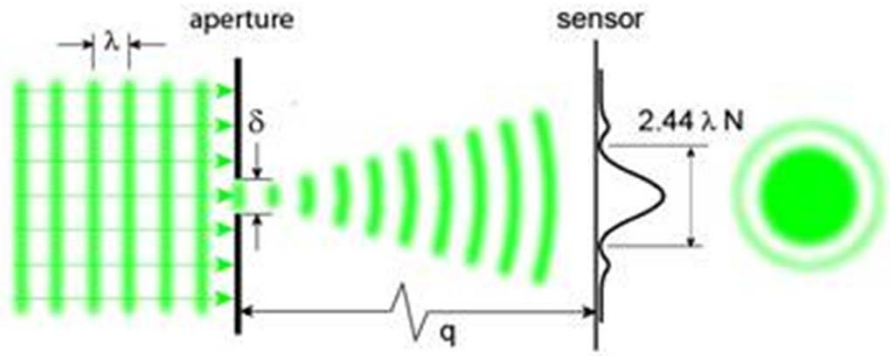
Blurring system

- Real image resolution is given by a width of the Airy disk
- Diffraction limited imaging system



$$f(x) = \int_{-\infty}^{\infty} K(x-t) \cdot g(t)dt$$

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De-blurring system (discrete form)

- Signal blurring in matrix form

$$\boldsymbol{f} = \boldsymbol{K}\boldsymbol{g}$$

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De-blurring system (discrete form)

- Signal blurring in matrix form

$$\boldsymbol{f} = \boldsymbol{K}\boldsymbol{g}$$

- Signal de-blurring in matrix form

$$\boldsymbol{g} = \boldsymbol{K}^{-1}\boldsymbol{f}$$

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De-blurring system (discrete form)

- Signal blurring in matrix form

$$\boldsymbol{f} = \boldsymbol{K}\boldsymbol{g}$$

- Signal de-blurring in matrix form

$$\boldsymbol{g} = \boldsymbol{K}^{-1}\boldsymbol{f}$$

- Corrupted signal de-blurring

$$\overline{\boldsymbol{g}} = \boldsymbol{K}^{-1}(\boldsymbol{f} + \boldsymbol{n}) = \boldsymbol{K}^{-1}\boldsymbol{f} + \boldsymbol{K}^{-1}\boldsymbol{n}$$

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$$\boldsymbol{f} = \boldsymbol{K}\boldsymbol{g}$$

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- Corrupted signal de-blurring

$$\overline{\boldsymbol{g}} = \boldsymbol{K}^{-1}(\boldsymbol{f} + \boldsymbol{n}) = \boldsymbol{K}^{-1}\boldsymbol{f} + \boldsymbol{K}^{-1}\boldsymbol{n}$$

- Regularized solution – trade off

$$\widetilde{\boldsymbol{g}} = (\boldsymbol{K} + \lambda \boldsymbol{I})^{-1}(\boldsymbol{f} + \boldsymbol{n})$$

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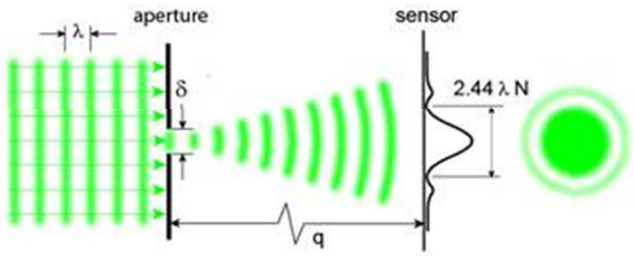
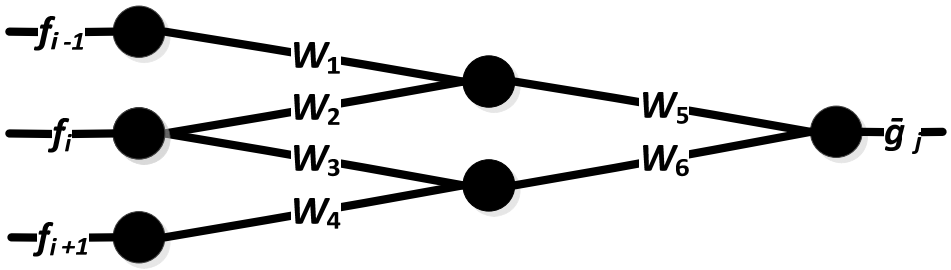
De-blurring system (a local form)



- Signal blurring in local area

$$f_i = \sum_{j=-N/2}^{j=N/2} K_{i,j} \cdot g_j.$$

- Deblurring mask (a cone)



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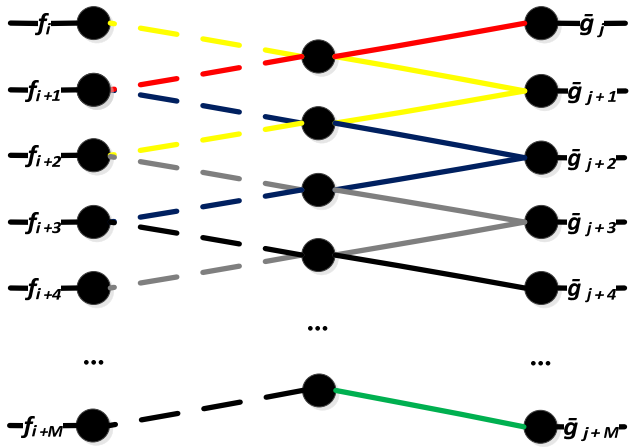
Connectionist models

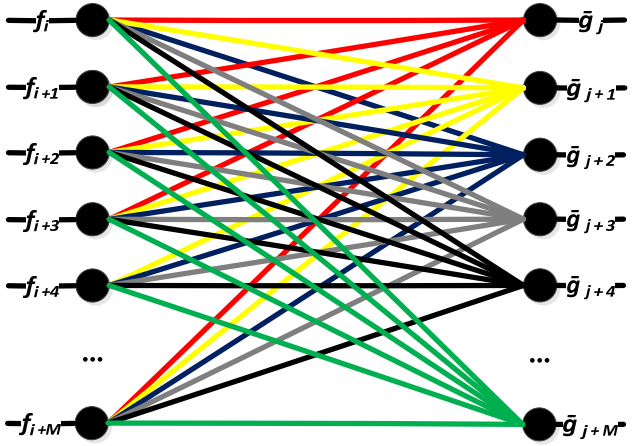
- Network of cones

$$f_i = \sum_{j=-N/2}^{j=N/2} K_{i,j} \cdot g_j$$



- Conventional

$$f = Kg$$



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Regularized solutions

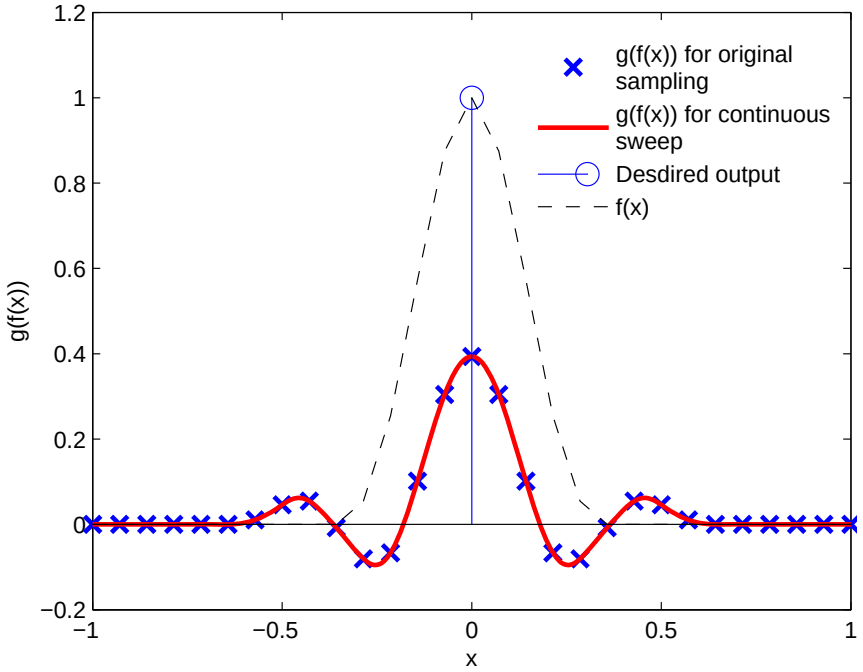

Fig. 1 *Spatially regularized cone solution*

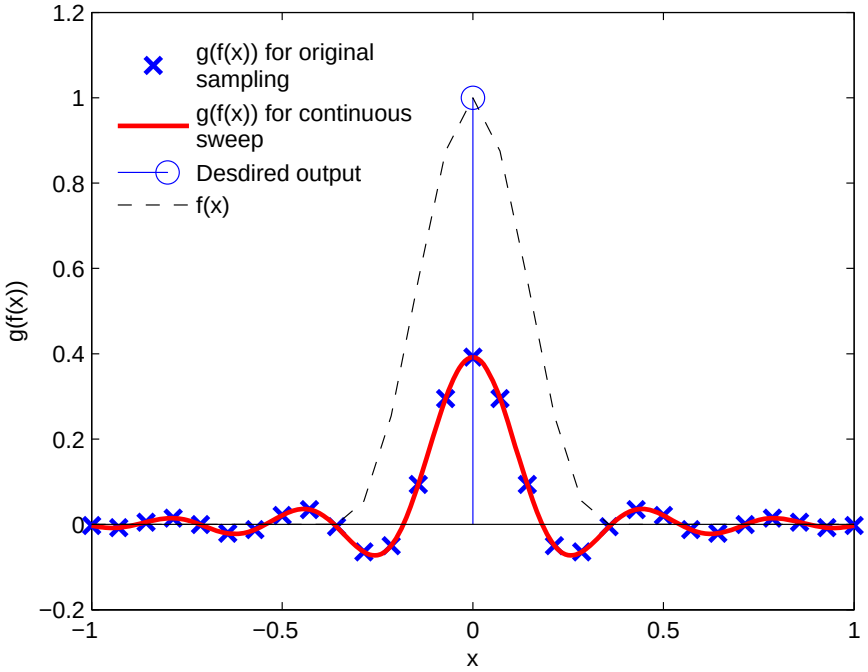

Fig. 2 *Strongly regularized conventional solution*

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Unregularized solutions

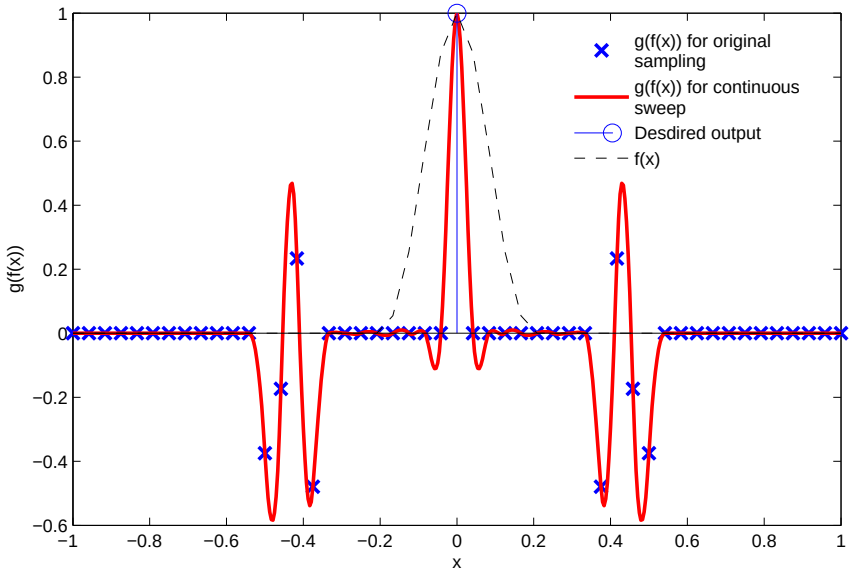

Fig. 3 *Unregularized cone solution*

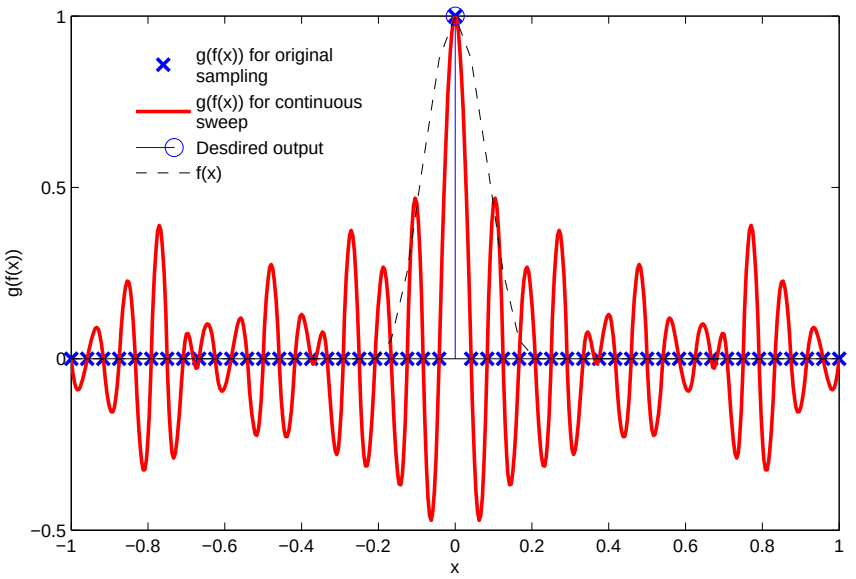

Fig. 4 *Unregularized (perfectly fitted) conventional solution*

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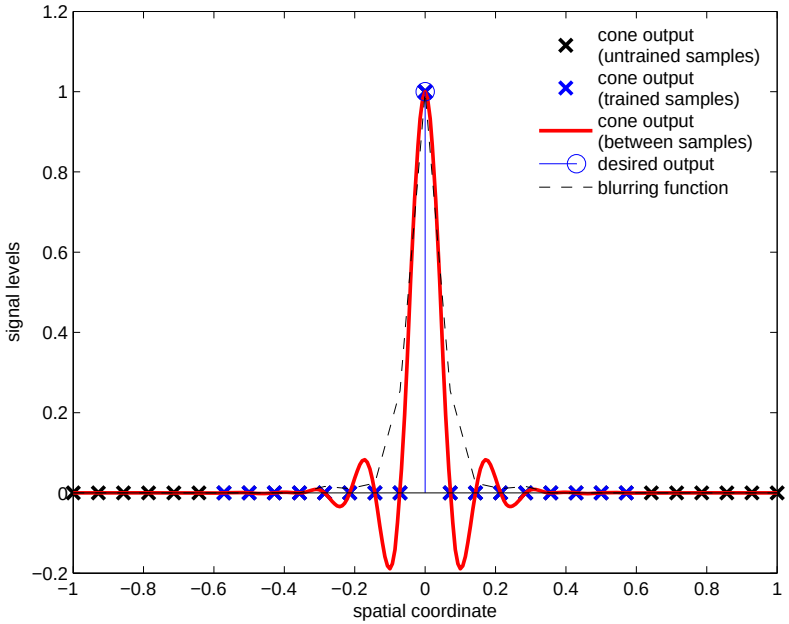
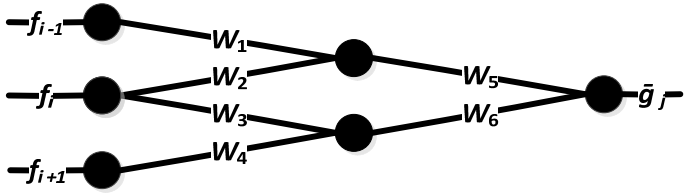
Closer to a hyperplane





$$\bar{\boldsymbol{g}} = f_{i-1}(w_1 w_5) + f_i(w_2 w_5 + w_3 w_6) + f_{i+1}(w_4 w_6)$$

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Thank you for your attention !

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