Image restoration:
A Machine learning approach

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Outline

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

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

\[ f(x) = \int_{-\infty}^{\infty} K(x - t) \cdot g(t) dt \]
De-blurring system (discrete form)

- Signal blurring in matrix form

\[ f = Kg \]
De-blurring system (discrete form)

- Signal blurring in matrix form
  \[ f = K g \]

- Signal de-blurring in matrix form
  \[ g = K^{-1} f \]
De-blurring system (discrete form)

- Signal blurring in matrix form
  \[ f = Kg \]
- Signal de-blurring in matrix form
  \[ g = K^{-1}f \]
- Corrupted signal de-blurring
  \[ \bar{g} = K^{-1}(f + n) = K^{-1}f + K^{-1}n \]
De-blurring system (discrete form)

- Signal blurring in matrix form
  \[ f = Kg \]

- Signal de-blurring in matrix form
  \[ g = K^{-1}f \]

- Corrupted signal de-blurring
  \[ \bar{g} = K^{-1}(f + n) = K^{-1}f + K^{-1}n \]

- Regularized solution – trade off
  \[ \tilde{g} = (K + \lambda I)^{-1}(f + n) \]
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)
Connectionist models

- Network of cones
  \[ f_i = \sum_{j=-N/2}^{N/2} K_{i,j} \cdot g_j \]

- Conventional
  \[ f = Kg \]
Regularized solutions

**Fig. 1** Spatially regularized cone solution

**Fig. 2** Strongly regularized conventional solution
Unregularized solutions

Fig. 3 Unregularized cone solution

Fig. 4 Unregularized (perfectly fitted) conventional solution
Closer to a hyperplane

\[ \bar{g} = f_{i-1}(w_1w_5) + f_i(w_2w_5 + w_3w_6) + f_{i+1}(w_4w_6) \]
Thank you for your attention!

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