Local Linear Models for Sensor Fusion

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Mixture Linear and Local Linear Models

- For regression, nonlinear PCA, adaptive transform coding, and sensor fusion.
- Why I'm a born again mixture linear modeler
  - Basis in probabilistic generative models
  - Quick to fit
  - Re-regularize without refitting
  - Easy to interpret
  - They work

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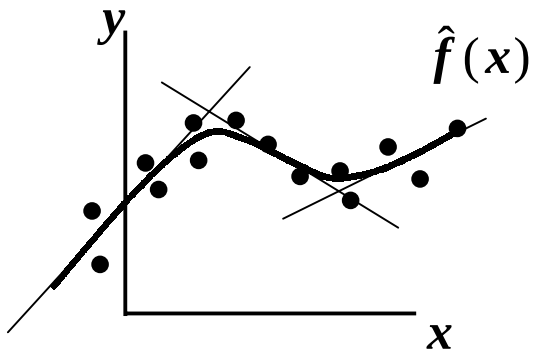
What's a Mixture Linear Model?

Regression example --
independent variable x, regressor $\hat{f}(x)$

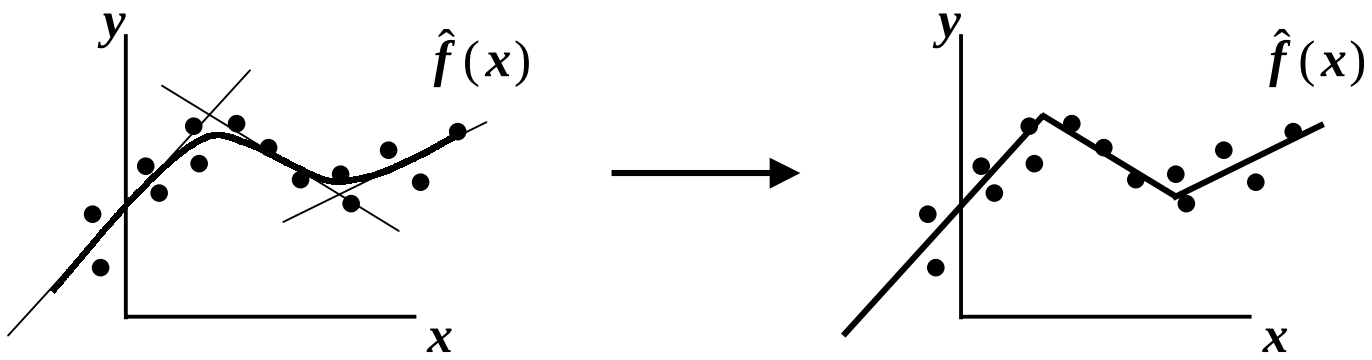


$$\hat{f}(x) = \sum_{i=1}^{m} p(i \mid x) \left(\Gamma_i x + \mu_i \right)$$

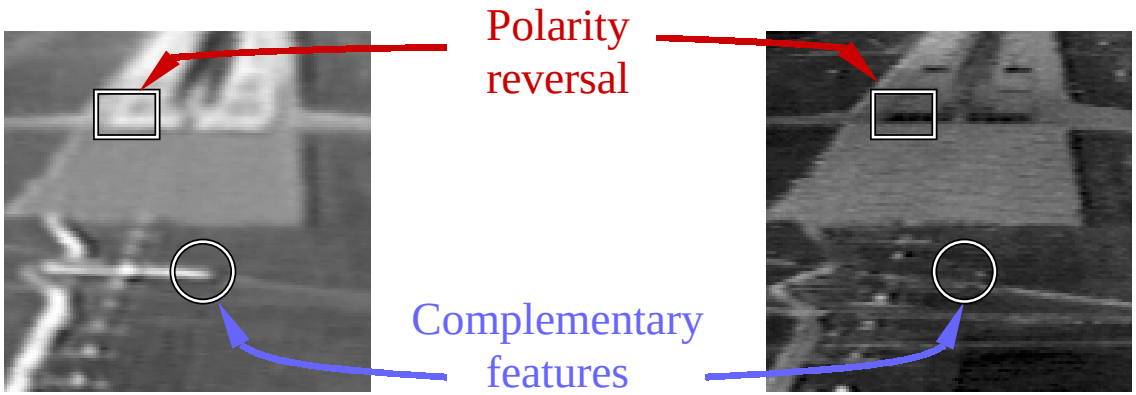
non-linear weighting of local, linear regressors

What's a Local Linear Model?

Instead of mixing the local models, choose which one (Γ_i, μ_i) to use in each region



Local Probabilistic Sensor Fusion



Visible band (TV) **Infrared (IR)**

- Sensors carry different information => fusion provides more “complete” information.

Probabilistic Sensor Fusion

- **Underlying <u>true</u> scene intensity s(x,y).**

- **Image formation model maps true scene s(x,y) to sensor images a_i(x,y)**

$$a_i(x,y) = f_i\left(s(x,y),\ x,y\right) + \varepsilon_i$$

varies with position in image, includes additive noise.

- **What's Fusion? Estimate true scene s(x,y) from sensor images a_i(x,y), here i=1,2. EG - maximum likelihood estimate**

$$\hat{s}_{ML} = \arg\max_s\ p(a_1, a_2 | s)$$

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Local Linear Image Formation Model

- Local affine (factor analysis) model

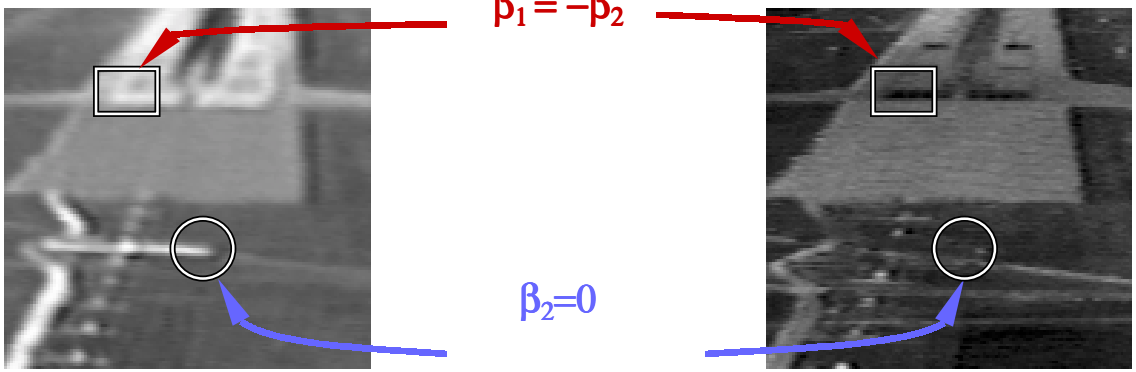
$$a_i(l) = f_i(s(x,y),x,y) + \varepsilon_i(x,y)$$
$$= \beta_i(x,y)\ s(x,y) + \alpha_i(x,y) + \varepsilon_i(x,y)$$

  - Estimate $\Sigma\varepsilon$ from motion-compensated video sequence; β, α from local second order statistics

ML Fusion

$$\hat{s}_{ML} = \arg\max_{s} [\ln p(a \mid s)]$$

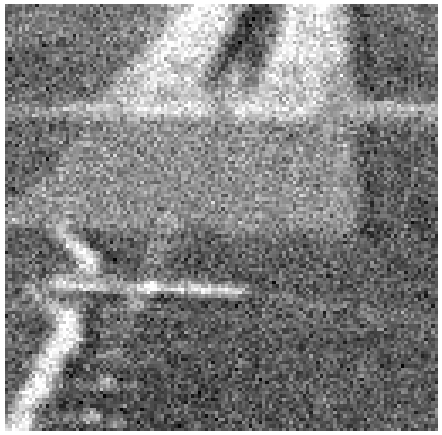
$$= \frac{\frac{\beta_1 (a_1 - \alpha_1)}{\sigma_{\varepsilon_1}^2} + \frac{\beta_2 (a_2 - \alpha_2)}{\sigma_{\varepsilon_2}^2}}{\frac{\beta_1^2}{\sigma_{\varepsilon_1}^2} + \frac{\beta_2^2}{\sigma_{\varepsilon_2}^2}} = \sum_{i=1}^{2} w_i (a_i - \alpha_i)$$



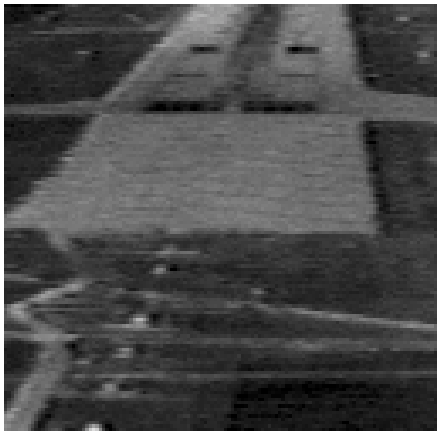
Visible band (TV)

Infrared (IR)

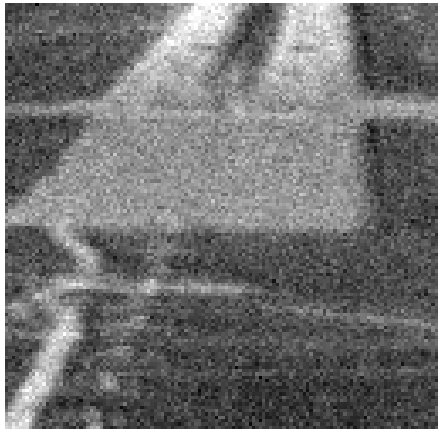
ML Fusion



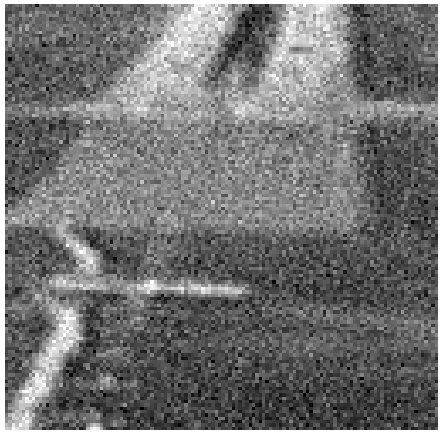
TV



IR



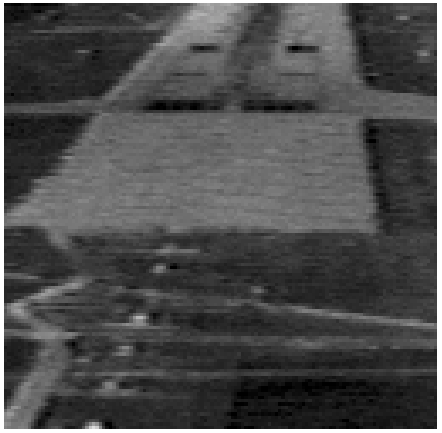
Averaging

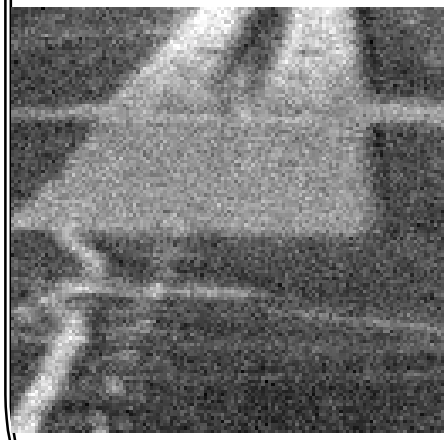


Selection

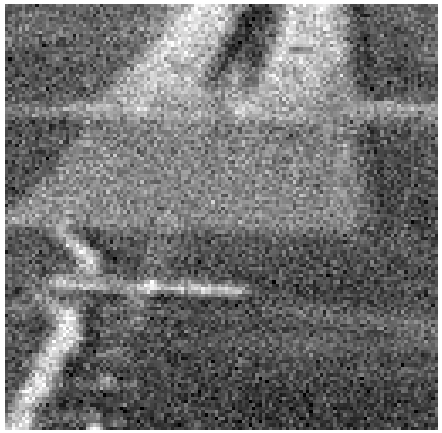
ML

MAP Fusion





Averaging



Selection

ML

MAP

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More Results

See Poster

References

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- Local linear regression -- Kambhatla, Ph.D. thesis, Oregon Graduate Institute, 1996.
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- This Work -- Sharma, Leen, and Pavel, Advances in Neural Information Processing Systems 11, MIT Press, 1999; Sharma, Ph.D. thesis, Oregon Graduate Institute, 1999.