Image Restoration

3 methods:

1. Inverse filter
2. Least square filters
3. Iterative technique

Key assumption:
Know $d(x,y)$
Blur function.

How about if we don't know $d(x,y)$?
When \( d(u_1, u_2) = \text{blurring } f_x \) is unknown

\[ \Rightarrow \text{Blind deconvolution.} \]

\[ f \xrightarrow{\text{LTI}} d(u_1, u_2) \xrightarrow{\oplus} g \]

1. **Estimate parameters of the blur \( f_x \).**
   Know what kind of blur...
   - Atmosphere
   - Out of focus
   - Motion

Approach: Look at F.T. of \( g \).

- Zeros of \( b(w_1, w_2) \) tell you about parameters of blur function.
- \( R \) in out of focus case.
- \( \theta \), \( \phi \), motion blur.
Can also look at cepstrum.

\[ \text{Spectrum of } G(w_1, w_2) \]
\[ \text{Cepstrum of } g = \tilde{g}(n_1, n_2) = - \sum_{k} \text{log} \left| G(w_1, w_2) \right|^2 \]

\[ \Rightarrow \]

\[ X \overset{\times}{\rightarrow} XY, \text{ multiplicative noise} \]

\[ \log(xY) = \log(x) + \log(y) \]

\[ \text{apply LT} \]
\[ = \log(x) \text{ box } \rightarrow x \]
$xy \rightarrow 1 \log (\log (x) + \log (y)) \xrightarrow{\text{CPP}} \exp \xrightarrow{} x$

$log(y) \rightarrow \mathcal{w}$

$log(x) \rightarrow \mathcal{w}$

Homoomorphic filtering.
Blind deconvolution where nothing is known about blur fn

\[ F(w_1, w_2) \rightarrow B(w_1, w_2) \rightarrow G(w_1, w_2) \]

Assumption: \( |B(w_1, w_2)| \) is smooth fn.

\[ G(w_1, w_2) = F(w_1, w_2) \cdot B(w_1, w_2) \]

\[ |G(w_1, w_2)| = |F(w_1, w_2)| \cdot |B(w_1, w_2)| \]

\[ |B(w_1, w_2)| \approx \sqrt{u_1^2 + u_2^2} \]
\[ |F(w_1, w_2)| \leq |F(w_1, w_2)|_L + |F(w_1, w_2)|_H \]

slowly varying component

fast varying component

\[ = \sqrt{w_1^2 + w_2^2} |F(w_1, w_2)|_H \]
\[ \{ \frac{\|L\|^2}{18}\} = \left\{ \frac{\|L\|^2}{18}\right\} + \sum_{i=1}^{10} \frac{\|L\|^2}{18} \]

For the results of the survey, we have:

\[ 18\|L\|^2 = \frac{\|L\|^2}{18} + \sum_{i=1}^{10} \frac{\|L\|^2}{18} \]

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\[
\text{IBL} \approx \text{IBL} \text{ F}_L \left( \frac{1}{\text{SNR}} \right)
\]
Reduction of more than 1 degrades

Convolutional noise + Additive noise

\[ f \xrightarrow{\ast} g \xrightarrow{\text{noise}} \hat{f} \]

\[ P_r(w_1, w_2) = P_f |D(w)| \]

\[ g \xrightarrow{\text{Pr}(w_1, w_2)} \frac{P_r(w_1, w_2)}{P_r + P_{w}} \] (\text{Pr}(w_1, w_2)) \]

\[ H(w_1, w_2) : \]

\[ \frac{P_f \cdot D^*}{P_f \cdot D \cdot D^* + P_w} \]
Algebraic Degradation

\[ f \rightarrow \text{Deg} 1 \rightarrow \text{Deg} 2 \rightarrow \cdots \]

\[ \text{Deg} N \rightarrow g \]

\[ g \rightarrow \text{Undo} \text{Deg} N \rightarrow \text{Undo} \text{Deg} N-1 \]

Reduction of multiplicative noise

\[ f \rightarrow \times \rightarrow g \]

\[ g' = f' + w' \]

\[ g'(h_1, h_2) = f'(h_1, h_2) w'(h_1, h_2) \]

\[ \log(g) = \log f + \log w \]

\[ \hat{f} = \exp([\log \text{additive noise red.}]) \rightarrow \text{apply any additive noise reduction technique.} \]
TV Signal:

30 frames/see.
frame \rightarrow even field
frame \rightarrow odd field.

frame: 500 lines.
  each line 500 pixels/line.

\[ 300 \times 500 \times 80 \times 24 = 5.25 \times 10^8 \text{ bits/see} \]

\approx 500 \text{ Mega bits/see.}

PSTL \approx 600 kbps \sim 1 \text{ mbit/s.}

cable \approx 1 \text{ mbit/s.}
$2 \times 10^8 \text{ bits/s}$.

$2 \times 60 \times 60 = 7200 \approx 10000 \approx 10^4$

$2 \times 10^{12} \text{ bits} \quad \Rightarrow \quad 200 \text{ GB}$

Giga byte = $10^9 \text{ bits}$

for 2 hour TV program.

Get to reduce BW of imagery and video.

Decode

Encode

Corrupt

Trash

Software

ASICs

Barge/Video
live

non-live

_one way or two age_

audio/video sync