Superresolution Imaging

from Equations to Embedded Applications

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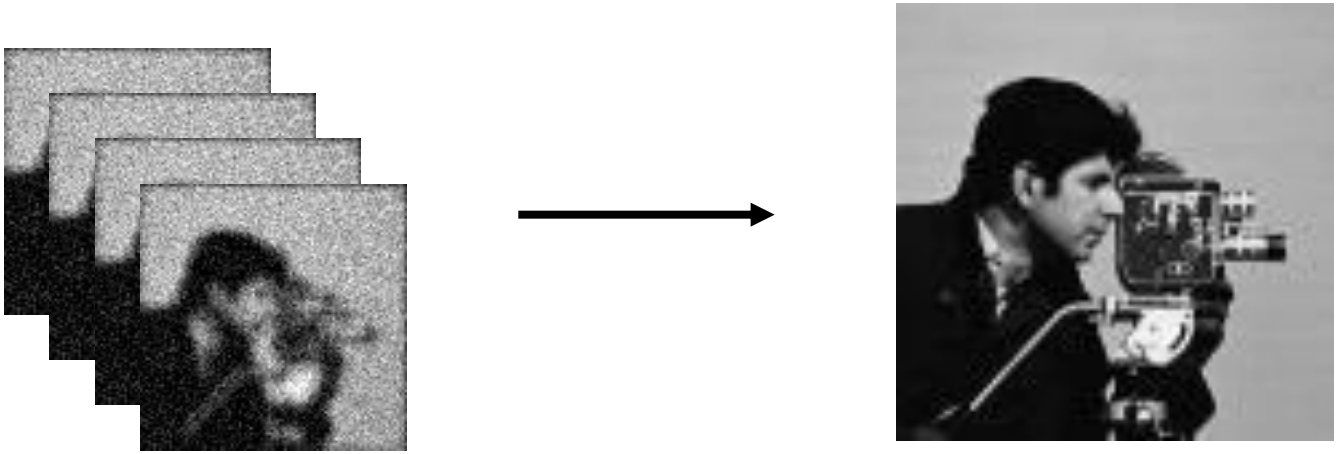
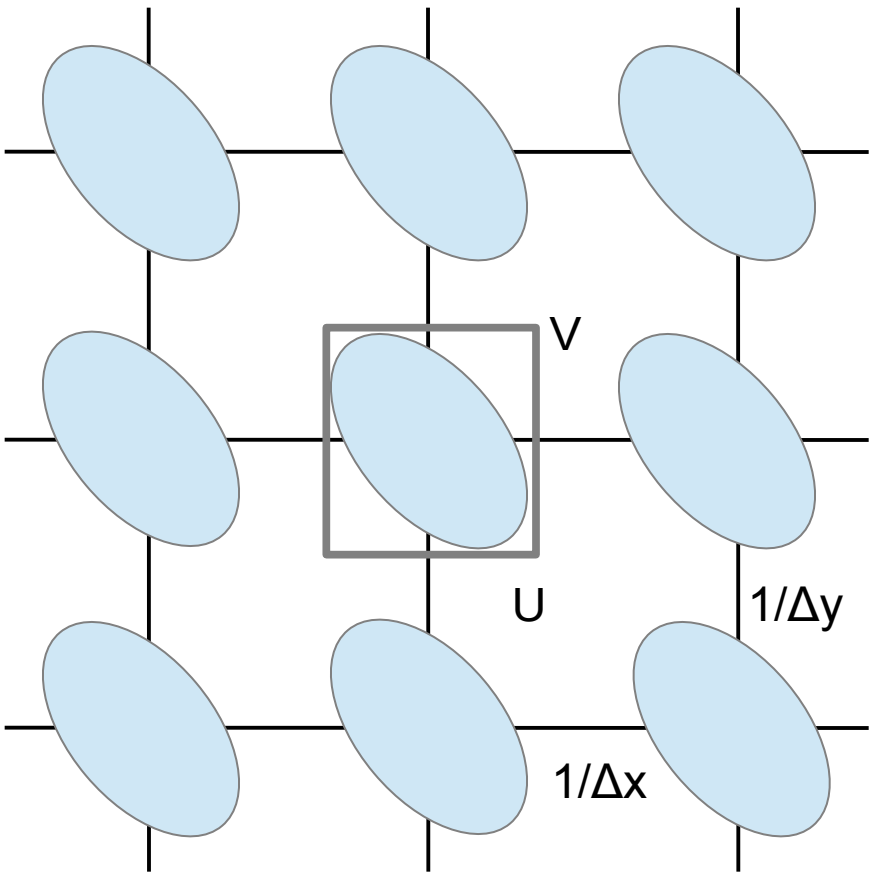
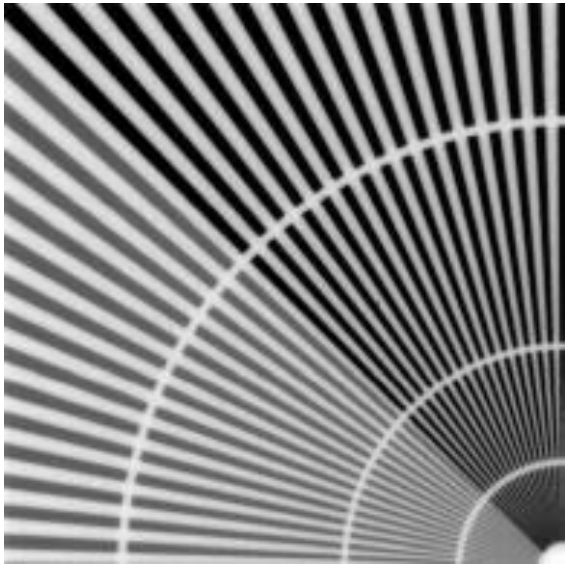
Superresolution



Recalling Nyquist



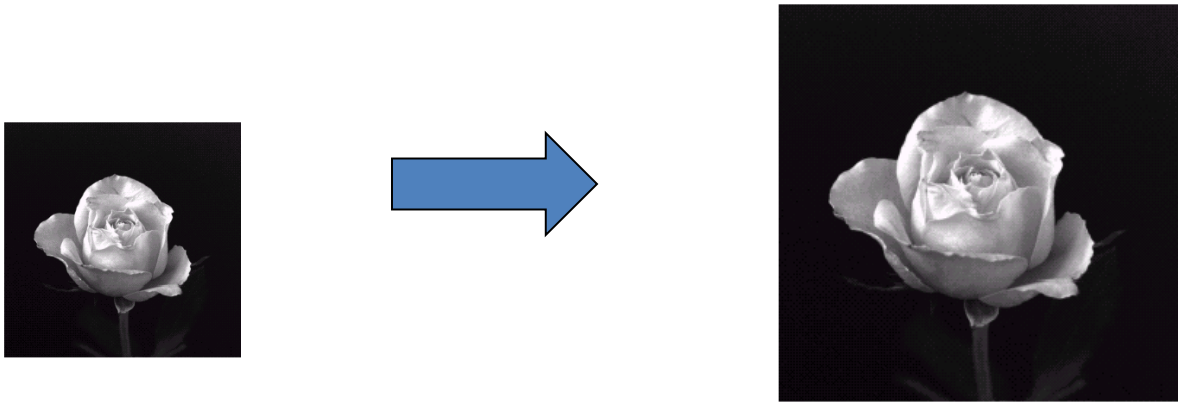


$$\Delta x \leq \frac{1}{2U}$$

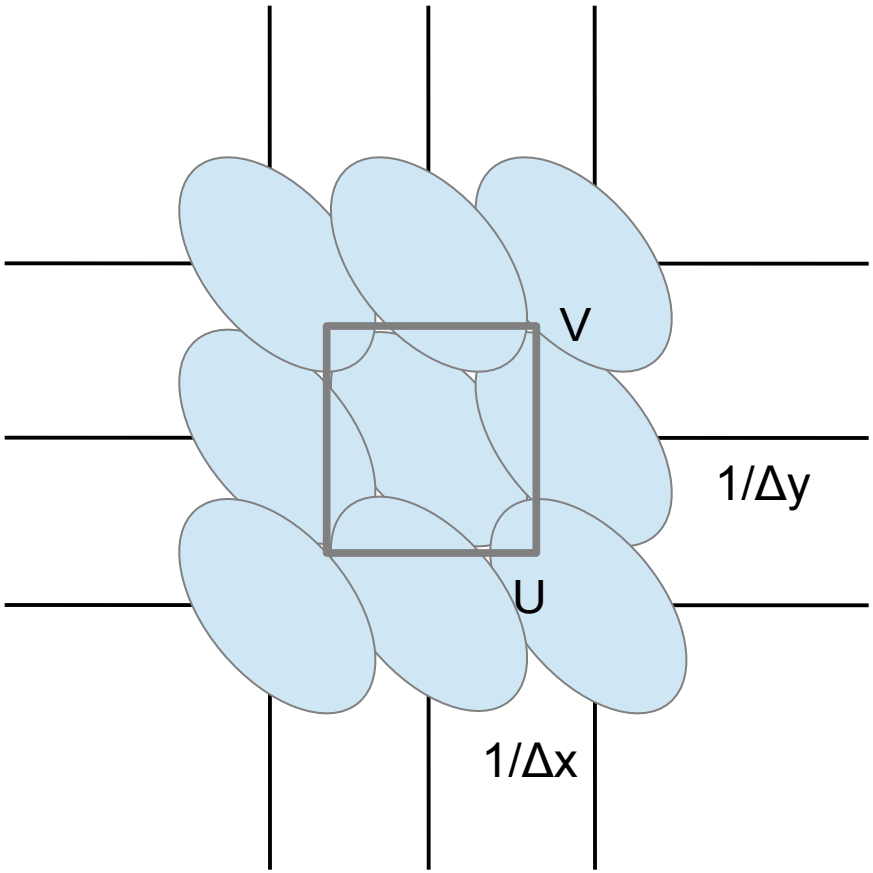
$$\Delta y \leq \frac{1}{2V}$$

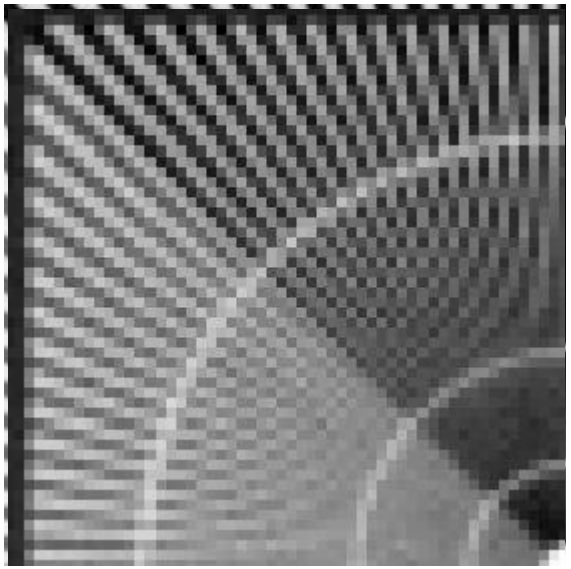
Nyquist Sampling

- Nyquist sampling → an "ideal" image, no frequencies are missed.
- Superresolution = scaling + interpolation



Recalling Nyquist



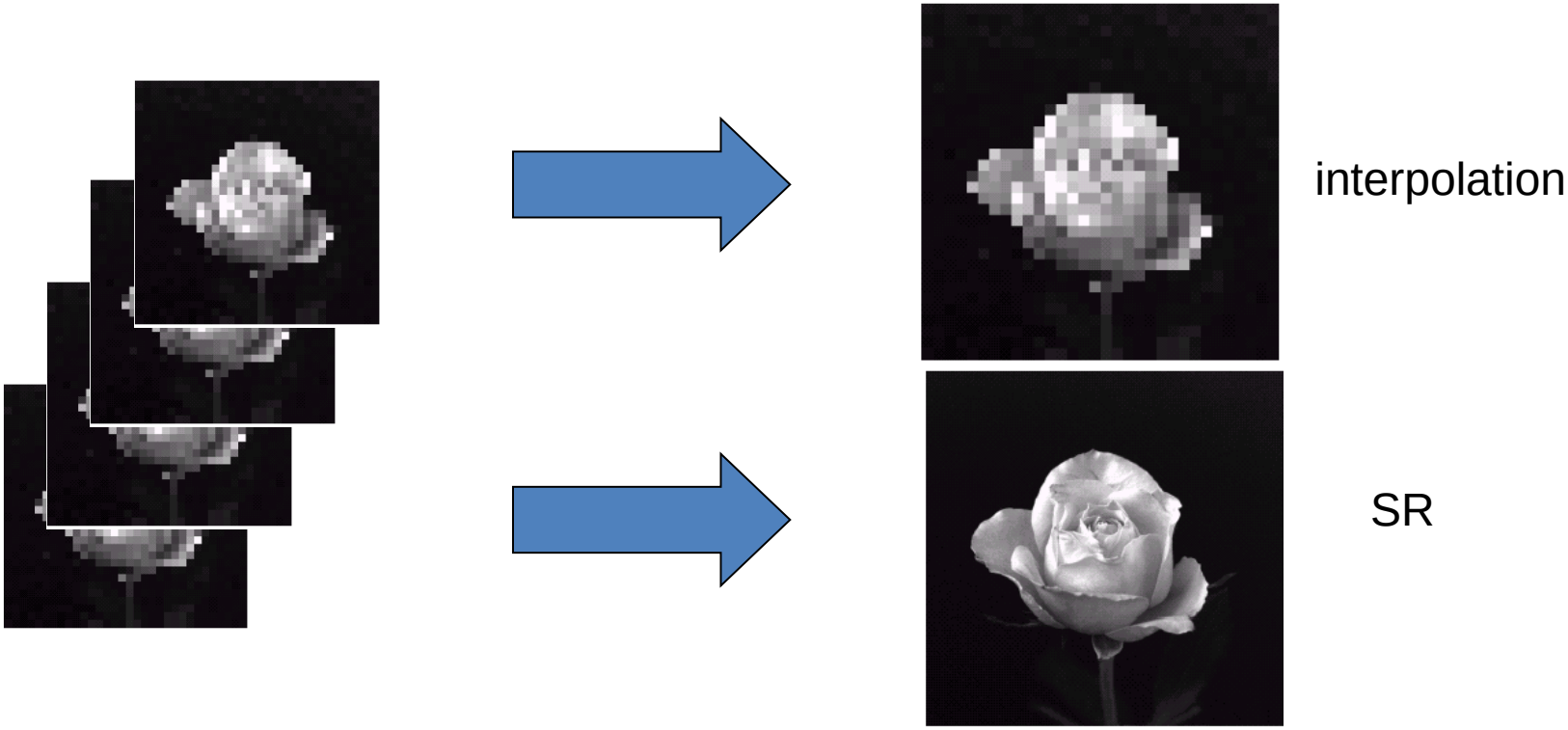


$$\Delta x > \frac{1}{2U}$$

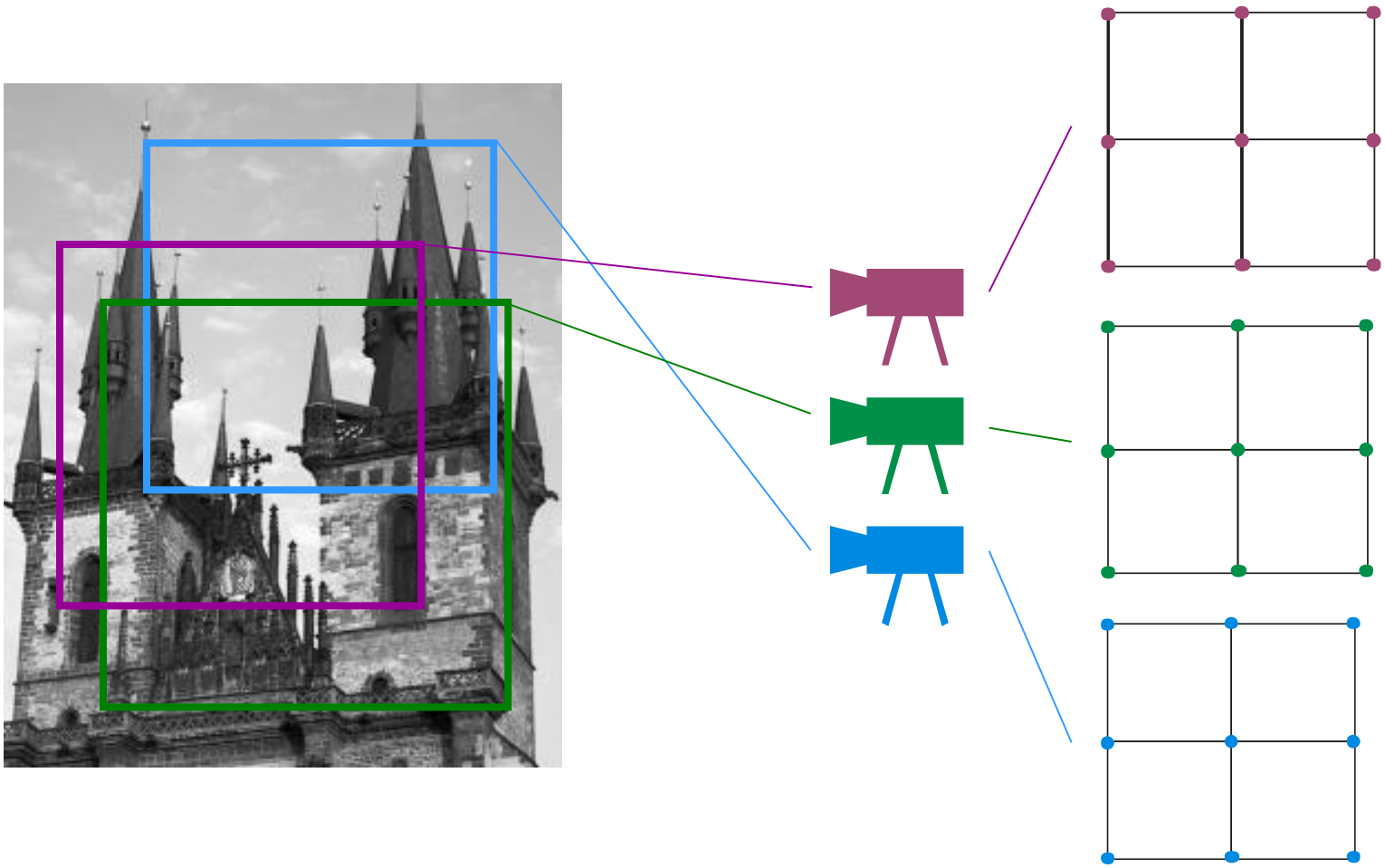
$$\Delta y > \frac{1}{2V}$$

Superresolution

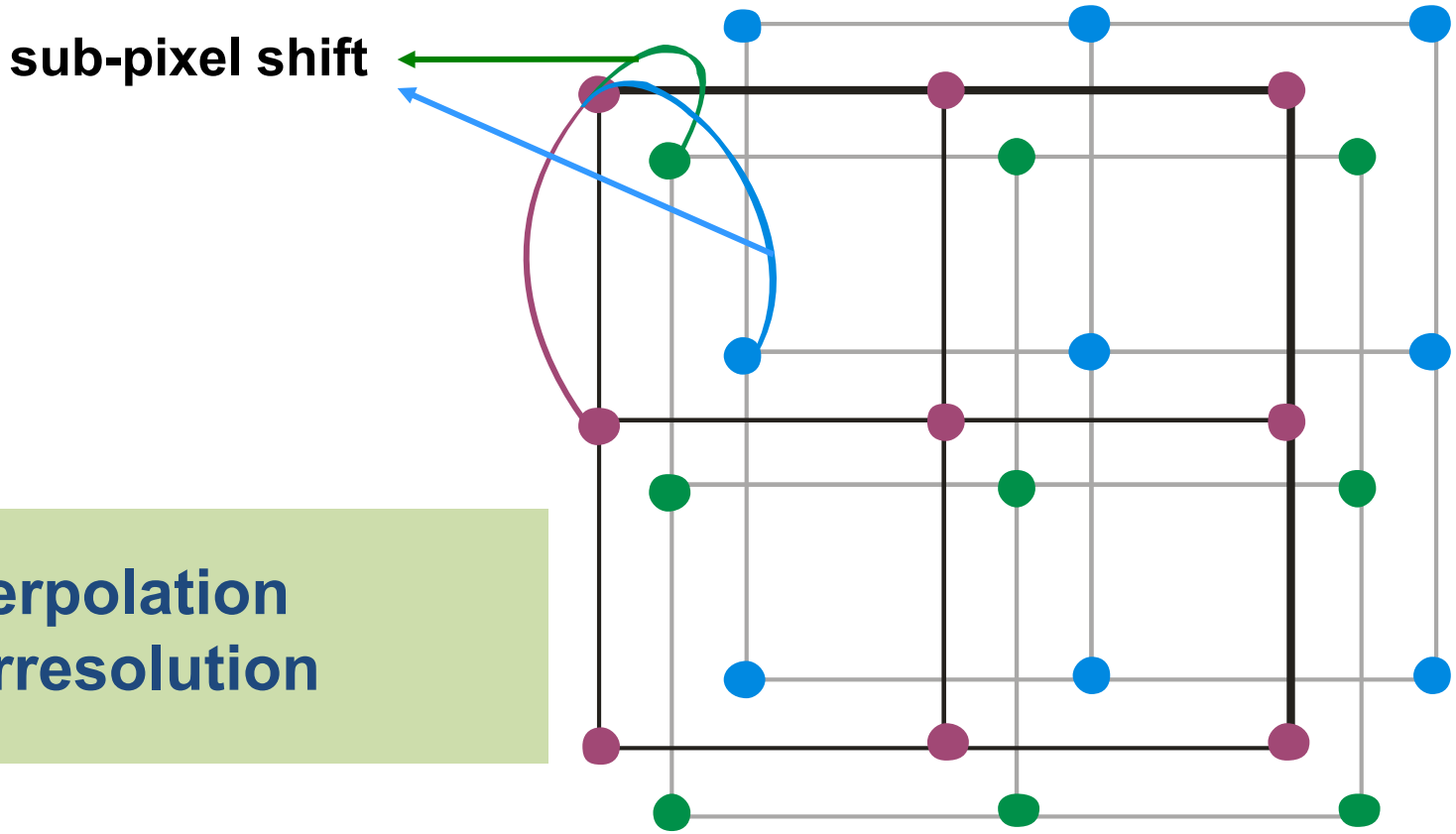
- Sub-Nyquist sampling → aliasing → high frequencies are lost or modified
- Superresolution can recover aliased data



Traditional superresolution sub-Nyquist sampling



Traditional superresolution



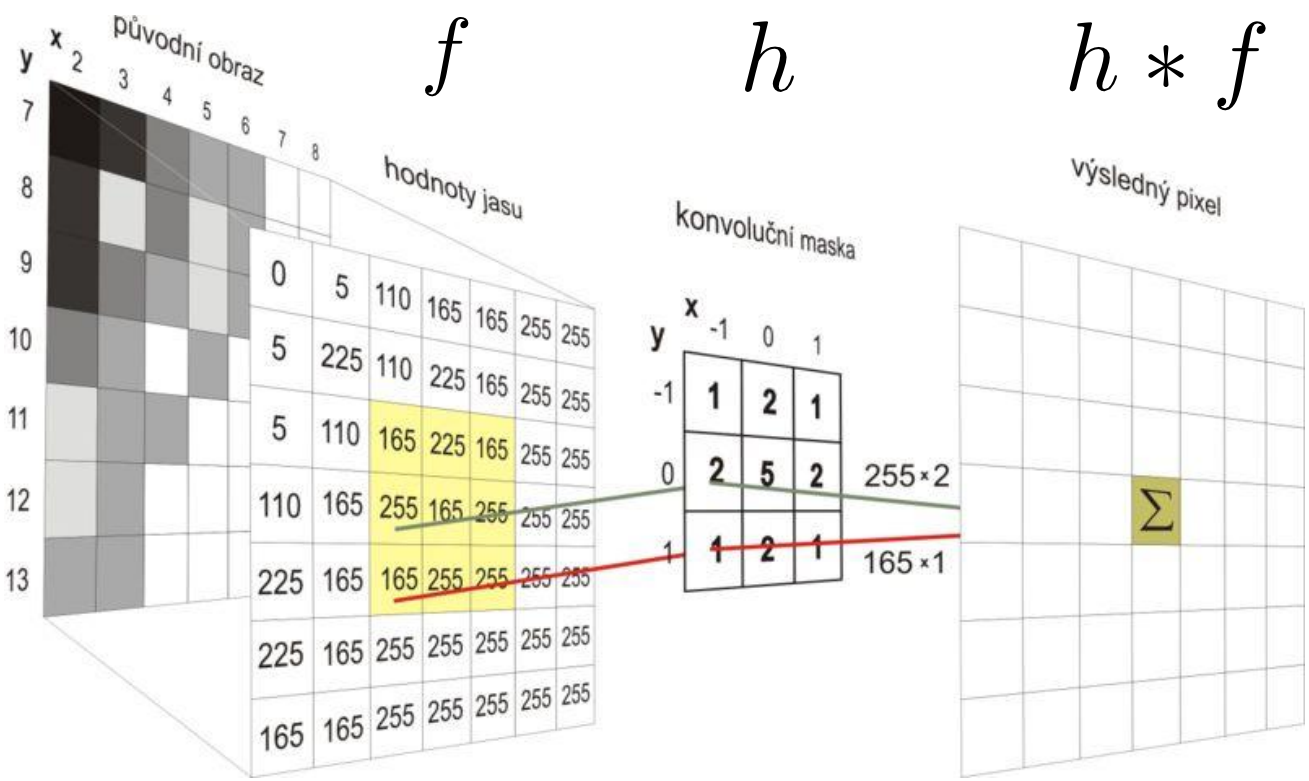
pixel interpolation
→ superresolution

Realistic Superresolution

Deconvolution

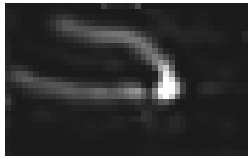
Convolution

$$h * f(x) = \int_{-\infty}^{\infty} h(x-\tau) f(x) d\tau$$



Motion Blur

*



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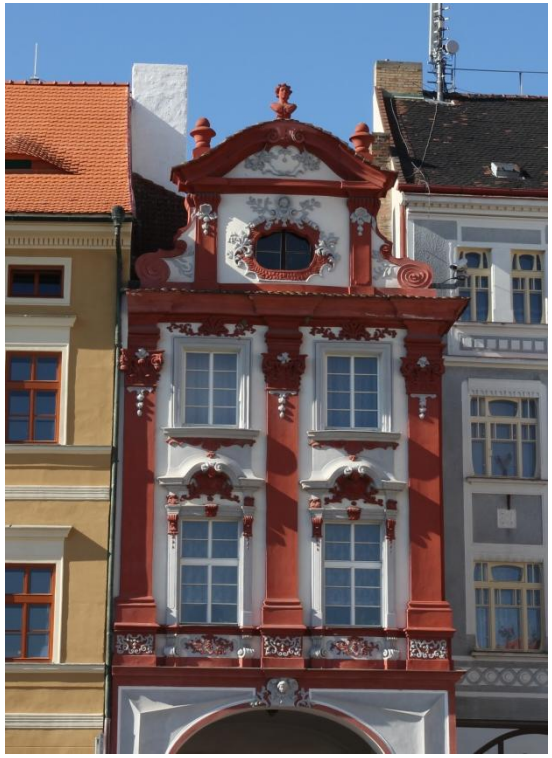
Out-of-focus Blur



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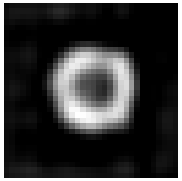

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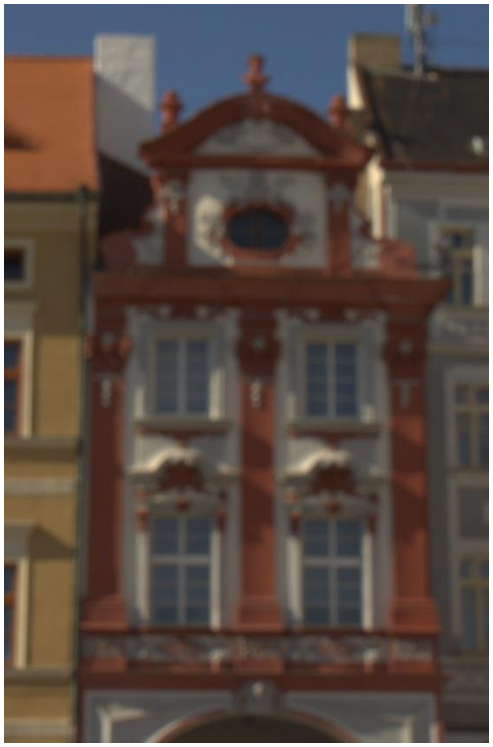
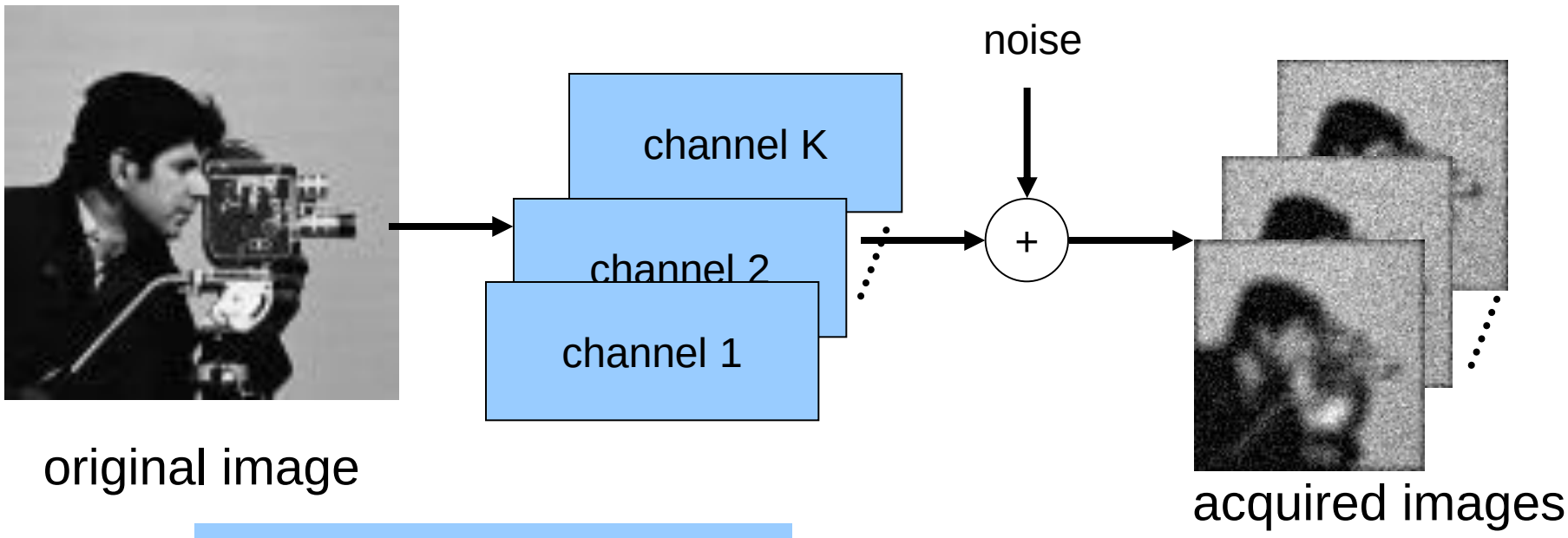


Multichannel Acquisition Model



$$D[u * h_k](x) + n_k(x) = z_k(x)$$

Realistic superresolution

- Acquisition model:
  + Noise
  + Blur
  + Shift
  + Downsampling

- Reconstruction method:
  + Multichannel blind deconvolution
  + Shift compensation
  + Resolution enhancement

Superresolution & Blind Deconv.

- Acquisition model

$$z_k = D(h_k * u) + n_k$$

- Optimization problem

$$F(u, \{h_k\}) = \frac{1}{2} \sum_{k=1}^{K} \|z_k - D(h_k * u)\|^2 + \lambda Q(u) + \gamma R(\{h_k\})$$

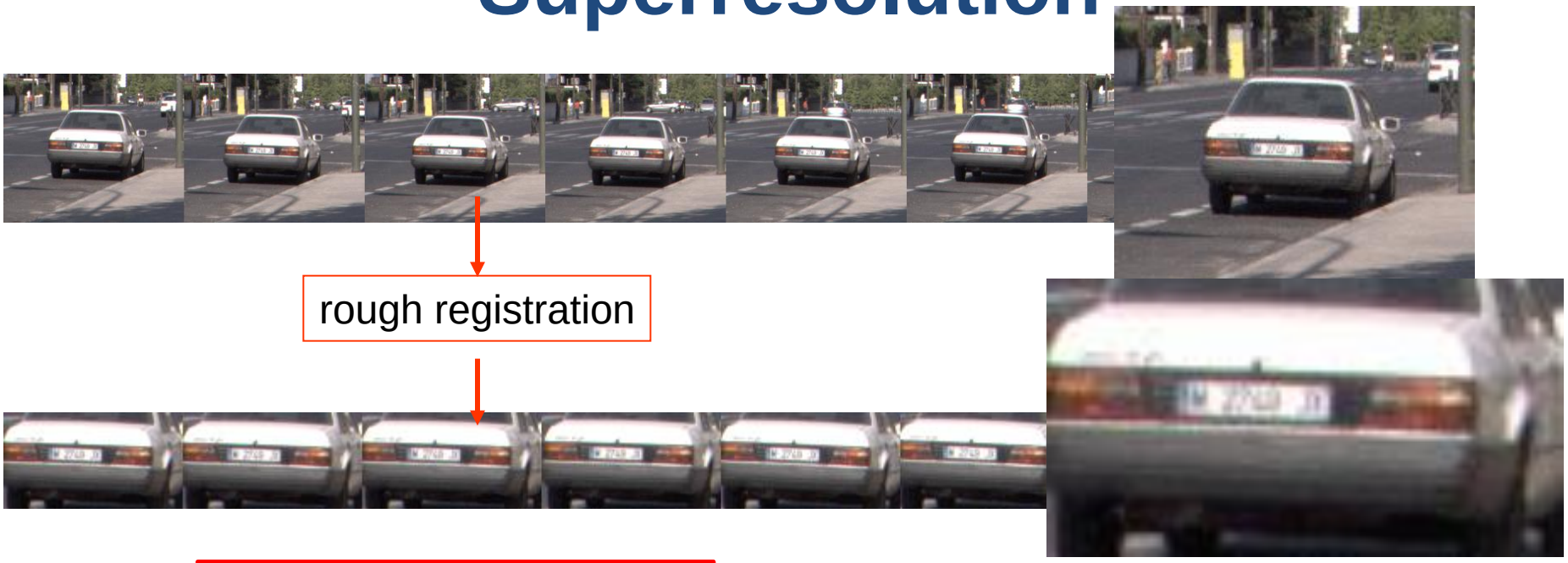
Data term

Image regularization term

Blur Regularization term

L2 norm | L1 norm | positivity

Superresolution



Superresolved image (2x)

Optical zoom (ground truth)

Space-variant Case

Space-variant Case

- Video with local motion
  - Masking

- Slowly changing PSFs and/or misregistered images
  - Patch-wise approach

interpolated

SR

interpolated

SR

t-2 t-1 t t+1 t+2

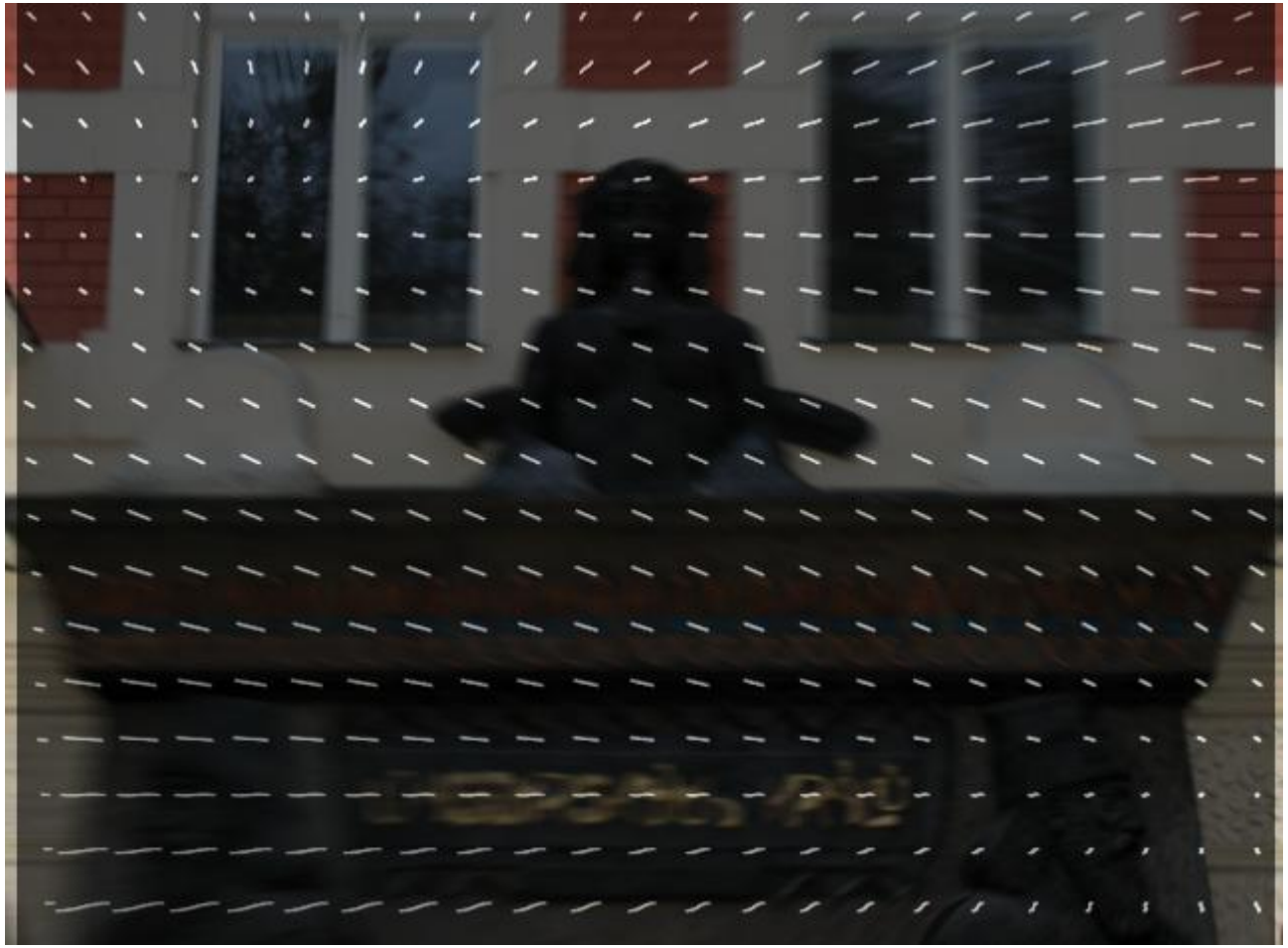
interpolated

SR

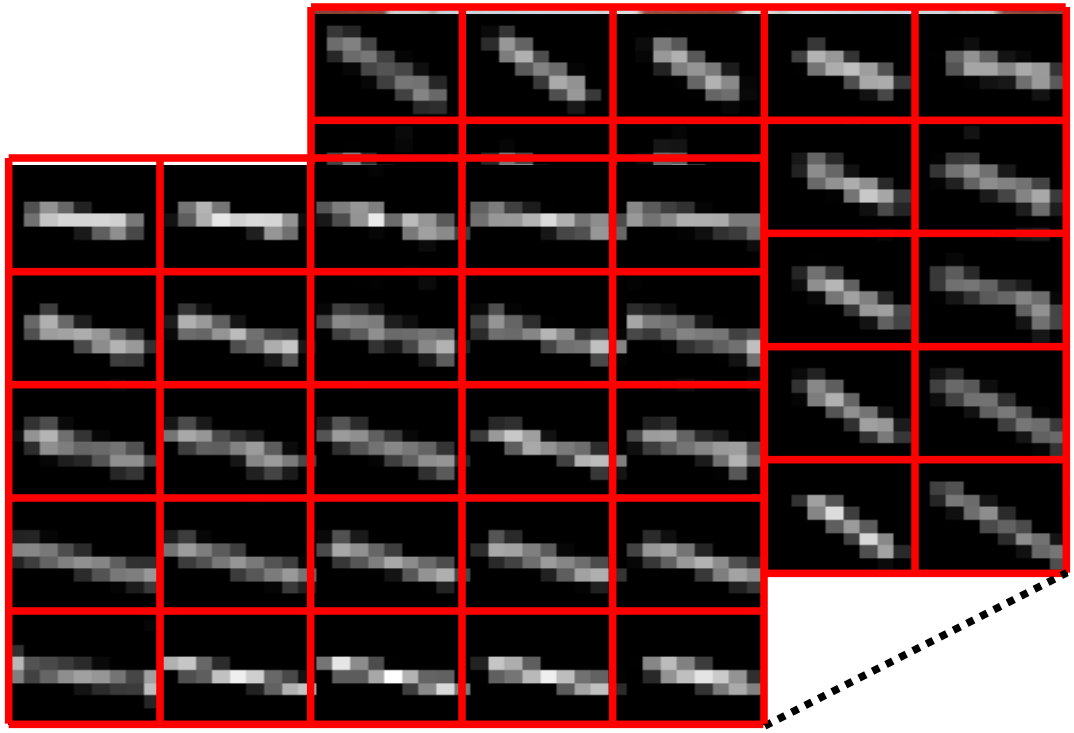
SR + masking

t-2 t-1 t t+1 t+2

Camera-motion Blur



Space-variant Superresolution




U ASSYRSKÝCH KRÁLŮ

Close-up

Input LR

Original

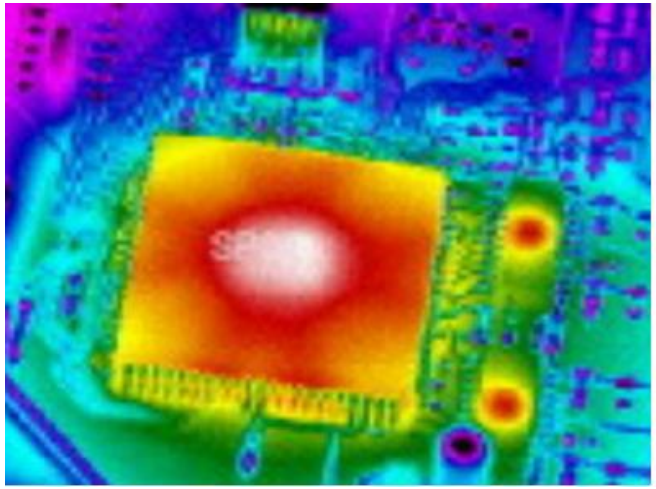
Space-variant
Reconstruction

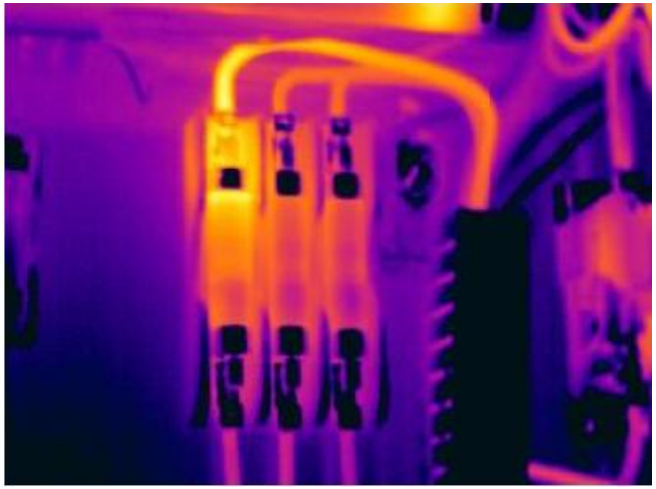
Space-invariant
Reconstruction

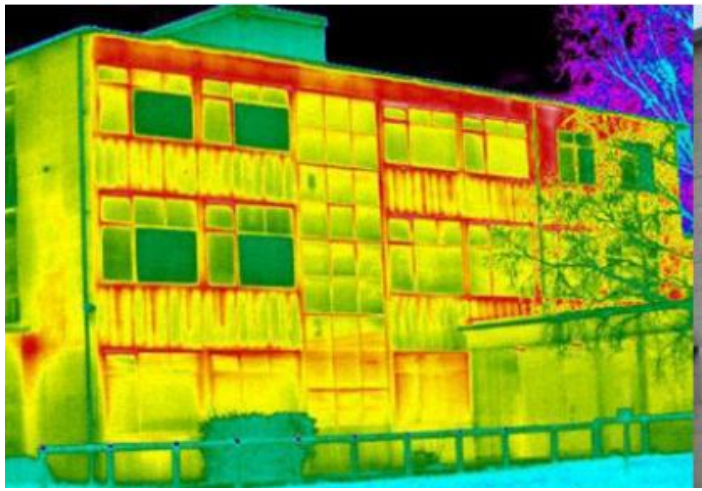
Infrared video super-resolution

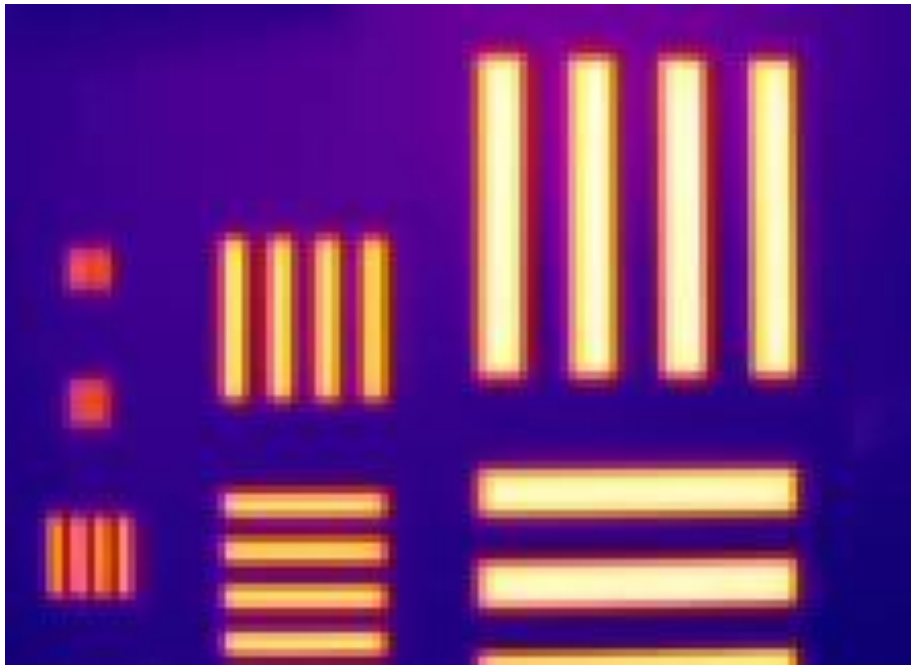
- Handheld IR camera
  - 160 x 120, 9 fps

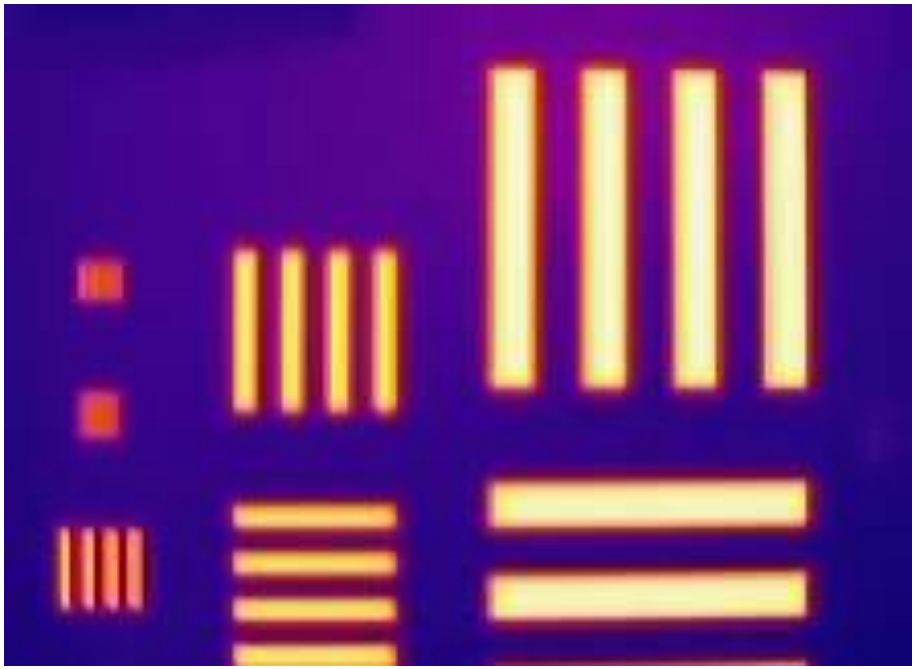
- Real-time super-resolution
  - with factor 2 (320 x 240)
  - computed directly inside the camera using DSP

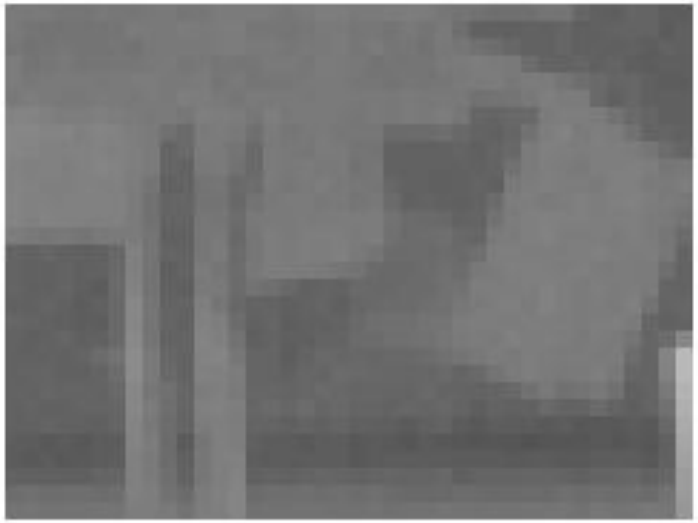


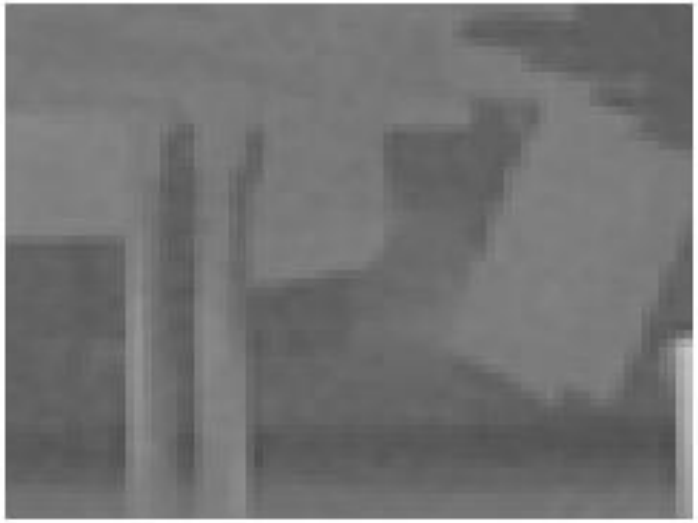










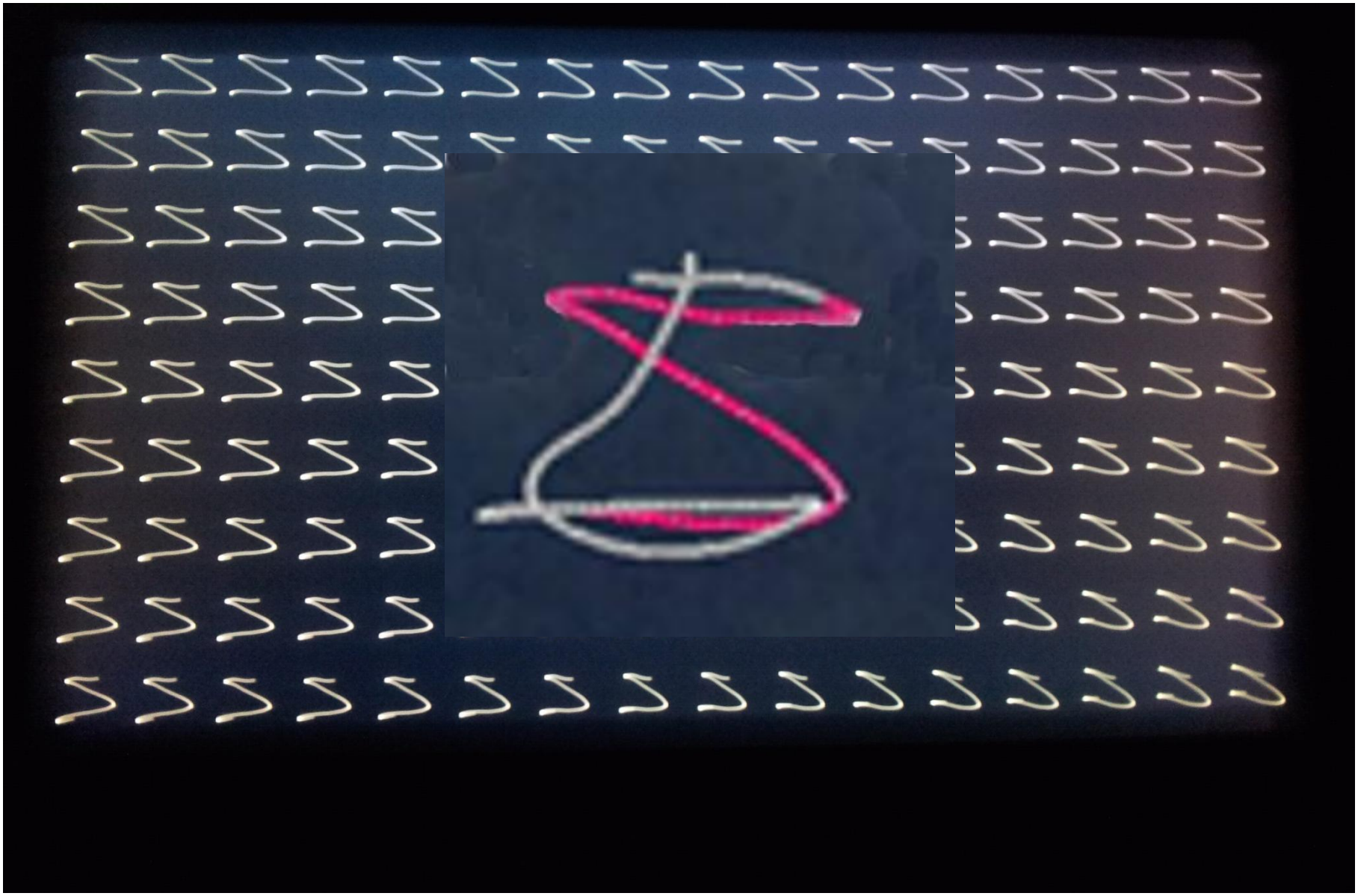


“Blind” Deconvolution on Smartphones

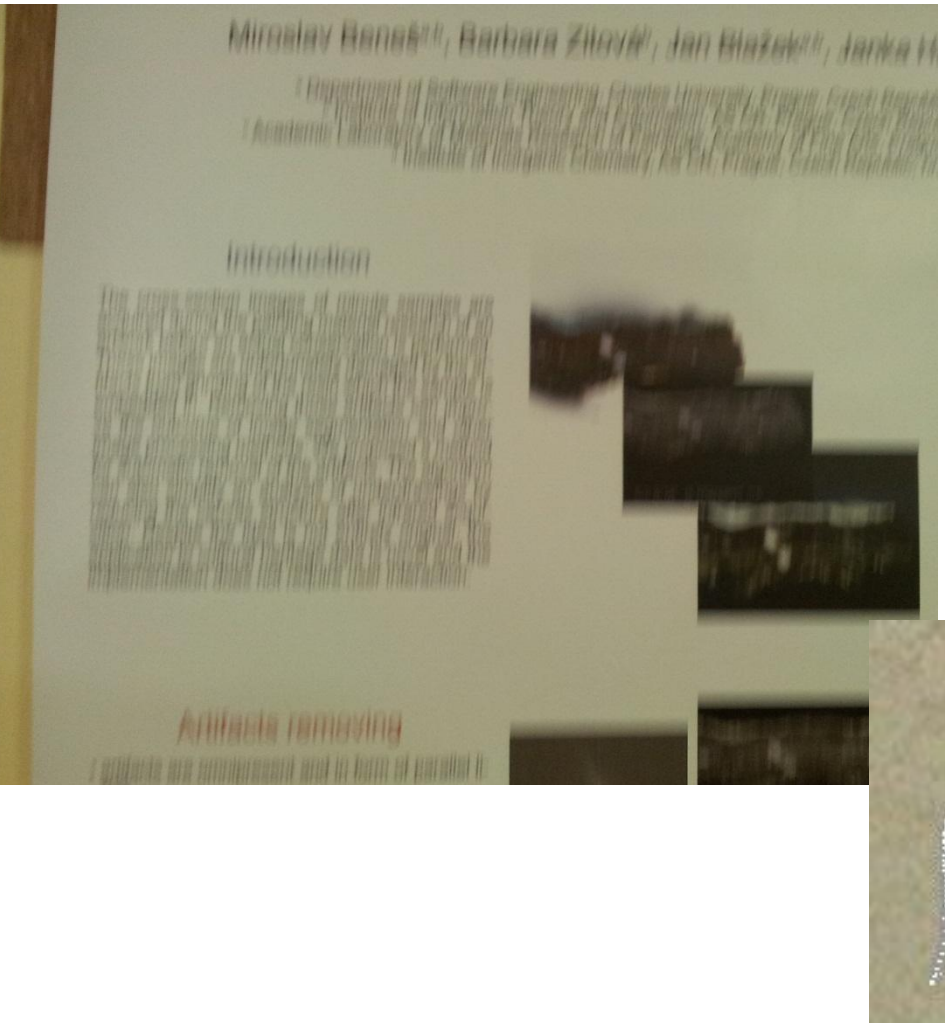
Using accelerometers and/or gyroscopes

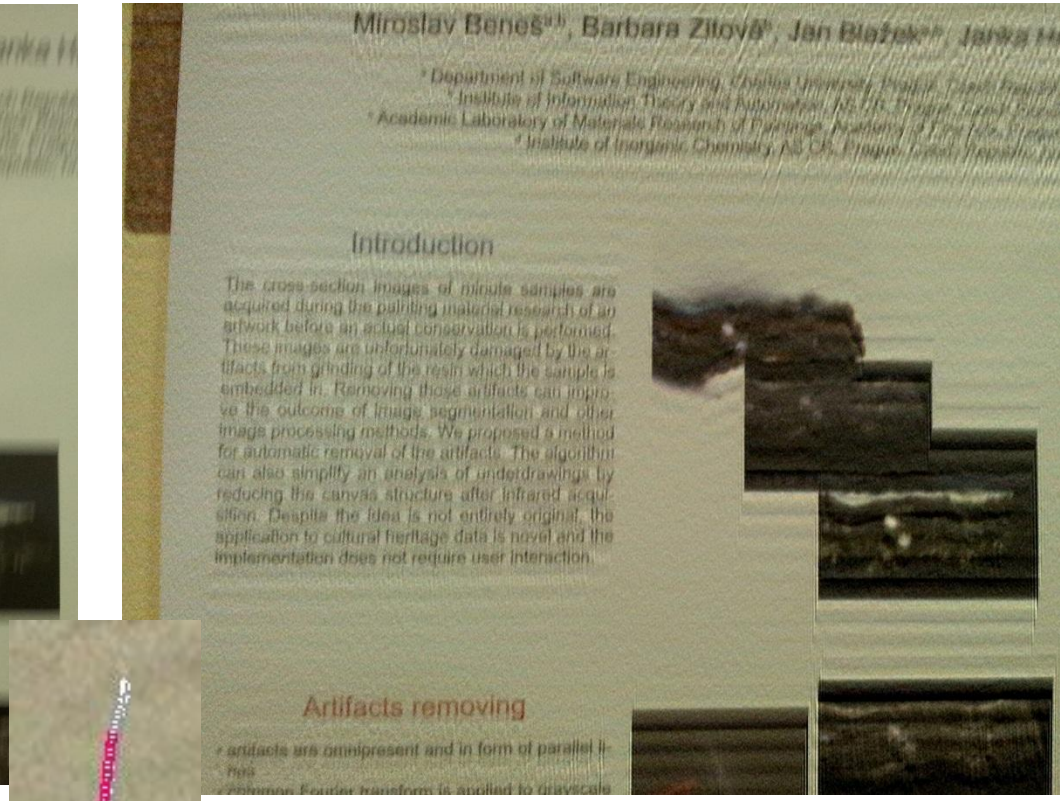
Rotation and translation of the phone


5:21 PM
Contacts
Camera
Gallery
FMRadio
Samsung Apps
Market
AllShare
My Files
Maps
Talk
Gmail
YouTube
ThinkFree Office
Qik Video
Skype
Settings
Music
Video
Internet
Home



Wiener Filtering on Android Smartphones





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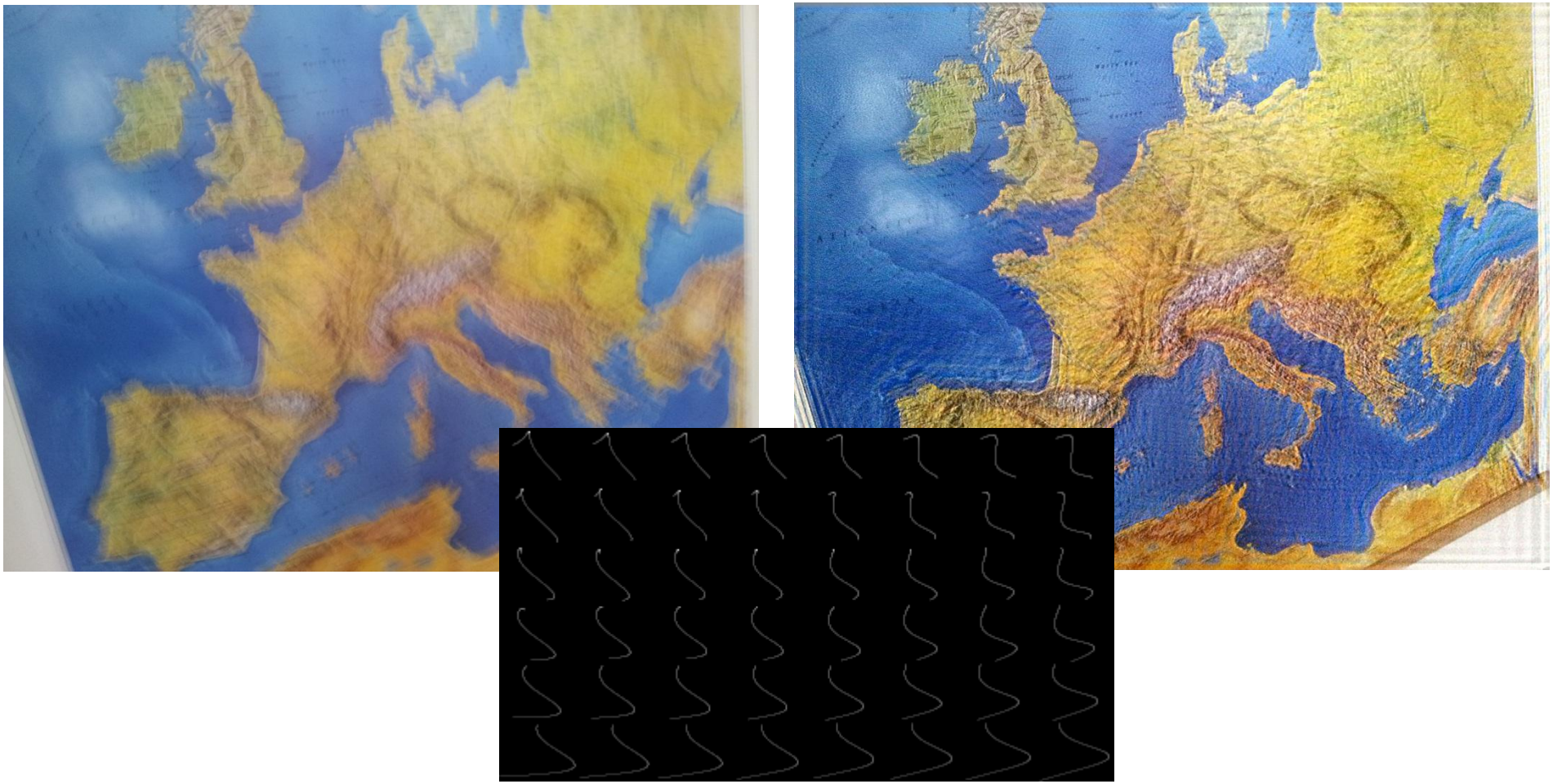

Thank You…

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Wiener Filtering on Android Smartphones

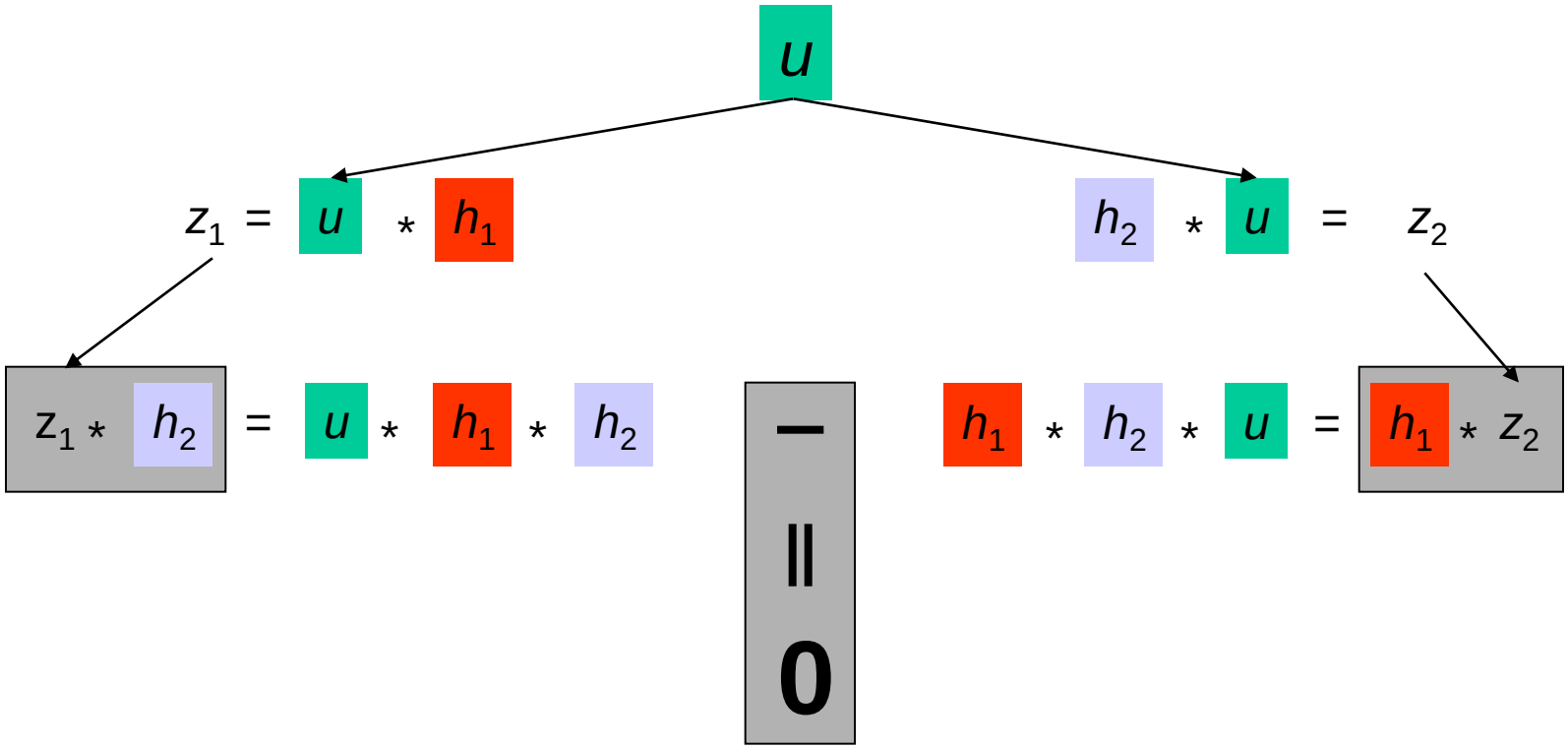
Regularization Terms

$$F(u, \{h_k\}) = \frac{1}{2} \sum_{k=1}^{K} \|z_k - D(h_k * u)\|^2 + \lambda Q(u) + \gamma R(\{h_k\})$$

$$Q(u) = \int \phi(|\nabla u(x)|) dx$$

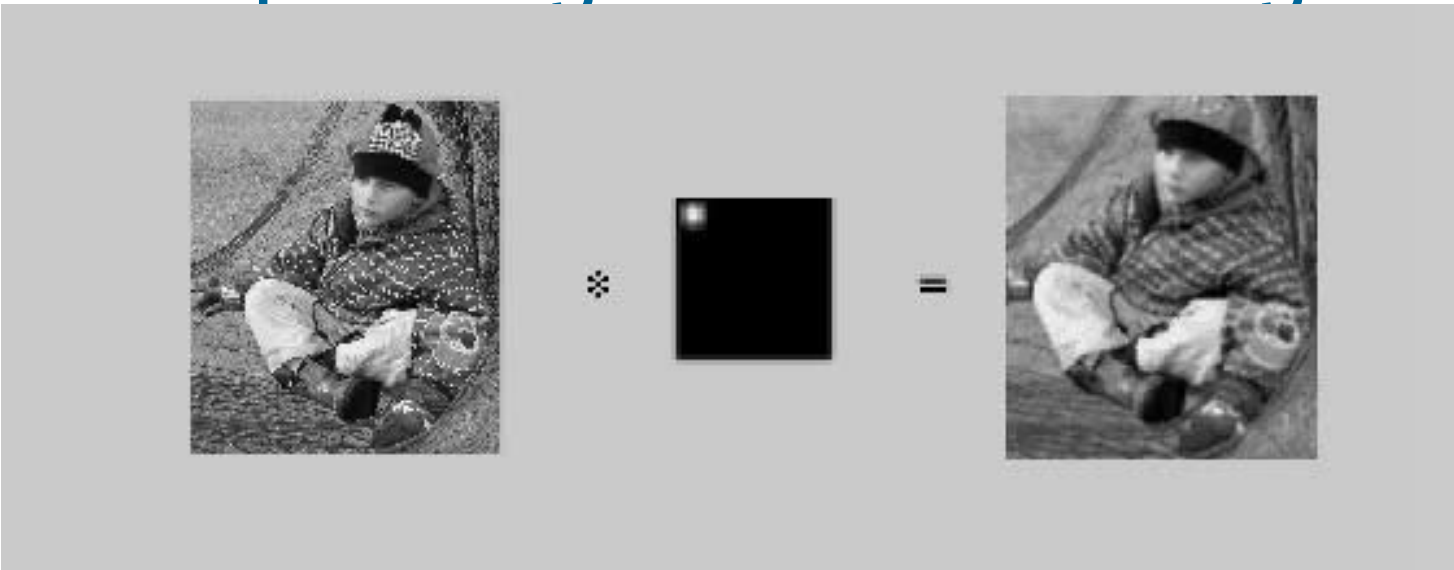
$$R(\{h_i\}) = \frac{1}{2} \sum_{1 \leq i,j \leq K} \|z_i * h_j - z_j * h_i\|^2$$

PSF Regularization



$$R(\{h_i\}) = \frac{1}{2} \sum_{1 \leq i,j \leq K} \|z_i * h_j - z_j * h_i\|^2$$

Incorporating a between-image shift



$$[u * h_k](\tau_k(x,y)) + n_k(x,y) = z_k(x,y)$$

$$[u * g_k](x,y) + n_k(x,y) = z_k(x,y)$$

Alternating Minimization

$$\min_{u,h} \frac{1}{2}\|z - D(h * u)\|_2^2 + \lambda\|\nabla u\|_1 + \gamma R(h)$$

- u-step

$$\min_{u} \frac{1}{2}\|z - D(h * u)\|_2^2 + \lambda\|\nabla u\|_1$$

- h-step

$$\min_{h} \frac{1}{2}\|z - D(h * u)\|_2^2 + \gamma R(h)$$

Variable Splitting

$$\min_{u,h} \frac{1}{2}\|z - D(h * u)\|_2^2 + \lambda\|\nabla u\|_1 + \gamma R(h)$$

- u-step

$$\min_{u,v} \frac{1}{2}\|z - D(h * u)\|_2^2 + \lambda\|v\|_1 \quad \text{s.t. } v = \nabla u$$

- h-step

$$\min_{h,w} \frac{1}{2}\|z - D(h * u)\|_2^2 + \gamma R(w) \quad \text{s.t. } w = h$$

Augmented Lagrangian Method

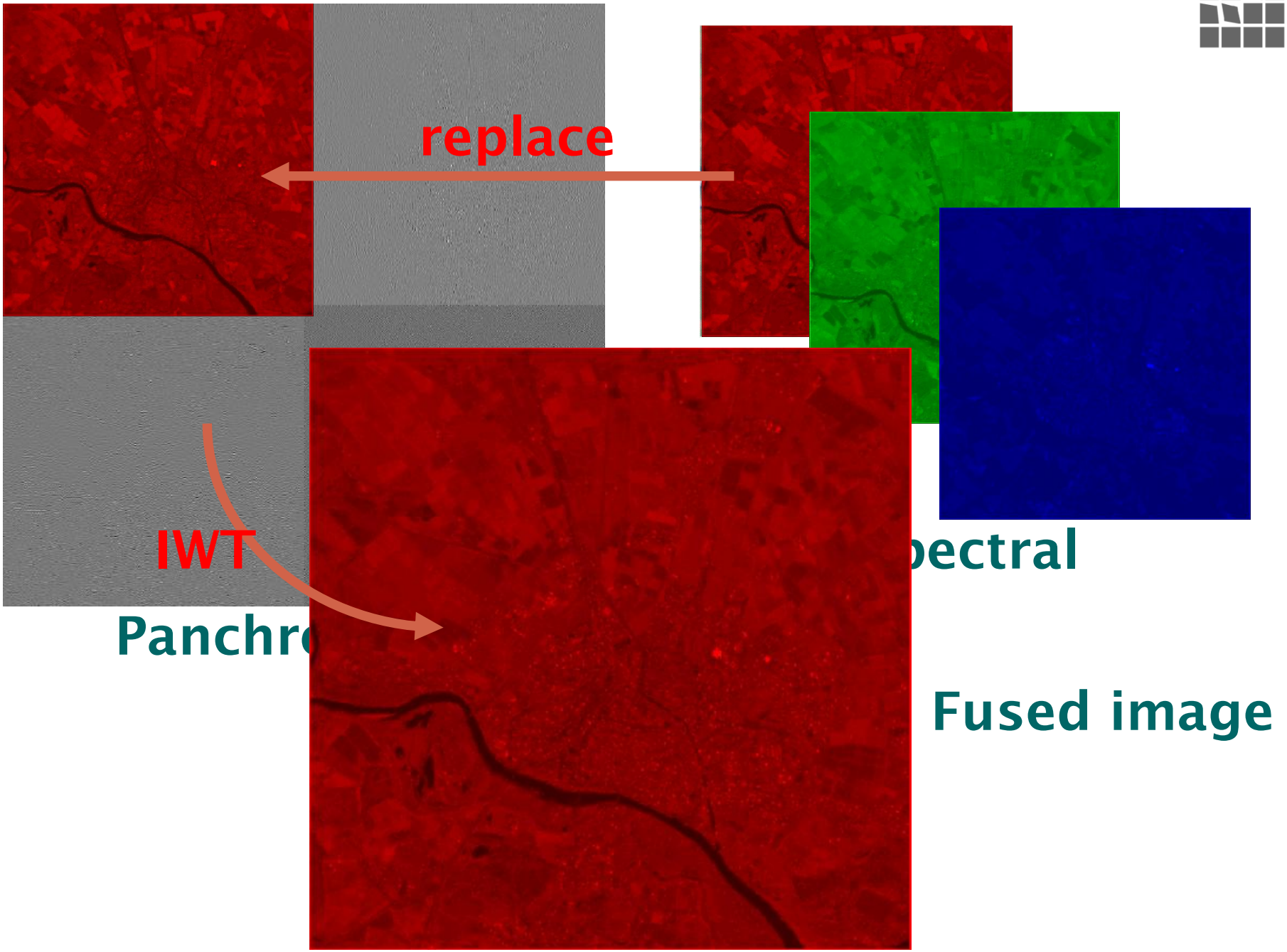
$$\min_{u,h} \frac{1}{2}\|z - D(h * u)\|_2^2 + \lambda\|\nabla u\|_1 + \gamma R(h)$$

- *u*-step

$$\min_{u,v} \frac{1}{2}\|z - D(h * u)\|_2^2 + \lambda\|v\|_1 - \frac{\alpha}{2}\|\nabla u - v - a\|^2$$

- *h*-step

$$\min_{h,w} \frac{1}{2}\|z - D(h * u)\|_2^2 + \gamma R(w) + \frac{\beta}{2}\|h - w - b\|^2$$


replace
IWT
pectral
Panchr
Fused image

Wiener Filtering in Android Smartphones