

Battling Camera Spatial and Temporal Resolution

Filip Šroubek

sroubekf@utia.cas.cz

www.utia.cas.cz



Akademie věd
České republiky

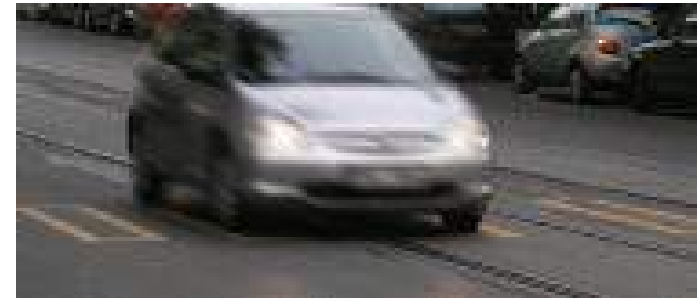
Strategie AV21

Špičkový výzkum ve veřejném zájmu

Limited SPATIAL and TEMPORAL resolution



Images



Better HW

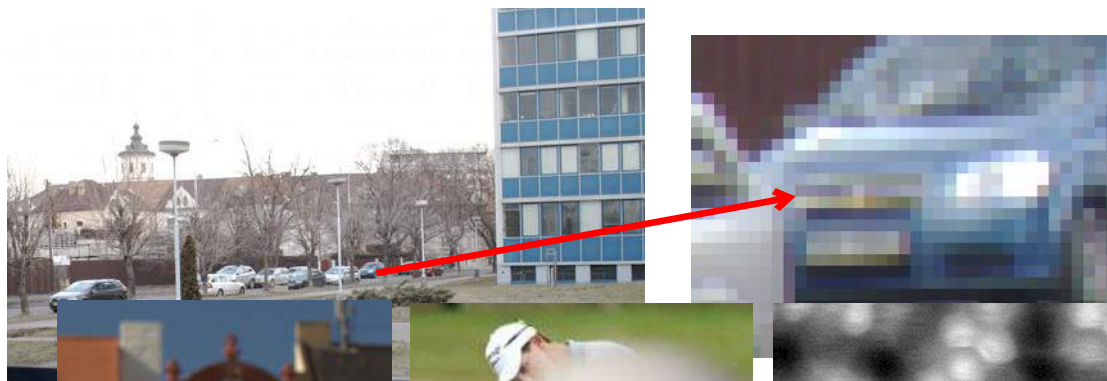
Sensors
Lenses
etc.

Mathematics

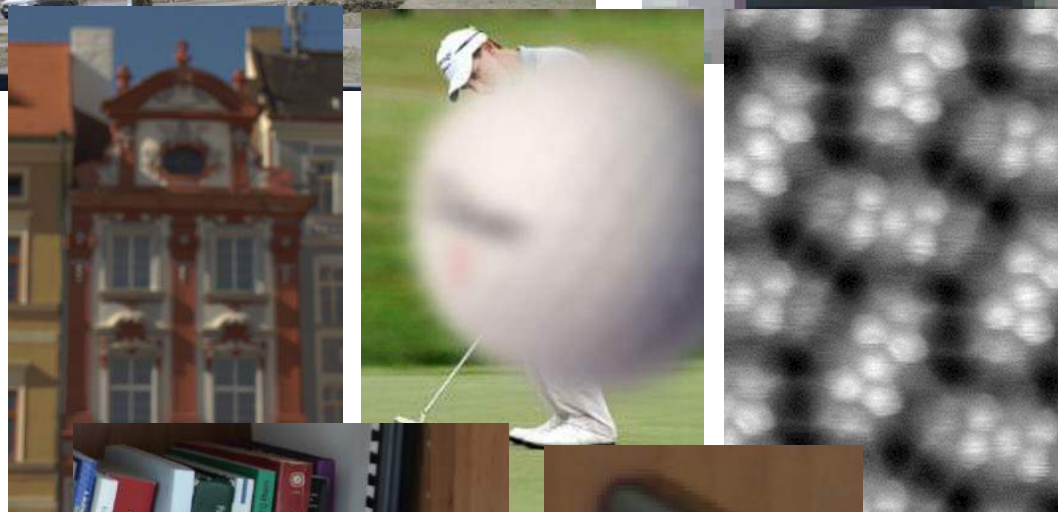
Computational Imaging
Denoising
Super-resolution
Deconvolution

Spatial resolution

- Finite pixel size



- Out-of-focus blur

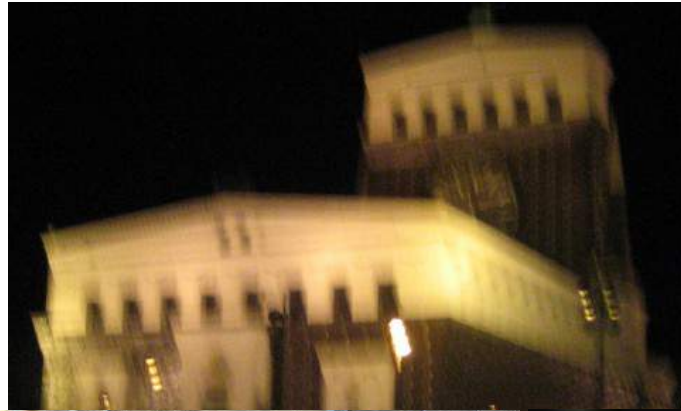


- Optical aberrations

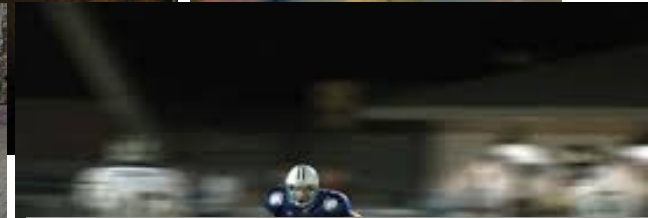


Temporal resolution

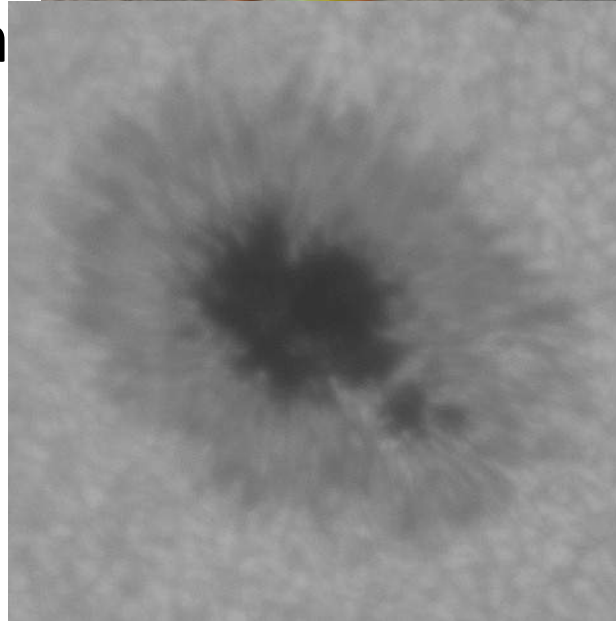
- Camera motion



- Object motion



- Media motion



How to avoid blur

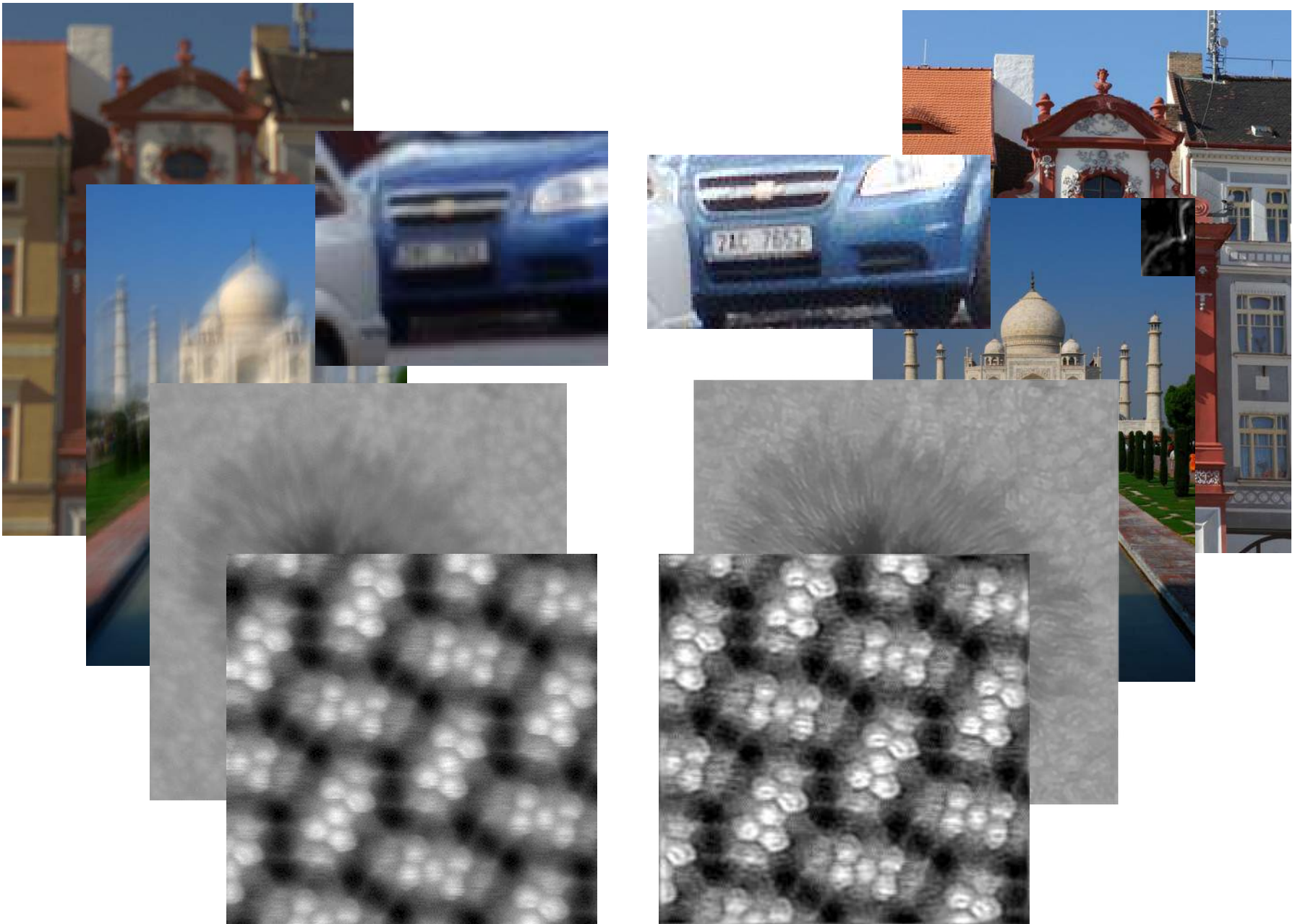
- Spatial resolution

	Manual	HW
Finite pixel size	Get closer to the object	Better sensor (noise, diffraction) Telephoto lens
Out-of-focus	Small aperture (noise)	Wavefront coding
Aberrations	Avoid high contrast	Higher end lens

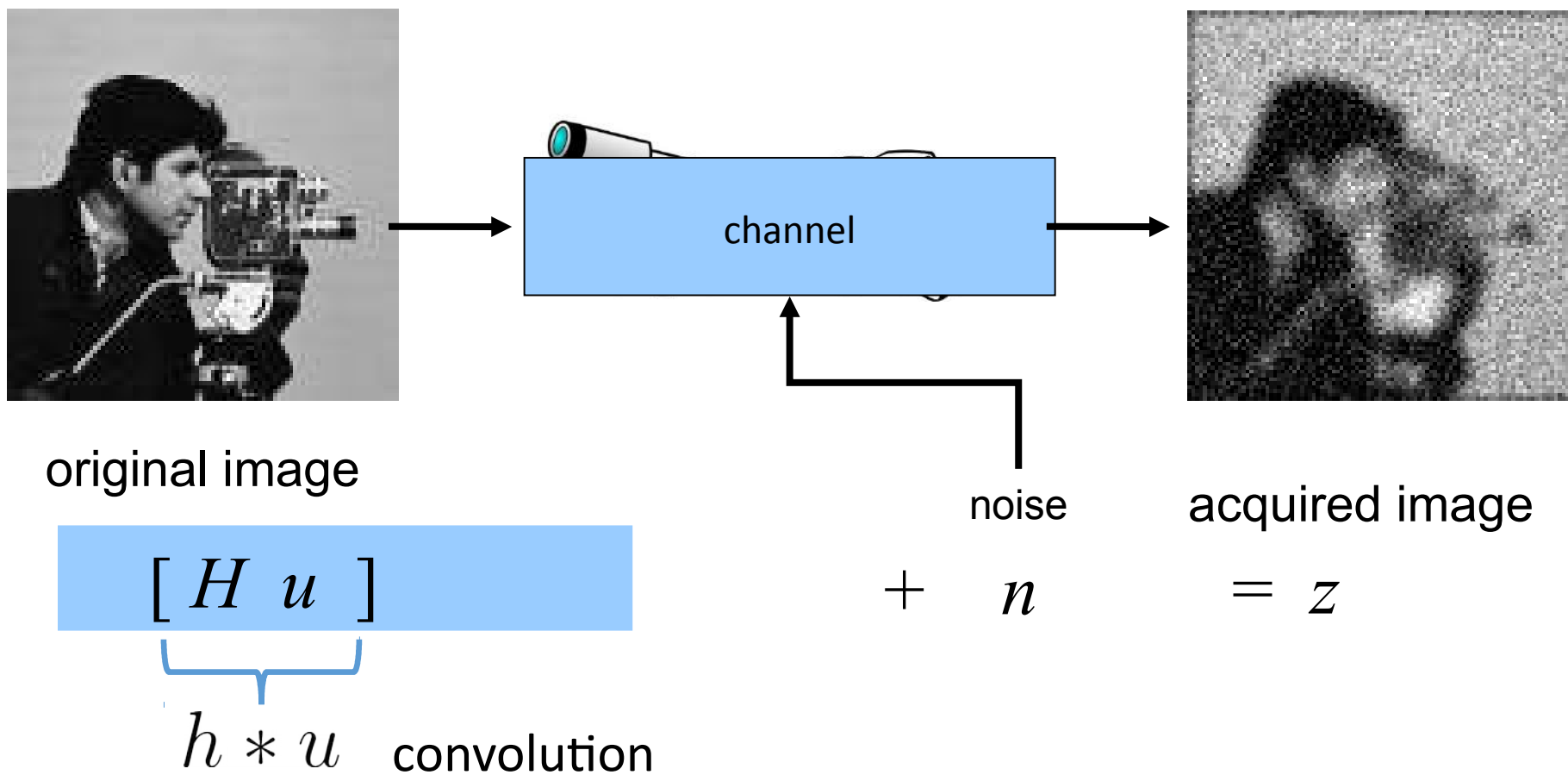
- Temporal resolution

	Manual	HW
Camera motion	Short exposure (noise)	Tripod
Object motion	Short exposure (noise)	Motion-invariant photography
Media motion	Short exposure (noise)	Adaptive optics

Image
Processing
Algorithms



Mathematical Model



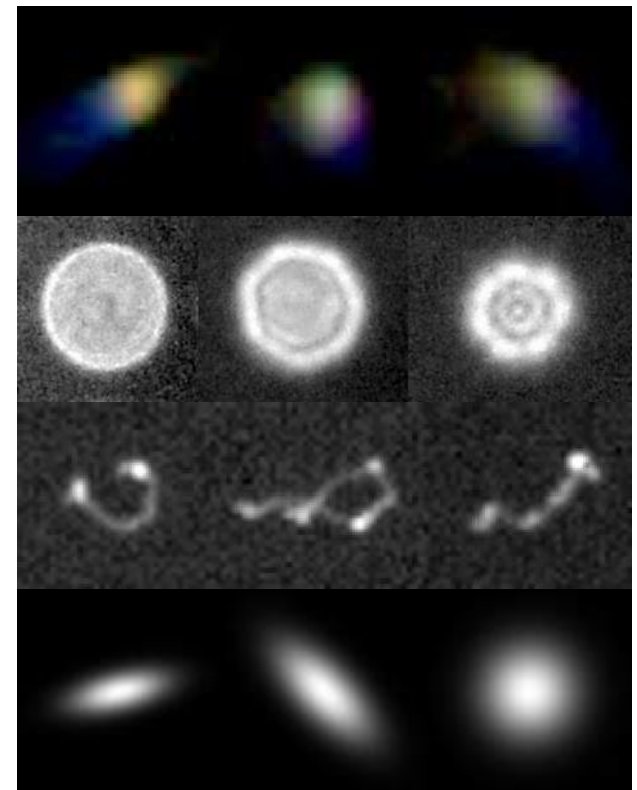
Finding the original image

$$h * u + n = z$$

- Complicated inverse linear problem
=> **Blind Deconvolution**

Blurs are unknown

- Different shapes
 - Aberrations
 - Out-of-focus
 - Camera motion
 - Media motion
- Often space variant



Out-of-focus



Blurred image

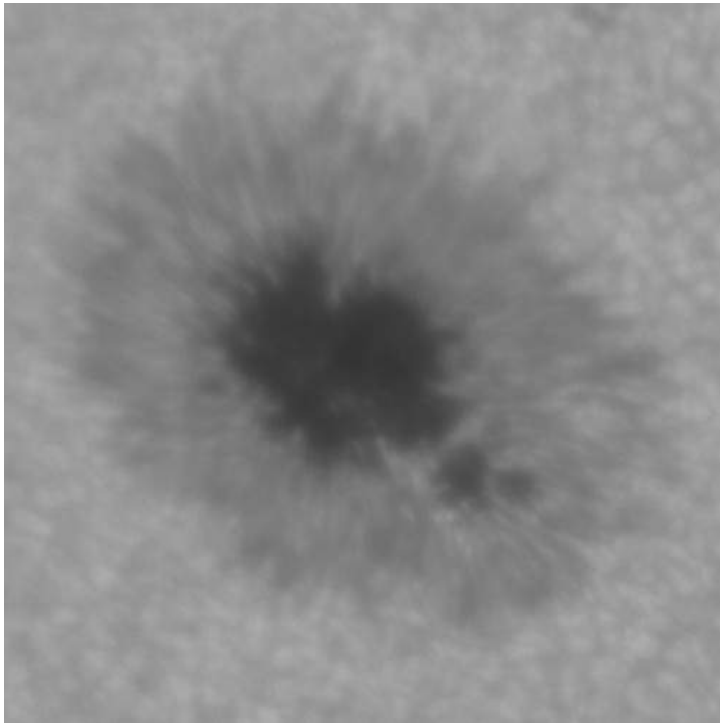


Reconstructed image

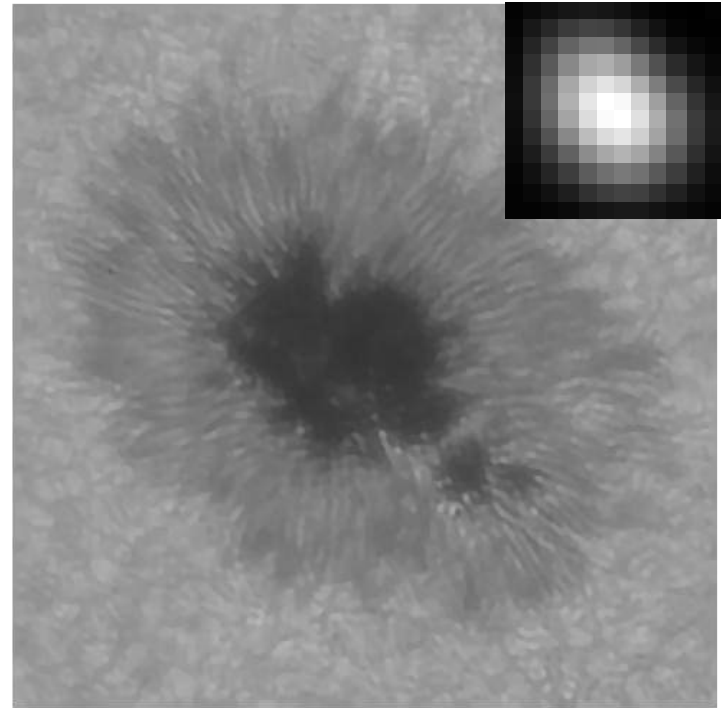
Camera motion



Atmospheric turbulence

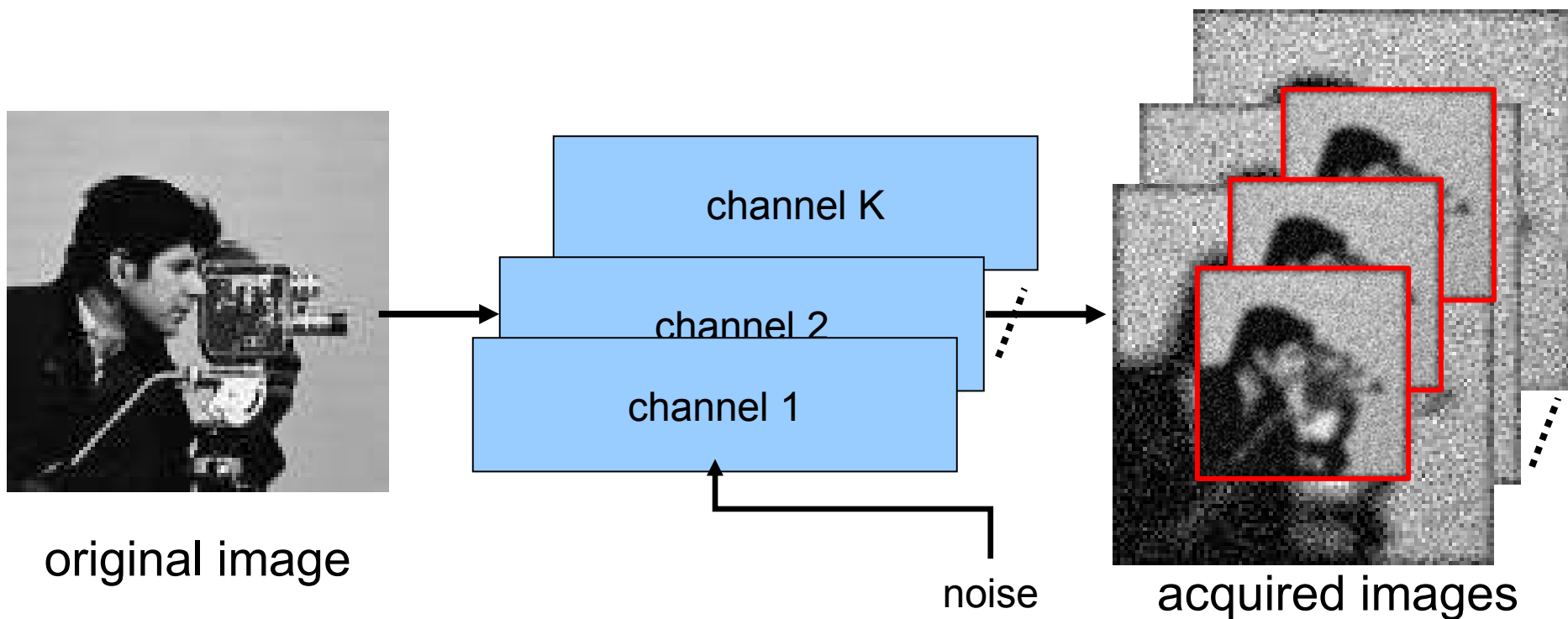


Blurred images



Reconstructed image

Multichannel model with decimation



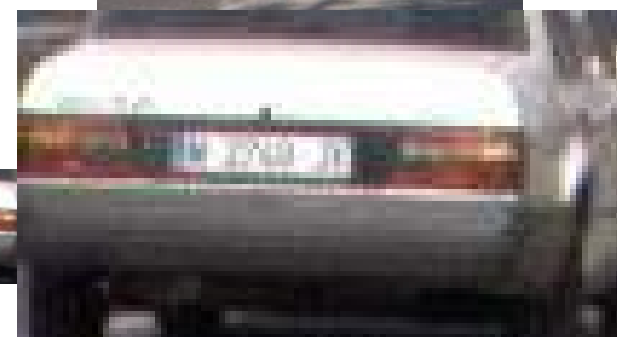
$$D [u * h_k] + n_k = z_k$$

Inverse problem of **Super-resolution**

Super-resolution



rough registration



Reconstructed image (2x)

Optical zoom (ground truth)

Model with object motion

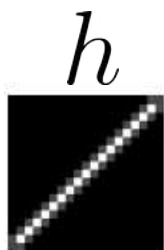
$$(1 - h * m)b + h * f = z$$

Inverse problem of
Blind Deconvolution
with Occlusion



z

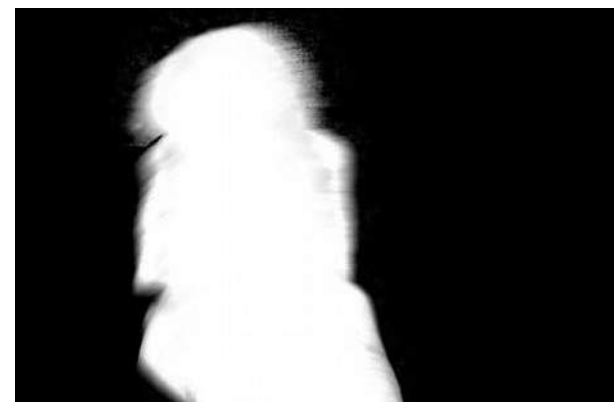
Alpha matting



*



=



Object motion

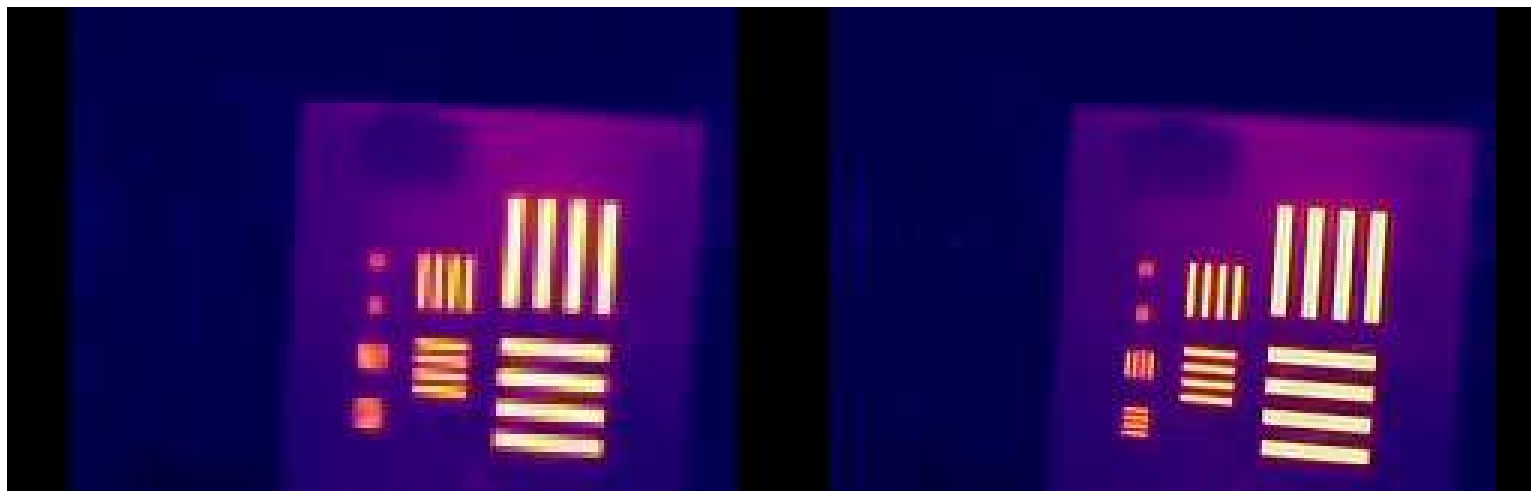


IR Camera

- Hand held IR camera
 - 160x120, 10fps
- Real-time super-resolution
 - 2x (320x240)



IR camera super-resolution



Input video

Super-resolution

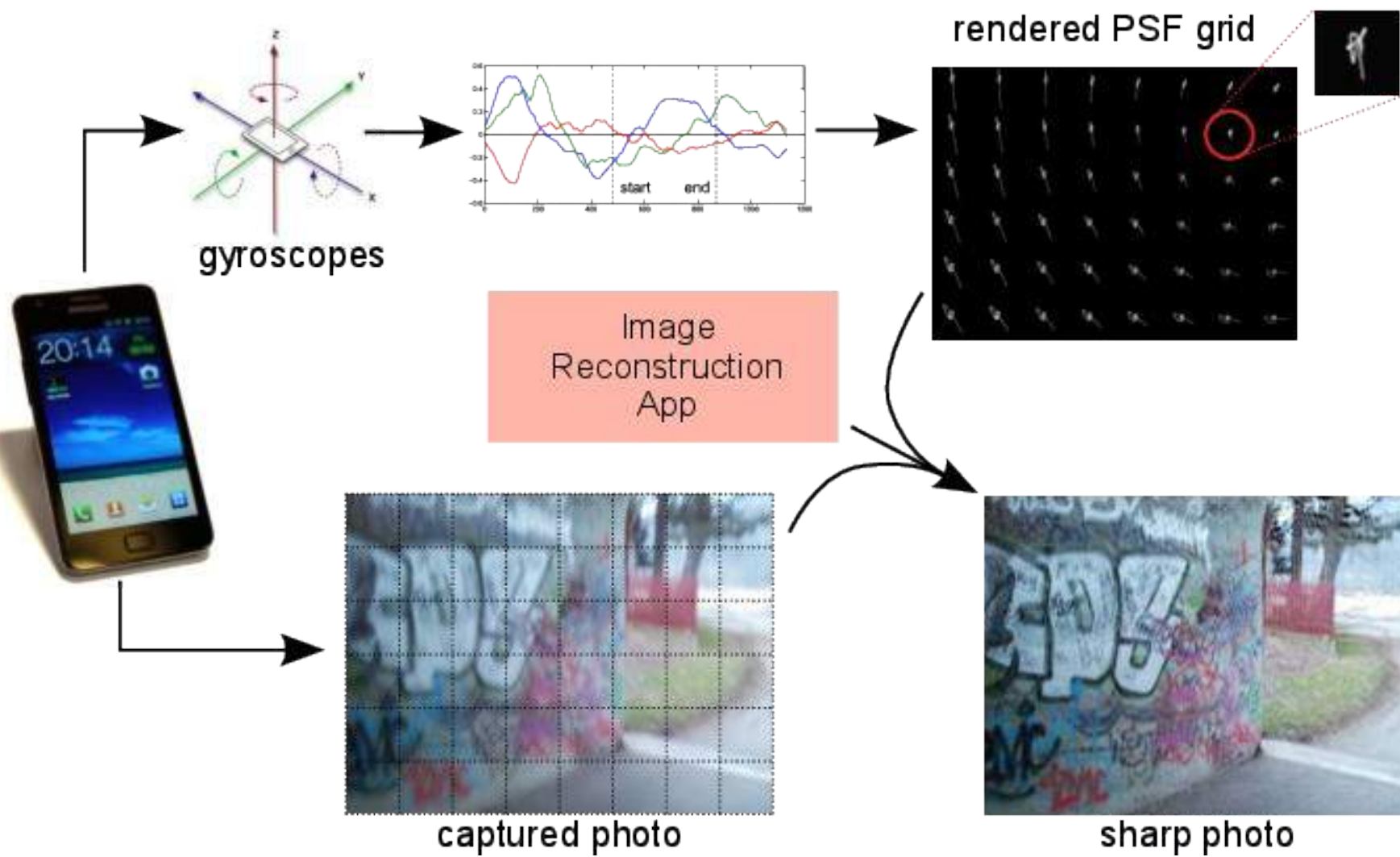
Mobile phone super-resolution



JPEG

SR

Mobile phone deblurring



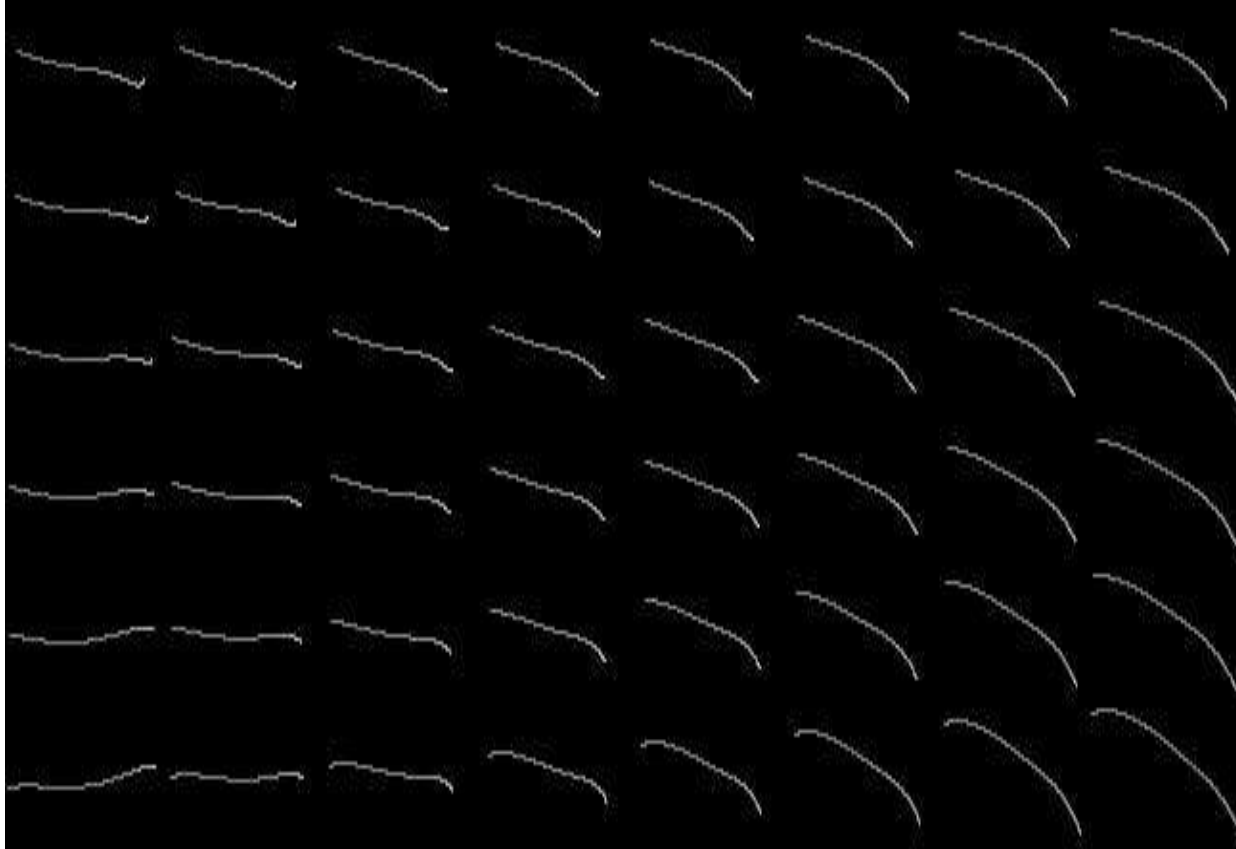


Acquired blurred image





Blur estimation





Patch-wise Deconvolution



Sport analysis

Temporal SR by interpolation



Thank You
For Your Attention