
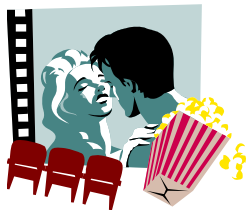
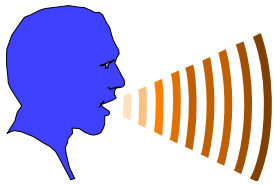


Video Processing & Communications

Video Stabilization and Debluring

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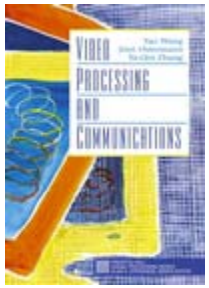


Outline

- Video stabilization
- Video deblurring

Video Stabilization

- A video may be unstable due to unwanted camera motion
- Especially prevalent in home video captured by hand-held cameras with a “shaky hand”

General Block Diagram

- Camera motion estimation between every two adjacent frames
- Motion smoothing in time
- Warping current frame to a reference frame
  - Use a global reference frame (every frame is registered to this frame)
    - Remove undesired global motion
  - Only correct unwanted small noisy motion, by registering over a local reference frame
- Filling missing pixels (on the border) in each frame

Camera Motion Estimation (AKA Global Motion Estimation)

- What motion model to use?
  - Ideally projective mapping
  - Affine is more commonly used
- Feature based:
  - Find a set of feature points in one frame
    - Harris Corner detector
    - SIFT feature
  - Find their corresponding points in the other frame (matching)
  - Fit the motion at these points into a global motion (e.g. affine)
- Intensity based:
  - Find the global motion parameters so that the image intensity at corresponding points are similar
  - Direct method: directly estimate the affine parameters
  - Indirect method: first find motions over regular blocks or selected points, then fit the motion at these points into a global motion

Global Motion Smoothing

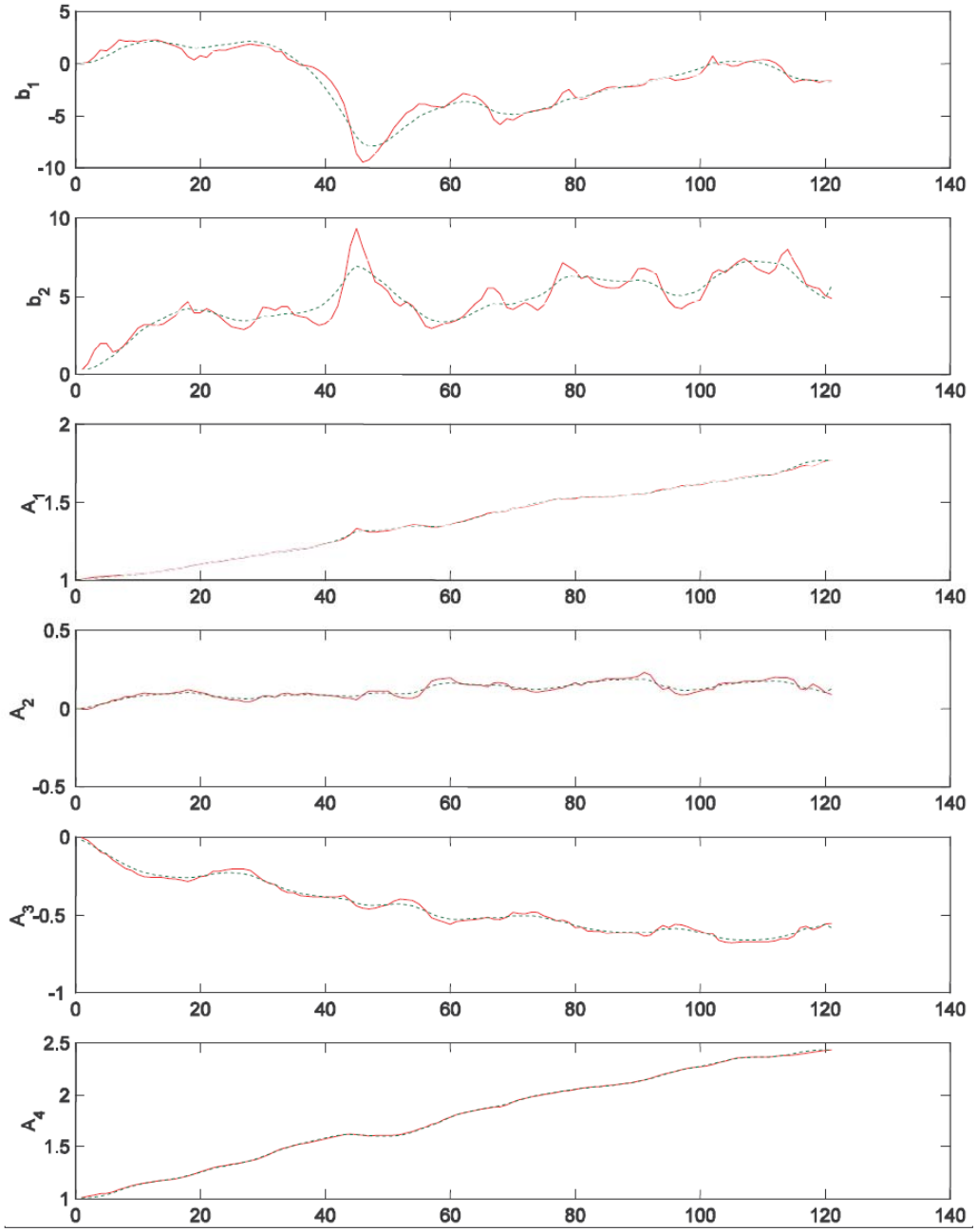
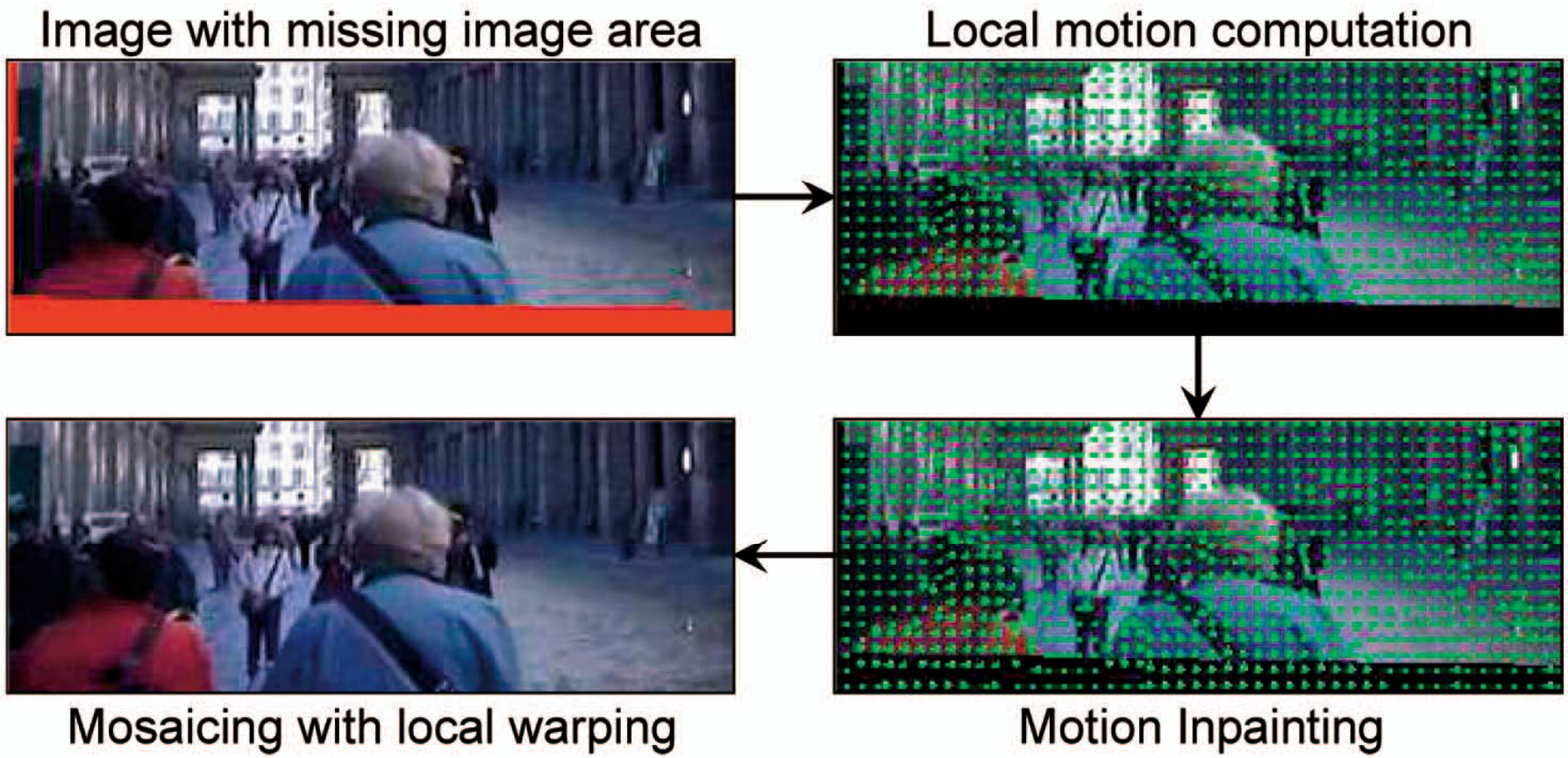
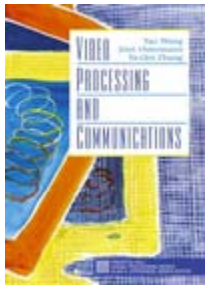


Figure 5: Red straight lines – Inter-frame motion parameters obtained for sequence A; Green dashed lines - intentional cumulative transform parameters estimated using smoothing Kalman filtering

Kalman filtering approach: Separating observed motion parameters into intentional and unwanted motion [Ref 2]

Video Completion by Motion Inpainting [Ref 1]





Sample Results (from [1])

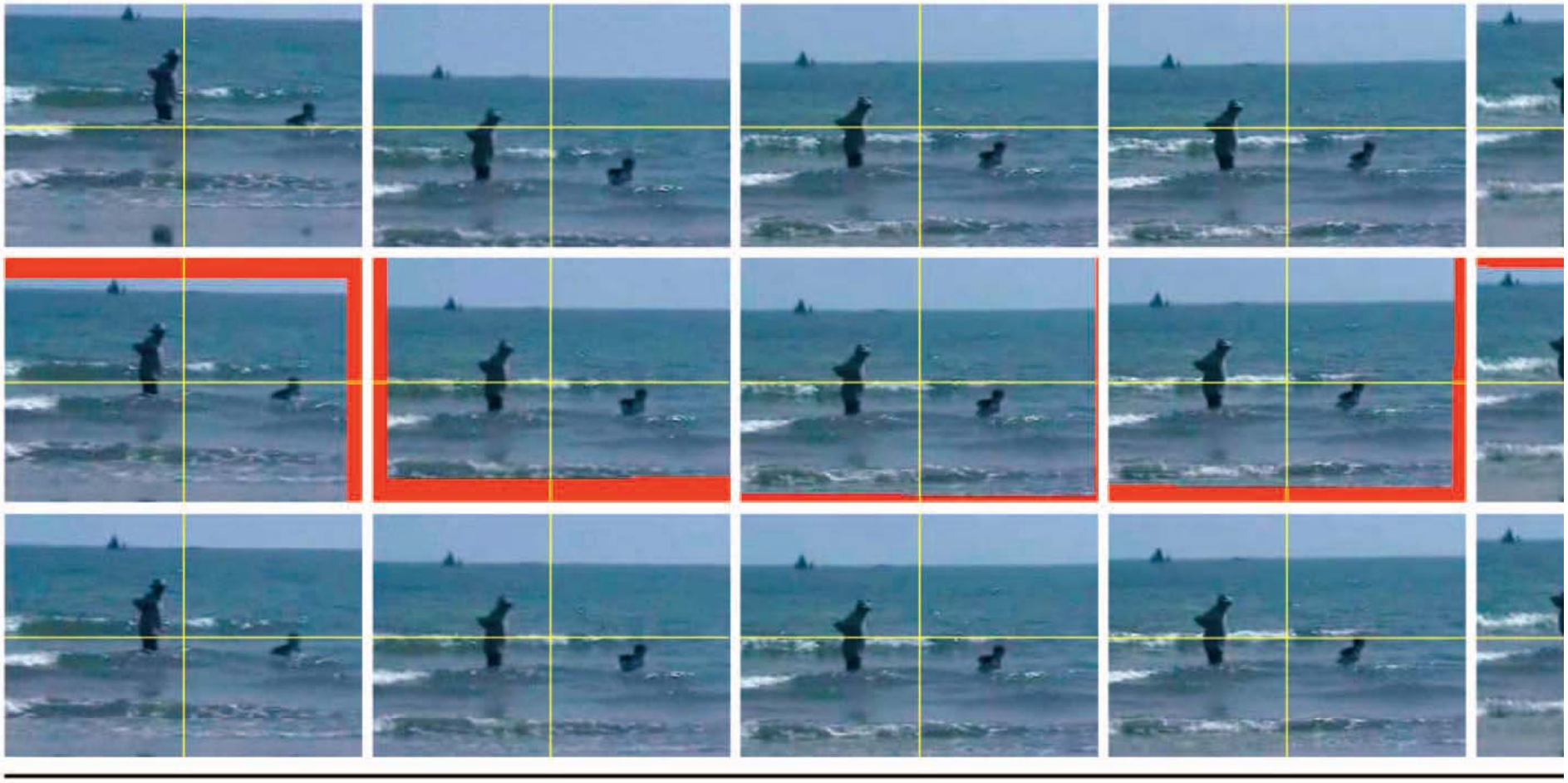


Image Deblurring

- When the object or camera is moving, the captured image is blurred, especially when the image is taken under low light with long exposure
- Fundamental:
  - motion blur can be modeled by a degradation filter (bluring kernel) which is motion dependent
- Two main approaches
  - Blind deblurring: Using a single captured image:
    - Estimate the motion and hence blurring kernel
    - Inverse filtering
  - Non-blind deblurring: Using multiple images (e.g. one blurred due to motion, one noisy due to short exposure) to help motion and blur kernel estimation [5]

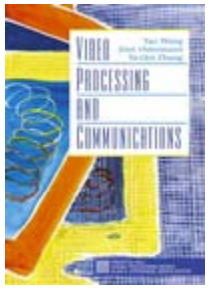
Debluring from a Blured and a Noisy Image [Ref 5]

(a) blurred image (b) noisy image (c) enhanced noisy image (d) our deblurred result

Figure 1: *Photographs in a low light environment. (a) Blurred image (with shutter speed of 1 second, and ISO 100) due to camera shake. (b) Noisy image (with shutter speed of 1/100 second, and ISO 1600) due to insufficient light. (c) Noisy image enhanced by adjusting level and gamma. (d) Our deblurred image.*

Debluring from a Blured and a Noisy Image [Ref 5]

- Denoising: Noisy image -> denoised image
- Kernel estimation:
  - Assume Blurred image = Original Image * kernel
    - b = A k
  - Using denoised image as the initial estimate of original image, estimate the kernel, by solving a optimization problem



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