Lag Camera: Separating Foreground and Background Motion

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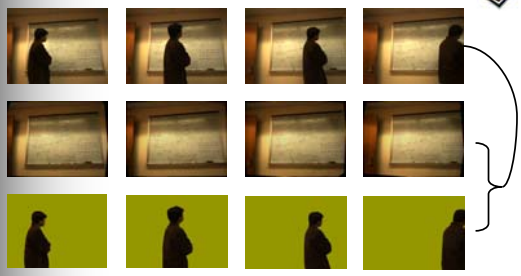
Goals



Goals

- Reconstruct the background in the presence of moving objects.
- Foreground object cutout from video.

Applications

- Capture and reconstruct busy environment.
- Enable compositing novel image sequences.

Related Work I

- Scene Acquisition
  - Image-based rendering
    - only static scenes
  - Spatial-temporal IBR
    - does not reconstruct background

Related Work II

- Motion segmentation
  - Image segmentation
    - uses static images
  - Video object cut and paste
  - Interactive object cutout
    - uses video from a static camera

Challenges

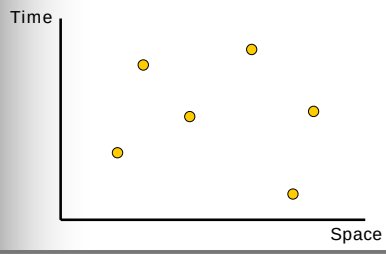
- Reconstructing background with a moving camera.
- Video object cutout is only known for static cameras.

Our solution

- Lag camera - a moving camera array.

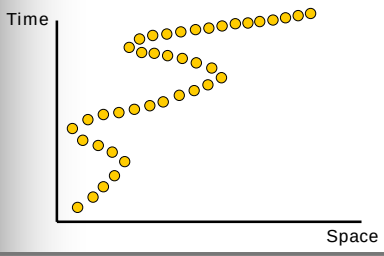
Still Camera

sparse and disjoint samples



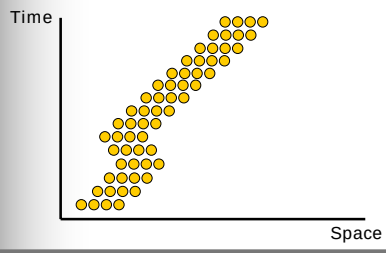
Video Camera

dense and continuous samples over space

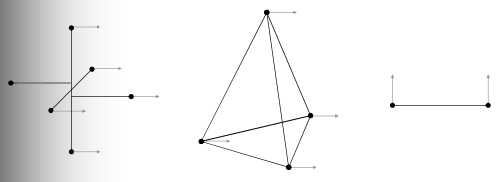


Lag Camera

dense and continuous samples over space and time

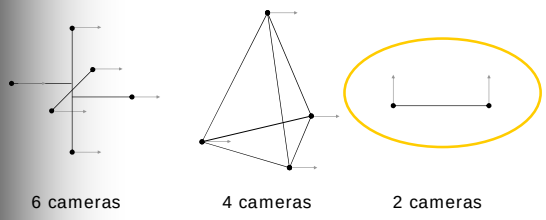


Lag Camera Configurations



6 cameras 4 cameras 2 cameras

Lag Camera Configurations



6 cameras 4 cameras 2 cameras

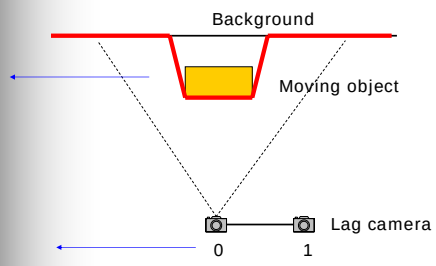
2-view Lag Camera

- For acquisition along a line, it obtains images from (approximately) the same viewpoint but at sequential instances in time.

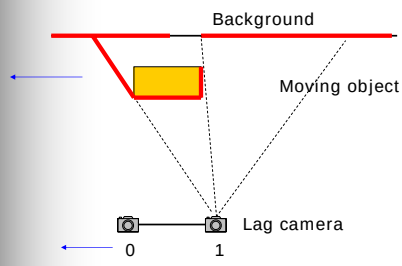
time 0

time 1

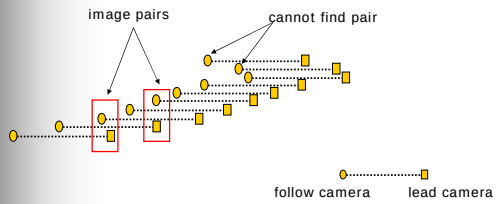
Lag Camera



Lag Camera



Lag Camera Image Pairs



Lag Camera Image Pairs

- Estimate camera pose
  - Currently we use a mechanically tracked arm
- Proxy-warp the lead image to follow image

follow image

warped lead image

Lag Camera Capturing

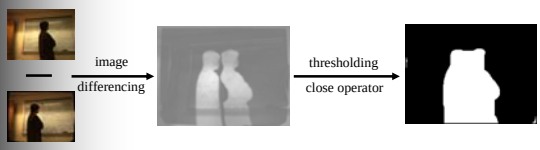
- capture.avi

Our Methods: Part 1

- Foreground Motion
  - A motion detection algorithm that identifies object motion even when camera is moving.
- Background Scene
  - A capturing method that samples a static scene in presence of moving objects.

Foreground: Motion Mask

- Isolate foreground using a motion mask



Stop Motion

- However, when motion stops, the difference image goes to zero.

3 consecutive frames of difference images

Stop Motion

- Re-project the nearby motion masks to the frame where motion stops.

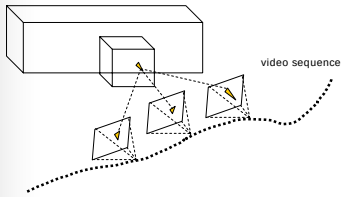
Motion Mask Composition

- Masks for different segments are composited together.

original frame | difference image | motion mask

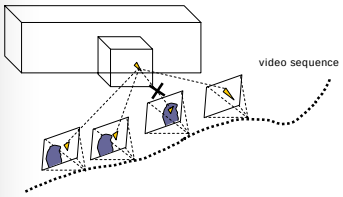
Background Rendering

- Unstructured Lumigraph Rendering (ULR)



weighted blending of triangles from reference images

Modified Unstructured Lumigraph



Results

- 2 board scenes with 142 and 102 images
  - board.avi
- 1 bookcase scene with 298 images
  - bookcase.avi

Problems So Far…

- Self-similarity of the moving object
  - Causes the mask to be zero when foreground object is similar to itself.
- Conservativeness of the motion mask
  - Sometimes the motion mask is too conservative.

Our Methods: Part 2

- Foreground Motion Segmentation
  - A color-segmentation-based method to include self-similarity regions in the initial motion mask.
  - An iterative segmentation algorithm for progressively refining the segmentation.

Initial Motion Mask

- The self-similarity problem:

Initial Motion Mask

- Use color segmentation to fill the regions.

Iterative Refinement

- Rank all the segments in all images.
- Choose the highest ranked segment and convert it from motion mask to background.
- Re-rank all the remaining regions.

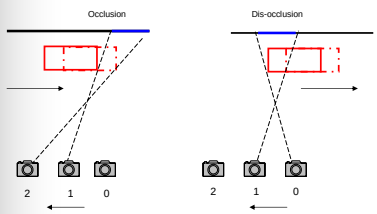
Iterative Refinement

- The definition of the score *S* of a segment:
  - *D*: re-project a segment to nearby images and compute the dissimilarity.
  - *C*: the percentage of the re-projected region inside the mask.
  - *S = w1*D + w2*C*

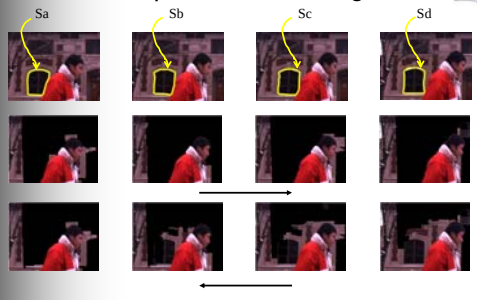
Interactive Editing Tool

- System iteratively updates the scores, refines the mask; until a threshold is reached.
- User removes some segments from the mask.

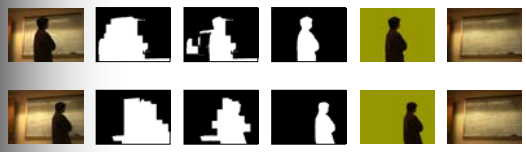
Occlusion-compatible Processing Order



Occlusion-compatible Processing Order

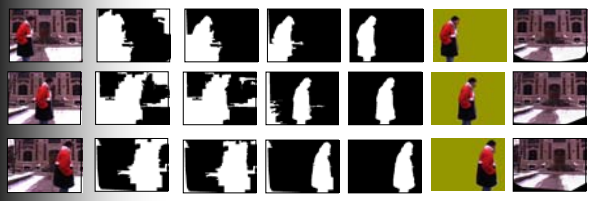


Results



boardisr.avi

Results



csisr.avi

Future Work

- Elimination of shadows.
- Vision based camera pose estimation.
- Other lag camera configurations.

Future Work

- Spatial-temporal coherent image segmentation
  - New formulation of the mean-shift clustering
- Generalized energy term
  - Min-cut

Conclusions

- An efficient motion detection algorithm with moving camera.
- A capturing method that samples a static scene in presence of moving objects.
- An editing tool for quickly segmenting moving foreground objects captured by moving cameras.
- An iterative segmentation algorithm for progressively refining the segmentation.