Sampling Based Scene-Space Video Processing

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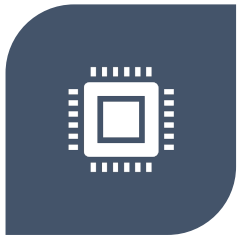
CMPT 985 - Computational Photography and Image Manipulation

Scene-Space Video Processing

Related Works



PRE-PROCESSING

DEPTH-IMAGE BASED RENDERING

POINT-BASED METHODS

FILTERING

DEPTH-AWARE VIDEO ENHANCEMENT

Motivation

Uncontrolled Condition

parallelizable

Pre Processing

- Pose Estimation
  - Simultaneous localization and mapping (SLAM)
  - Structure from motion (SFM)

- Depth Maps → computationally expensive → Solution

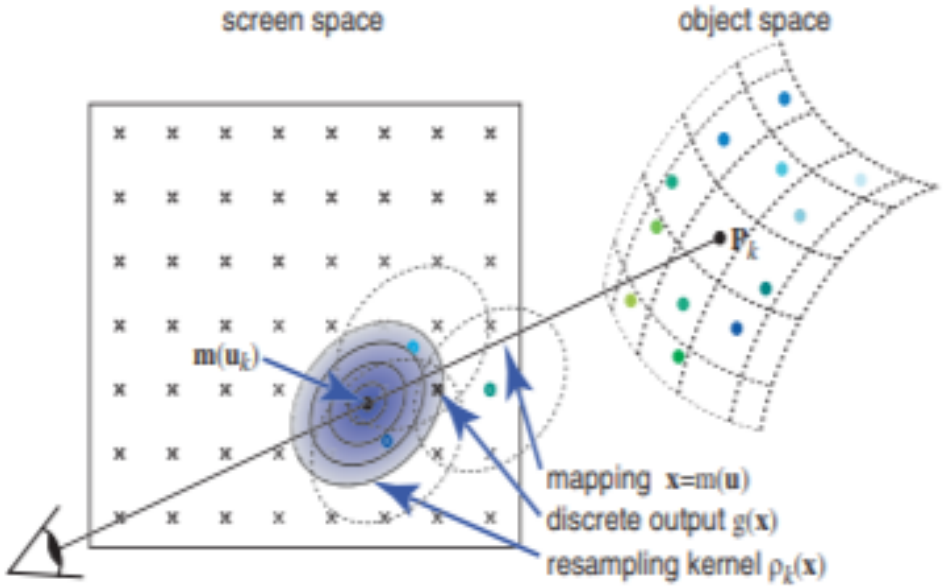
Depth-image Based Rendering

SYNTHESIZE VIEW FROM
ARBITRARY PERSPECTIVES

PROCESSING THE
RECORDED VIDEO FRAMES

Point-based Methods

- Surface Splatting

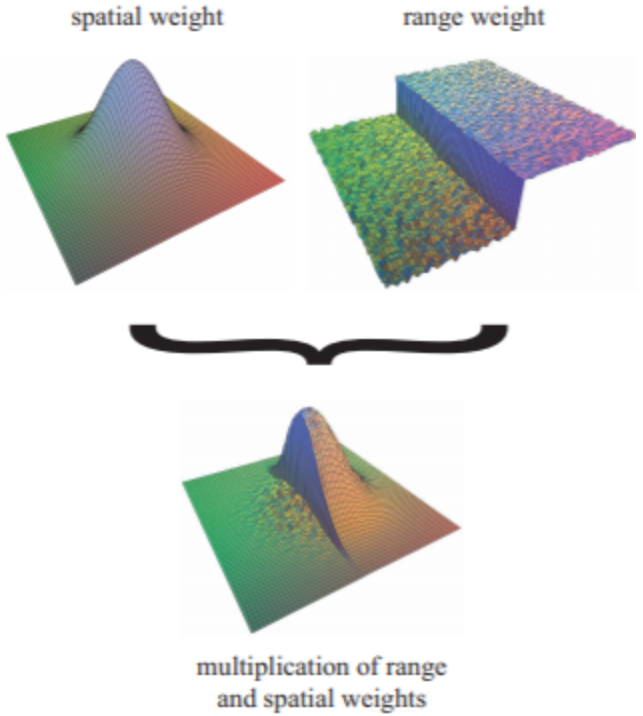


[Zwicker et al. 2001].

- Paper's method

Filtering

- Edge-aware Filtering



Zhang et al. [2009c]

- Problems

Robustness

Single Images

Depth-aware Video Enhancement

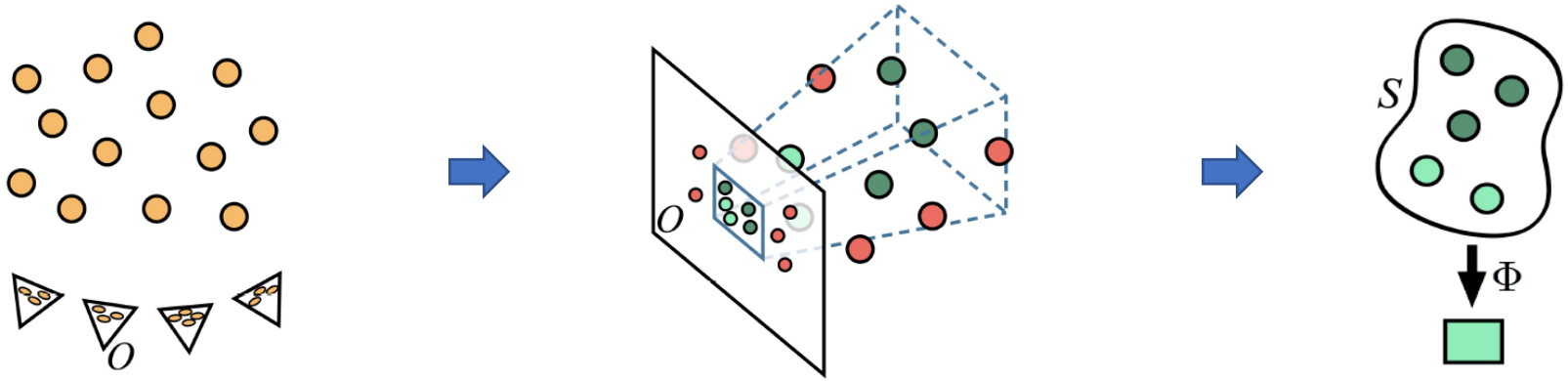
- Depth Video Effects
  - Manipulating Still Images by Registering Stock 3D Models
  - Stylization and Relighting [Richardt et al. 2012]
  - Novel Still Images from Short Videos [Sunkavalli et al. 2012]

[Kholgade et al. 2014],

- Problem
  - Rely on Accurate Scene Information
  - Directly Affected by Depth Noise
  - Operates in Image-space

Sampling Based Scene-Space Video Processing

- Preprocessing
- Gathering
- Filtering

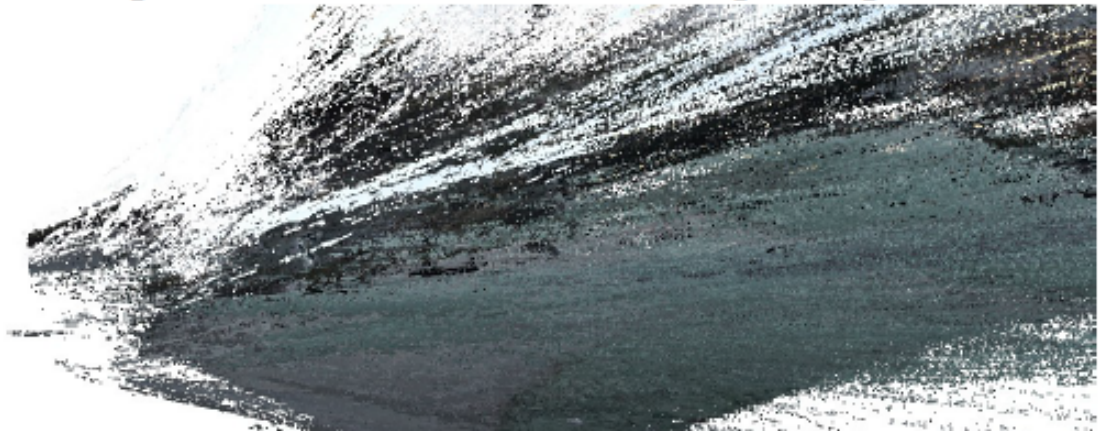


Preprocessing

- Camera Calibration Parameters
- Depth Information

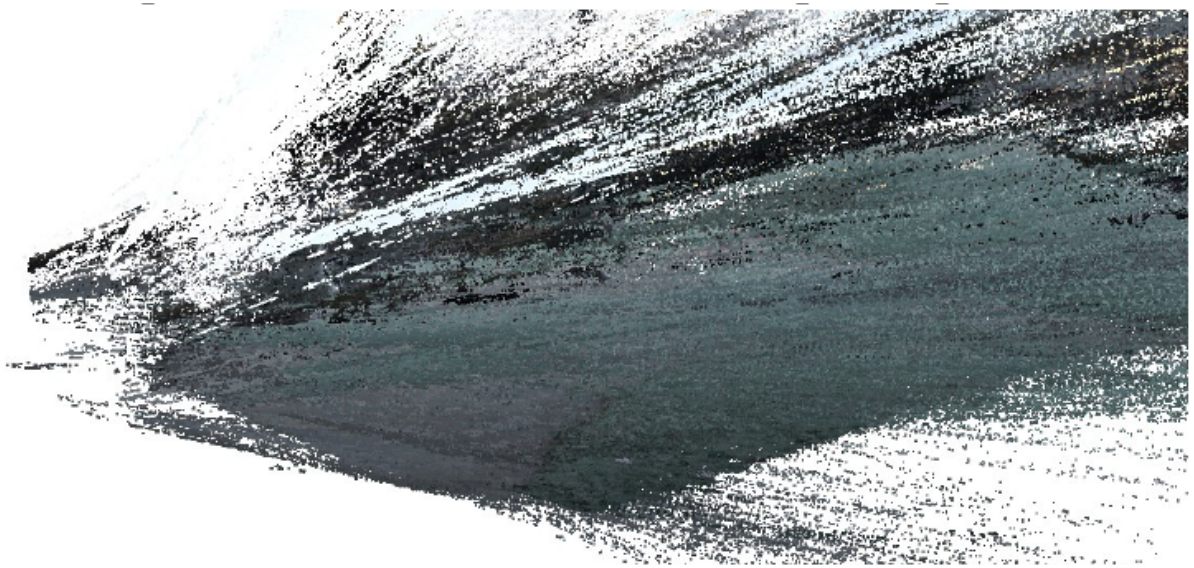
Input

Depth map



Gathering

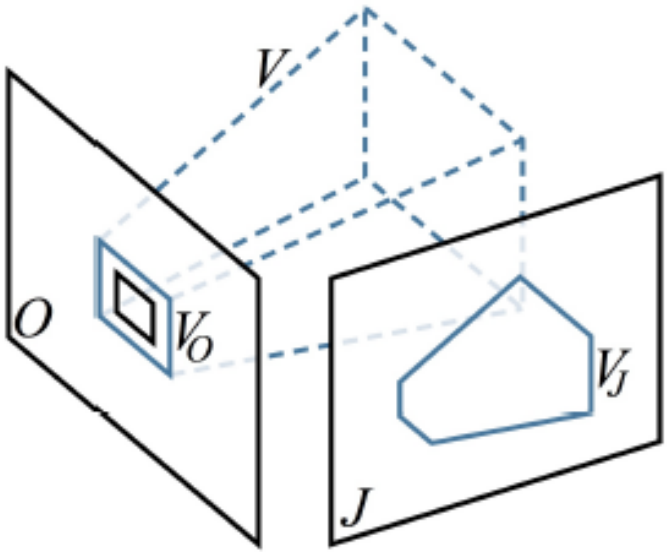
- Straight forward approach
- computationally intractable
- Scene and 2D projection Duality

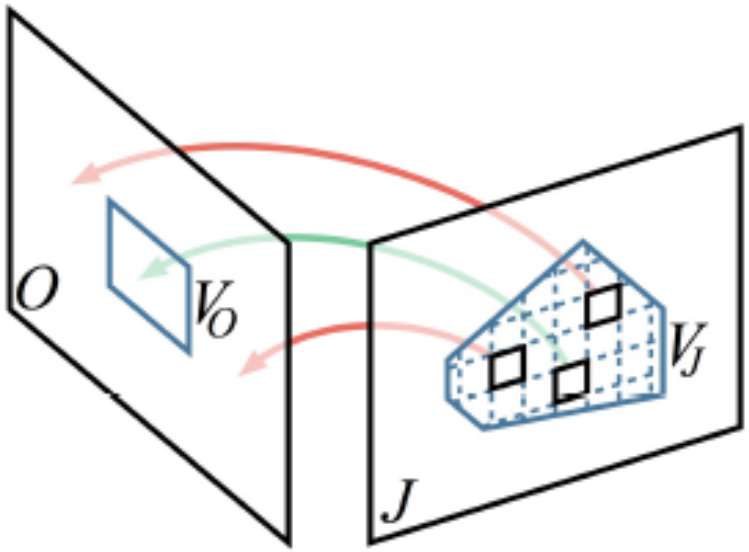


Point cloud

Gathering

$$\boldsymbol{V} = \{C_O^{-1} \cdot [p_x \pm \frac{l}{2}, p_y \pm \frac{l}{2}, \{near, far\}, 1]^T)\}$$



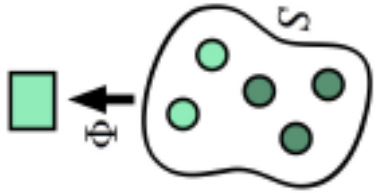


$$\|p - C_O \cdot C_J^{-1} \cdot [q_x, q_y, q_d, 1]^T\|_1 < \frac{l}{2}$$

Filtering

- Application-specific Weight
- Fast Computing
- Applications

$$O(p) = \Phi(S(p)) = \frac{1}{W} \sum_{s \in S(p)} w(s) s_{rgb}$$



Applications

- Denoising
- Deblurring
- Super Resolution
- Inpainting and Semi-transparency
- Computational Scene-space Shutters
- Virtual Apertures

$$O(p) = \Phi(S(p)) = \frac{1}{W} \sum_{s \in S(p)} w(s) s_{rgb}$$

Denoising

- Mean Sampling
- Reference Sample

Input | Scene-space denoising | BM3D [Dabov et al. 2007]

$$w_{denoise}(s) = \exp\left(-\frac{(s_{ref} - s)^2}{2\sigma^2}\right),$$

Deblurring

- Blurriness Term

Input

Scene-space deblurring

[Cho et al. 2012]

$$w_{deblur}(s) = \exp\left(-\frac{(s_{ref} - s)^2}{2\sigma^2}\right) \sum_{q \in \boldsymbol{I}^{s}f} |\nabla \boldsymbol{I}^{s}f\,(q)|$$

Super Resolution

- Traditional Approach
  - Sub-pixel Shifts [Sunkavalli et al. 2012]
  - External Priors [Sun et al. 2008].

Input | Scene-space super resolution | Infognition super resolution [2015]

- Weighting Scheme
  - Scene-space Area

$$w_{sr}(s) = \exp\left(-\frac{(s_{ref} - s)^2}{2\sigma^2}\right) \exp\left(-\frac{{s_{area}}^2}{2\sigma_{area}}\right)$$

down-weights far away sample

Inpainting and Semi-transparency

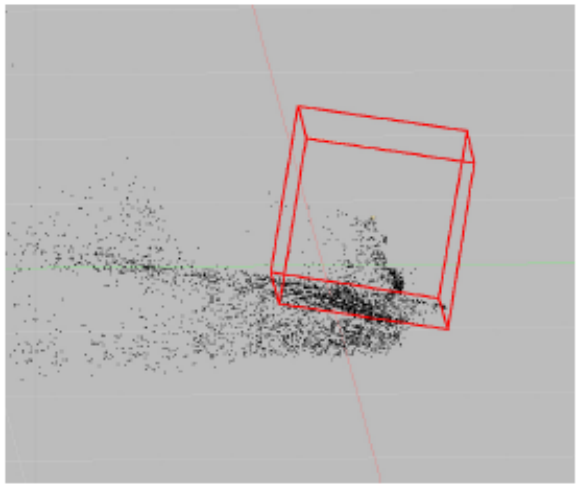
- Per-frame Binary Image Masks
- Scene-space Bounding Region

$$s_{ref} = \frac{1}{|\boldsymbol{S}(p)|} \sum_{s \in \boldsymbol{S}(\boldsymbol{p})} s$$

$$w_{inpaint}(s) = \begin{cases} \exp\left(-\frac{(s_{ref}-s)^2}{2\sigma^2}\right) & \text{when } \boldsymbol{M}(s_p) = 0 \\ 0 & \text{else} \end{cases}$$

Inpainting and Semi-transparency

Input



3D mask

3D mask reprojected

Scene-space semi-transparency

Virtual Apertures

- Aperture Size and Depth of Field
- Sample Area
- Large Camera Arrays[Wilburn et al 2005]

$$a(z) = a_0 + |z_0 - z| * a_s$$

$$w_{va} = \begin{cases} \frac{s_{area}}{\pi a(r)^2} & \text{when } q < a(r) \\ 0 & \text{else .} \end{cases}$$

distance along the camera viewing ray

distance from the ray to s

Novelty

Error Robustness

Parallelable

Simple and General

Evaluation

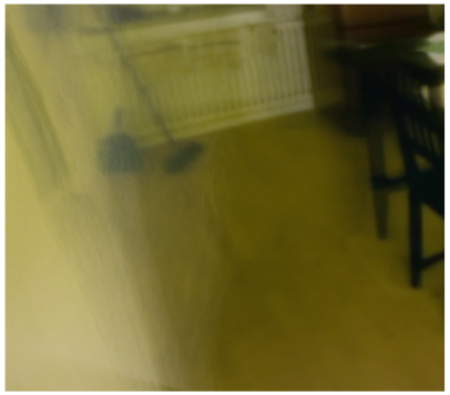
- Implementation

- Results (yechizi monde)

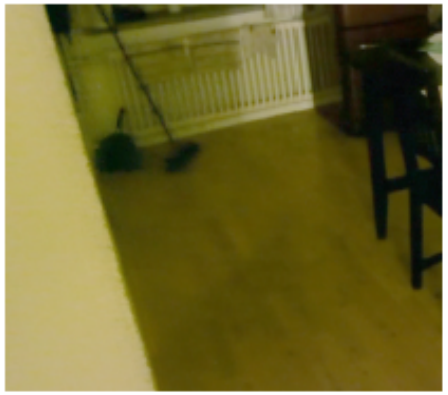
	samples/pixel	sec./frame
Preprocessing	-	1.5
Depth Computation	-	28.5
Denoising	500	3.4
Deblurring	250	8.9
Action shots	100	4.7
Video Inpainting	1000	16.0
Virtual Aperture	12000	10.2
Motion Trails	600	29.0
Super resolution (9×resolution)	800	140.1

Evaluation

- Results
  - Variety of Depth Map
  - Filtering



a) Mean of all samples



Our method

b) Mean of all samples

Our method

Limitation

- Fast Moving Objects
  - Object Space
- Occlusion

Thank You For Your Attention

Any Questions?