[ICIP 2009. Nov. 07 – 10, Cairo, Egypt]

Virtual View Rendering using Super-resolution with Multiview Images

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- Motivation and overview
- Proposed method
  - Stereo matching
  - Geometric based forward warping
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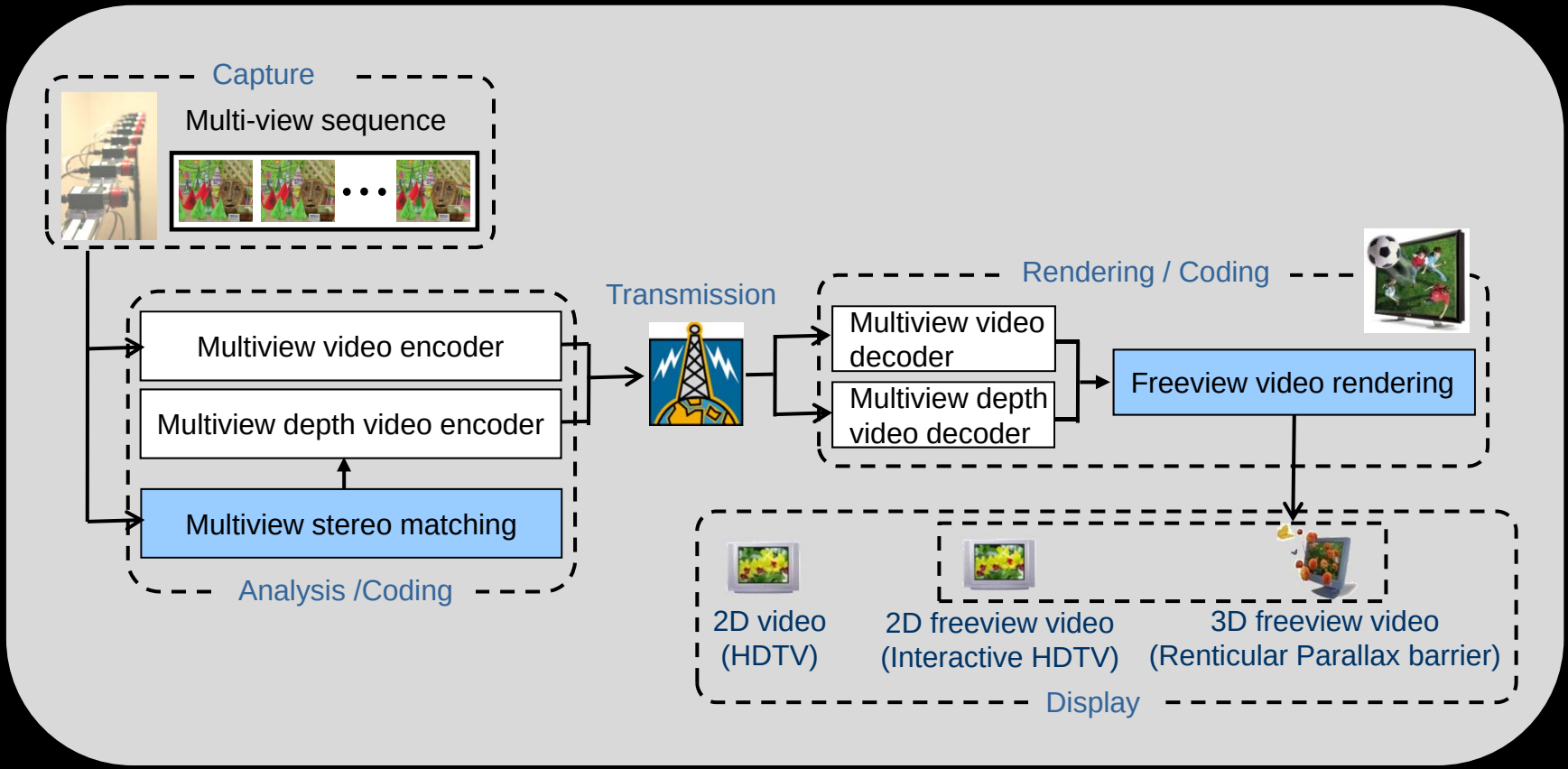
Introduction

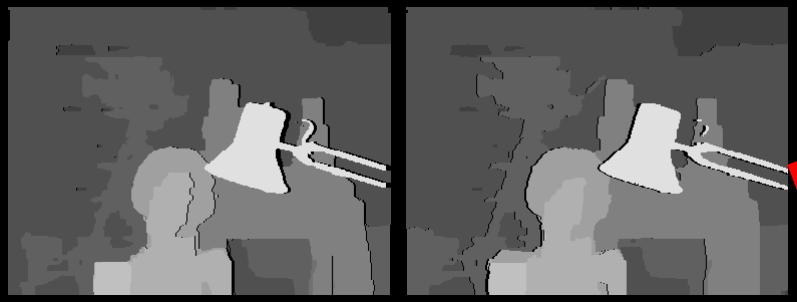
- Feature of 3DTV system
  - User interactivity
  - 3D depth feeling
- Components of 3DTV system
  - Ability of capturing 3D video
  - Analysis & compression of multiview images
  - Transmission of huge amount of data
  - Display 3D video

Introduction

- An example of 3DTV system



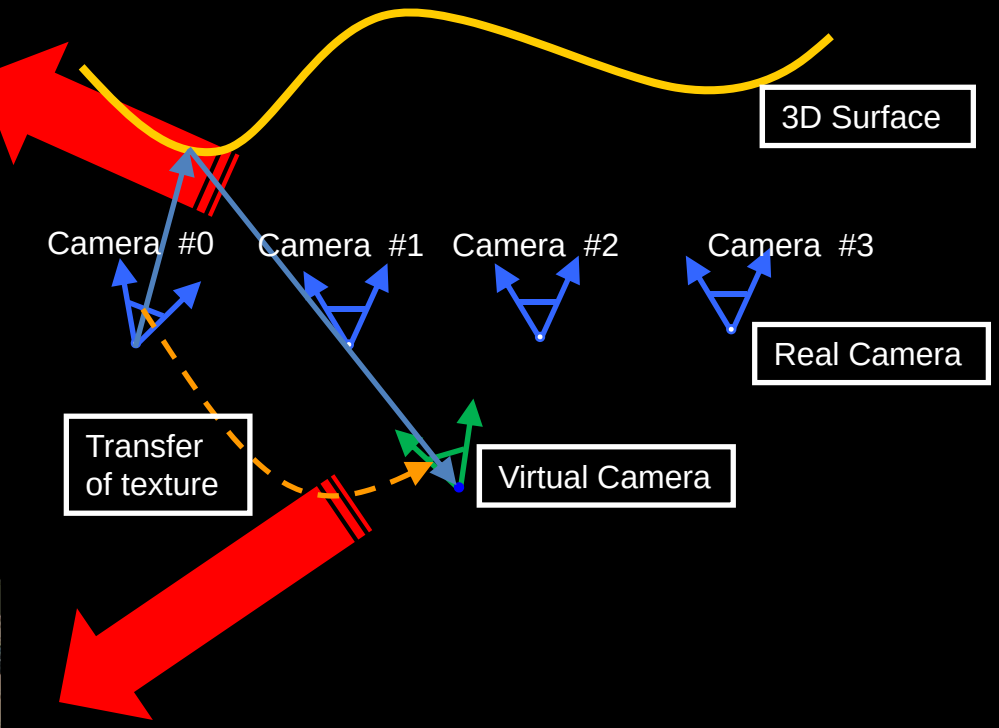
Virtual View Rendering



$$x^v - x_c = f\frac{(x_i - x_c)B/d_i + T_x}{fB/d_i + T_z} = \frac{(x_i - x_c) + d_i\alpha_x}{1 + d_i\alpha_z/f}$$

$$y^v - y_c = f\frac{(y_i - y_c)B/d_i + T_y}{fB/d_i + T_z} = \frac{(y_i - y_c) + d_i\alpha_y}{1 + d_i\alpha_z/f}$$

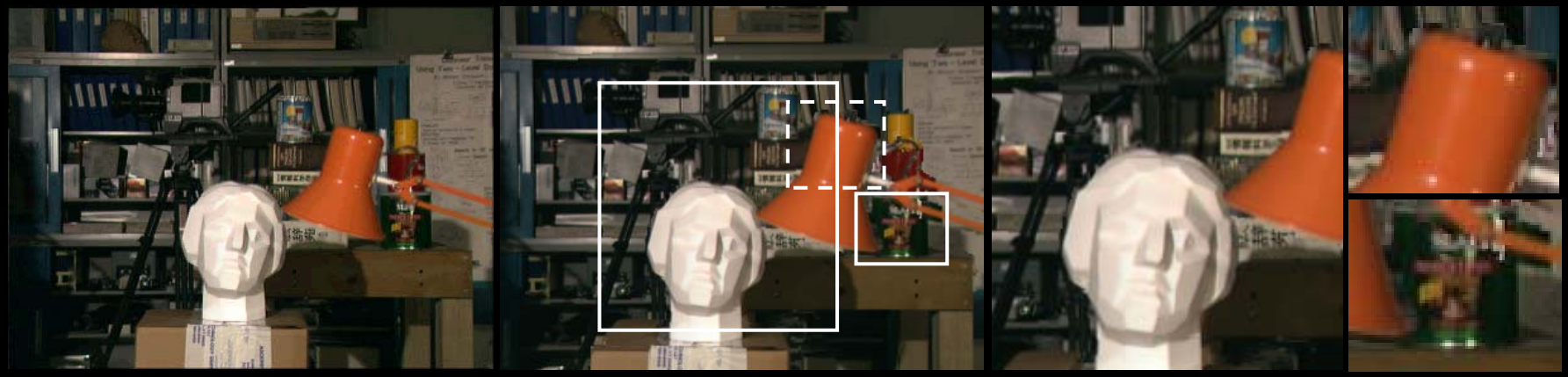
$$(T_x/B, T_y/B, T_z/B) = (\alpha_x, \alpha_y, \alpha_z)$$



$$I_v(x,y) = Vis^{L}(x,y)(1-\alpha)I_v^{L}(x,y) + Vis^{R}(x,y)\alpha I_v^{R}(x,y)$$

Motivation and overview

- Motivation



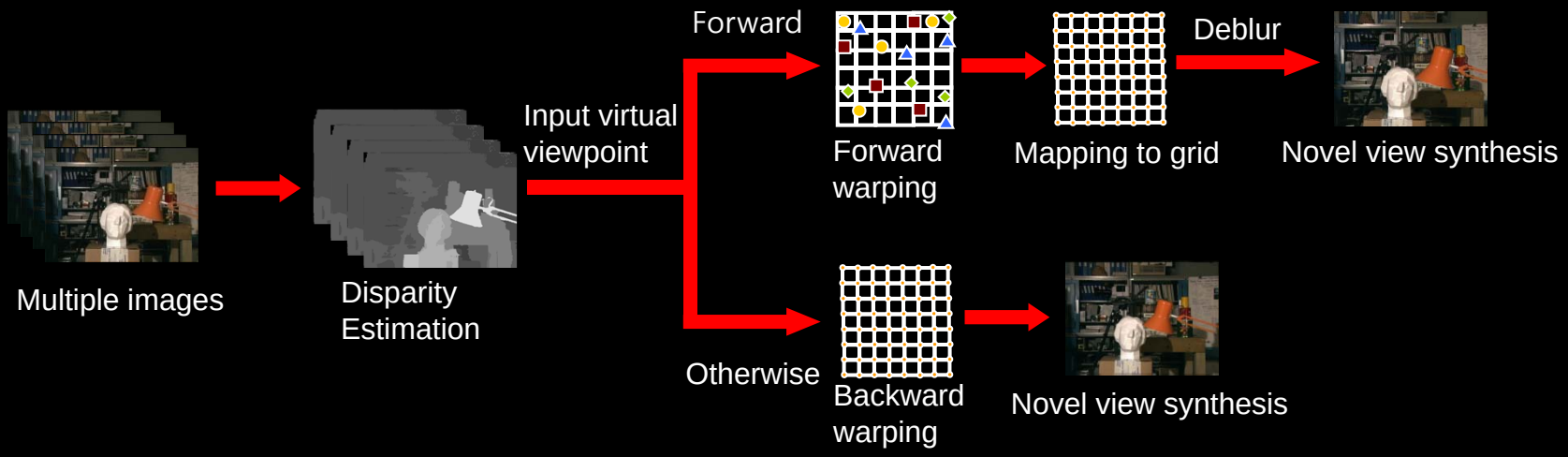
Observation

When the virtual camera moves forward, the synthesized view is degraded.

In multiview configuration, We prevent the quality of a virtual view from being degraded using super-resolution concept.

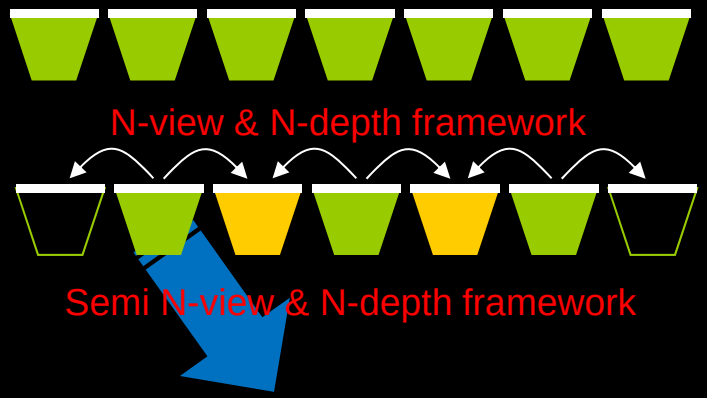
Motivation and overview

- Overview
  - Stereo matching
  - Geometric based forward warping
  - Hole filling using backward warping
  - Deblur



Proposed Method

- Stereo matching
  - Min's algorithm



Forward warping of cost function

Backward warping of cost function

Reference views

Target views with symmetric warping

Semi-target views with asymmetric warping

Cost aggregation

$$e(p,d) = E(p,d) + n$$

$$E^{k+1}(p) = \bar{e}(p) + \bar{E}^{k}(p)$$

$$= \frac{e(p) + \lambda \sum_{m \in N(p)} w(p,m) E^{k}(m)}{1 + \lambda \sum_{m \in N(p)} w(p,m)}$$

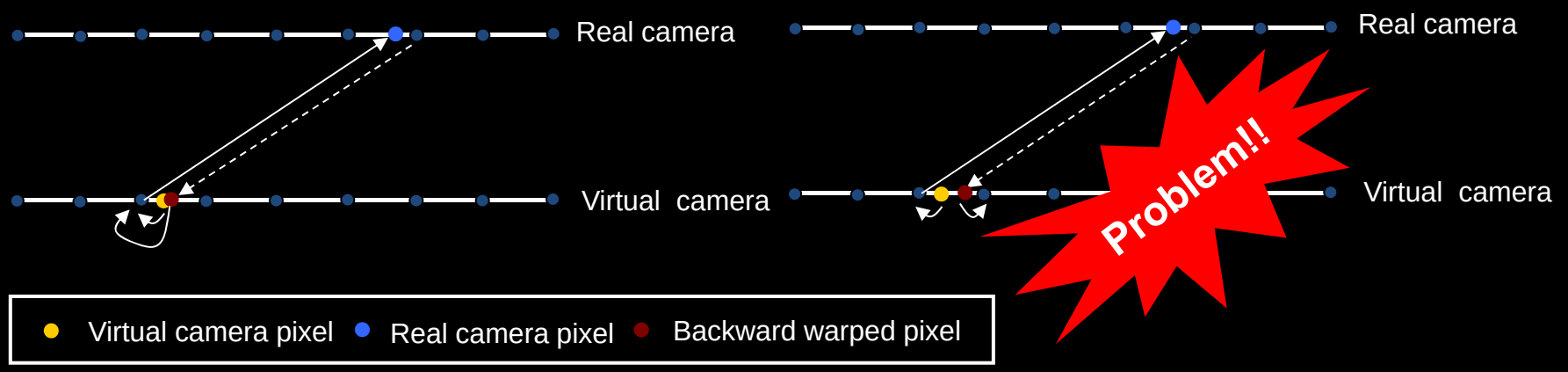
D. Min and D. Kim and K. Sohn, "2D/3D Freeview Video Generation for 3DTV System," ICIP 2008.

Proposed Method

- Geometric based forward warping
  - Forward warping : Multiple matching → hole problem
  - Backward warping

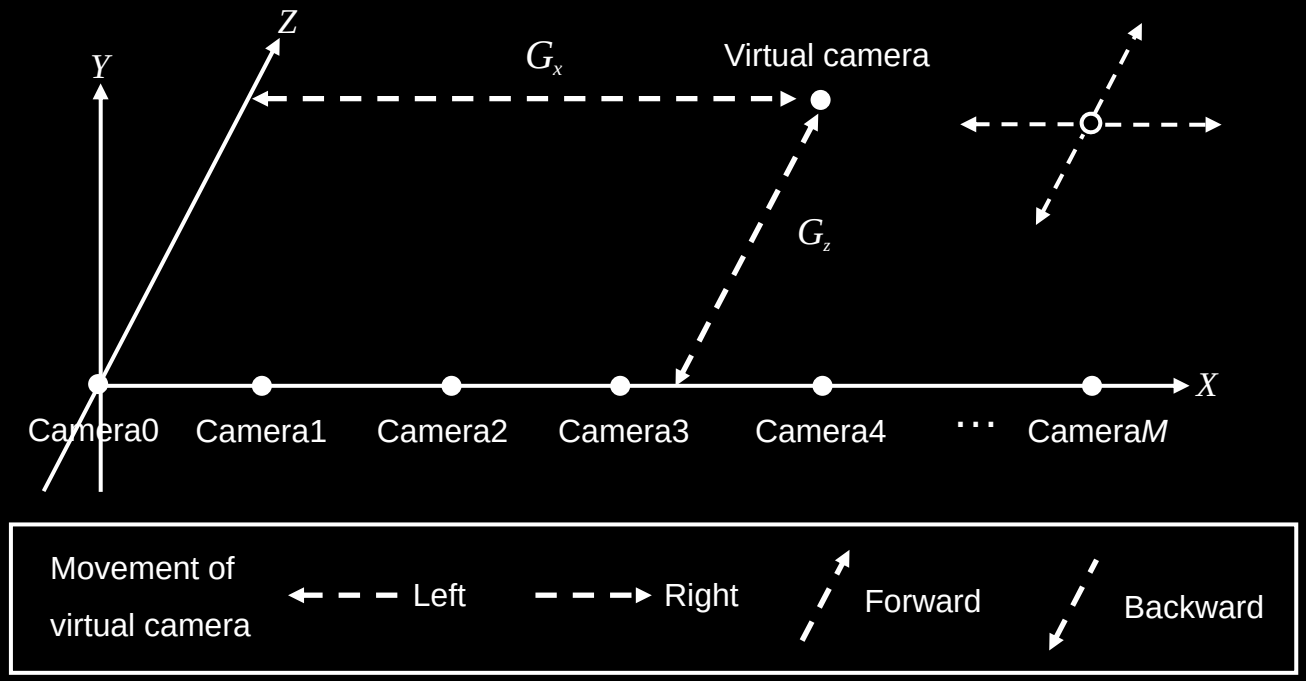
However, we do not use interpolation!

Forward is more suitable than backward warping



Proposed Method

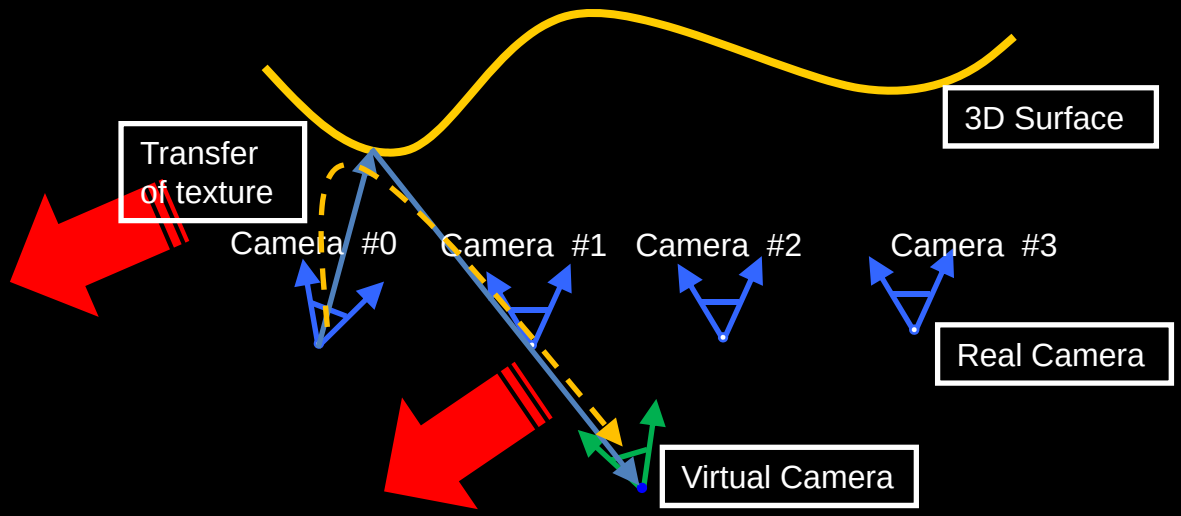
- Geometric based forward warping



Proposed Method

- Geometric based forward warping

Foreground object : large disparity



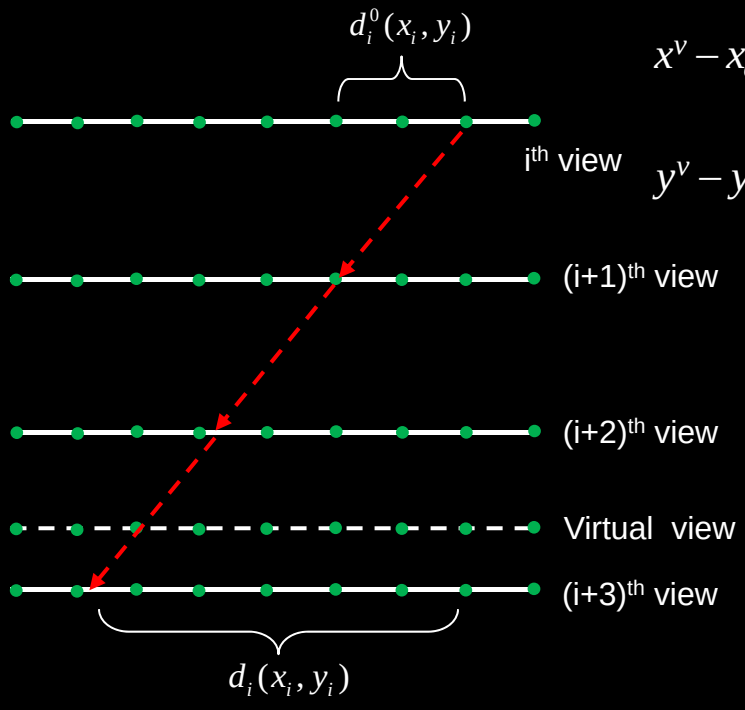
$$I^v(x^v, y^v) = I_i(x_i, y_i)$$

$$x^v - x_c = f\frac{(x_i - x_c)B_i / d_i(x_i, y_i) + T_{i,x}}{fB_i / d_i(x_i, y_i) + T_{i,z}} = \frac{(x_i - x_c) + d_i(x_i, y_i)\alpha_{i,x}}{1 + d_i(x_i, y_i)\alpha_{i,z} / f}$$

$$y^v - y_c = f\frac{(y_i - y_c)B_i / d_i(x_i, y_i) + T_{i,y}}{fB_i / d_i(x_i, y_i) + T_{i,z}} = \frac{(y_i - y_c) + d_i(x_i, y_i)\alpha_{i,y}}{1 + d_i(x_i, y_i)\alpha_{i,z} / f}$$

Proposed Method

- Geometric based forward warping
  - Disparity refinement
    - Disparity influences the quality of synthesized view.



$$x^v - x_c = f\frac{(x_i - x_c)B_i / d_i(x_i, y_i) + T_{i,x}}{fB_i / d_i(x_i, y_i) + T_{i,z}} = \frac{(x_i - x_c) + d_i(x_i, y_i)\alpha_{i,x}}{1 + d_i(x_i, y_i)\alpha_{i,z} / f}$$

$$y^v - y_c = f\frac{(y_i - y_c)B_i / d_i(x_i, y_i) + T_{i,y}}{fB_i / d_i(x_i, y_i) + T_{i,z}} = \frac{(y_i - y_c) + d_i(x_i, y_i)\alpha_{i,y}}{1 + d_i(x_i, y_i)\alpha_{i,z} / f}$$

$$d_i(x_i, y_i) = \begin{cases} d_i^0(x_i, y_i) + \sum_{k=i+1}^{\lfloor G_z \rfloor} d_k(x_k, y_k) \\ x_k = x_{k-1} - d_{k-1}^0(x_{k-1}, y_{k-1}) \\ d_i^0(x_i, y_i) + \sum_{k=\lceil G_x \rceil}^{i-1} d_k(x_k, y_k) \\ x_k = x_{k+1} + d_{k+1}^0(x_{k+1}, y_{k+1}) \end{cases}$$

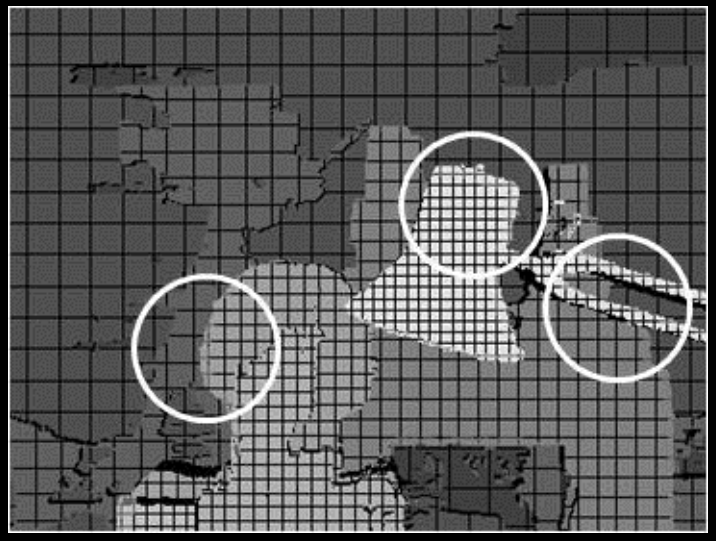
Proposed Method

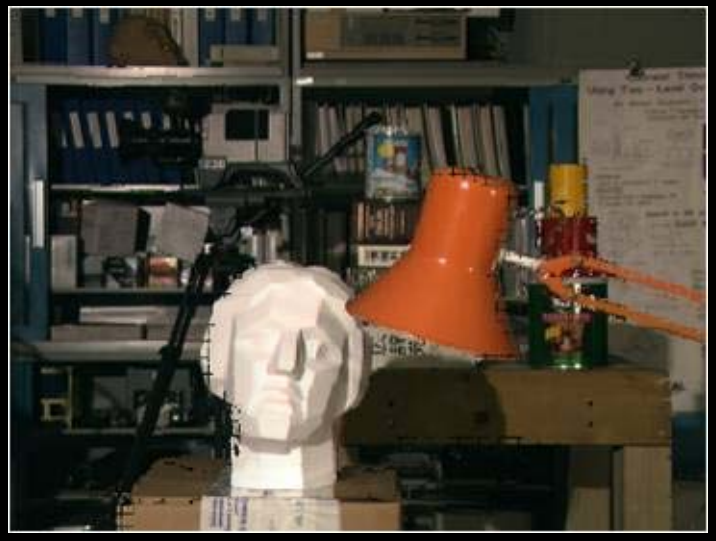
- Geometric based forward warping
  - Two problem
    - Background disparity penetrates the foreground regions.
    - NOT one-to-one correspondence → Hole

Proposed Method

- Geometric based forward warping
  - Background disparity penetrates the foreground regions.
    - Depth ordering : pixels with largest disparity are visible.

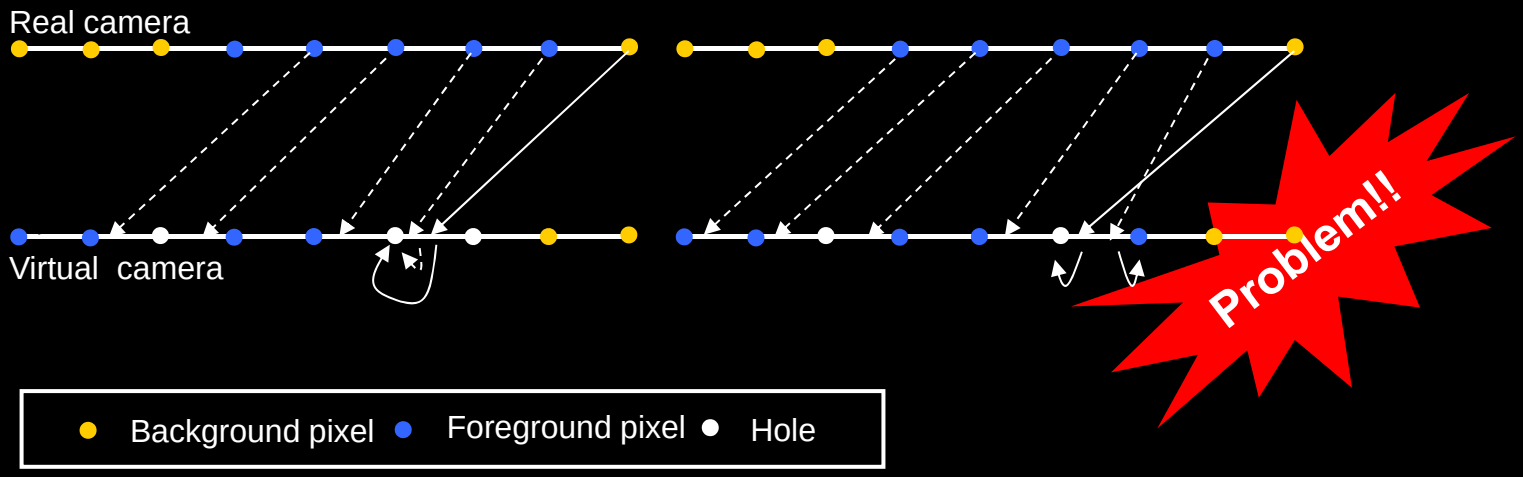
However, this problem still occurs!





Proposed Method

- Geometric based forward warping
  - The reason why this problem occurs.



  - Similarity comparison : using neighboring disparity

Proposed Method

- Hole filling using backward warping
  - NOT one-to-one correspondence → Hole
    - Backward warping with interpolated disparity map.
    - Geometric resampling : only used to change coordinate

Interpolated disparity map

$$x_i = (x^v - x_c)(1 - f\alpha_{i,z}Dis_i(x^v, y^v)) + x_c + \alpha_{i,x}Dis_i(x^v, y^v)$$
$$y_i = (y^v - y_c)(1 - f\alpha_{i,z}Dis_i(x^v, y^v)) + y_c + \alpha_{i,y}Dis_i(x^v, y^v)$$

- Visibility function is needed.

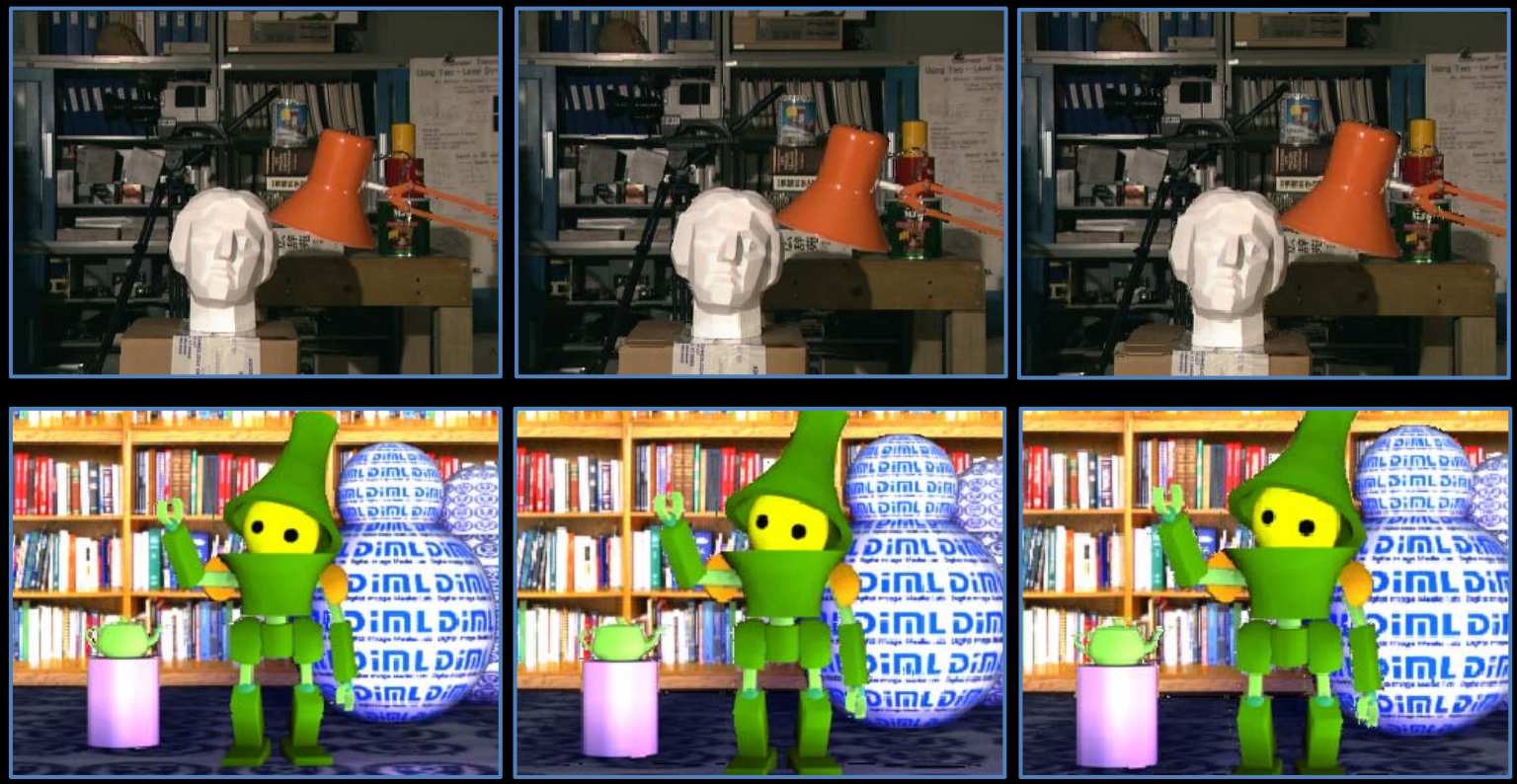
$$I^v(x^v, y^v) = I_i(x_i, y_i)V_i(x^v, y^v)$$

Experimental Results : Exp1

- Conventional method
  - (from left to right) the virtual camera moves forward more.

Experimental Results : Exp1

- Proposed method
  - (from left to right) the virtual camera moves forward more.



Experimental Results : Exp1

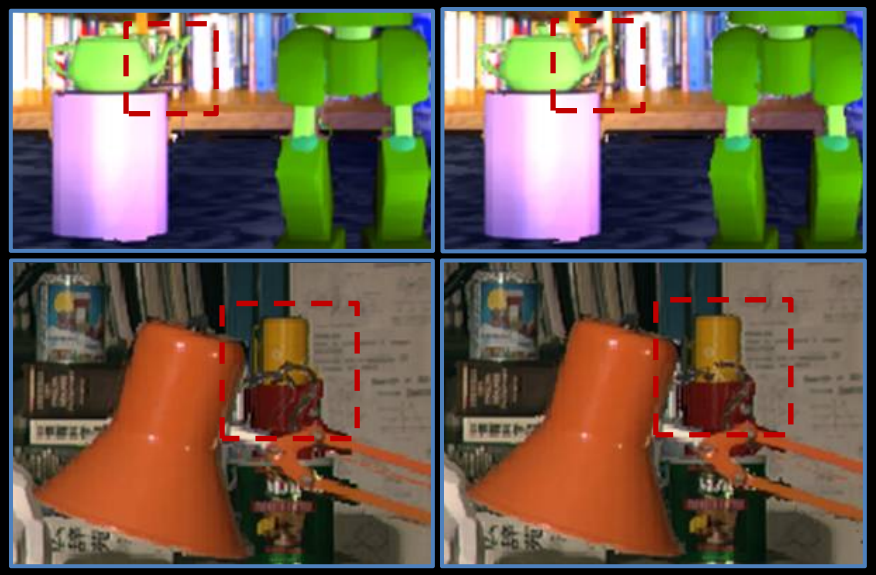
- Conventional method

Experimental Results : Exp1

- Proposed method

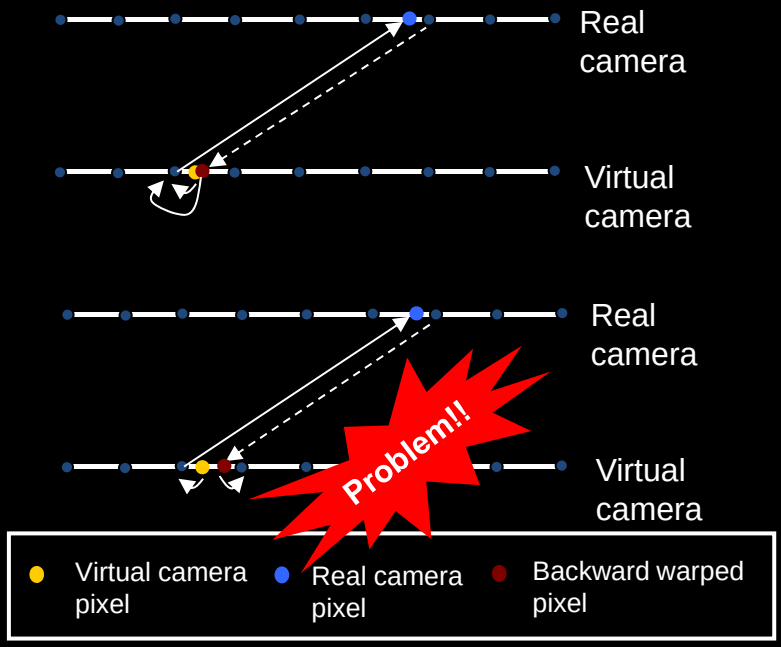
Experimental results : EXP2

- A scene is synthesized by only applying backward warping.
- Not use interpolation



Backward warping based method

Proposed method



Experimental Results

- Complexity
  - Assume it takes N operation when one view is warped to the virtual camera coordinate
  - Conventional method : 11N
    - Disparity warping (2N)
    - Texture mapping (6N)
    - Blending (3N)
  - Proposed method : 12N (if we use 4 reference images)
  - Hole filling is ignored

Sequence	*Tsukuba (ms)*	*Venus (ms)*	*Teddy (ms)*	*Cone (ms)*	*Robot (ms)*
Conventional method	111.52	177.87	180.56	180.09	79.81
Proposed method	126.81	194.83	194.04	195.02	88.80

Experimental Results

- Objective evaluation : ‘Robot’ sequence
  - PSNR gain is mild (0.9dB) in comparison with visual quality.
    - Enhanced regions, that is, the foreground, occupy small portion.
    - Outliers - Disparity error.

Conclusion

- Summary
  - Quality enhancement scheme
    - Prevent synthesized view from being degraded when the virtual camera moves forward
    - Apply SR concept to IBR
    - Forward and backward warping are used, properly
- Further work
  - Investigate more elaborate data fusion
    - Robust to disparity error
  - Overall PSNR gain is mild
    - Explore this in order to show good results both PSNR and visual quality

Thank You!
Any Questions?

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