



# **View Interpolation With Structured Depth From Multiview Video**

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# Outline

- Motivation
- Depth Consistency Testing
- Inter-view Connection Information
- Structured Depth Maps
- Virtual View Interpolation
- Experimental Results
- Conclusions

# Imaging



## Classical Imaging

*Newspaper*

# Imaging



## Multiview Imaging

*Newspaper*

# Application



User



Free Viewpoint TV

# Application



User



Free Viewpoint TV

•  
•  
•

# Application



User



Free Viewpoint TV

# Virtual View



*Newspaper*

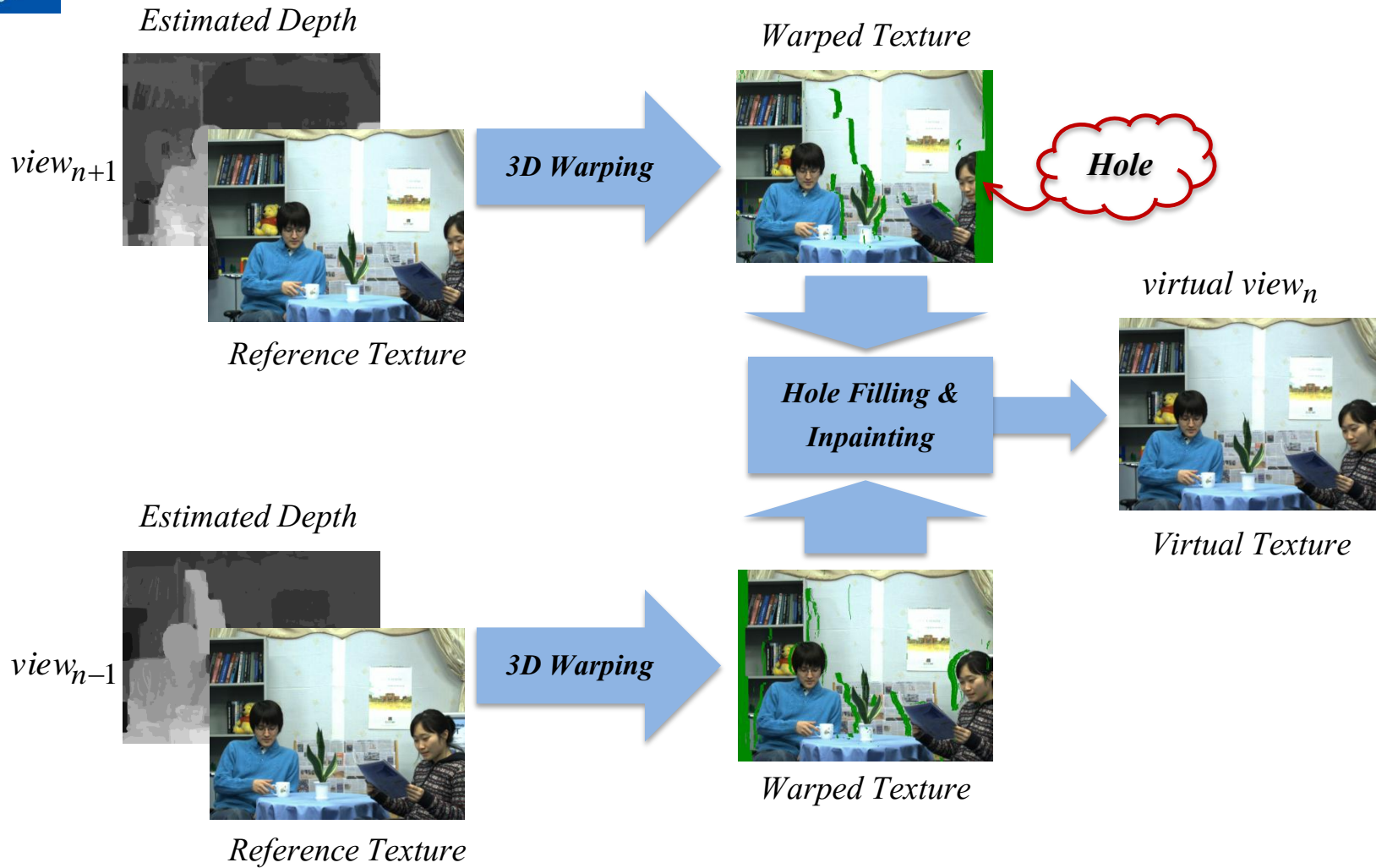


# Virtual View



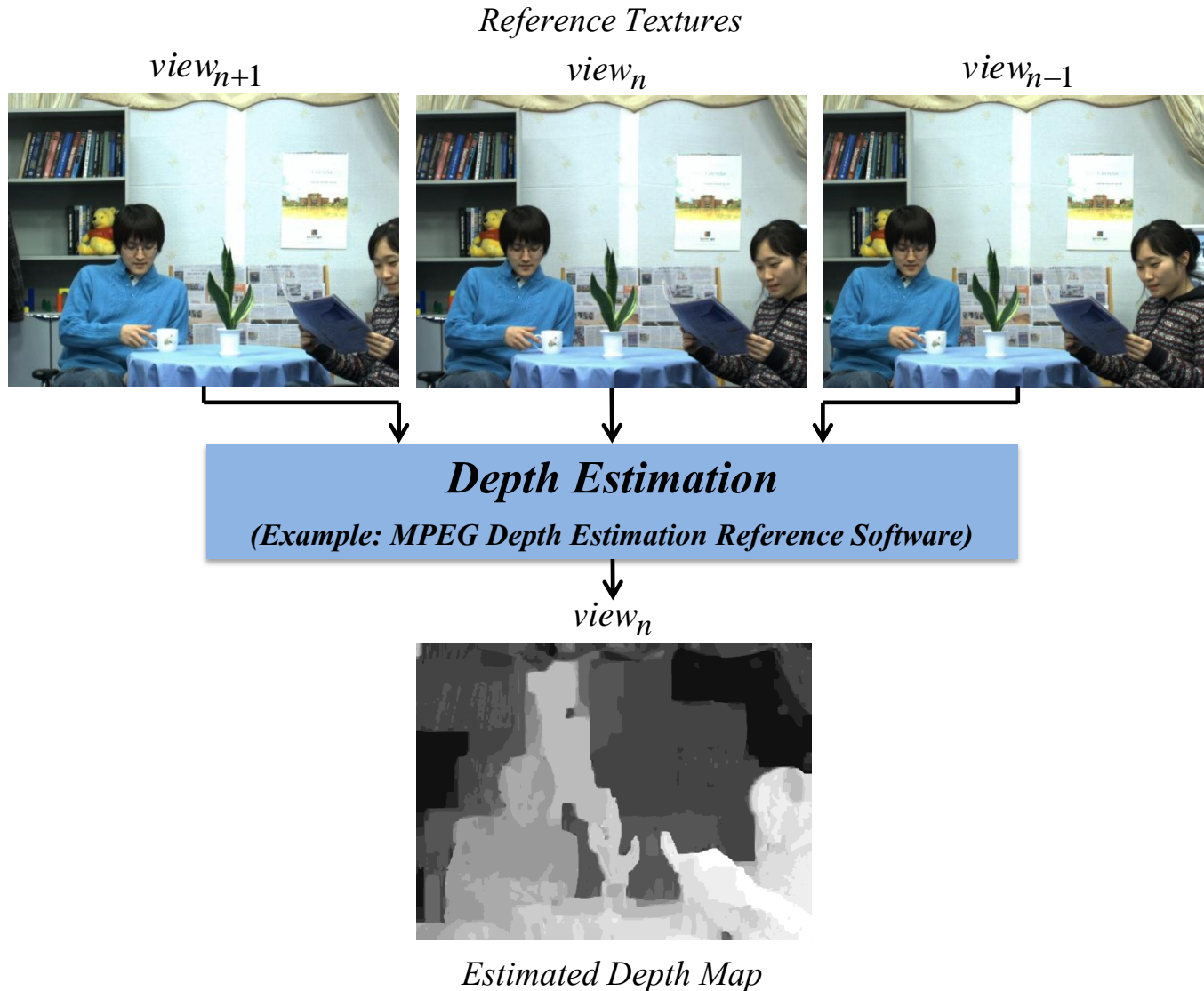
*Newspaper*

# Virtual View Rendering



(Example: MPEG View Synthesis Reference Software)

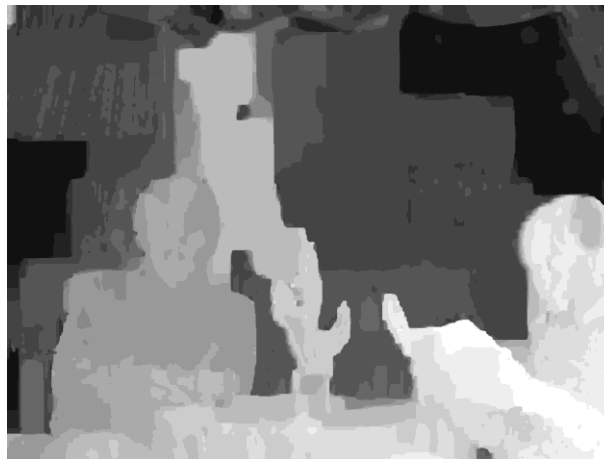
# Depth Estimation



# Inter-view Depth Inconsistency



$view_{n+1}$



$view_n$



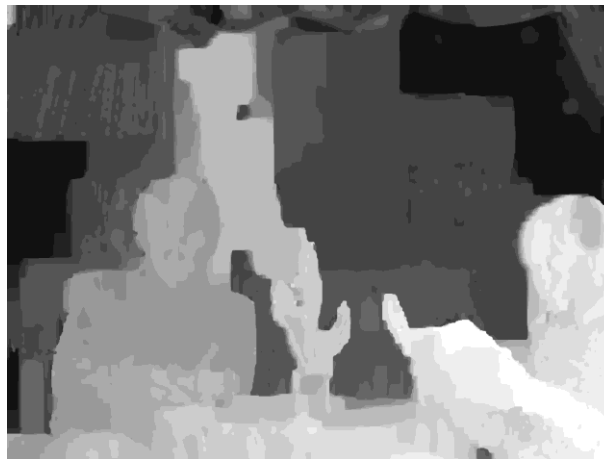
$view_{n-1}$

*Newspaper*

# Inter-view Depth Inconsistency



$view_{n+1}$



$view_n$



$view_{n-1}$

*Newspaper*

# Inter-view Depth Inconsistency



$view_{n+1}$



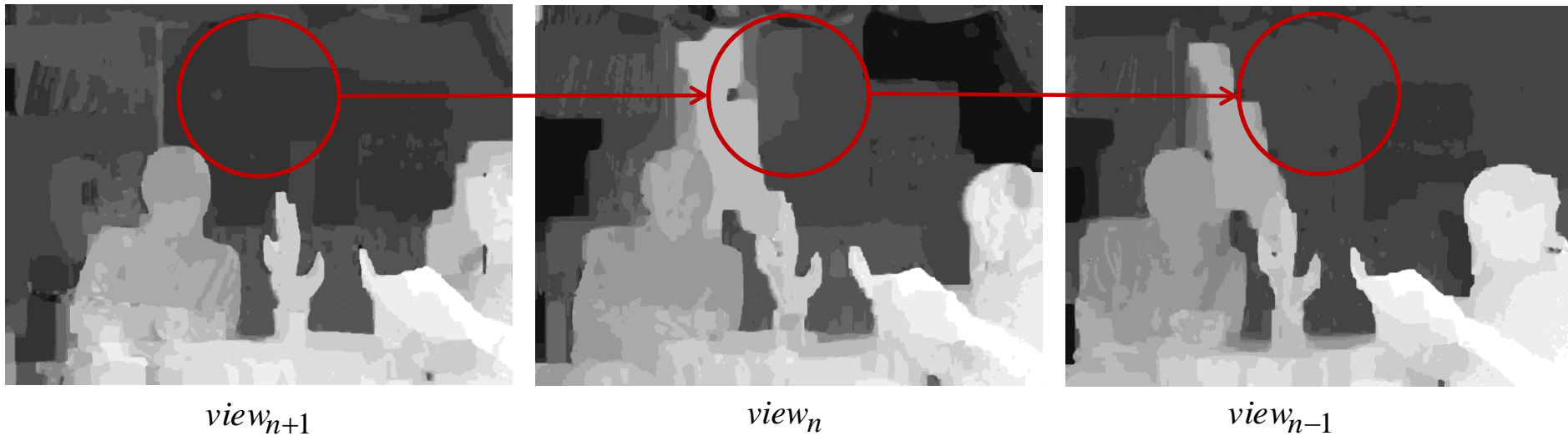
$view_n$



$view_{n-1}$

*Newspaper*

# Inter-view Depth Inconsistency



*Newspaper*

# Multiple Depth Warping



*view 1*



*view 2*

...



*view n*



# Multiple Depth Warping



*view 2*

...



*view n*

*3D Warping to  
a principal  
viewpoint  $p$*

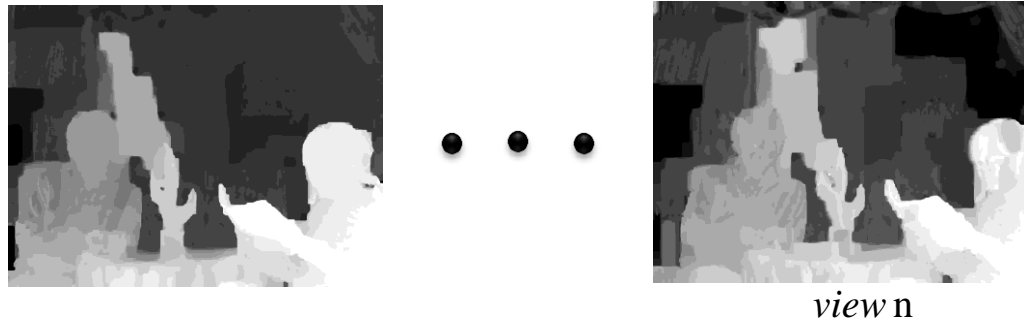


*view 1*

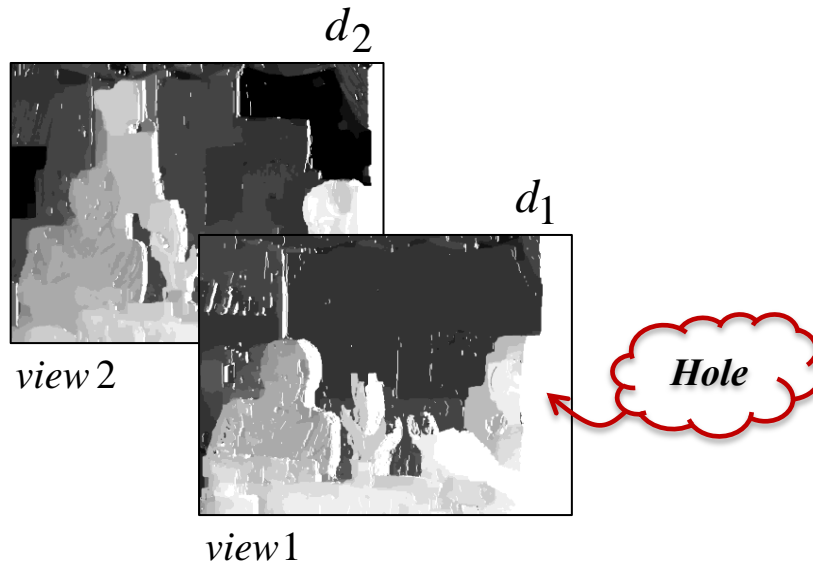
$d_1$

*Hole*

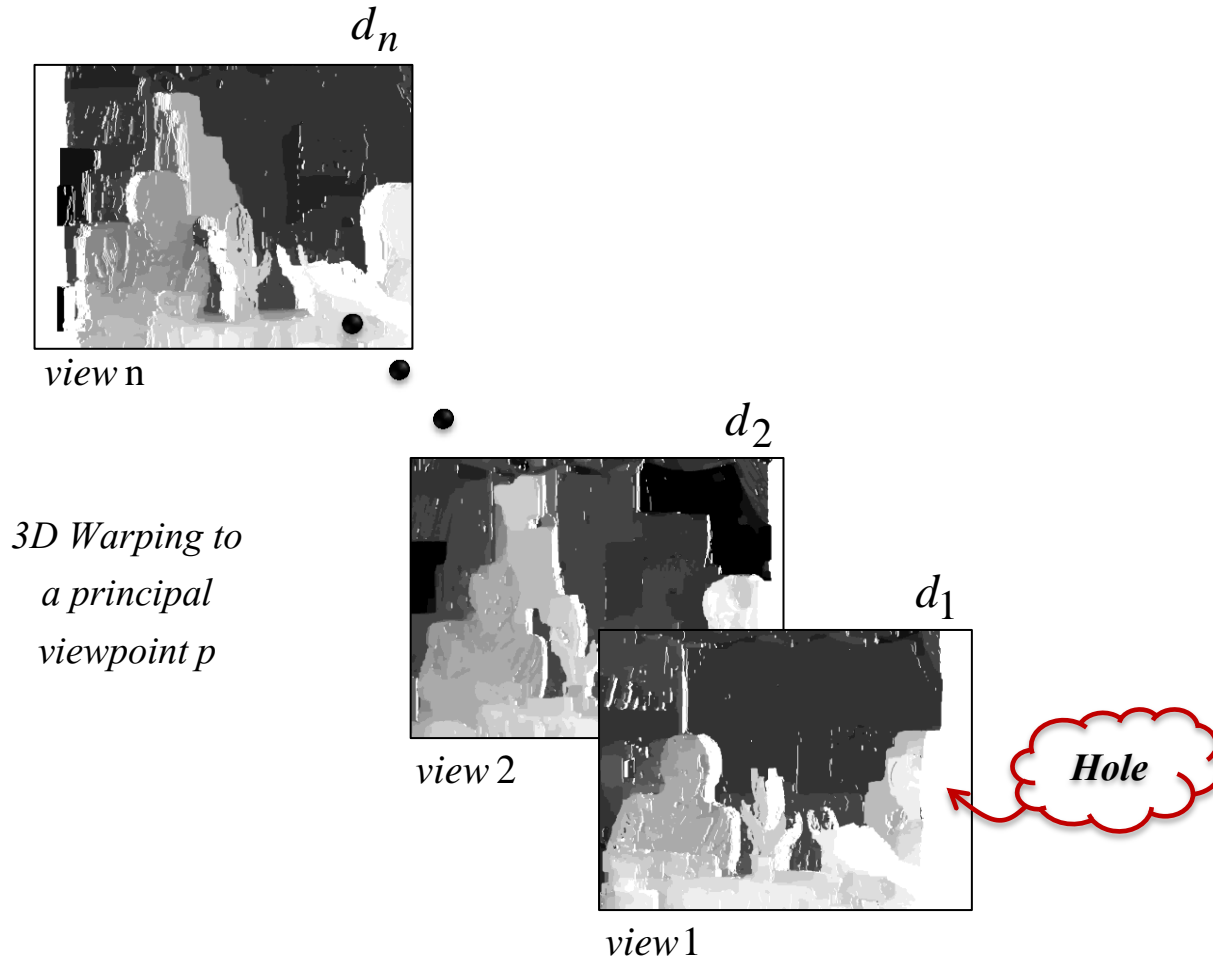
# Multiple Depth Warping



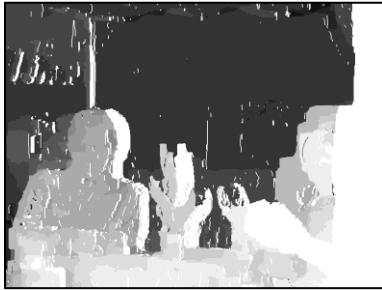
*3D Warping to  
a principal  
viewpoint  $p$*



# Multiple Depth Warping



# Connection Evidence

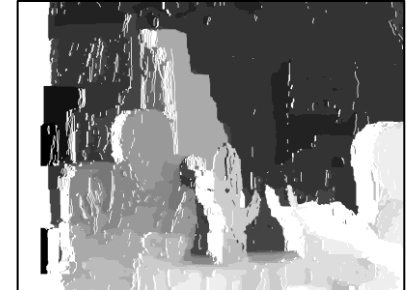


view 1



view 2

...



view n

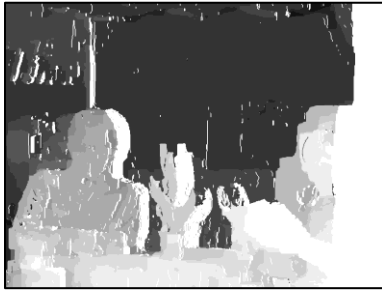
Absolute Difference  
Matrix (ADM)  
per pixel

=

$$\begin{pmatrix} 0 & \Delta_{1,2} & \cdots & \Delta_{1,n} \\ \Delta_{2,1} & 0 & \cdots & \Delta_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \Delta_{n,2} & \Delta_{n,2} & \cdots & 0 \end{pmatrix}$$

where,  $\Delta_{i,j} = |d_i - d_j|$  and is a measure of depth consistency between the corresponding depth pairs  $(d_i, d_j)$  at a principal pixel.

# Connection Evidence

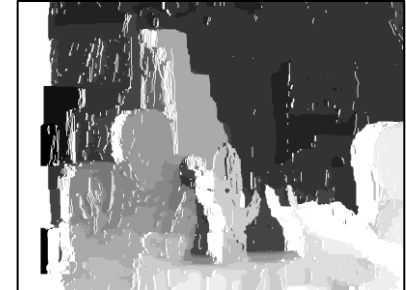


view 1



view 2

...



view n

Absolute Difference  
Matrix (ADM)  
per pixel

=

$$\begin{pmatrix} 0 & \Delta_{1,2} & \cdots & \Delta_{1,n} \\ \Delta_{2,1} & 0 & \cdots & \Delta_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \Delta_{n,2} & \Delta_{n,2} & \cdots & 0 \end{pmatrix}$$

*Inter-view  
Connection  
Evidence*

where,  $\Delta_{i,j} = |d_i - d_j|$  and is a measure of depth consistency between the corresponding depth pairs  $(d_i, d_j)$  at a principal pixel.

# Connection Evidence Testing

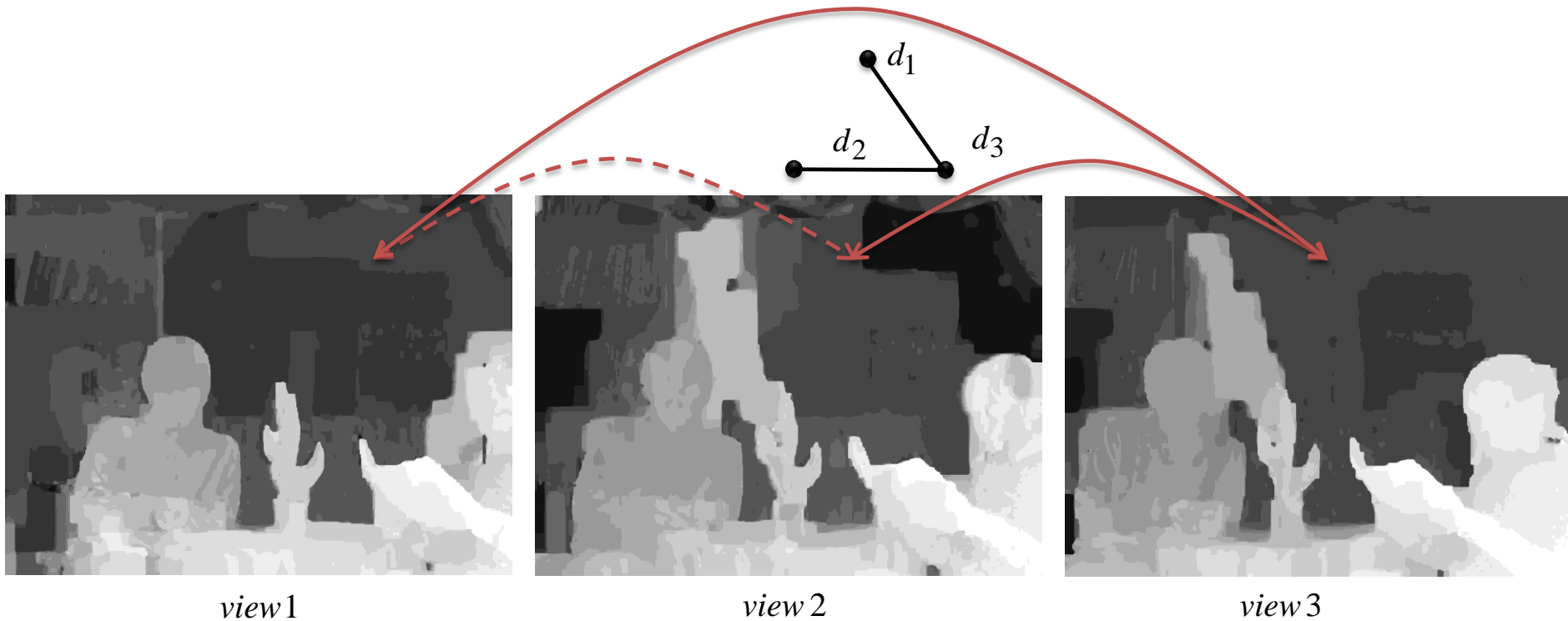
- Connection evidence is a measure of inter-view consistency.
- The connection threshold ( $T_f$ ) relates to the quality of the connectivity and defines a criterion for depth consistency testing for each frame  $f$  according to

$$T_f = \mu_f + \lambda \sigma_f, \lambda \in [0, 1]$$

## Testing Rules:

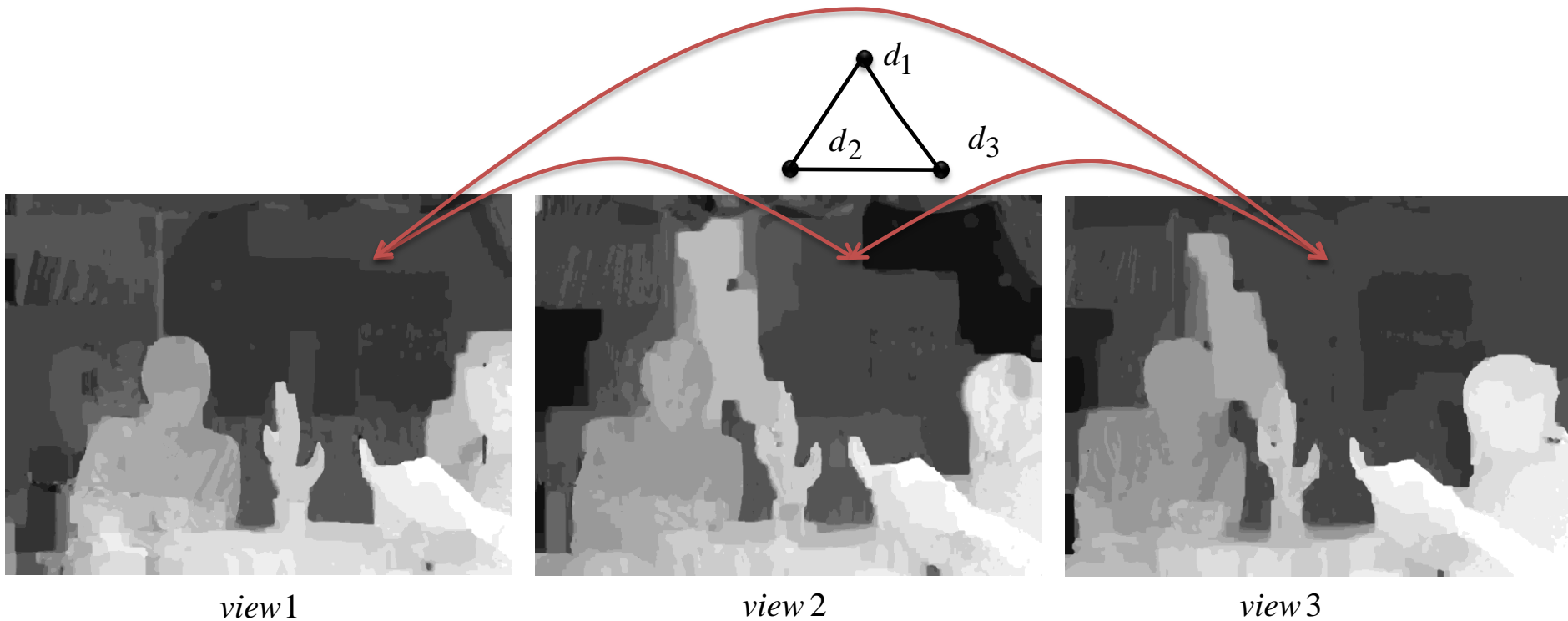
- $\Delta_{i,j} < T_f$ : Accept the connection evidence and assume that the corresponding depth values have a consistent depth representation.
- $\Delta_{i,j} \geq T_f$ : Reject the connection evidence.

# Inter-View Connection Information



Example for inter-view connection information with three reference views,  $n=3$ .

# Inter-View Connection Information

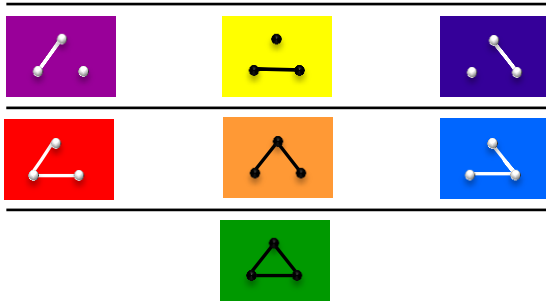


Example for inter-view connection information with three reference views,  $n=3$ .

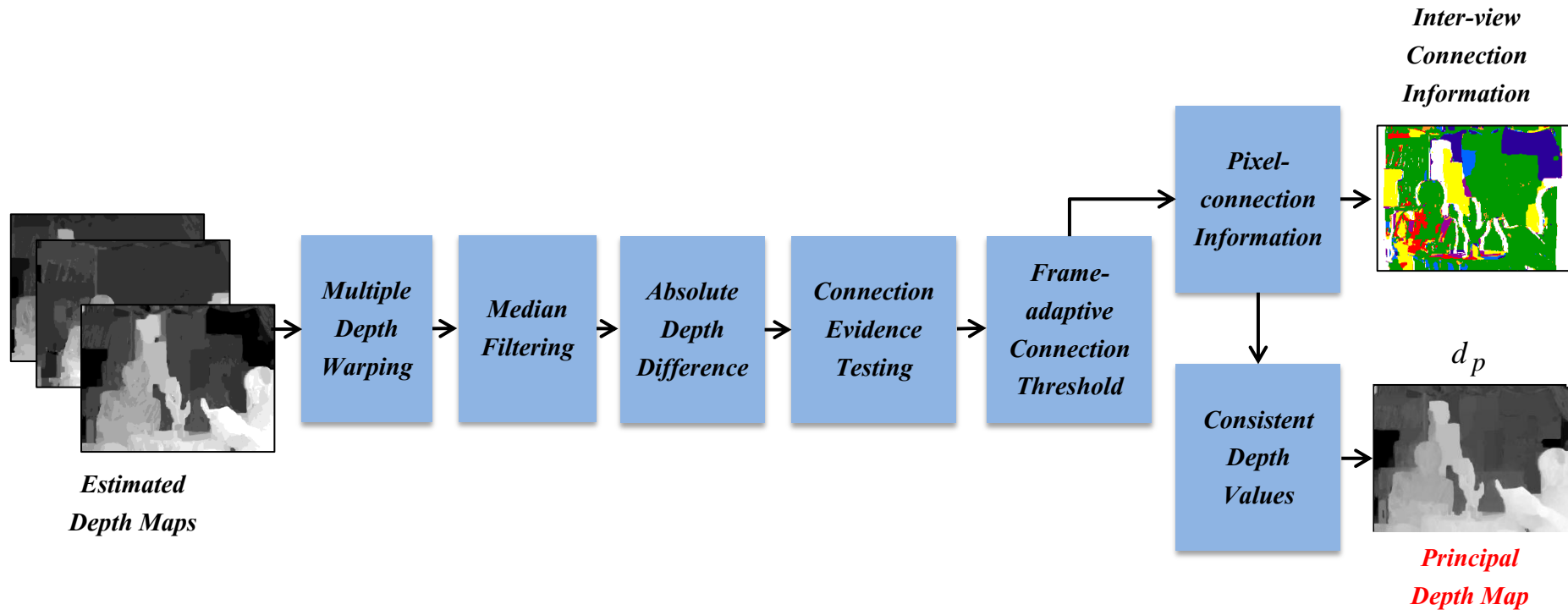


# Inter-View Connection Information

Possible cases of inter-view connectivity for  $n = 3$ :

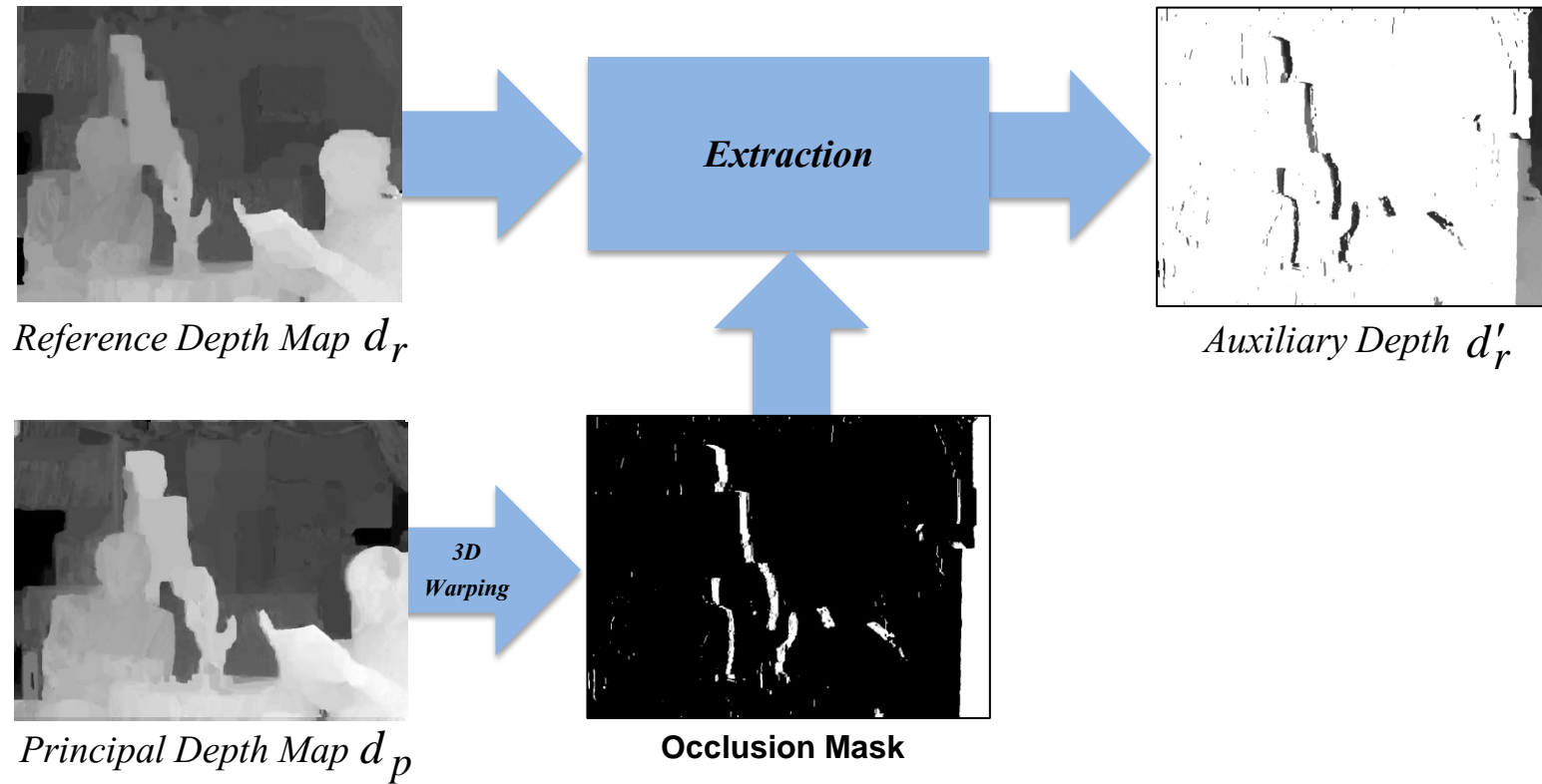


# Principal Depth Map

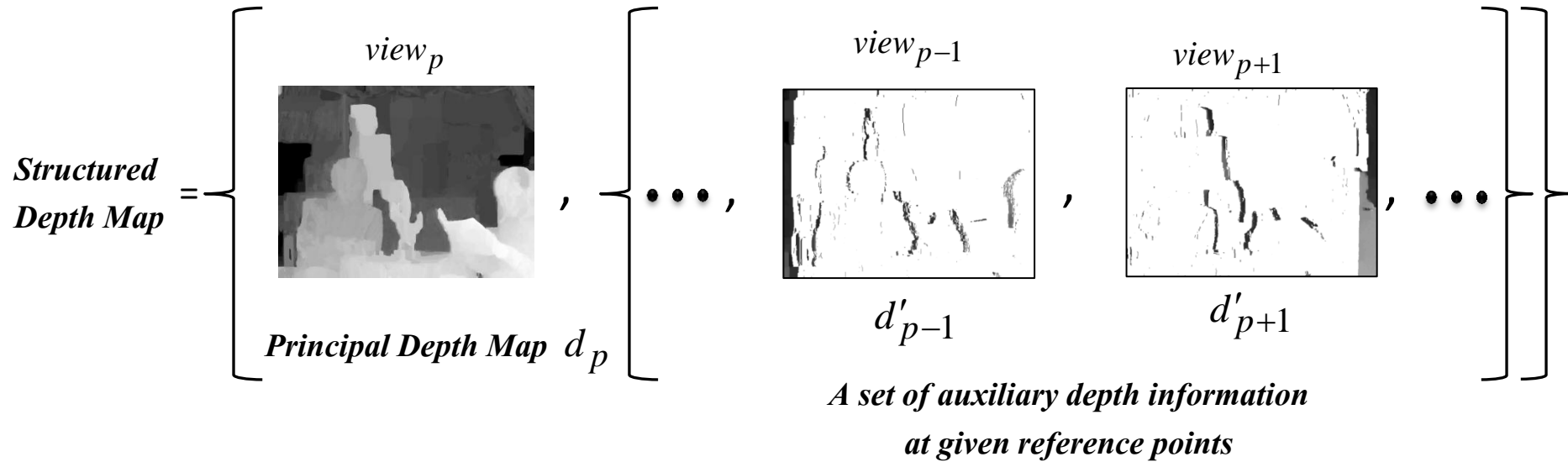


Depth Consistency Testing Algorithm

# Extraction of Auxiliary Depth



# Structured Depth Map

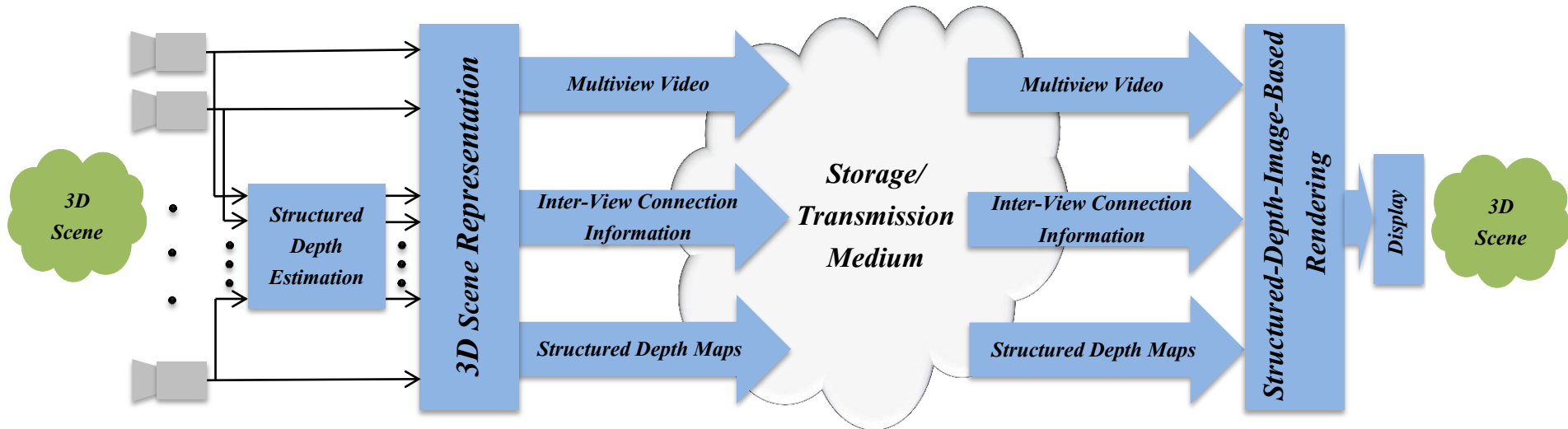


Cardinality of the set of auxiliary depth information:

$$|d'| = \begin{cases} (n-1) & \text{if } p = r, \forall r, \\ n & \text{if } p \neq r, \forall r, \end{cases}$$

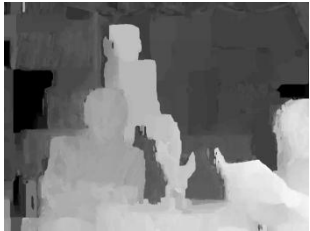
where,  $n$  is the number of reference views used in the depth consistency testing.

# Structured-Depth-Image-Based Rendering

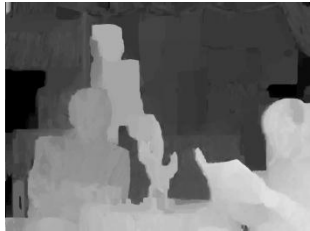


# Virtual View Rendering Using Inter-View Connection

$view_{n+2}$



$view_{n+1}$



$view_{n-1}$



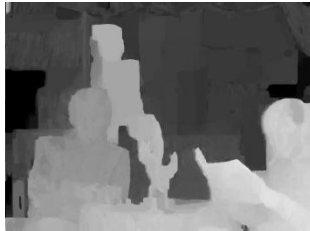
$virtual\ view_n$

# Virtual View Rendering Using Inter-View Connection

$view_{n+2}$



$view_{n+1}$



$view_{n-1}$



# Virtual View Rendering Using Inter-View Connection

$view_{n+2}$



$view_{n+1}$



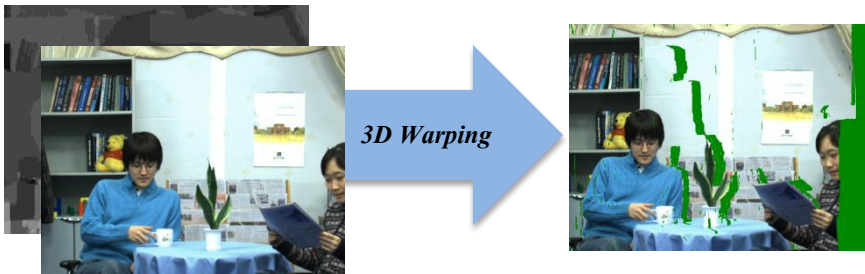
$view_{n-1}$



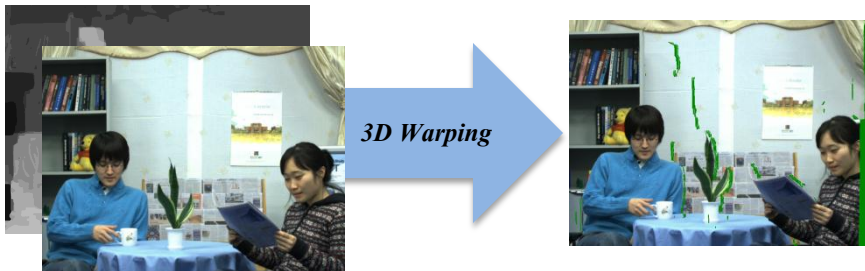


# Virtual View Rendering Using Inter-View Connection

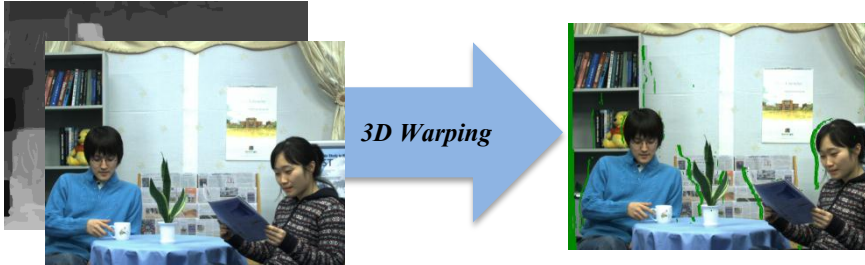
$view_{n+2}$



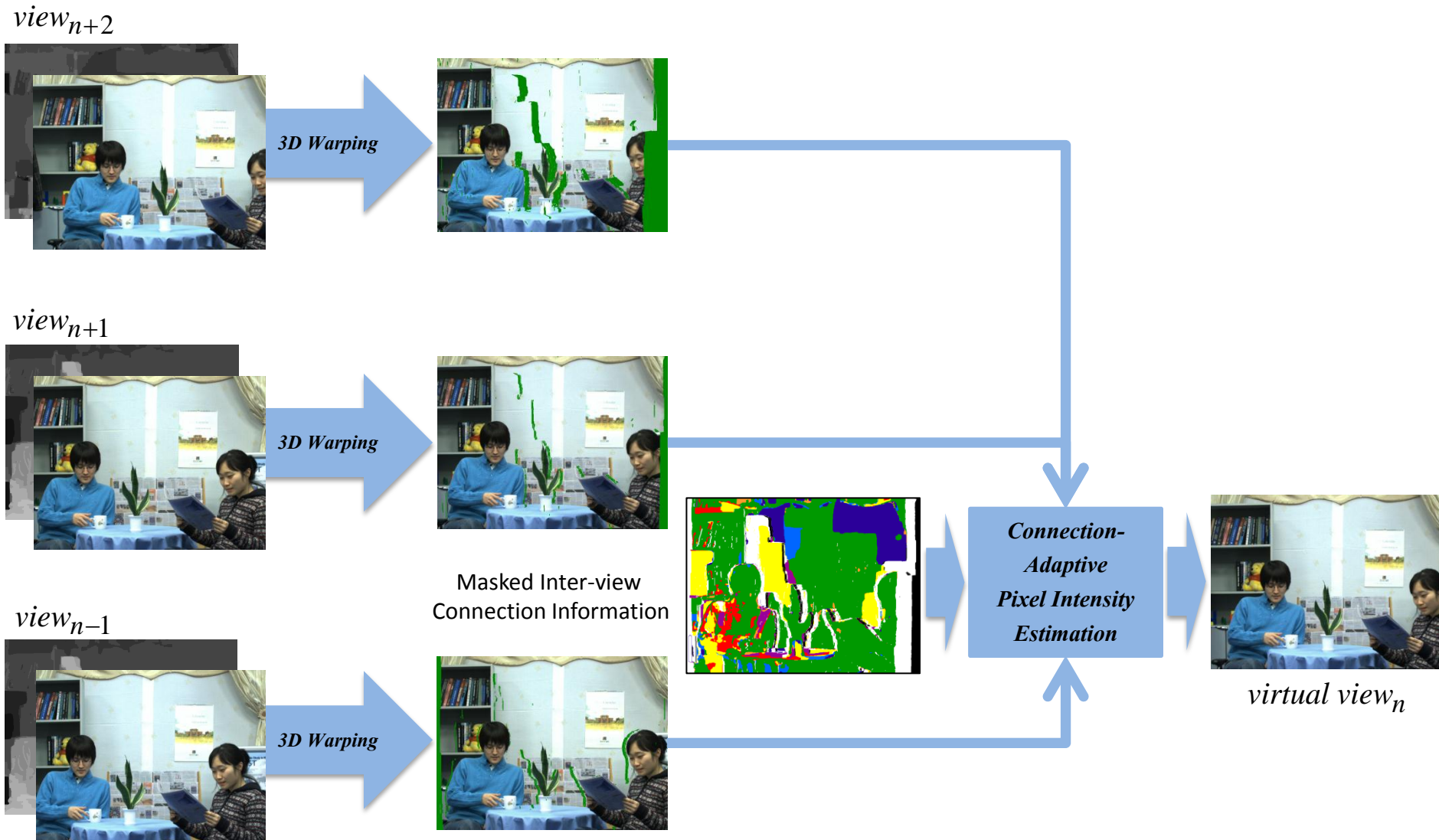
$view_{n+1}$



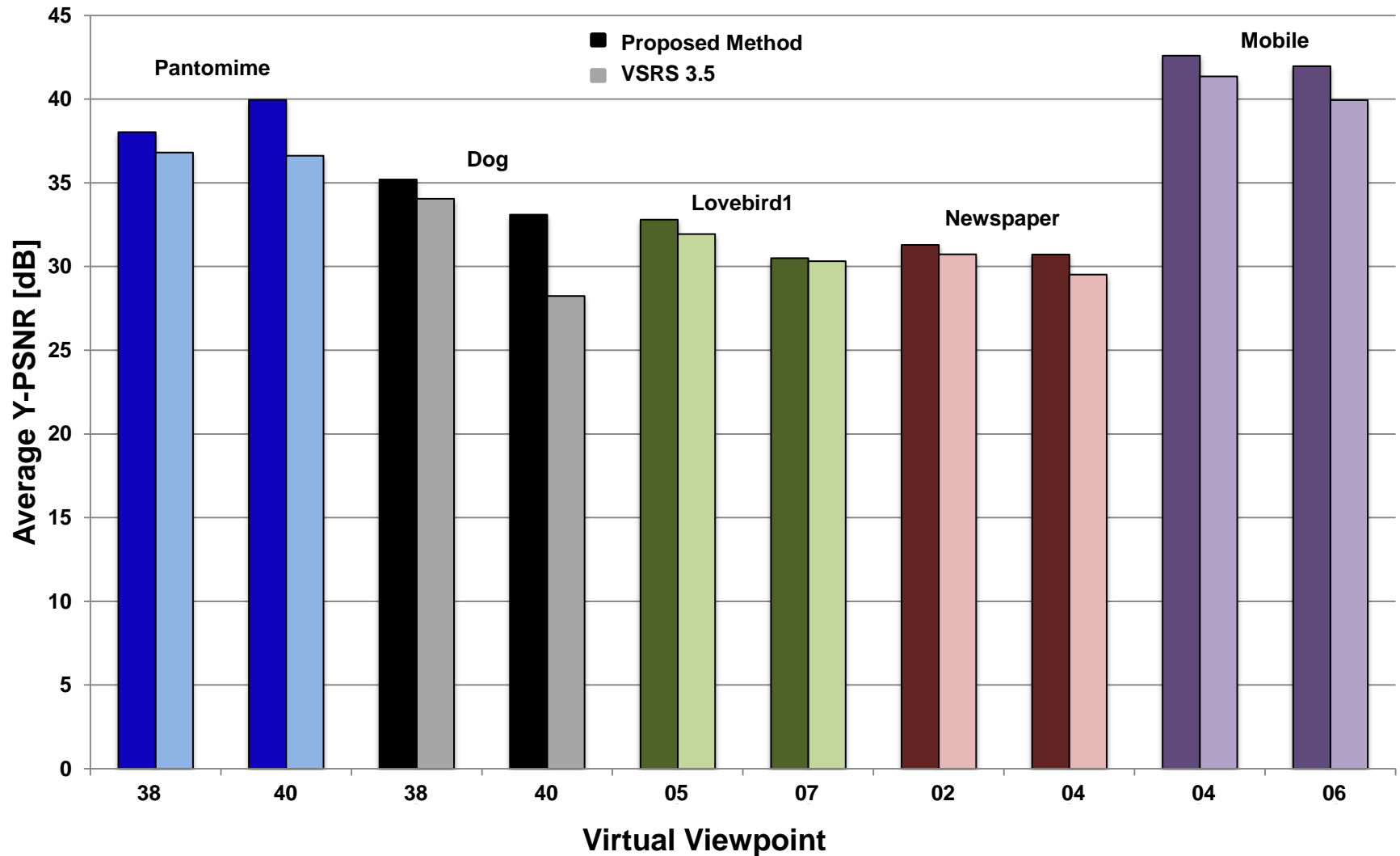
$view_{n-1}$



# Virtual View Rendering Using Inter-View Connection



# Experimental Results



# Experimental Results



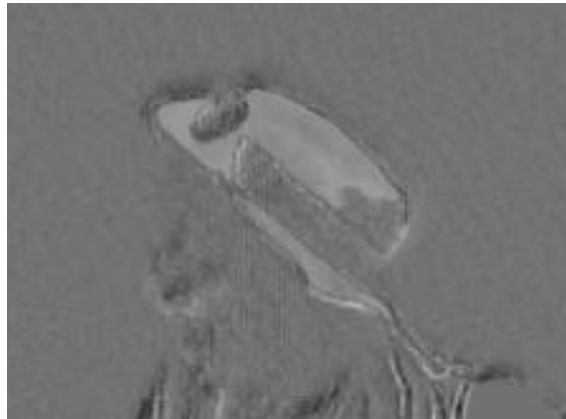
*Original*



*VSRS 3.5*

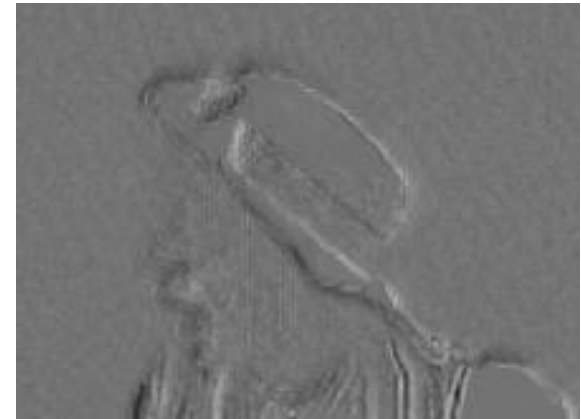


*Proposed Method*



*VSRS 3.5*

*Pantomime*



*Proposed Method*

# Conclusions

- It exploits the inter-view connectivity information among multiview video and takes advantage of a consistent principal depth map
- It addresses the problems of inter-view depth inconsistencies and varying illumination conditions
- Structured depth maps permit an appealing 3D scene representation on the encoder side by avoiding depth consistency testing for each interpolated pixel on the decoder side.
- It improves the subjective visual quality as well as the objective quality of rendered views

Thank You