Depth Consistency Testing for Improved View Interpolation

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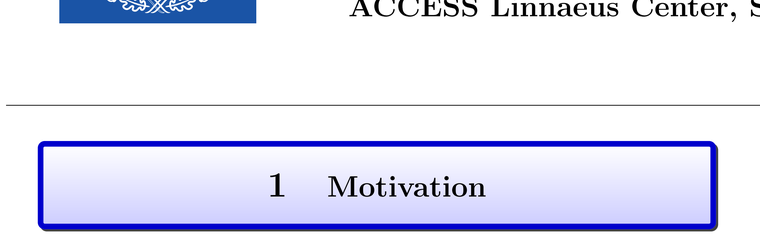
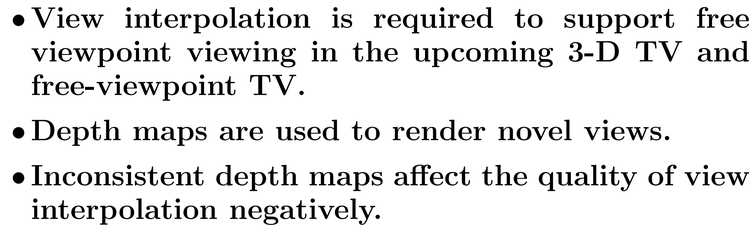
1 Motivation

- View interpolation is required to support free viewpoint viewing in the upcoming 3-D TV and free-viewpoint TV.
- Depth maps are used to render novel views.
- Inconsistent depth maps affect the quality of view interpolation negatively.

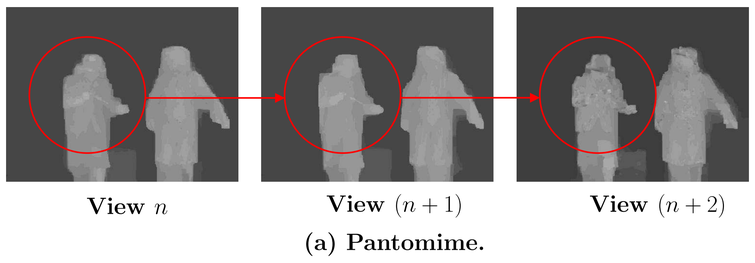
(a) Pantomime.



(b) Dog.



(c) Lovebird1.



(d) Newspaper.

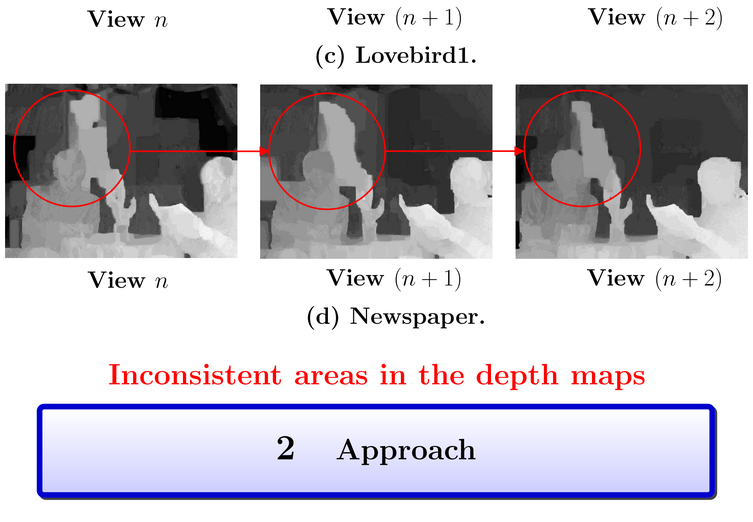
Inconsistent areas in the depth maps

2 Approach

Depth Consistency Testing

- Warp multiple reference depth maps to a virtual viewpoint
- Test the consistency among warped depth values and improve the depth value information
- Enhance the quality of view interpolation by using improved depth information

2.1 Multiple Depth Warping



$$ADM = \begin{pmatrix} 0 & h_{1,2} & h_{1,3} & \dots & h_{1,n} \\ h_{1,2} & 0 & h_{2,3} & \dots & h_{2,n} \\ h_{1,3} & h_{2,3} & 0 & \dots & h_{3,n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ h_{1,n} & h_{2,n} & h_{3,n} & \dots & 0 \end{pmatrix}$$

where, each $h_{j,k} = |d_j - d_k|$ is a *connection evidence*.

2.2 Connection Hypothesis Testing

Connection evidence is a measure of inter-view consistency.

Connection Threshold (T_f):

- A criterion for depth consistency for a frame f,

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

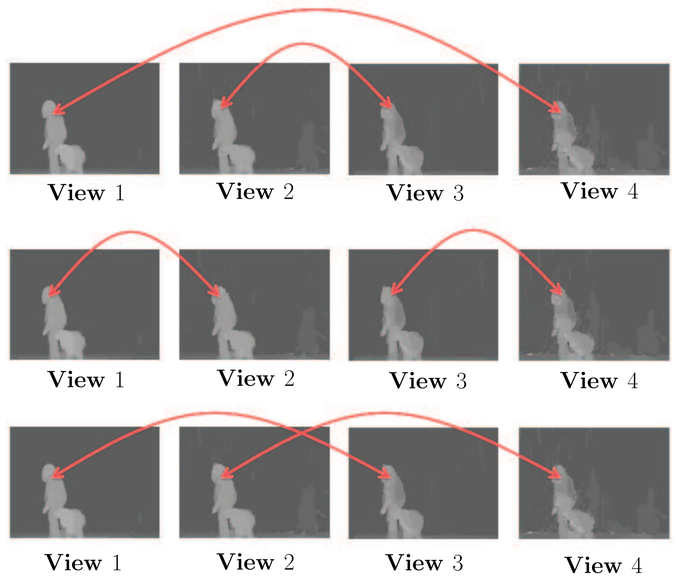
Testing Rules:

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

2.3 Example: Four Reference View Configuration

Various cases of connectivity:

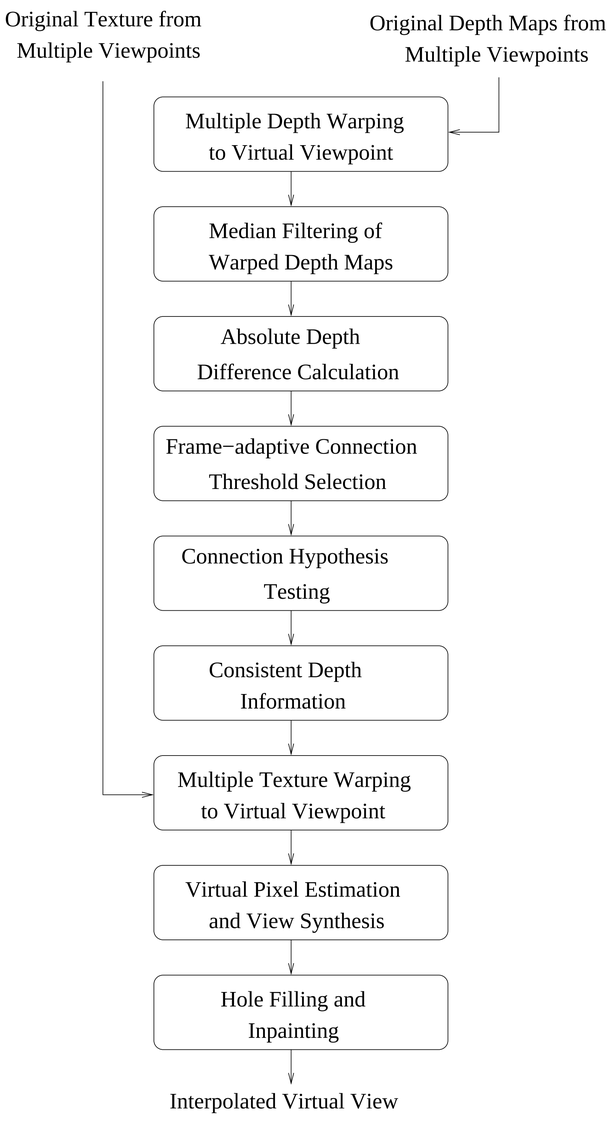
- ***Null-Hypothesis Case:*** Unable to determine a consistent pixel intensity.
- ***One-Hypothesis Case:*** Assume that the corresponding depth pixel pair describe the same 3-D object point.
- ***Two-Hypothesis Case:*** Two distinct pairs of warped depth values are individually consistent.



Two-hypothesis cases

Six-Hypothesis Case: All depth pixels are consistent.

3 Application to View Interpolation



- **Null-Hypothesis Case:** Use inpainting.
- **General-Hypothesis Case:** Warp specified pixels in the reference views to the virtual view.

Illumination-Adaptive Pixel Intensity Estimation:

- **Nearest Reference:** For significantly varying pixel intensities
- **Simple Averaging:** For similar pixel intensities
- **Weighted Averaging:** For irregular baseline views

4 Experimental Results

Four Reference View Configuration:

- Compare to MPEG View Synthesis Reference Software 3.5
- Obtain reference depth maps with MPEG Depth Estimation Reference Software 5.0

Test Sequence	Virtual View	Proposed Algorithm (a)	VSRS 3.5 (b)	△ Y-PSNR [dB] (c)=(a)-(b)
Pantomime	40	39.3	38.7	0.6
	43	38.5	37.2	1.3
Dog	40	35.0	31.4	3.6
	43	32.4	31.2	1.2
Lovebird1	05	33.2	32.6	0.6
	08	32.6	32.0	0.6
Newspaper	04	30.0	29.5	0.5
	05	32.5	29.3	3.2

(a) Original view. (b) VSRS 3.5.

(c) Proposed algorithm.

Synthesized view of Pantomime

(a) Original view. (b) VSRS 3.5.

(c) Proposed algorithm.

Synthesized view of Newspaper

5 Conclusion

- Improved inter-view connectivity among multiple depth maps resulting in consistent depth maps.
- Improved the quality of the synthesized views up to 3 dB when compared to VSRS 3.5.
- Future work: Use backward warping of consistent depth maps to improve depth maps at reference viewpoints.

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