



# Inverting a Rolling Shutter Camera: Bring Rolling Shutter Images to High Framerate Global Shutter Video

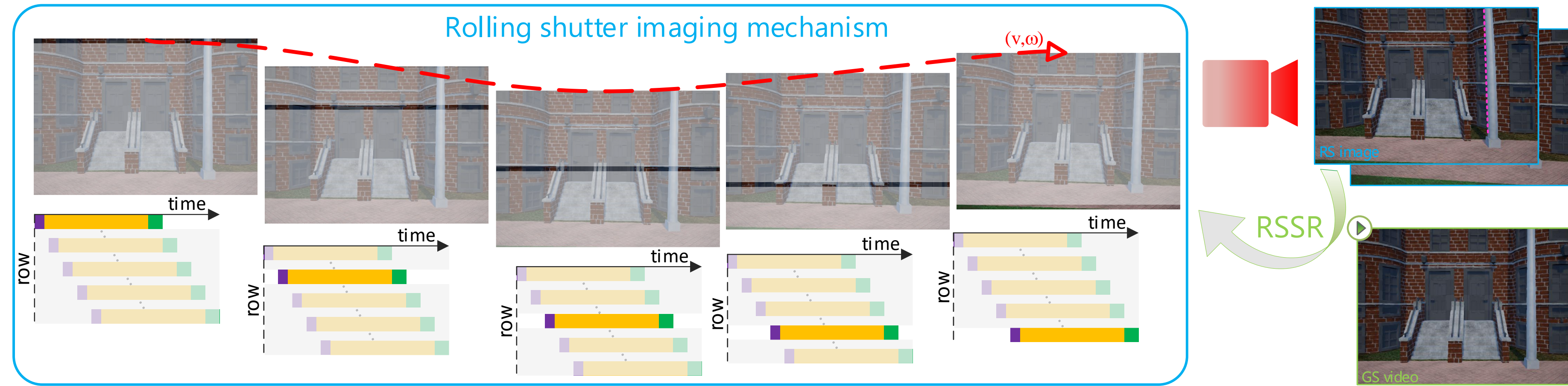
Bin Fan, Yuchao Dai\*

School of Electronics and Information, Northwestern Polytechnical University, Xi'an, China



## Objective

Inverting the rolling shutter (RS) imaging mechanism, *i.e.*, **RS temporal super-resolution (RSSR)**, is extremely challenging, *e.g.*, recovering 1440 global shutter (GS) image sequences from two 720-height rolling shutter images, which is far from being solved in the deep learning framework.



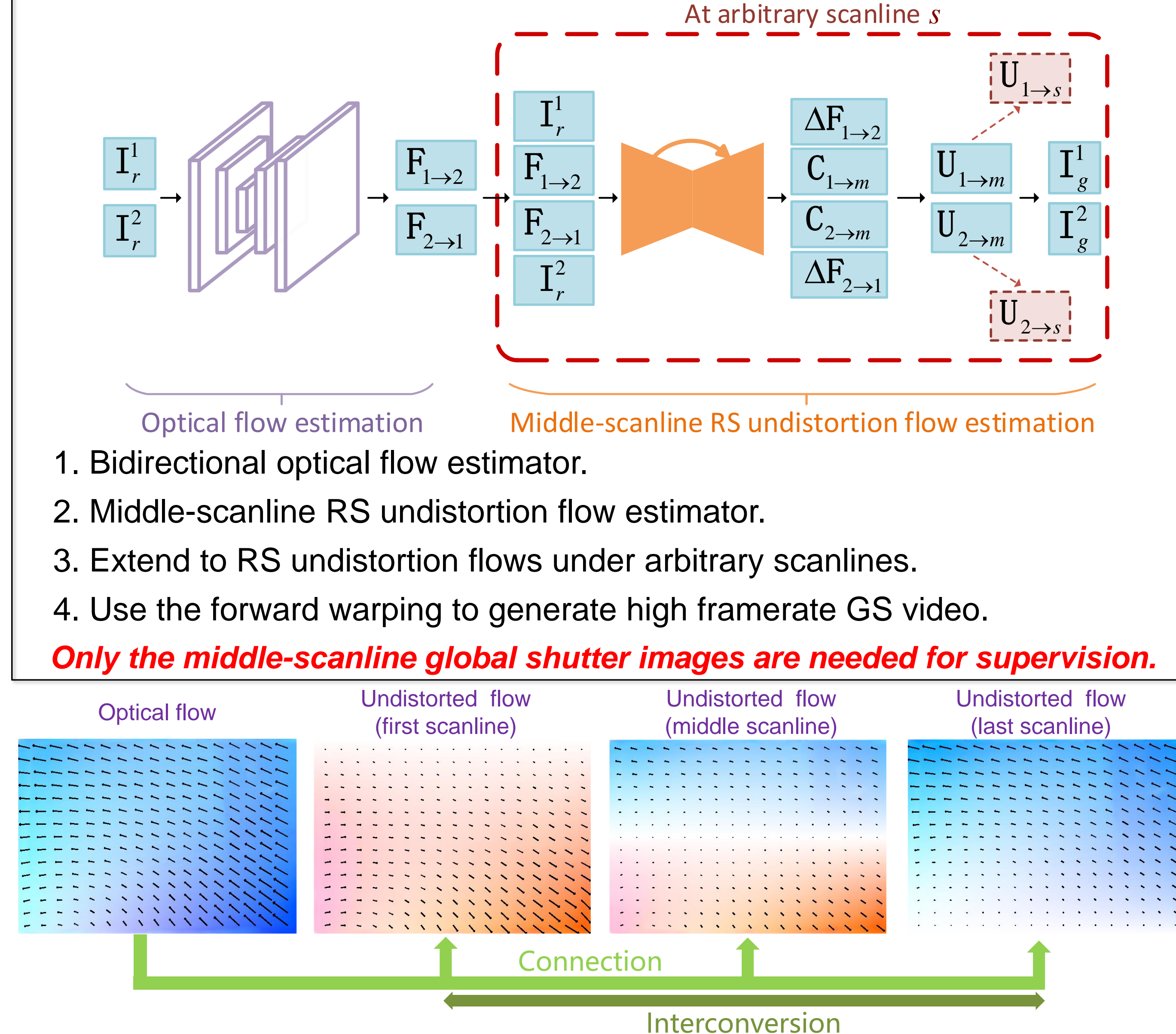
## Contribution

- Detailed proof of the scanline-dependent nature of the bidirectional RS undistortion flows:** the intrinsic geometrical nature of rolling shutter correction problem.
- The first geometry-aware learning-based RSSR solution:** extracting latent global shutter video sequence from two consecutive rolling shutter images, which brings rolling shutter images alive.
- Superior RSSR performance:** outperforming state-of-the-art methods in both rolling shutter effect removal and inference efficiency, and producing a smooth and continuous global shutter video.

$$\begin{bmatrix} \mathbf{u}_u^{i,j} \\ \mathbf{u}_v^{i,j} \end{bmatrix} = c \begin{bmatrix} \mathbf{f}_u^{i,j} \\ \mathbf{f}_v^{i,j} \end{bmatrix}, c \in \begin{cases} (0, 1) & \text{if } i < \frac{h}{2} \\ 0 & \text{if } i = \frac{h}{2} \\ (-1, 0) & \text{if } i > \frac{h}{2} \end{cases}$$

**Note:** We prove for the first time that there is a constrained linear relationship between RS undistortion flow and optical flow under the constant velocity assumption.

## RSSR Network Framework



## Results

### Performance on Carla-RS and Fastec-RS datasets

Method	PSNR↑			SSIM↑		LPIPS↓	
	CRM	CR	FR	CR	FR	CR	FR
DeepUnrollNet [20]	26.90	26.46	26.52	0.81	0.79	0.0703	0.1222
DiffHomo [42]	19.60	18.94	18.68	0.61	0.61	0.1798	0.2229
DiffSfM-PWCNet [41]	19.53	18.62	18.59	0.69	0.63	0.2042	0.2416
DiffSfM-RAFT [41]	24.20	21.28	20.14	0.78	0.70	0.1322	0.1789
RSSR (Ours)	30.17	24.78	21.26	0.87	0.78	0.0695	0.1424

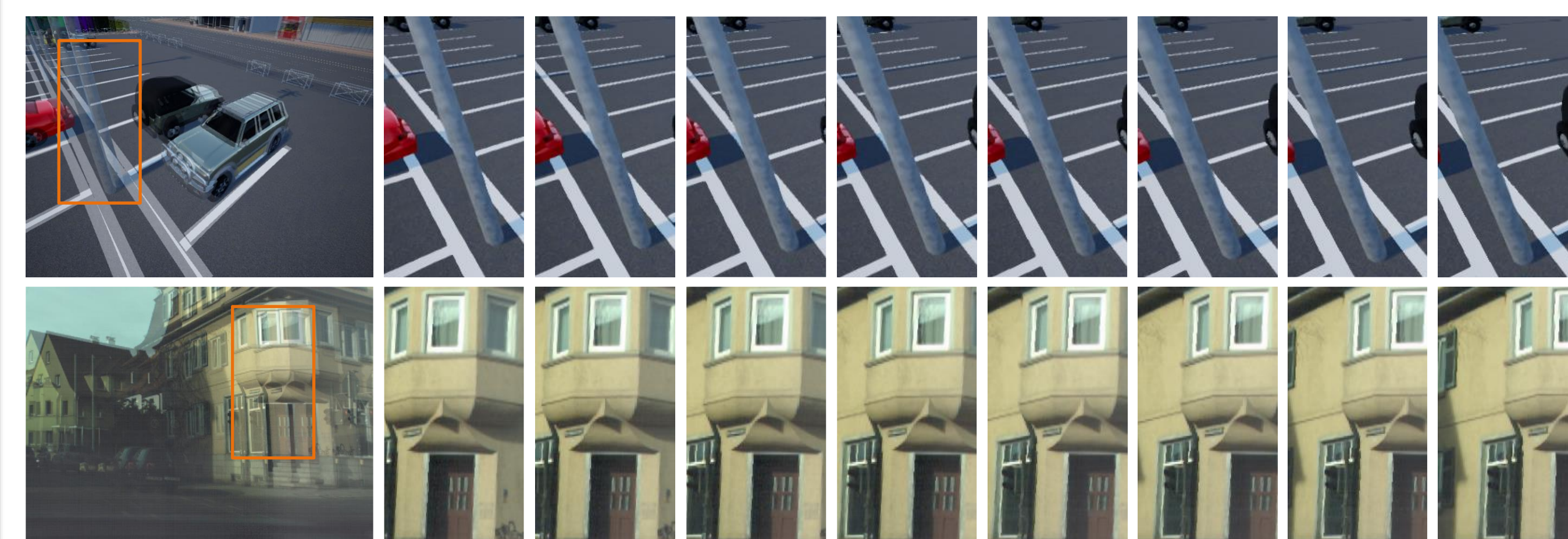
**Note:** Our method can produce a smooth video sequence far beyond the reach of [20].

### Qualitative results



Inputs (Overlay) DeepUnrollNet DiffHomo DiffSfM RSSR (Ours) Ground truth

### Generating high framerate global shutter video



Inputs (Overlay) I<sub>1</sub>→0.0h I<sub>1</sub>→0.3h I<sub>1</sub>→0.6h I<sub>1</sub>→0.9h I<sub>2</sub>→0.0h I<sub>2</sub>→0.3h I<sub>2</sub>→0.6h I<sub>2</sub>→0.9h

### Inference time

Method	Times	Outputs	
DeepUnrollNet (SOTA)	0.34 s	1 GS image	NVIDIA RTX 2080Ti GPU, 640×480 image resolution
Two-stage method	5 min	960 GS images	
RSSR (Ours)	0.12 s 1.8 s	2 GS images 960 GS images	

<https://github.com/GitCVfb/RSSR>