SUNet: Symmetric Undistortion Network for Rolling Shutter Correction

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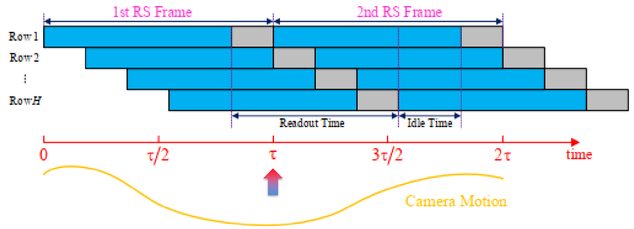
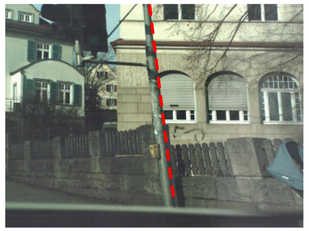
Introduction

- **Enlightening Observation**: The first and second rolling shutter images have different contributions to different regions of the time-centered global shutter image.
- **Distinct Advantage:** The use of symmetric architecture to improve the efficient aggregation of contextual information.
- **Major Innovations:** Context-aware cost volume layer and symmetric consistency constraint effectively aggregate the contextual cues of two input rolling shutter images.

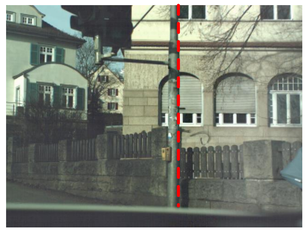
Motivation



- Rolling shutter cameras are usually time-synchronized with other sensors (*e.g.*, global shutter camera, IMU, *etc.*) by referring to the first scanline time.
- It is of both theoretical interest and great practical importance to **recover the global shutter image corresponding to the first scanline of the second frame** (*i.e.*, the intermediate time τ of these two frames).



Rolling shutter image



Global shutter image

Rolling shutter image 1

Rolling shutter image 2

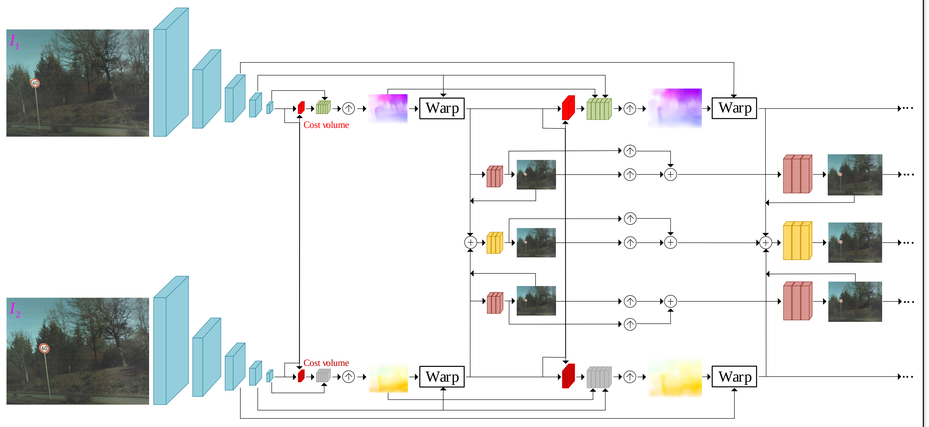
Ground truth global shutter image

Predicted only by rolling shutter 1

Predicted only by rolling shutter 2

Our final corrected image

Symmetric Undistortion Network



1. PWC-based undistortion flow estimator
   - **Symmetric network architecture:** estimate the pixel-wise undistortion flows based on PWC (pyramid, warping, and context-aware cost volume).
   - **Context-aware cost volume:** promote contextual consistency at different scales.
2. Time-centered global shutter image decoder
   - **Symmetric consistency constraint:** facilitate contextual in a coarse-to-fine manner.

Results

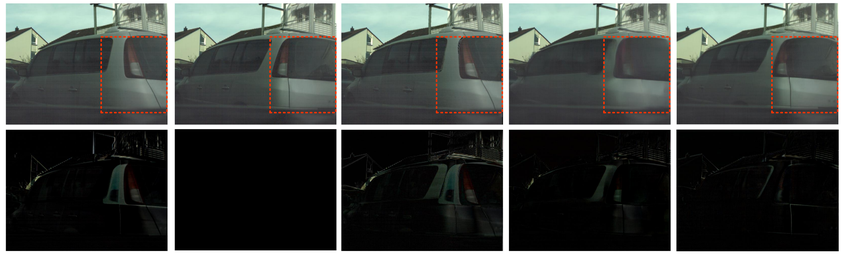
Performance on Carla-RS and Fastec-RS benchmarks

Methods	PSNR↑ (dB)			SSIM↑	
	CRM	CR	FR	CR	FR
SMARSC [38]	18.70	18.47	-	0.58	-
DiffSfM [36]	25.93	22.88	21.44	0.77	0.71
DSUN [20]	26.90	26.46	26.52	0.81	0.79
SUNet (Ours)	**29.28**	**29.18**	**28.34**	**0.85**	**0.84**

Inference time

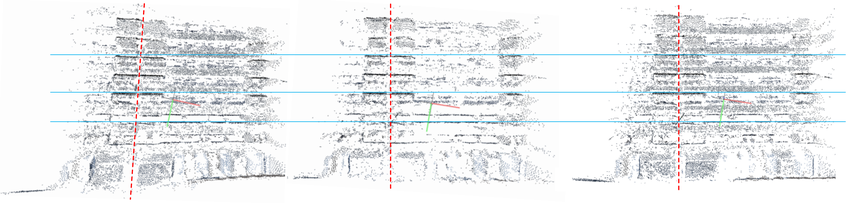
Method	Time	Hardware
DiffSfM (SOTA classic-model-based)	~ 8 minutes	i7-7700K CPU
DSUN (SOTA deep-learning-based)	0.34 seconds	NVIDIA GeForce 2080Ti GPU
SUNet (Ours)	**0.21 seconds**	NVIDIA GeForce 2080Ti GPU
	640×480 image resolution	

Qualitative results



Input | Ground truth | Zhuang *et al.* | Liu *et al.* | Ours

3D reconstruction



Original result | Corrected result | Ground truth

https://github.com/GitCVfb/SUNet