ComputerVisionLab
Seoul National University

AIM 2020 Challenge on Video Temporal Super-Resolution

Sanghyun Son, Jaerin Lee, Seungjun Nah, †Radu Timofte, Kyoung Mu Lee

Department of ECE, ASRI, SNU, Korea
†CVL, ETH Zurich

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CVL Computer Vision Lab

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AIM 2020

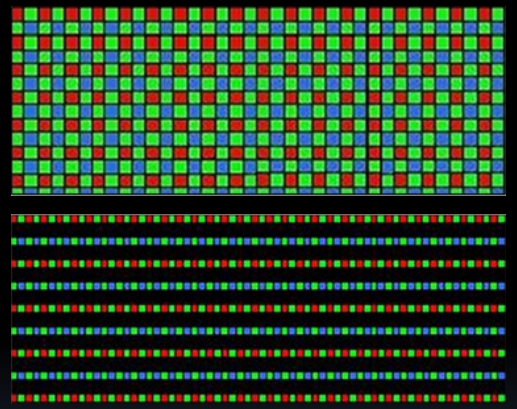

15 fps video
60 fps video
banila co.
Foam Machine
QX-1000

Recording High-Speed Videos

- **Hardware requirements**
  - Fast processor
  - Large & fast storage

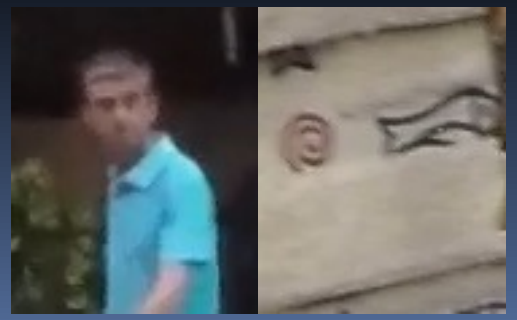
Large & Fast storage

- **Visual quality degradation**
  - Low effective resolution (line skips)
  - High compression
  - Short exposure & high noise



Bayer sensor full pattern

Line skipping at readout

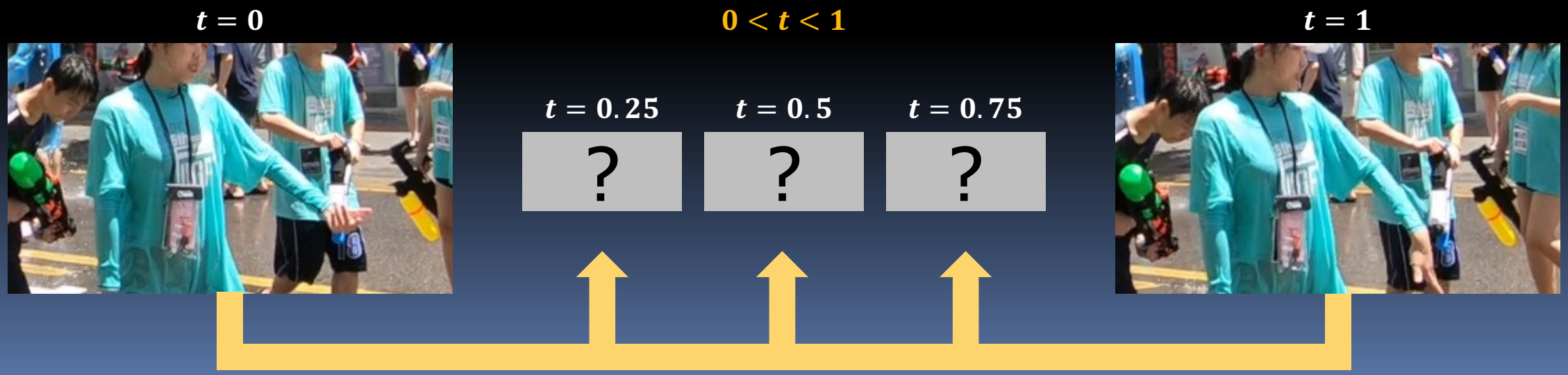


GoPro Hero4 240 fps

Video Frame Interpolation

- **Goal**
  - Enhance temporal smoothness by interpolating frames

- **Challenges**
  - Real-world motions are highly complex
  - Efficient algorithms are required to handle thousands of frames



REDS_VTSR Dataset

- Real-world dataset for AIM 2019 and 2020 VTSR Challenges
  - **Strong dynamics** with **nonlinear motion**
  - Diverse scenes and locations
  - Provides 15, 30, 60 fps videos for the same scene
  - High-quality, 1280×720 (HD) resolution


Zoo, Korea


Old Village, Korea


Street, Turkey


Harbor, Turkey


Uphill, Germany

VTSR Datasets: Quantitative Comparison

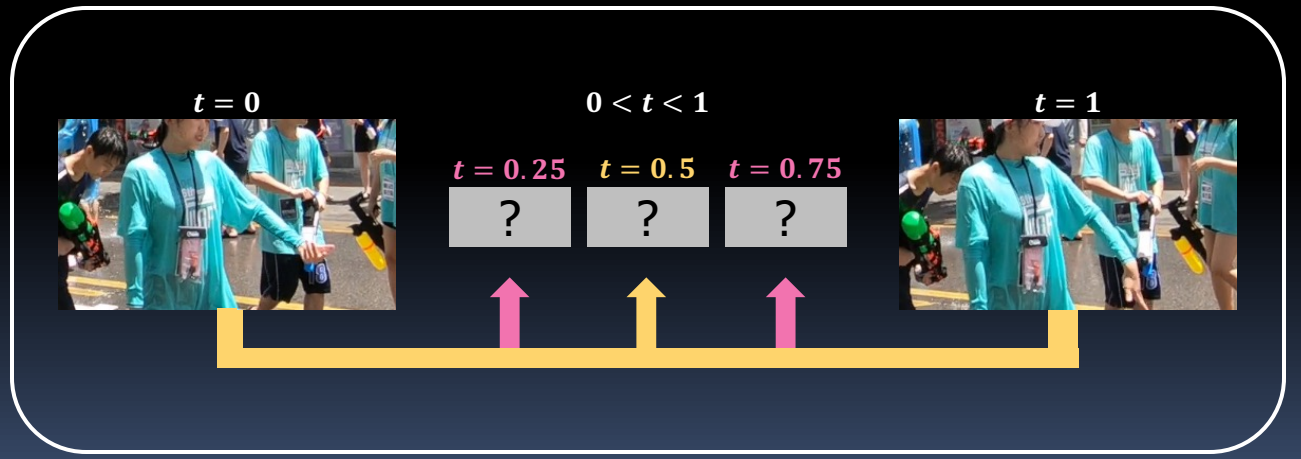
Dataset	Resolution	fps	#Sequences	#Frames	Note
For Training					
YouTube clips	Varying resolutions	Varying fps	-		Collected from YouTube
UCF101			13,320	-	
Vimeo-90k			73,171	219,513	Triplet dataset
KITTI raw			56	16,951	
GoPro (Nah *et al.**)	1280×720 (HD)		33	3,214	Captured by GoPro 4
DAVIS 2016+2017	720×480 (SD)		200	13,914	
REDS_VTSR	**1280×720 (HD)**	**Maximum 60 fps**	**240**	**43,200**	**Captured by GoPro 6**
For Evaluation (Validation + Test)					
Middlebury	Varying resolutions	Varying fps	8	58	
THUMOS 2015			5,613	-	
SlowFlow			46	-	Captured by TS5Q camera
Sintel			19	-	Synthetic
HD			11	-	
REDS_VTSR	**1280×720 (HD)**	**Maximum 60 fps**	**60**	**10,800**	**Captured by GoPro 6**

*Nah *et al.*, "Deep Multi-scale Convolutional Neural Network for Dynamic Scene Deblurring," in CVPR 2017.

AIM 2020 VTSR Challenge

- **Goal**
  - Encourage development of the **state-of-the-art** Video Temporal Super-Resolution (a.k.a. frame interpolation) algorithm
  - Compare various methods in a unified environment

- **Task**
  - 15 fps video → 30 fps video
    → 60 fps video



AIM 2020 VTSR Challenge

- **Evaluation**
  - **240** training + **30** validation sequences provided (with ground-truth)
  - Tested on disjoint **30** sequences (no ground-truth provided)

- **Metrics**
  - **PSNR** / SSIM
  - Reproducibility / Runtime (for reference)
  - LPIPS* (experimental)
    - Reference-based perceptual metric
    - Shows better correlation with human perception

*Zhang *et al.*, "The Unreasonable Effectiveness of Deep Features as a Perceptual Metric," in CVPR 2018.

AIM 2020 VTSR Challenge

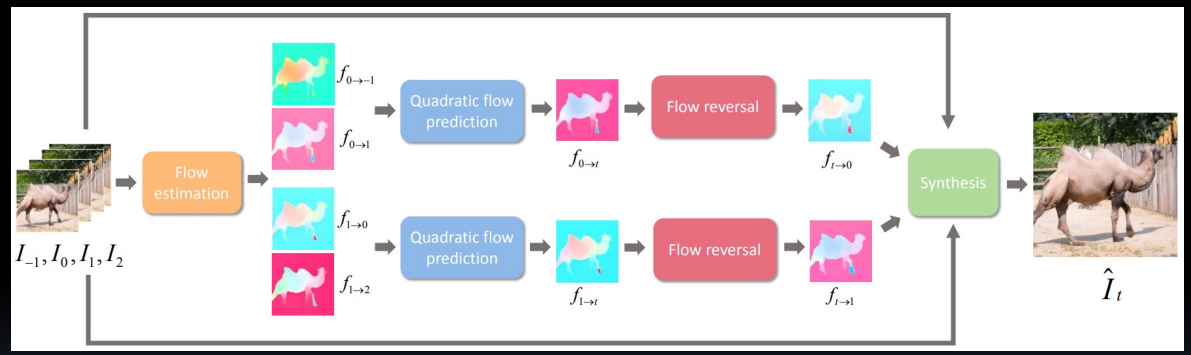
- **Challenge schedule**
  - May 1st, 2020: Development phase starts
  - July 10th, 2020: Testing phase starts
  - July 17th, 2020: Testing phase finishes
  - July 19th, 2020: Final rank announcement

- **Participants**
  - **68** participants in the CodaLab
  - **5** teams submitted their final solutions (one withdrawn)

Review: AIM 2019 VTSR Challenge

- The winner: **Quadratic Video Interpolation (QVI)**

from the **SenseSloMo** team



$$f_{0\to t} = \frac{f_{0\to1} + f_{0\to-1}}{2} t^2 + \frac{f_{0\to1} - f_{0\to-1}}{2} t$$

Li *et al.*, "Quadratic Video Interpolation for VTSR Challenge," in AIM 2019 Workshop in conjunction with ICCV 2019.
Xu *et al.*, "Quadratic Video Interpolation," in NeurIPS 2019.

AIM 2020 VTSR Challenge: Methods

- **XPixel (Challenge Winner)**
  - Enhanced Quadratic Video Interpolation
- **KAIST-VICLAB**
  - Quadratic Video Frame Interpolation with Multi-frame Synthesis Network
- **BOE-IOT-AIBD**
  - Multi Scale Quadratic Interpolation
- **TTI**
  - STARnet*

- **Top 3** methods are based on the **QVI** model!

*Haris *et al.*, "Space-Time-Aware Multi-Resolution Video Enhancement," in CVPR 2020.

AIM 2020 VTSR Challenge: Results

All values are reproduced by challenge organizers

15 fps → 30 fps	PSNR↑	SSIM↑	LPIPS↓*	Reproducibility	Runtime**
XPixel (Winner)	**24.78**	0.7118	0.268	O	12.4s / frame
KAIST-VICLAB	24.69	0.7142	**0.222**	O	1.5s / frame
BOE-IOT-AIBD	24.49	0.7034	0.249	O	1.0s / frame
TTI	23.59	0.6720	0.289	O	6.5s / frame
QVI (AIM 2019 Winner)	24.56	0.7065	-	O	-

15 fps → 60 fps	PSNR↑	SSIM↑	LPIPS↓*	Reproducibility	Runtime**
XPixel (Winner)	**25.69**	0.7425	0.214	O	-
KAIST-VICLAB	25.61	0.7462	**0.181**	O	-
BOE-IOT-AIBD	25.27	0.7269	0.230	O	-
TTI	24.36	0.6995	0.253	O	-
QVI (AIM 2019 Winner)	25.47	0.7383	-	O	-

*Experimental. Zhang *et al.*, "The Unreasonable Effectiveness of Deep Features as a Perceptual Metric," in CVPR 2018.
Measured on a single **Quadro RTX 8000 GPU for team TTI (due to the memory requirements), **RTX 2080 Ti** for the other teams.


banila co.
삼계탕
GT


CAFFÉ PASCUCCI
banila co.
PREMIUM STORE
삼계탕
XPixel


banila co.
KAIST-VICLAB

AIM 2020 VTSR Challenge: Results

- Frames with high performance variances
  - One shows superior performances than the others

Seq. 16 Frame 358
15 fps → 60 fps

GT
(PSNR/LPIPS)

XPixel
(**32.64**/**0.072**)

KAIST-VICLAB
(22.42/0.242)

BOE-IOT-AIBD
(23.86/0.254)

TTI
(30.64/0.168)

AIM 2020 VTSR Challenge: Results

- Frames with high performance variances
  - One shows superior performances than the others

Seq. 19 Frame 182
15 fps → 60 fps

GT
(PSNR/LPIPS)

XPixel
(29.33/0.171)

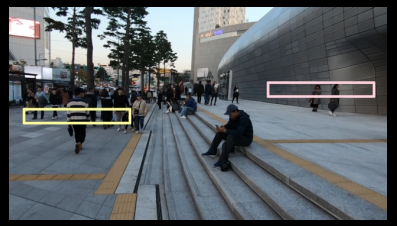
KAIST-VICLAB
(**30.19/0.143**)

BOE-IOT-AIBD
(27.89/0.197)

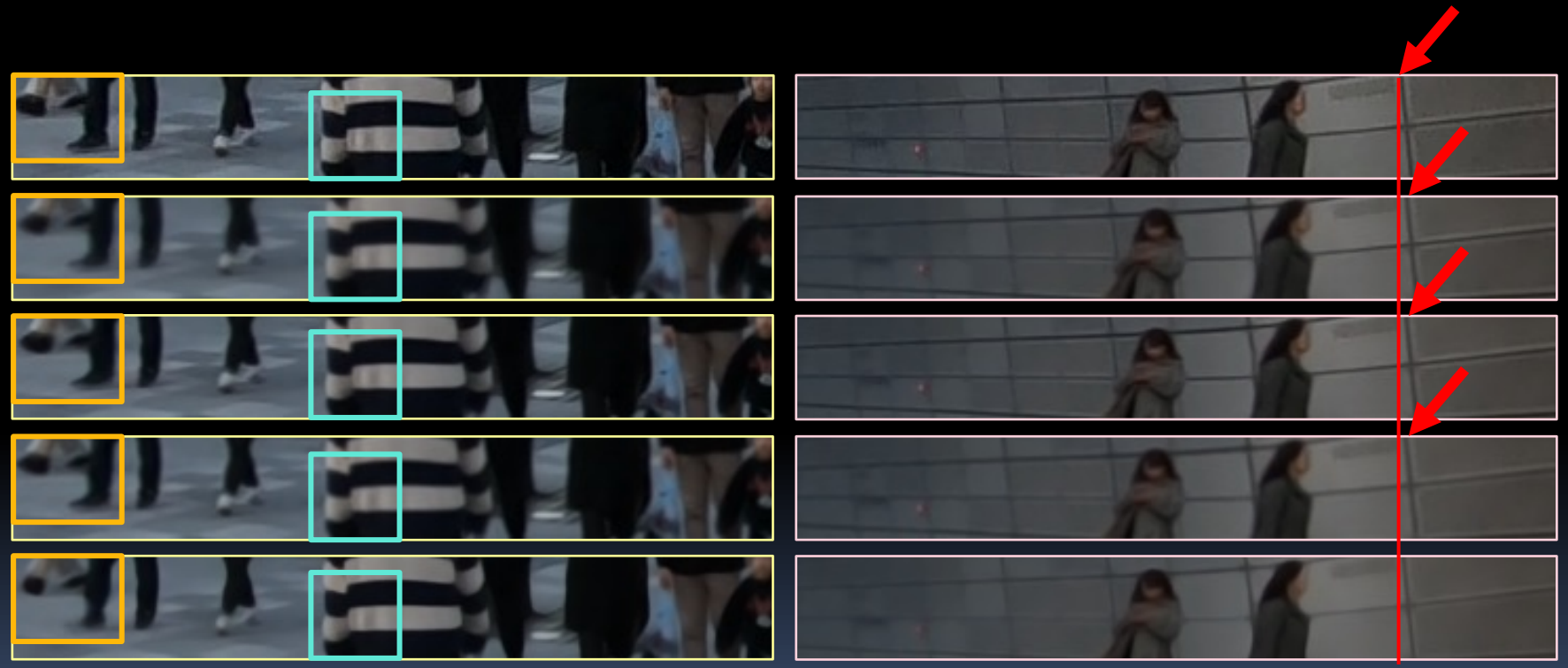
TTI
(20.30/0.226)

AIM 2020 VTSR Challenge: Results

- Frames with high performance variances
  - One shows superior performances than the others



Seq. 29 Frame 134
15 fps → 60 fps



GT
(PSNR/LPIPS)

XPixel
(23.33/0.167)

KAIST-VICLAB
(22.92/**0.100**)

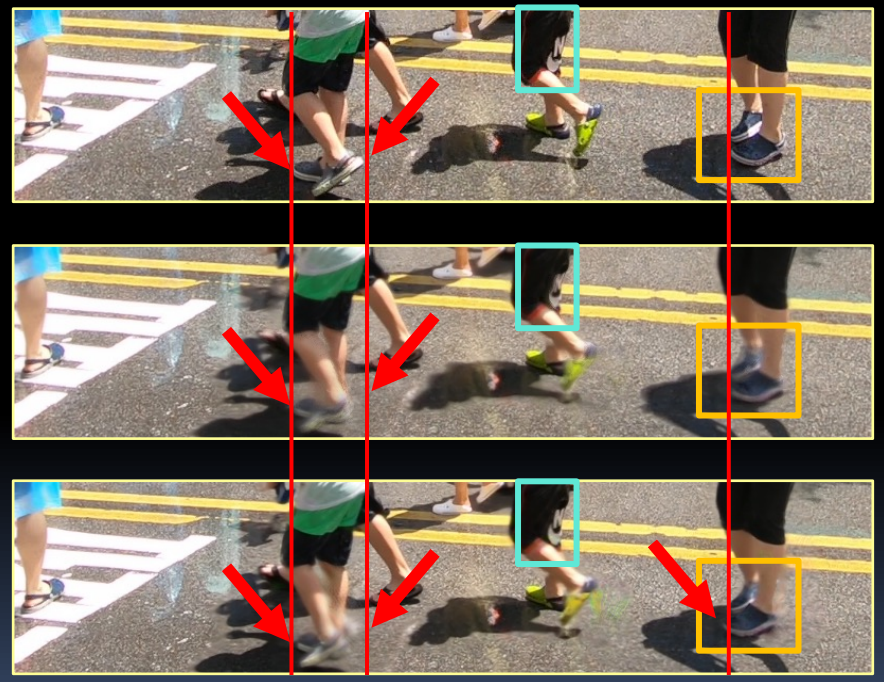
BOE-IOT-AIBD
(23.86/0.166)

TTI
(**29.11**/0.158)

AIM 2020 VTSR Challenge: Results

- PSNR vs. LPIPS (Experimental)

Seq. 7 Frame 358
15 fps → 60 fps



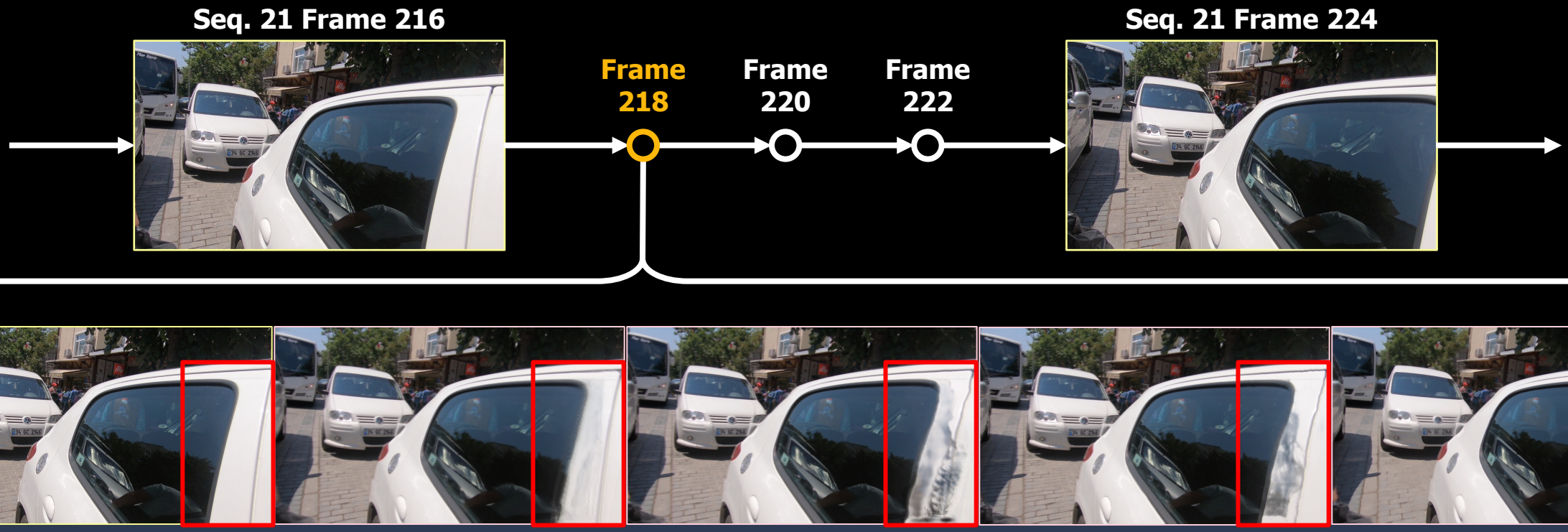
GT
(PSNR/LPIPS)

XPixel
(**27.04**/0.085)

KAIST-VICLAB
(25.67/**0.070**)

AIM 2020 VTSR Challenge: Results

- Failure cases
  - Still have rooms for improvement!



AIM 2020 VTSR Challenge: Results

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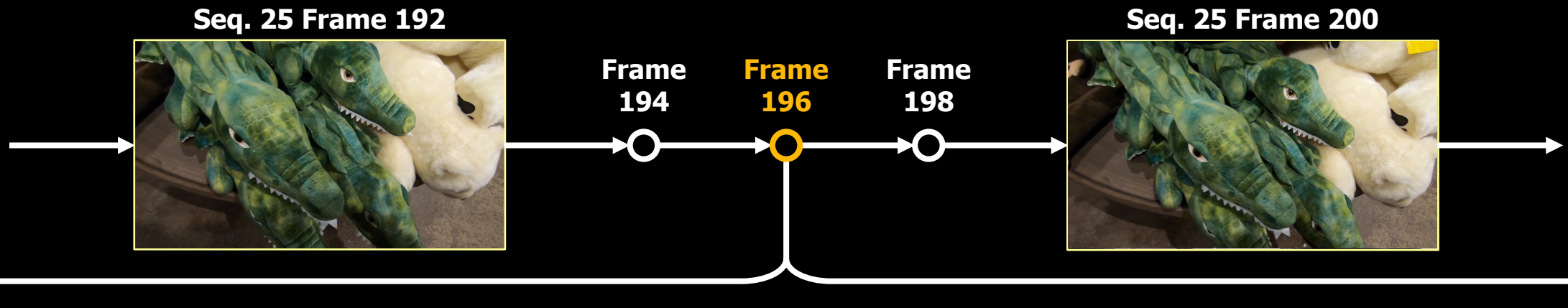
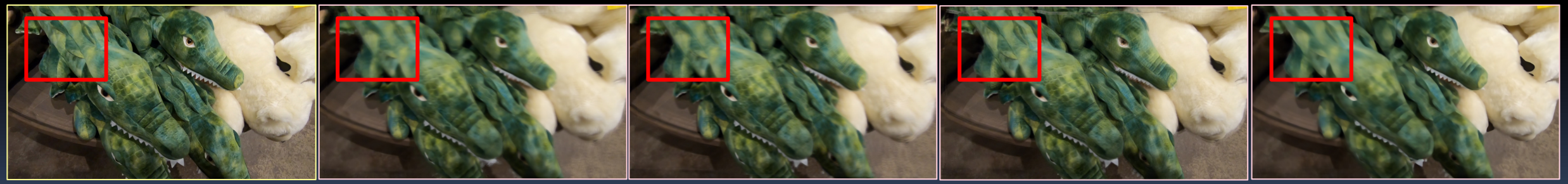




GT
(PSNR/LPIPS)

XPixel
(24.25/0.416)

KAIST-VICLAB
(23.43/0.417)

BOE-IOT-AIBD
(22.70/**0.267**)

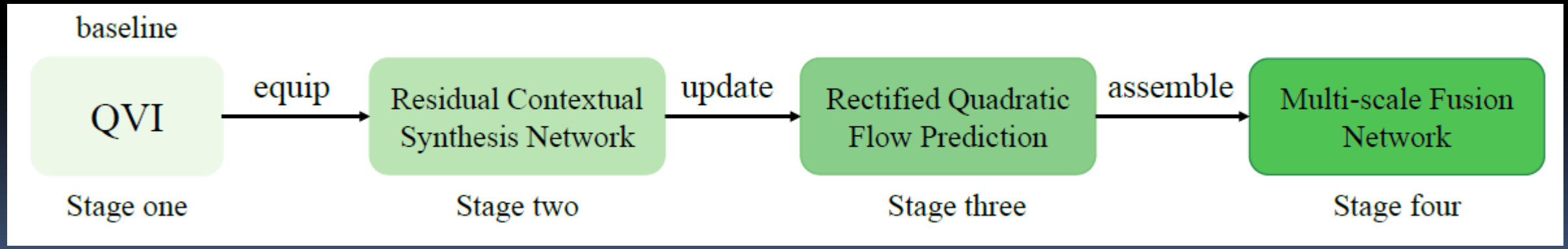
TTI
(**28.41**/0.354)

The Winning Method

Enhanced Quadratic Video Interpolation

from the **XPixel** team

Yihao Liu, Xie Liangbin, Li Siyao, Wenxiu Sun,
Yu Qiao, and Chao Dong



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Thank you

https://data.vision.ee.ethz.ch/cvl/aim20/

Contact:
(AIM 2020 VTSR official) aim2020.vtsr@gmail.com
(Sanghyun Son) sonsang35@gmail.com