



**SIGGRAPH
ASIA 2023
SYDNEY**

ExtraSS: A Framework for Joint Spatial Super Sampling and Frame Extrapolation

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Background



LOW PERFORMANCE

Background

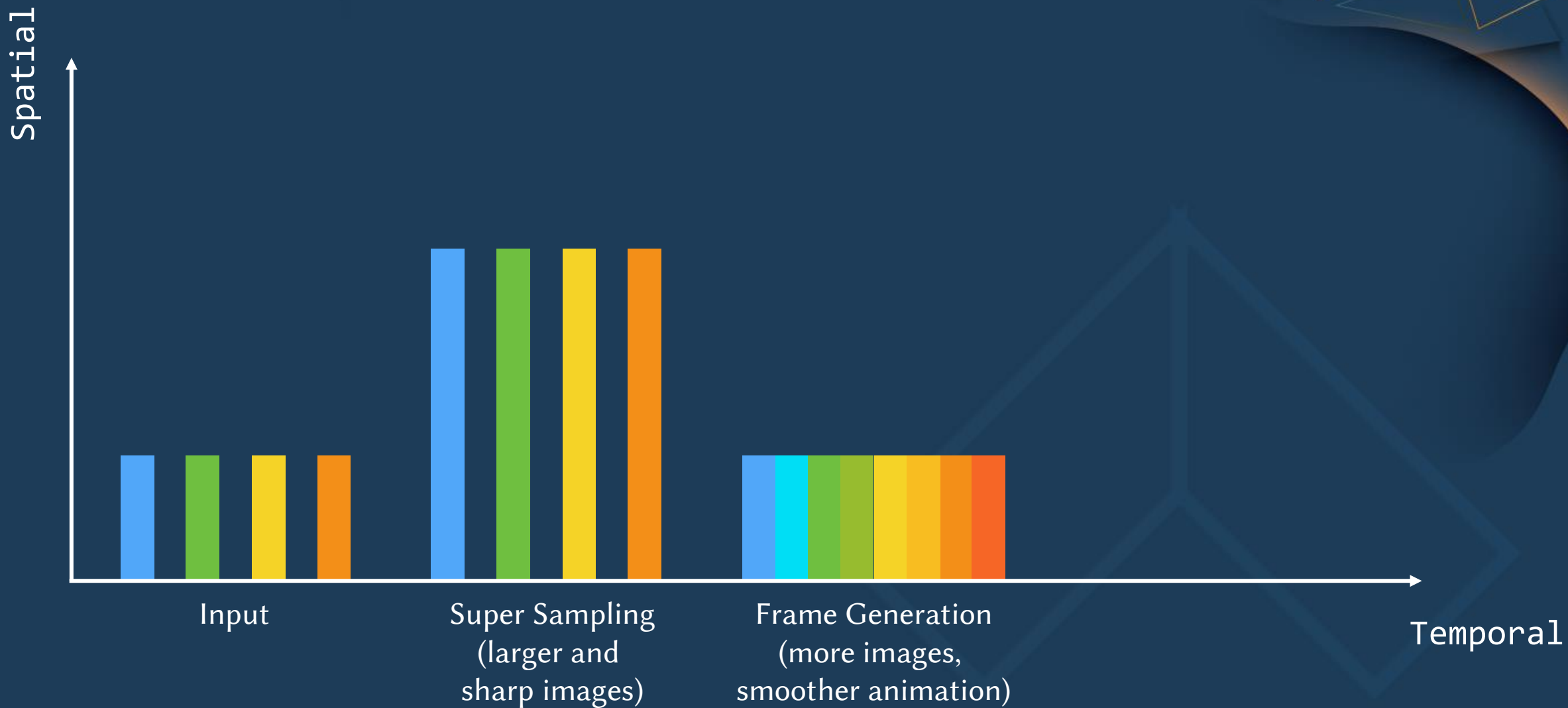
LOW PERFORMANCE



High quality results in real time rendering

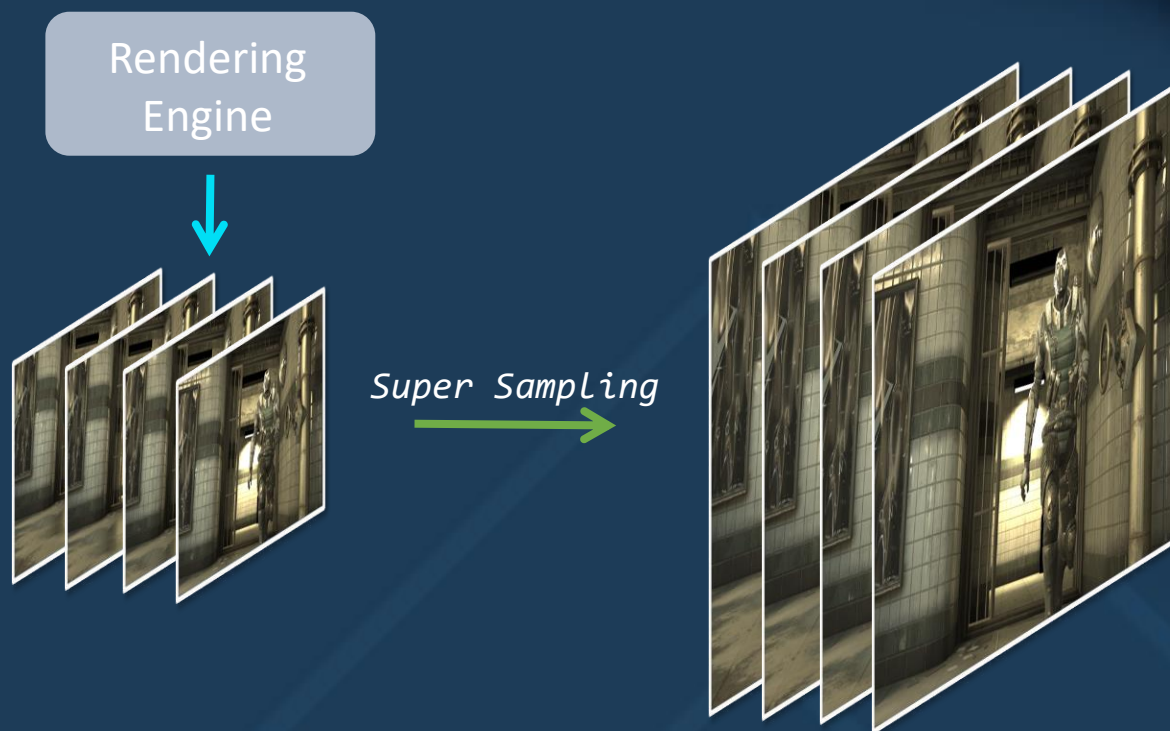
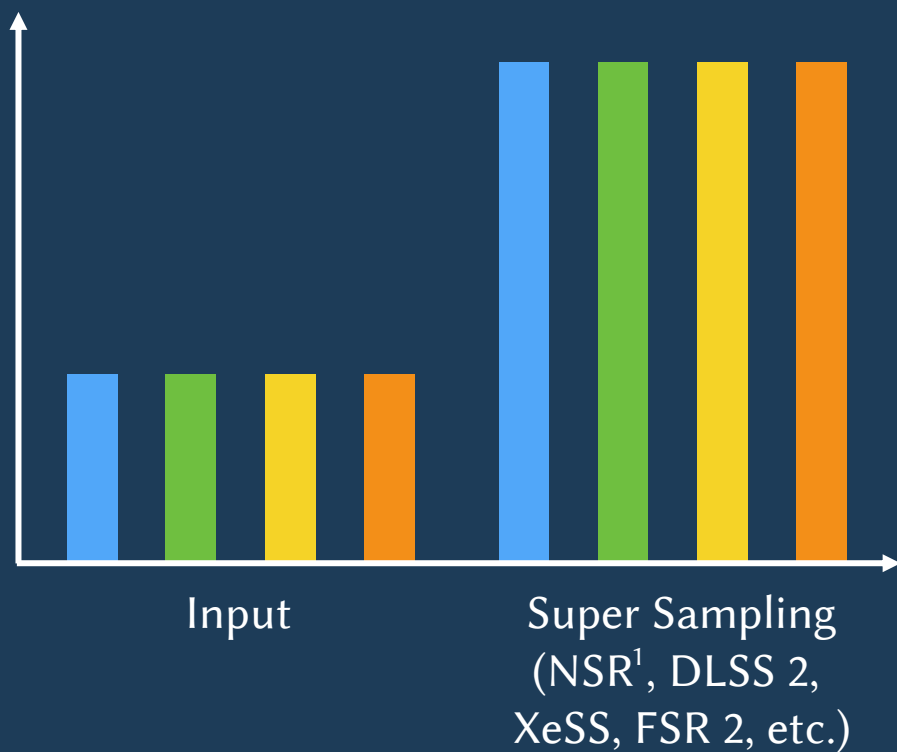


Related Work



Related Work

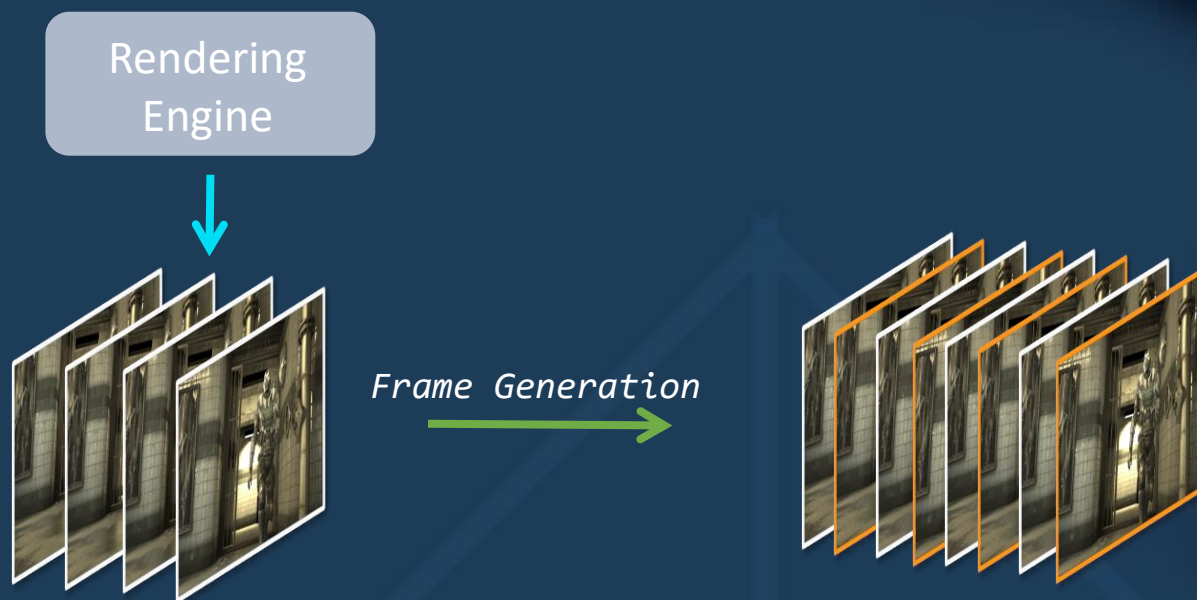
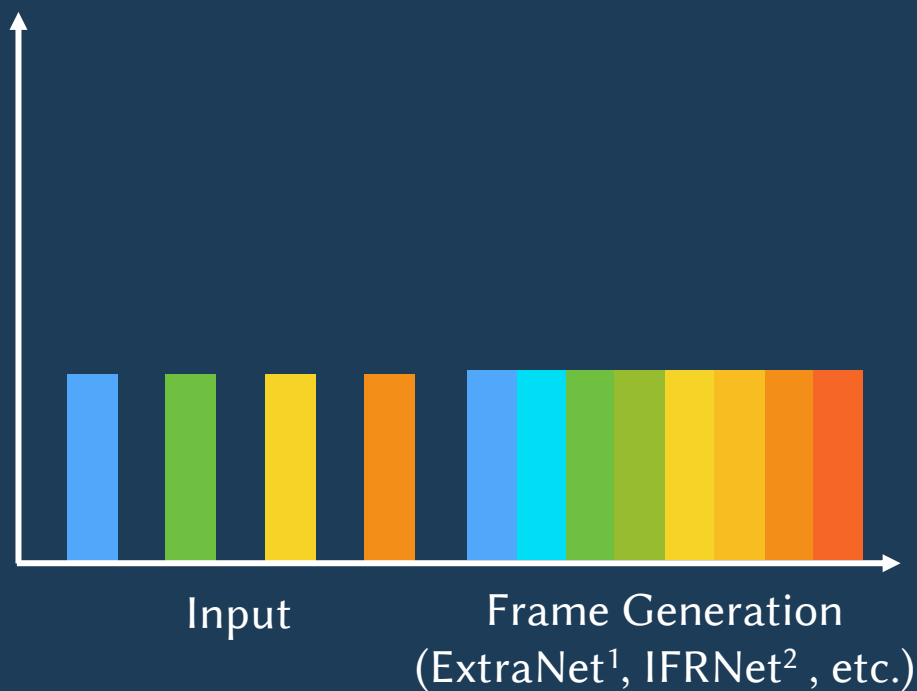
Super Sampling



1. Xiao, Lei, et al. 2020 "Neural supersampling for real-time rendering."

Related Work

Frame Generation



1. Guo, Jie, et al 2021. "Extranet: Real-time extrapolated rendering for low-latency temporal supersampling."
2. Kong, Lingtong, et al. 2022 "Ifnnet: Intermediate feature refine network for efficient frame interpolation."

Related Work

Frame Generation



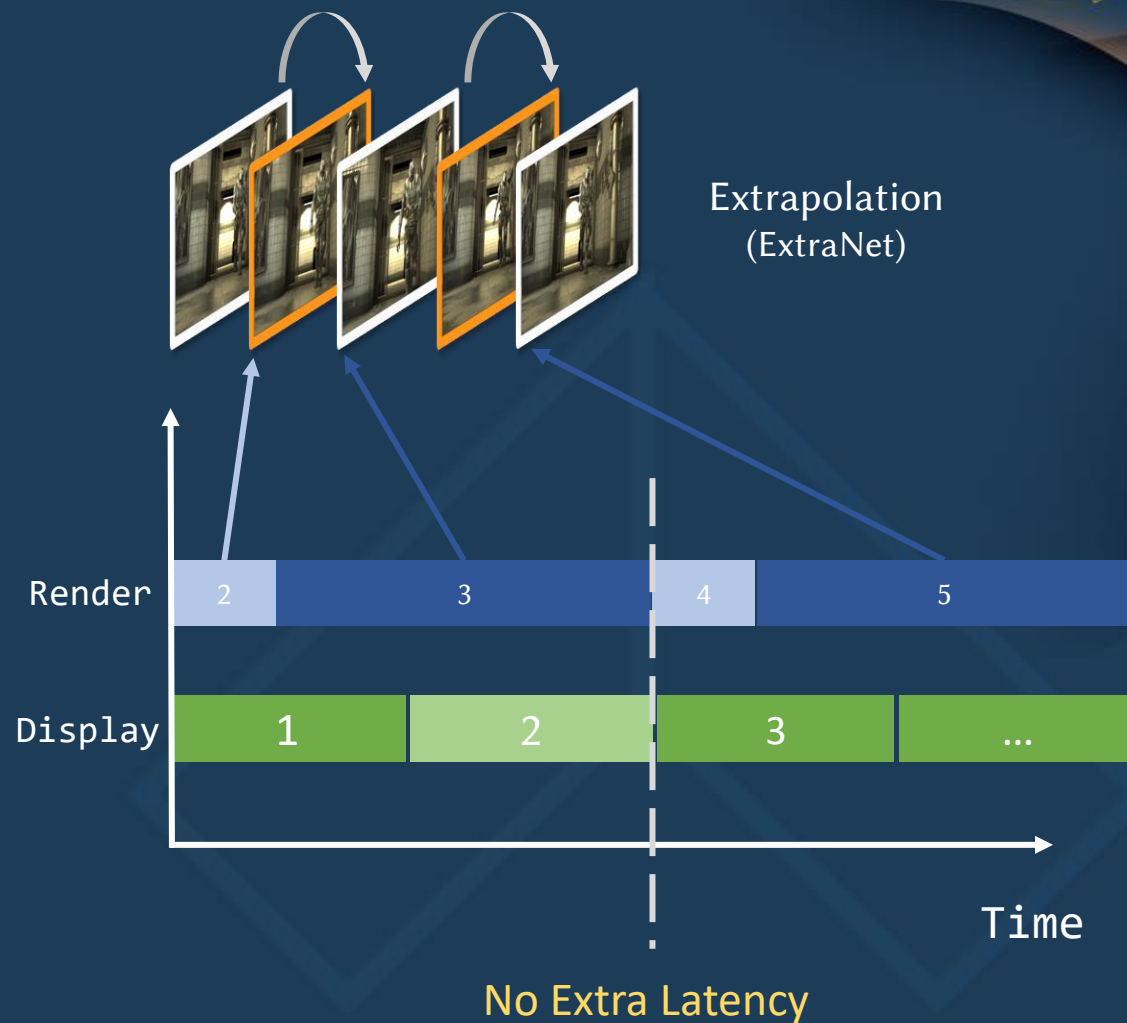
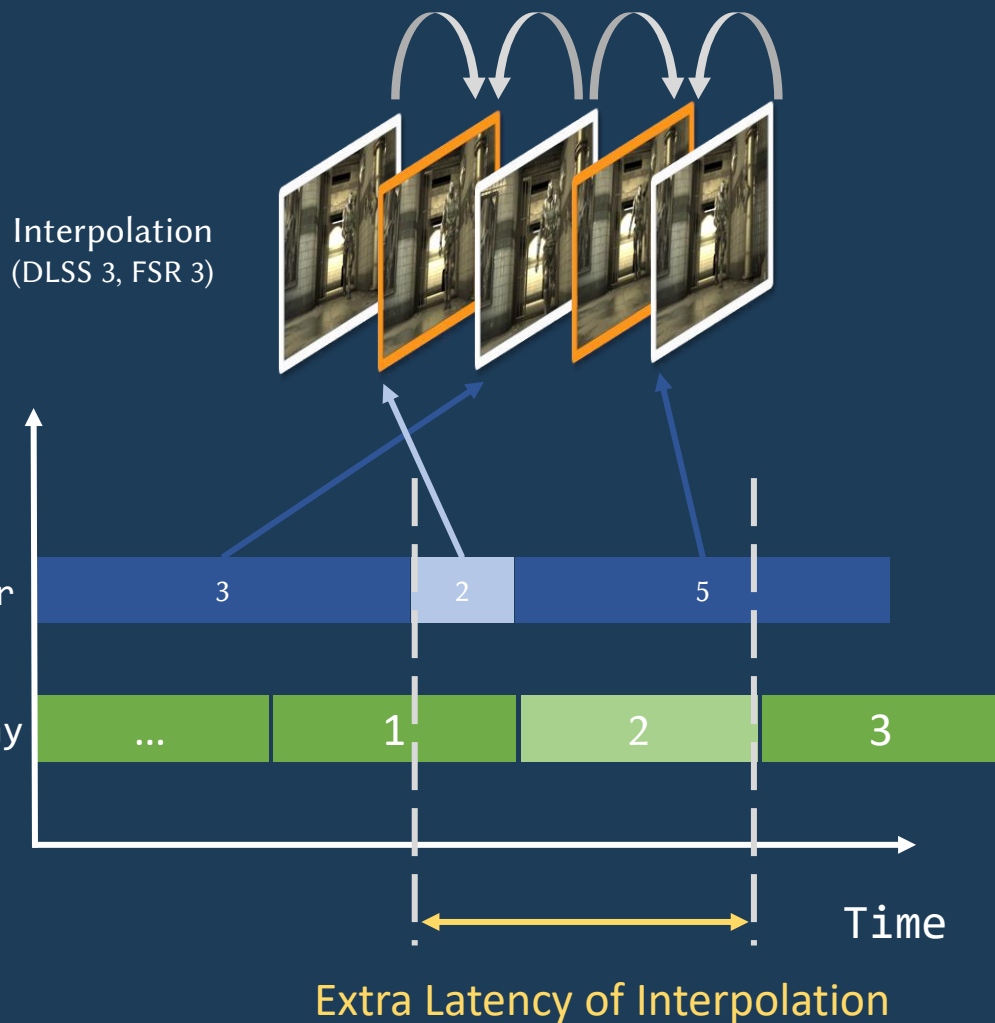
Interpolation
(DLSS 3, FSR 3)



Extrapolation
(ExtraNet)

Related Work

Interpolation vs. Extrapolation



Motivation

- Why do we choose *extrapolation*?
- Why do we combine *spatial* and *temporal* super sampling together?

Motivation

Why do we choose *extrapolation*?

Interpolation



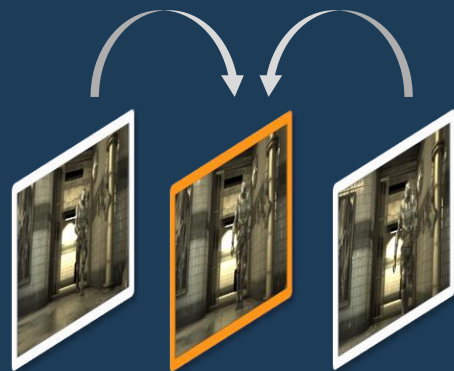
Extrapolation



Latency

>

Quality (?)



<



G-buffers

Motivation

Why do we combine *spatial* and *temporal* super sampling together?



Case 1: $n \times \frac{m}{4}$

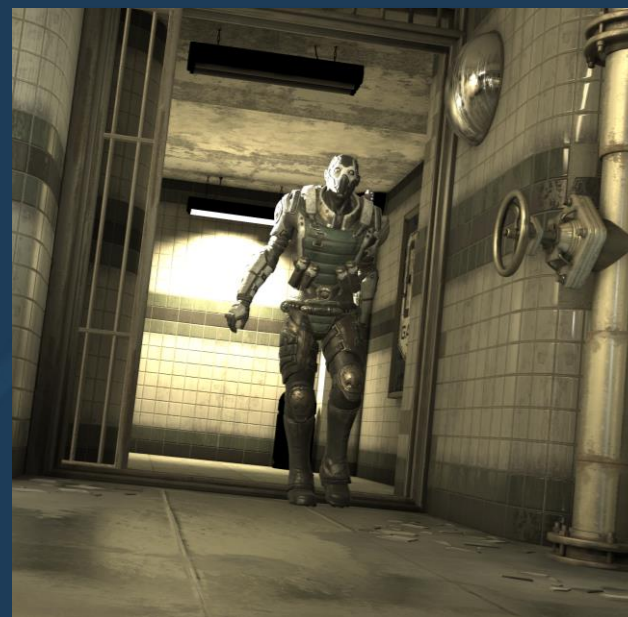


Case 2: $\frac{n}{2} \times \frac{m}{2}$

Input

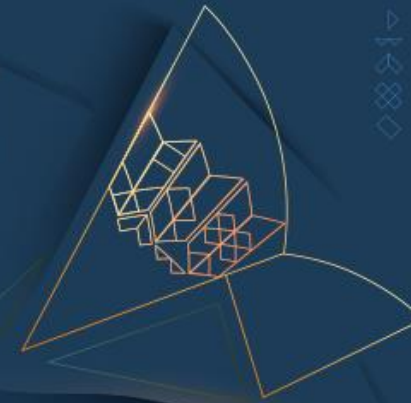


Spatial Super Sampling



$n \times m$

Target



Motivation

Why do we combine *spatial* and *temporal* super sampling together?



$n \times m$

Input

Target

Motivation

Why do we combine *spatial* and *temporal* super sampling together?



Case 1 (Spatial-only)

$$k \times \frac{n \times m}{4}$$

Case 2 (Temporal-only)

$$\frac{k}{4} \times n \times m$$

Input

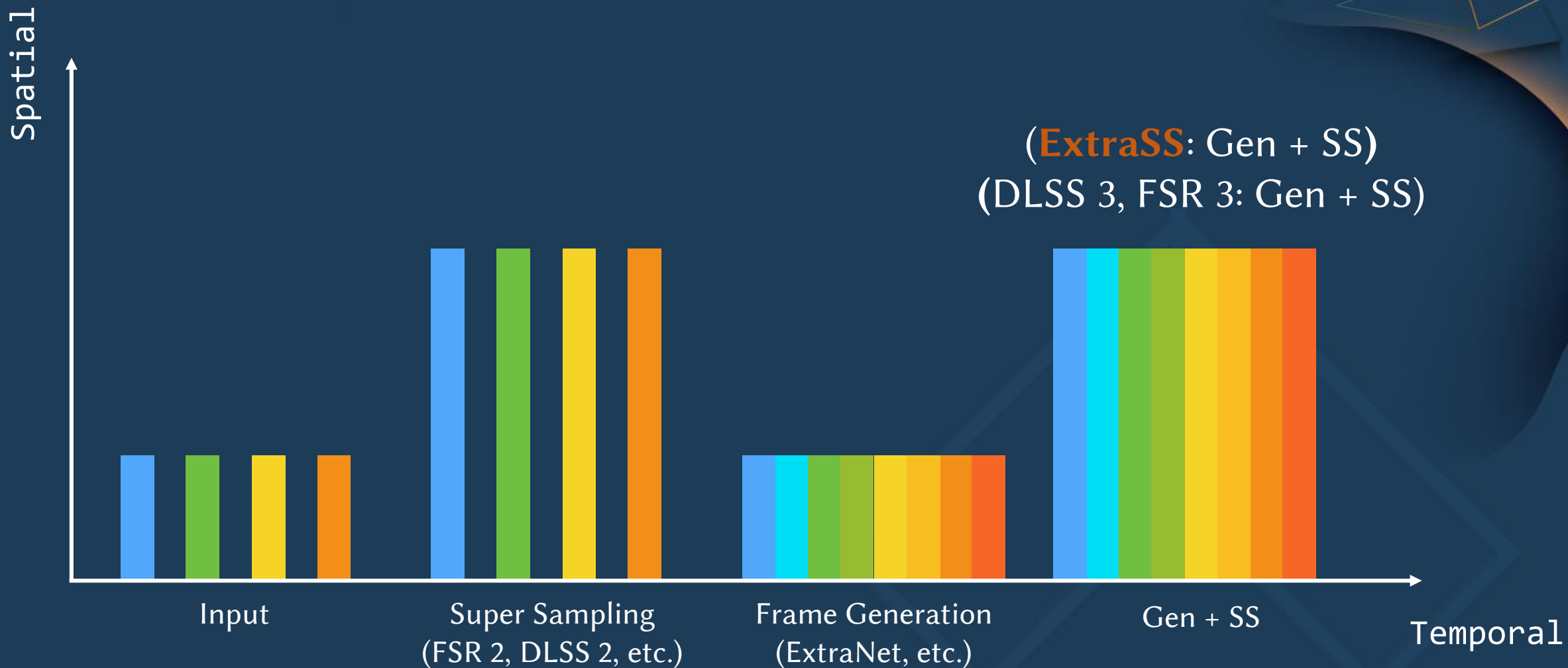
Case 3 (Spatial-Temporal)

$$\frac{k}{2} \times \frac{n \times m}{2}$$

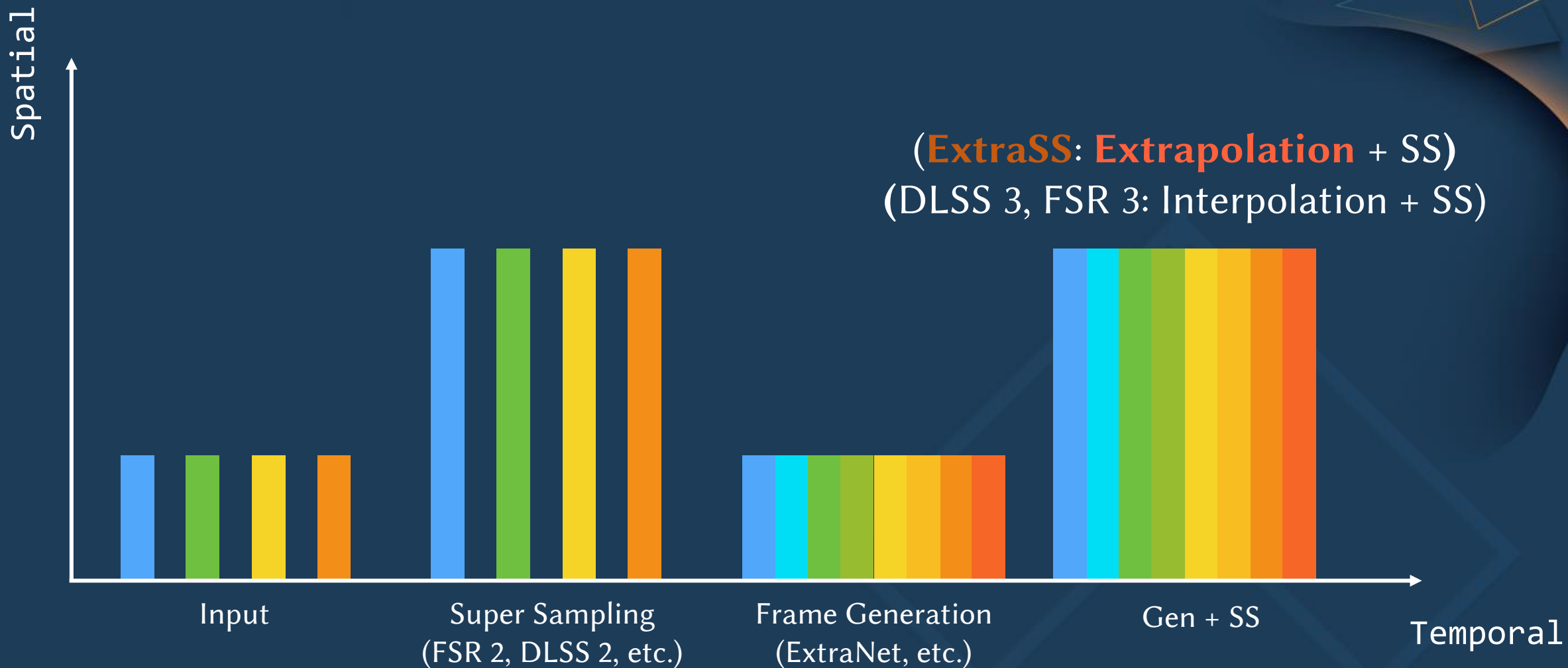
$k \times n \times m$

Target

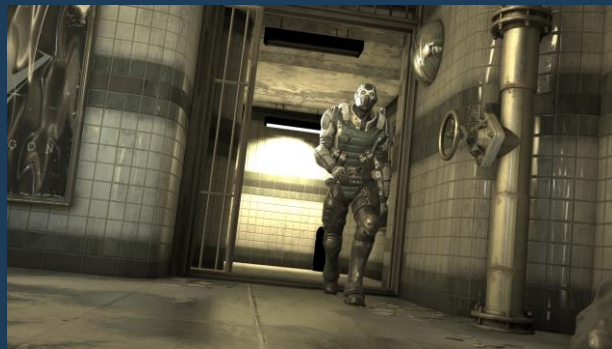
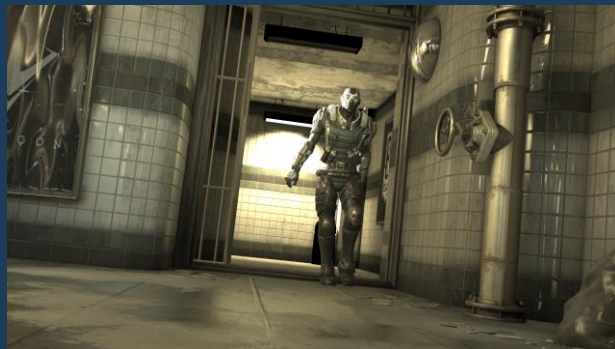
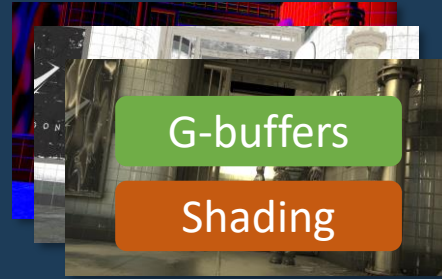
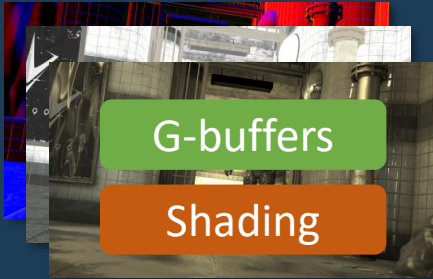
Our method



Our method

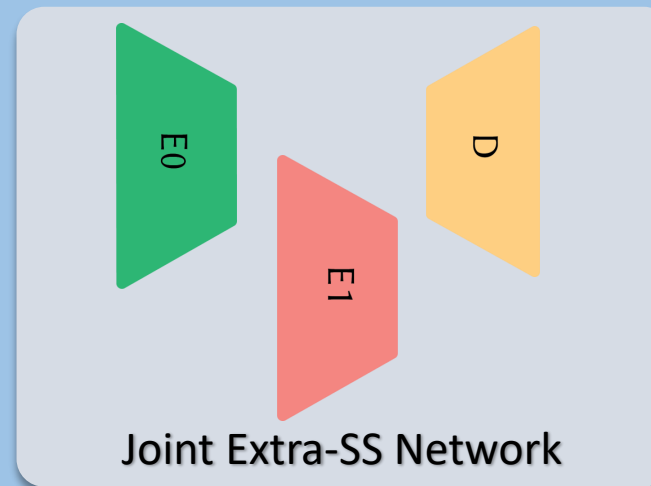
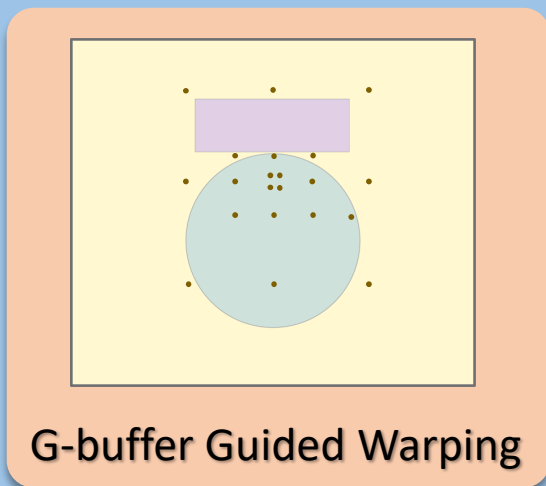


Overview

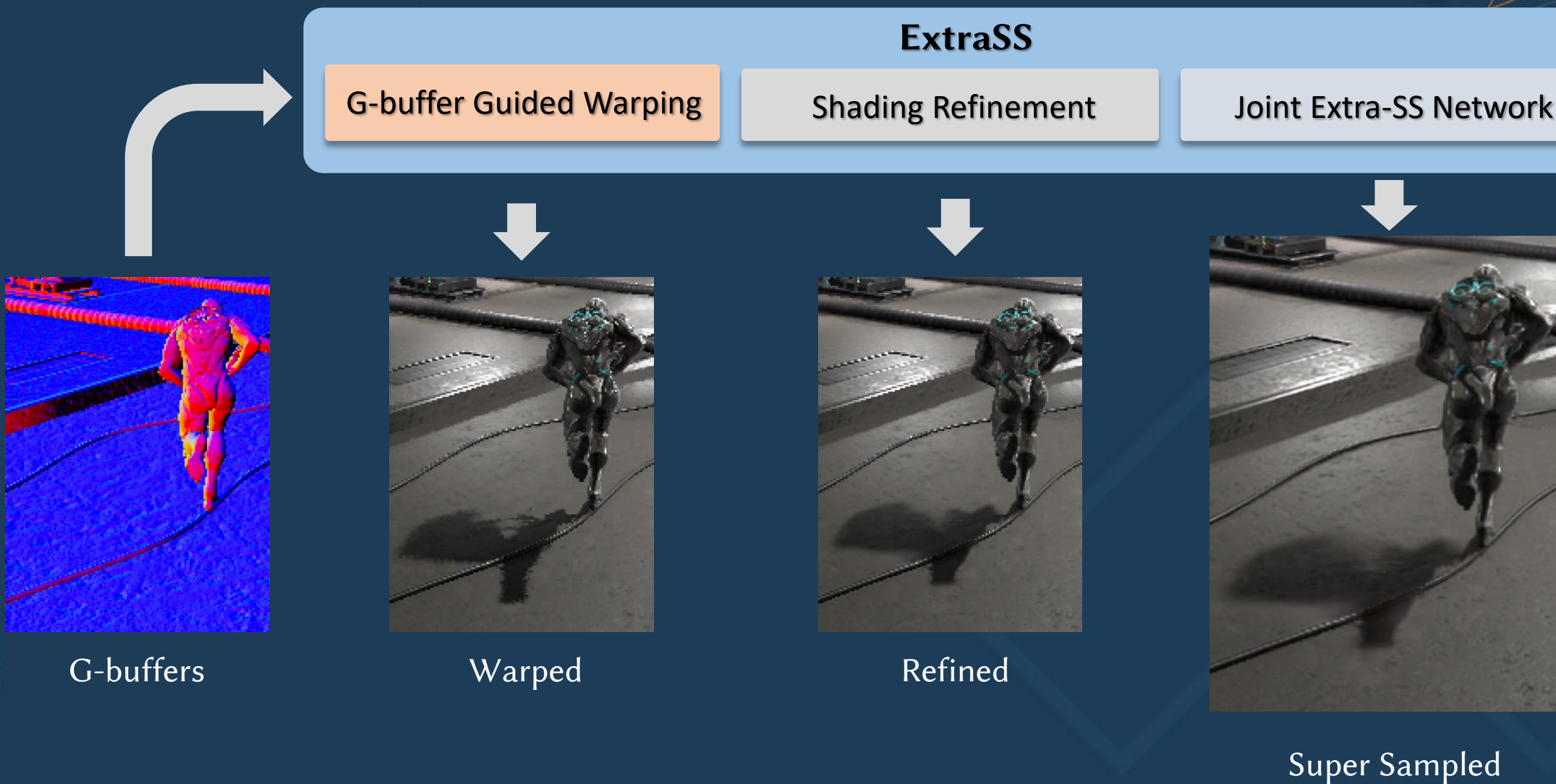


Overview

ExtraSS



Overview



G-buffer Guided Warping

Warping



Previous Frame



Traditional Warping



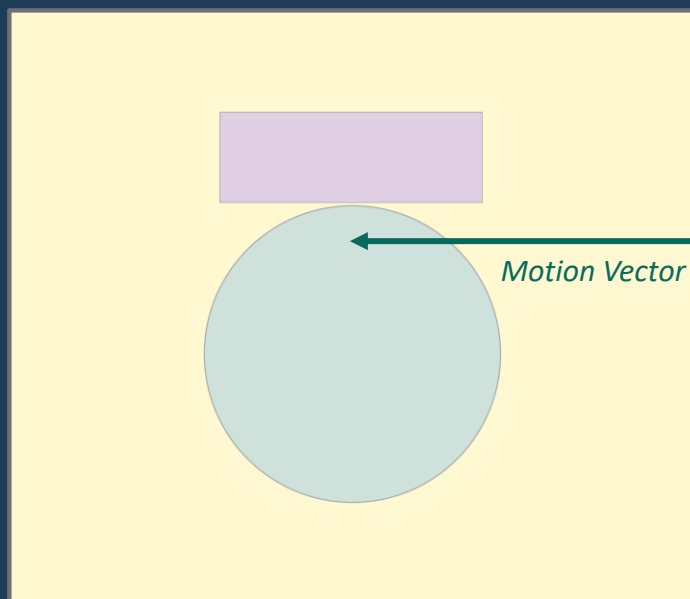
Occlusion Motion Vector¹



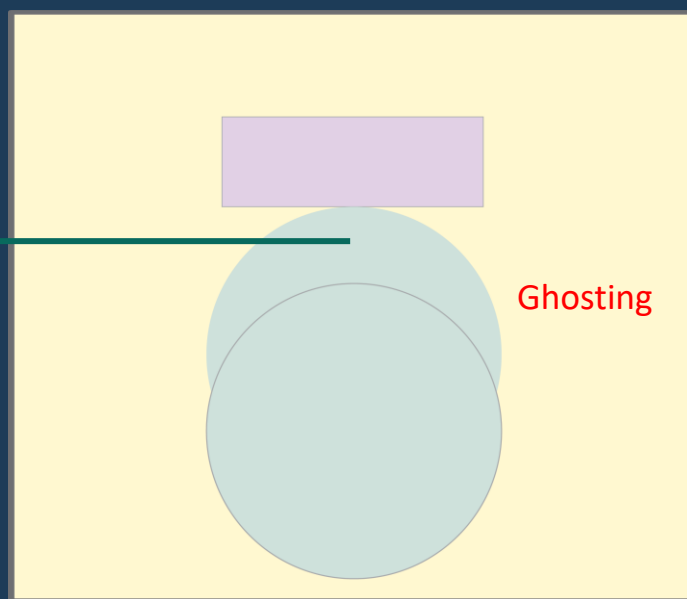
Ours

1. Zeng, Zheng, et al. 2021 "Temporally Reliable Motion Vectors for Real-time Ray Tracing."

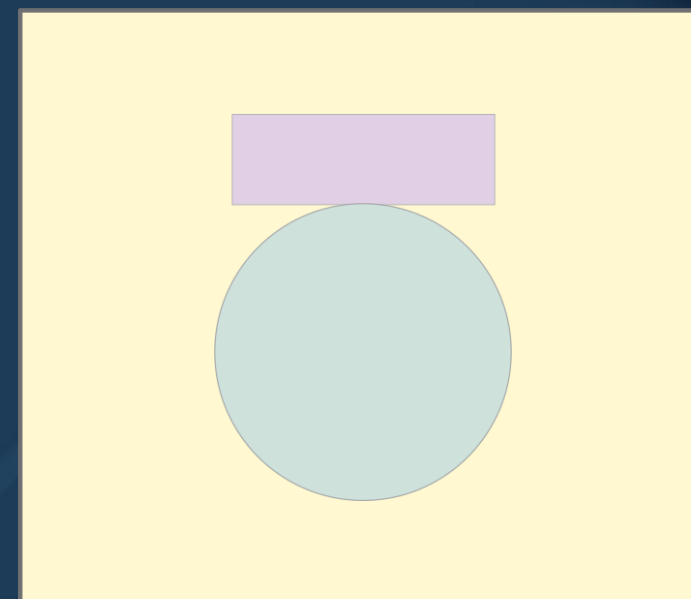
Traditional Warping



Frame i-1

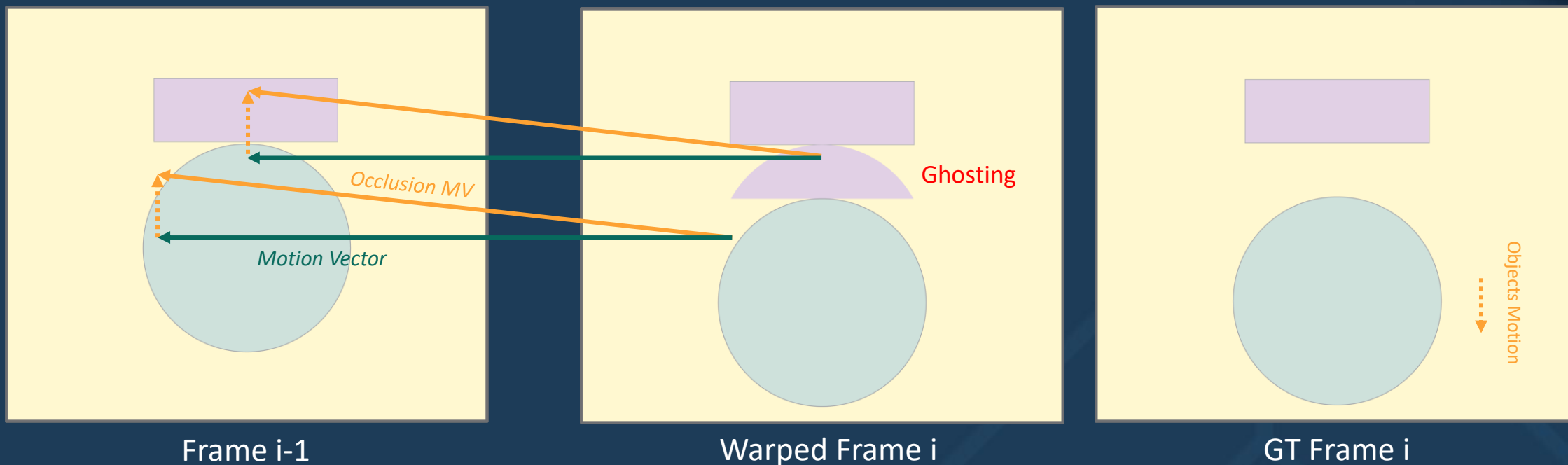


Warped Frame i

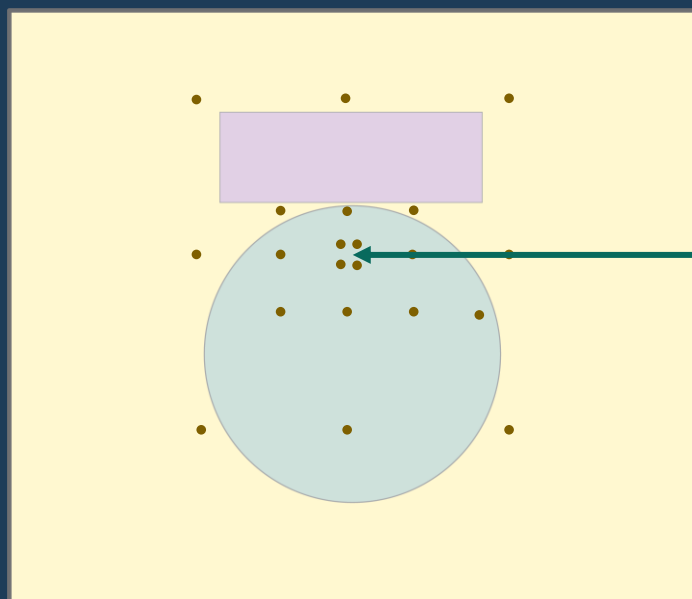


GT Frame i

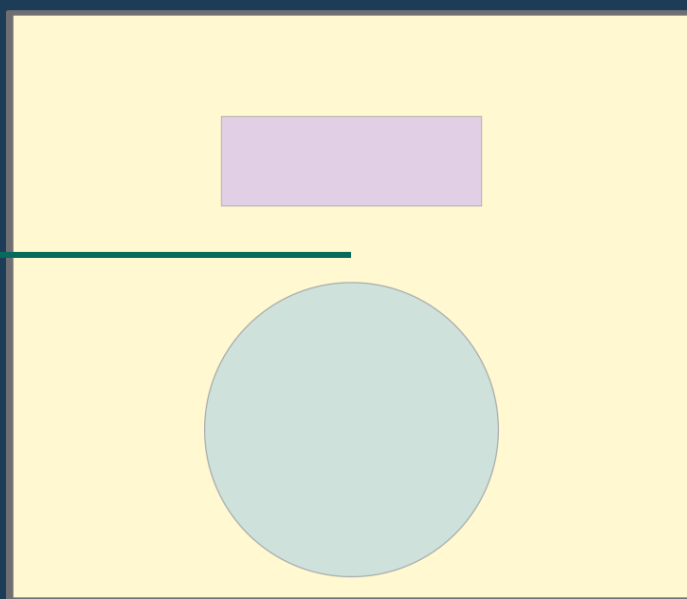
Occlusion Motion Vector¹



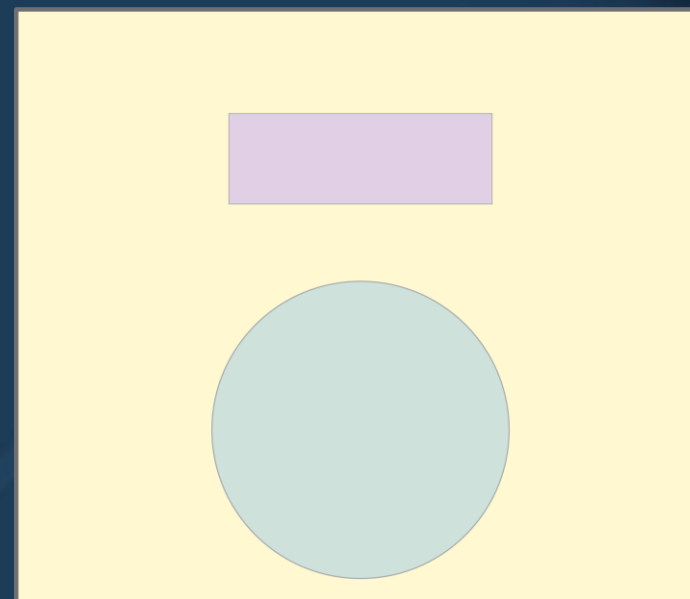
G-buffer Guided Warping



Frame i-1



Warped Frame i

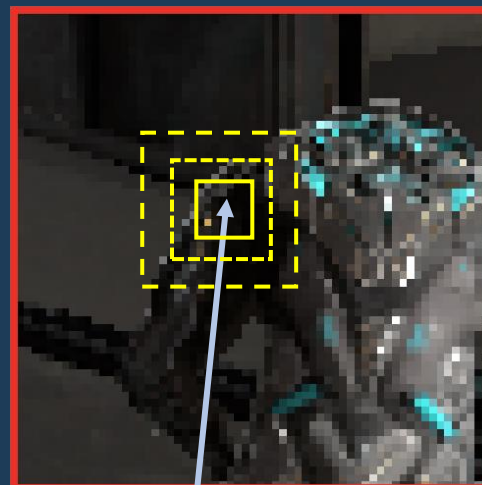


GT Frame i

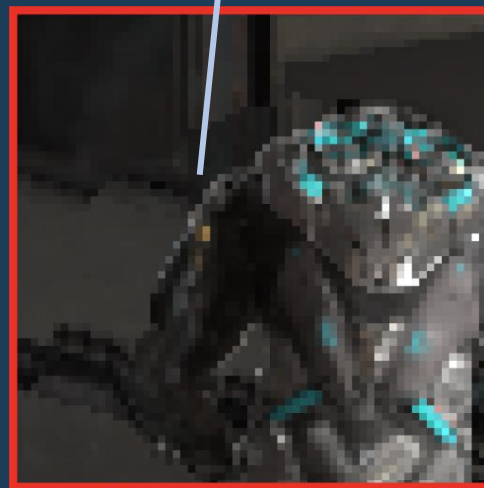
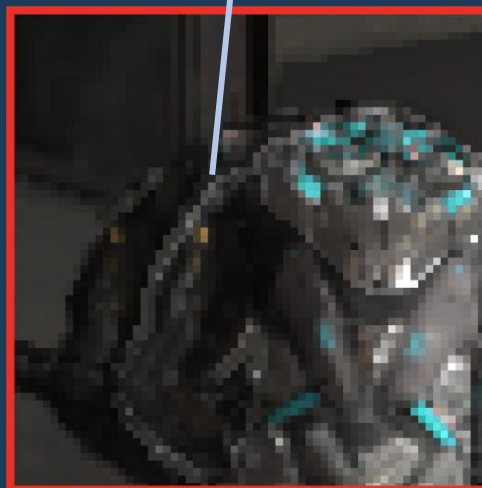
*A-trous Kernel
(Larger Receptive Field)*

*G-buffer's Similarity
(Weight Samples)*

G-buffer Guided Warping



Previous Frame

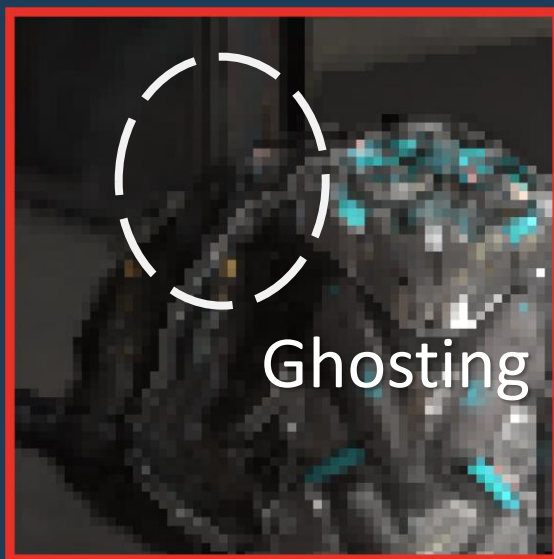


Traditional Warping

Occlusion Motion Vector

Ours

G-buffer Guided Warping



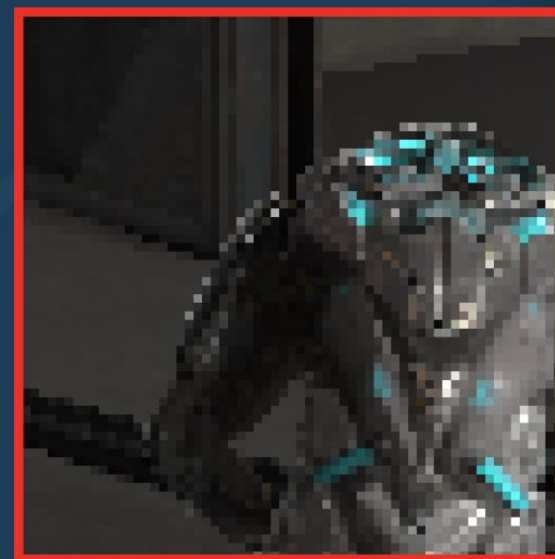
Traditional Warping



Occlusion Motion Vector

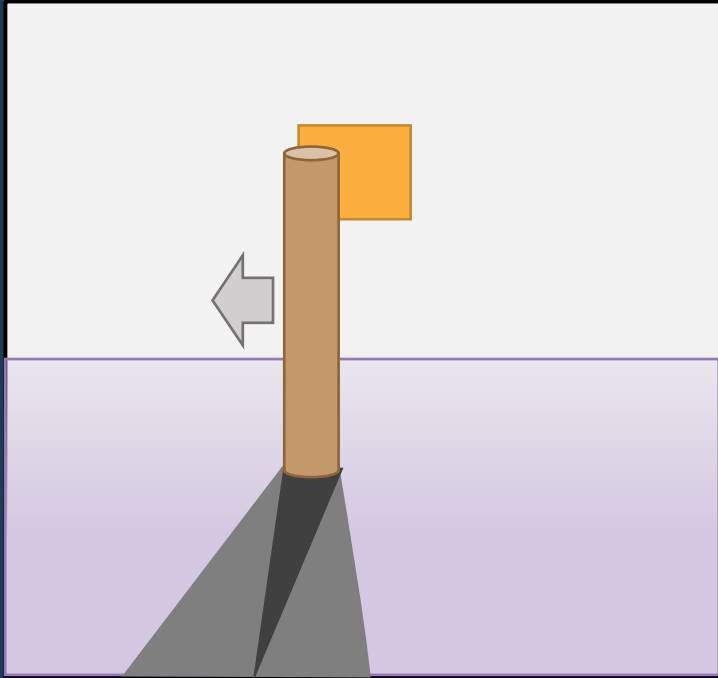


Ours

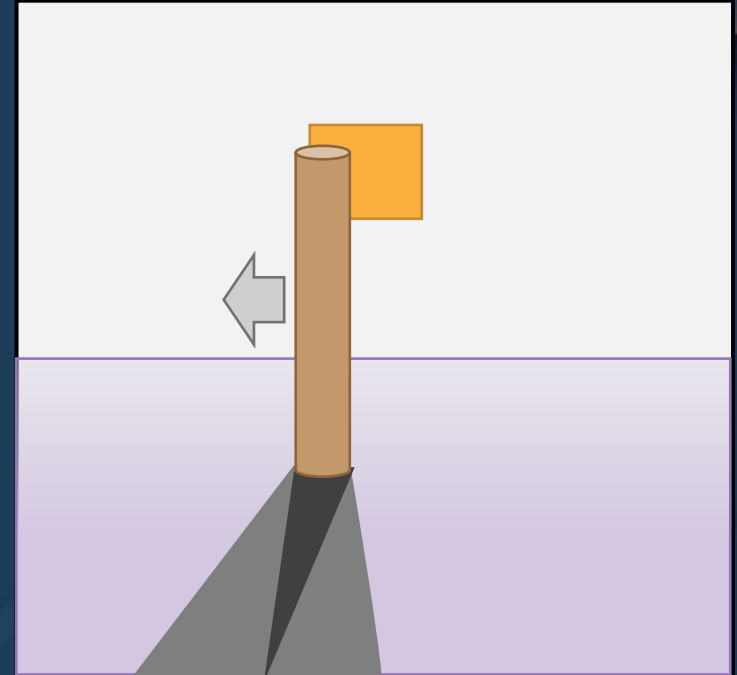


Ground Truth

Issues of Warping

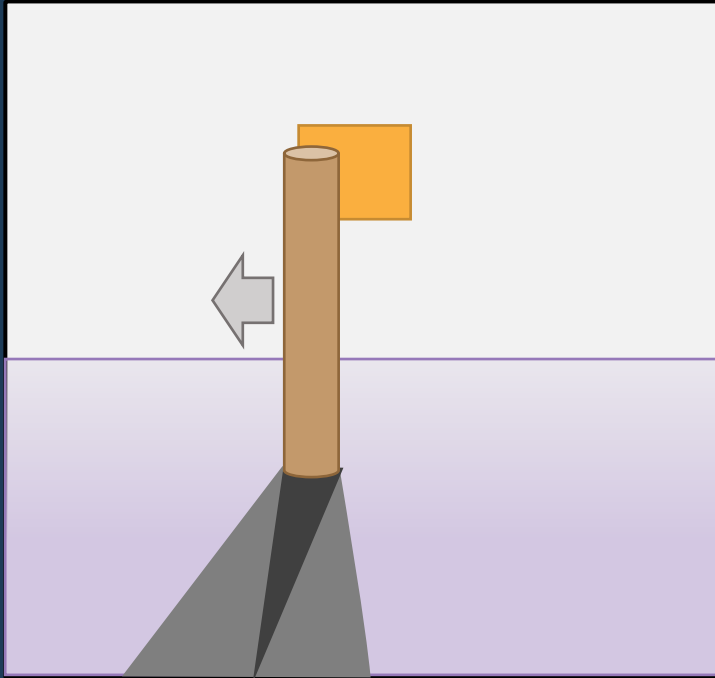


Frame i

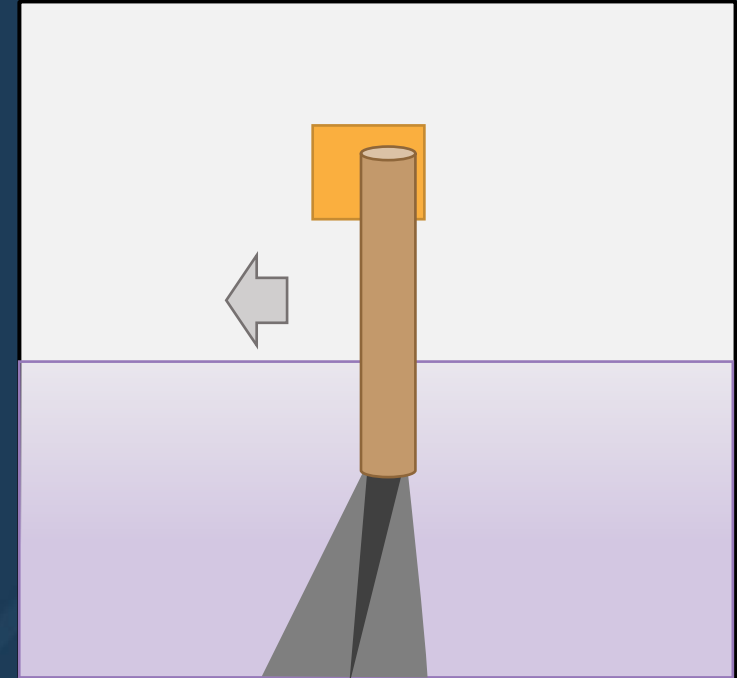


Frame i

Issues of Warping

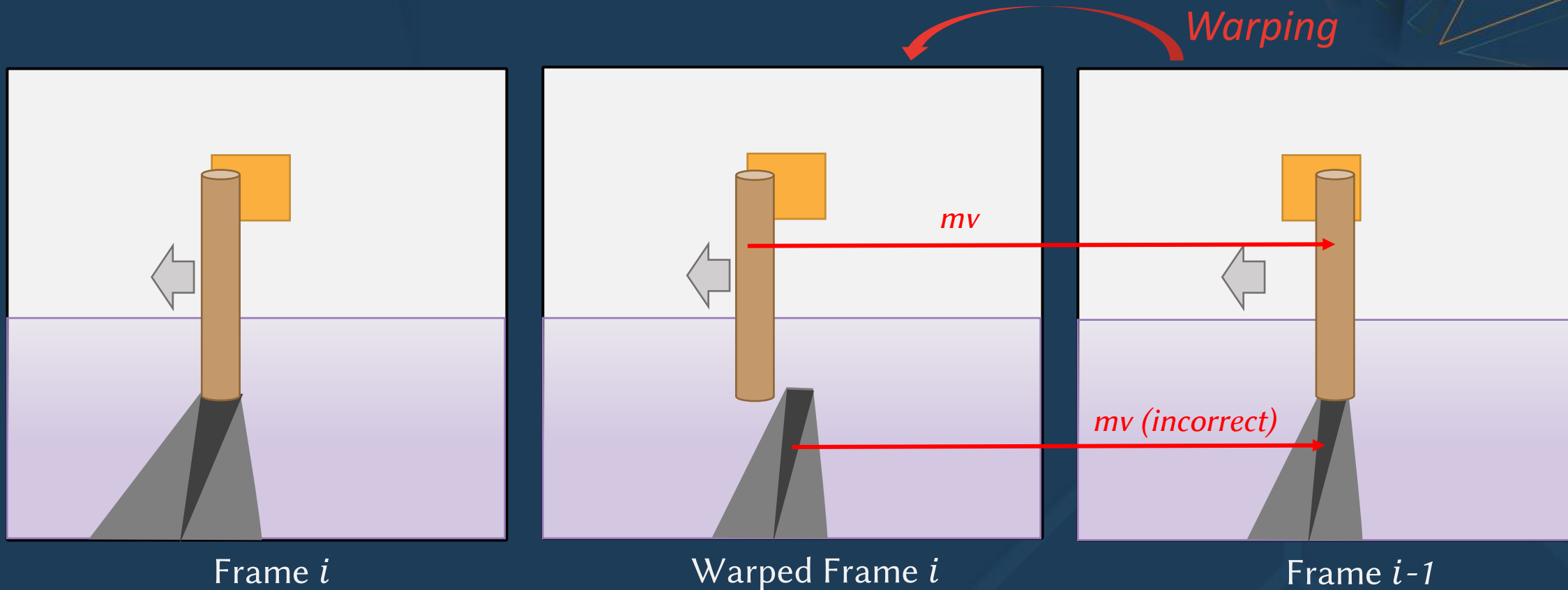


Frame i



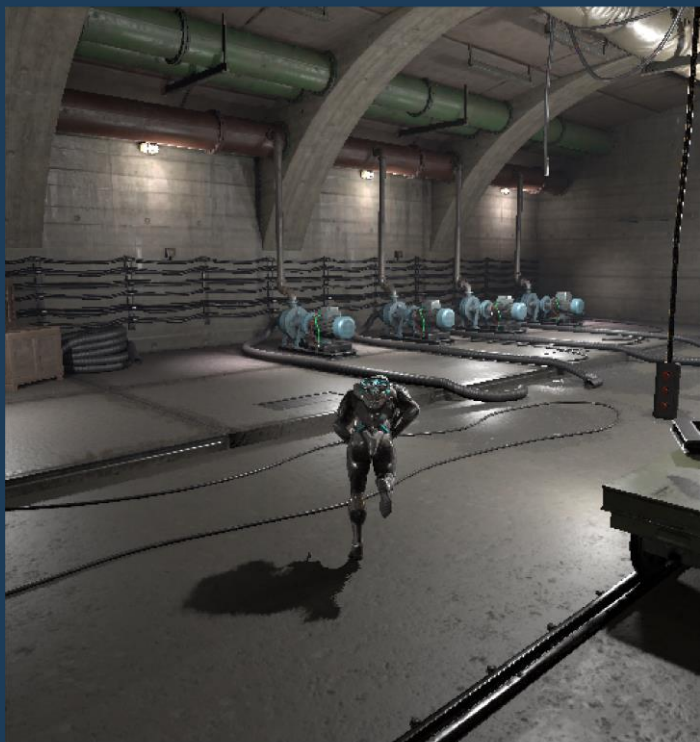
Frame $i-1$

Issues of Warping



Shading Issues

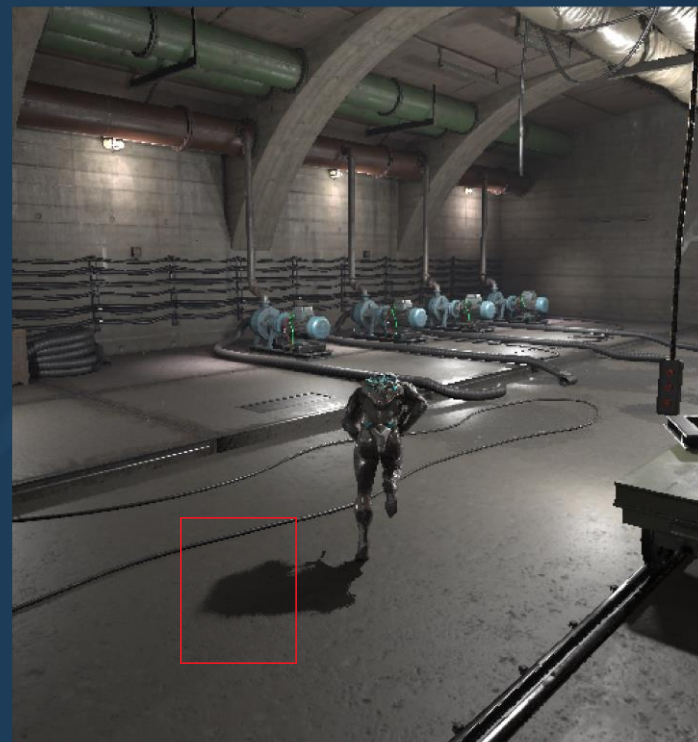
G-buffer Guided Warping



Frame i-1



Warped Frame i



GT Frame i

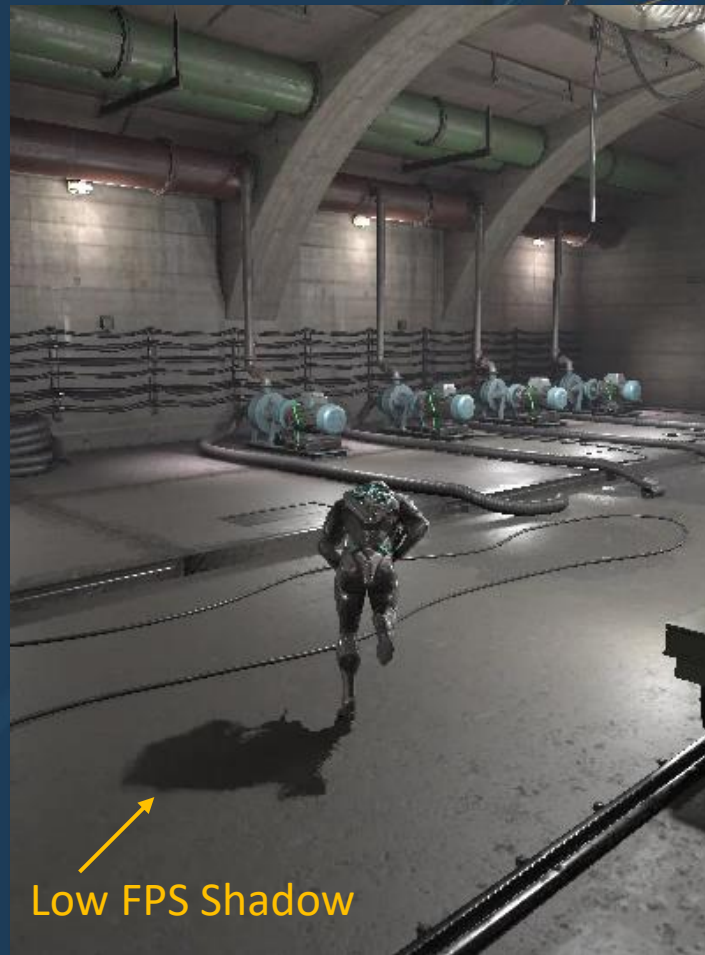
Shading Issues



Warped Frame i



GT Frame i



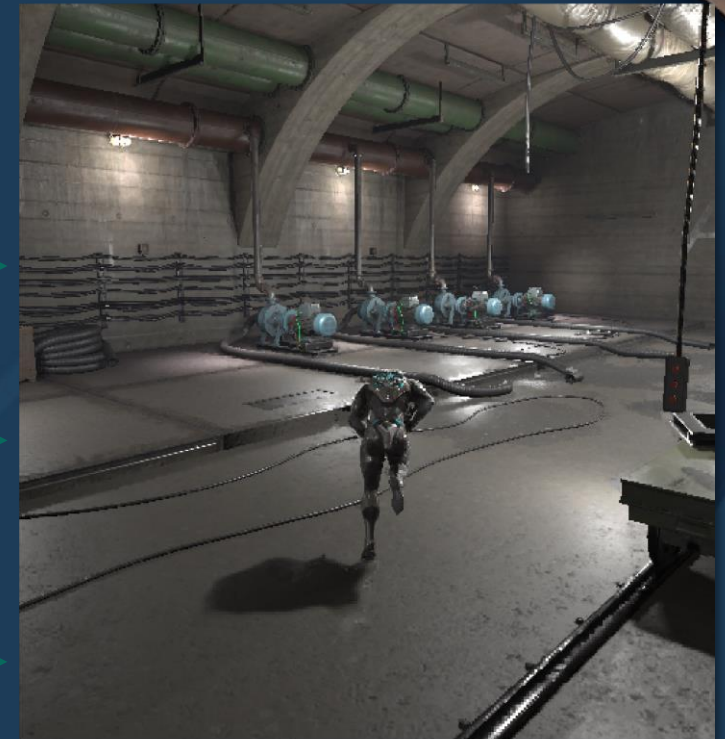
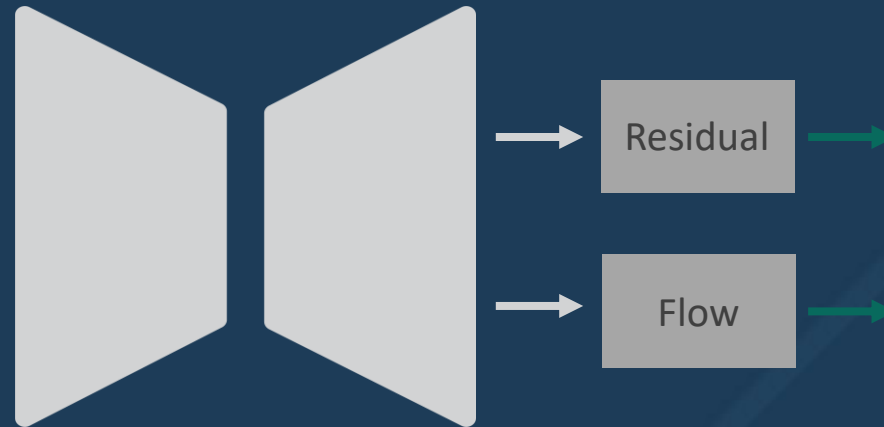
Low FPS Shadow

Shading Refinement



Warped

Flow-Refinement Network

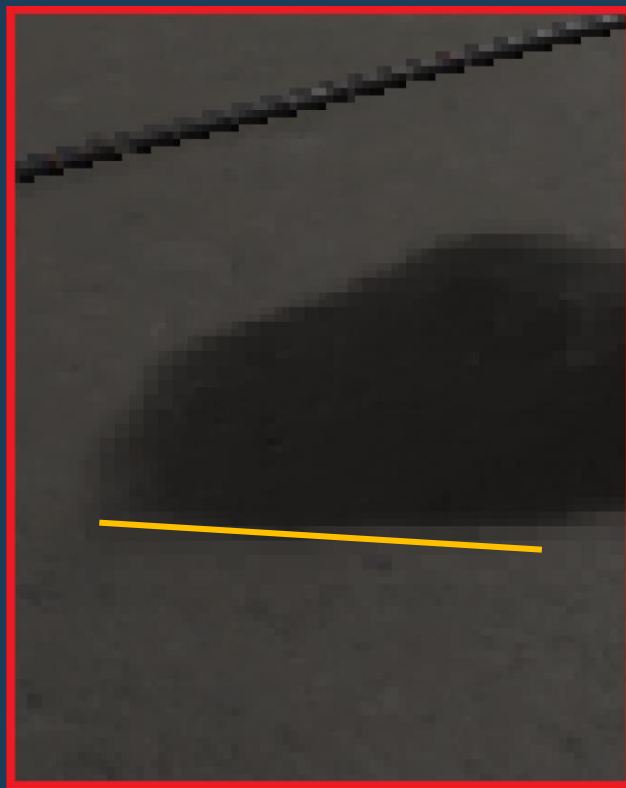


Refined

Shading Refinement



Warped

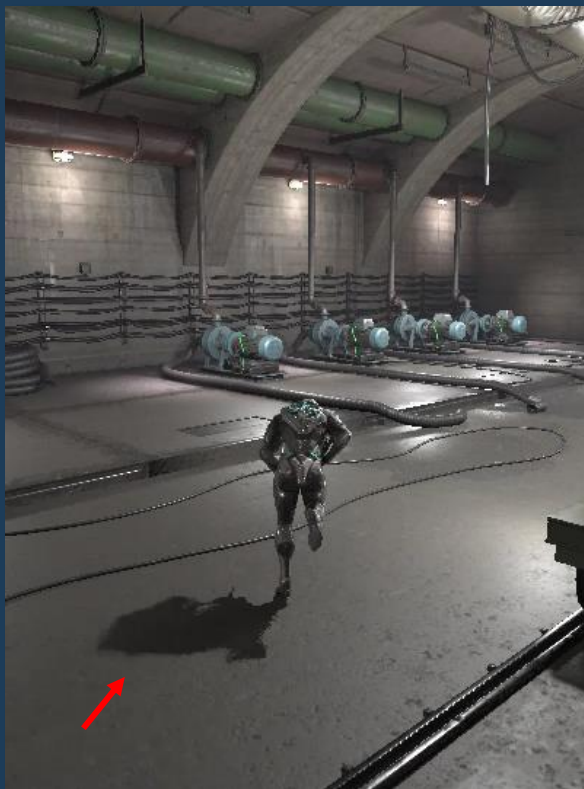


Refined

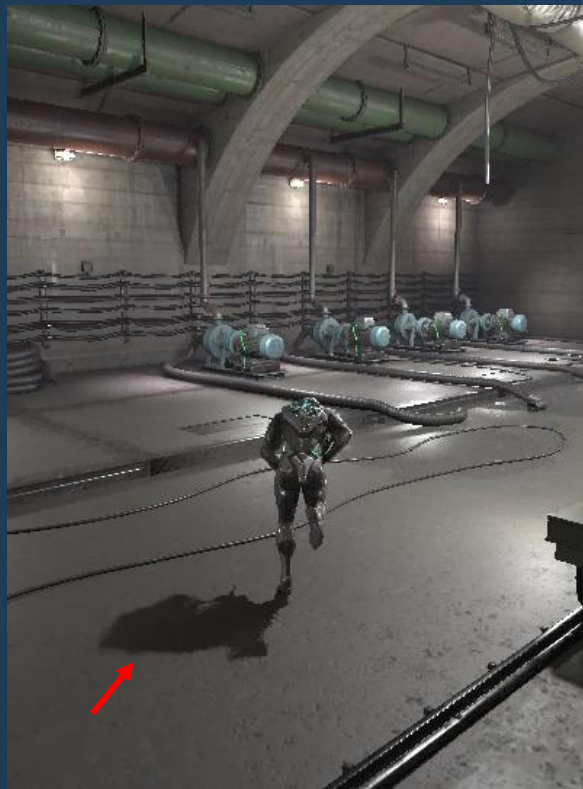


GT

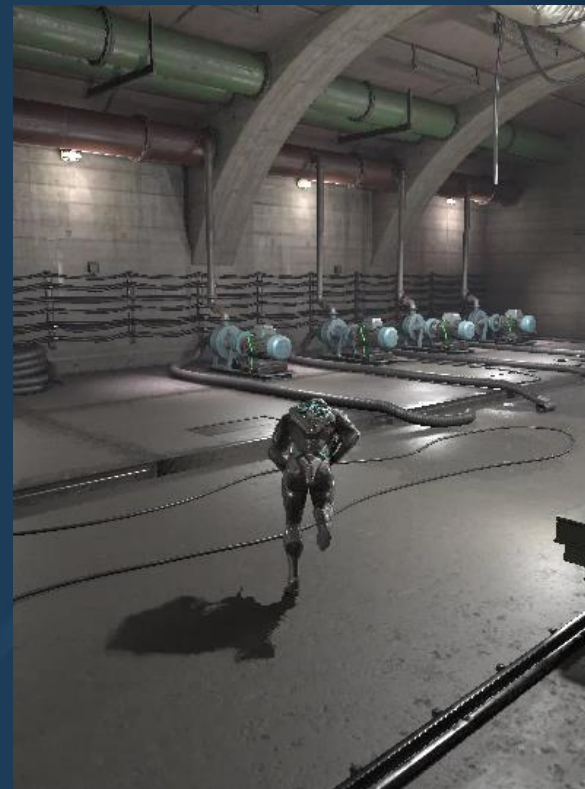
Shading Refinement



Warped



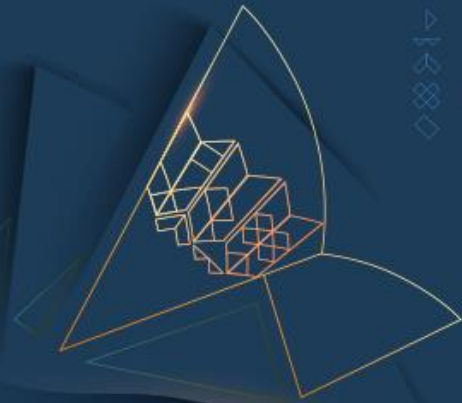
Refined



GT



Comparison with Frame Generation Methods



ExtraNet
(extrapolation)

IFRNet
(interpolation)

ExtraNet

IFRNet

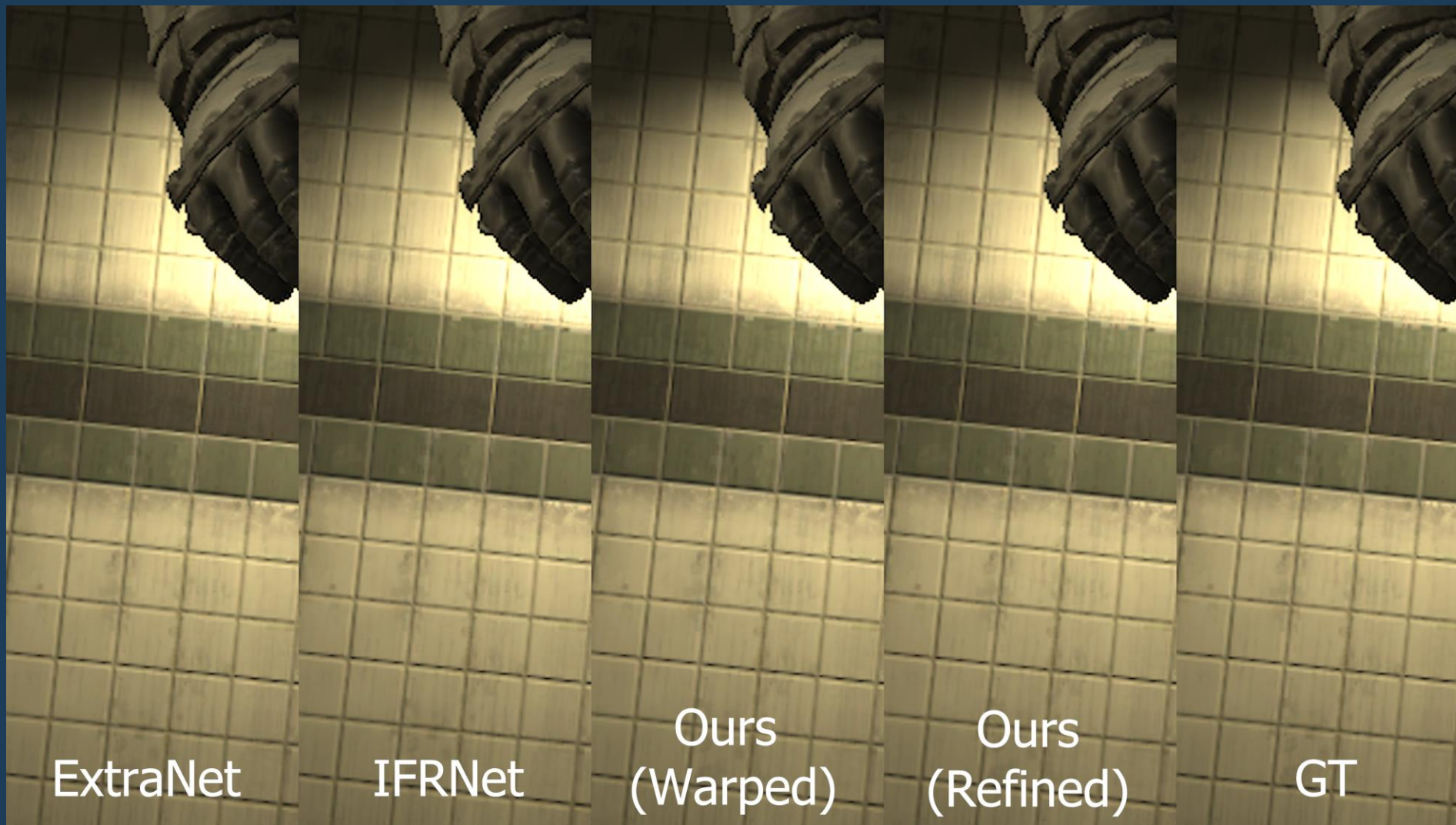
Ours
(Warped)

Ours
(Refined)

GT



Comparison with Frame Generation Methods



ExtraNet
(extrapolation)

IFRNet
(interpolation)

Joint Extra-SS Network

Frame i



G-buffers + Shading

Frame i+1



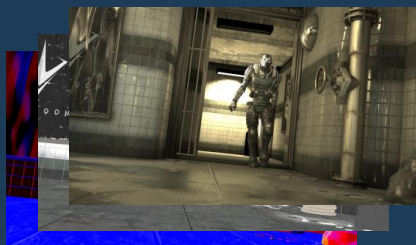
G-buffers

G-buffer Guided
Warping

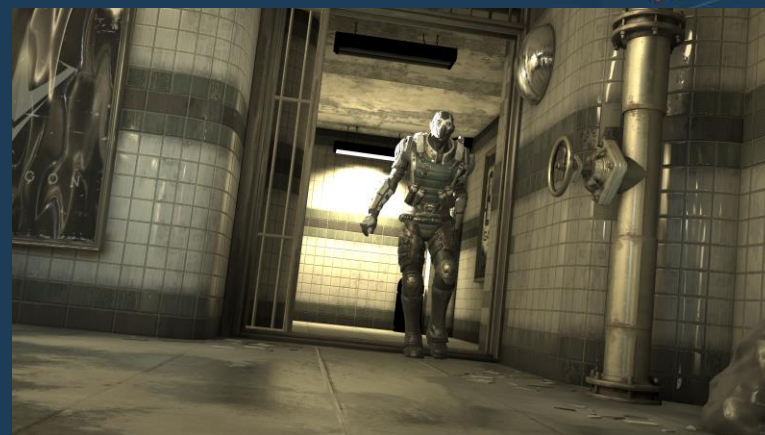
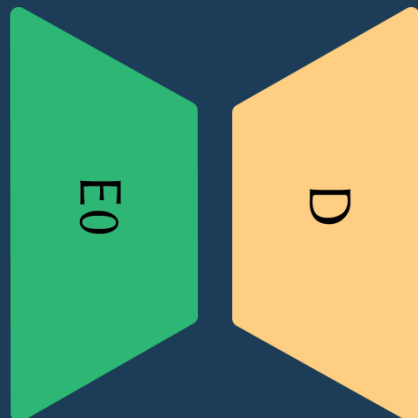
Shading
Refinement

Joint Extra-SS Network

Frame i



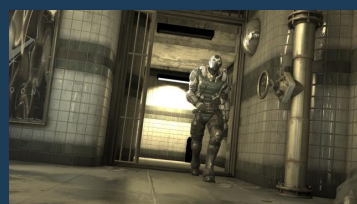
G-buffers + Shading



Frame i+1



G-buffers



New Shading



(Low Resolution)

(High Resolution)

Joint Extra-SS Network



E0

D



Temporal Loss

Temporal Loss



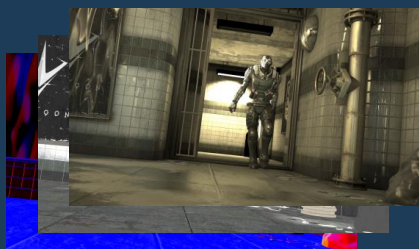
E1

D



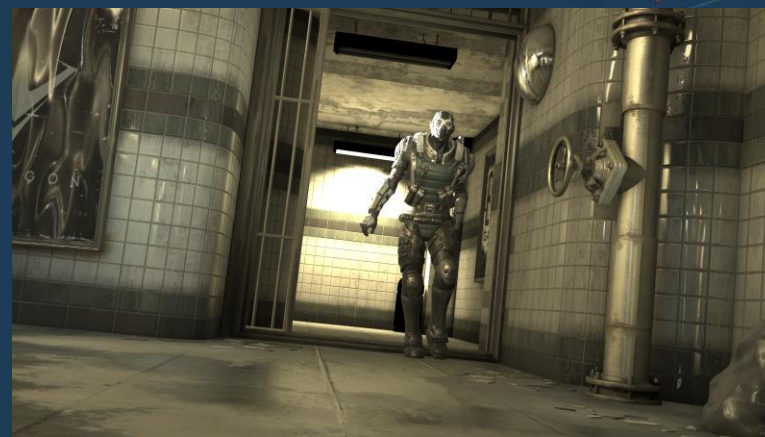
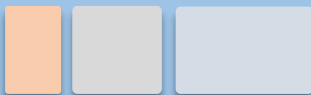
ExtraSS Framework

Frame i



G-buffers + Shading

ExtraSS

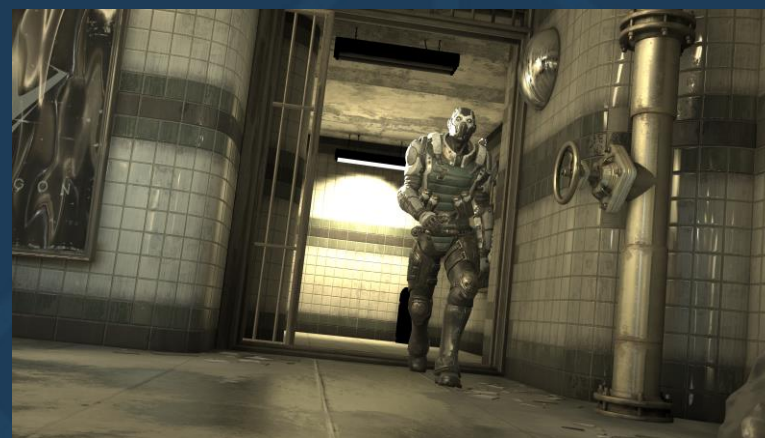
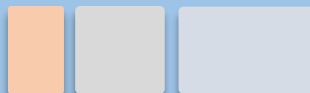


Frame i+1



G-buffers

ExtraSS



(Low Resolution)

(High Resolution)



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Results

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Our Results

$(2x)^2$ Resolution

(540p -> 1080p)

(720p -> 1440p)

(1080p -> 2160p)

2x Frame Rate

(15 FPS -> 30 FPS)

Our Results



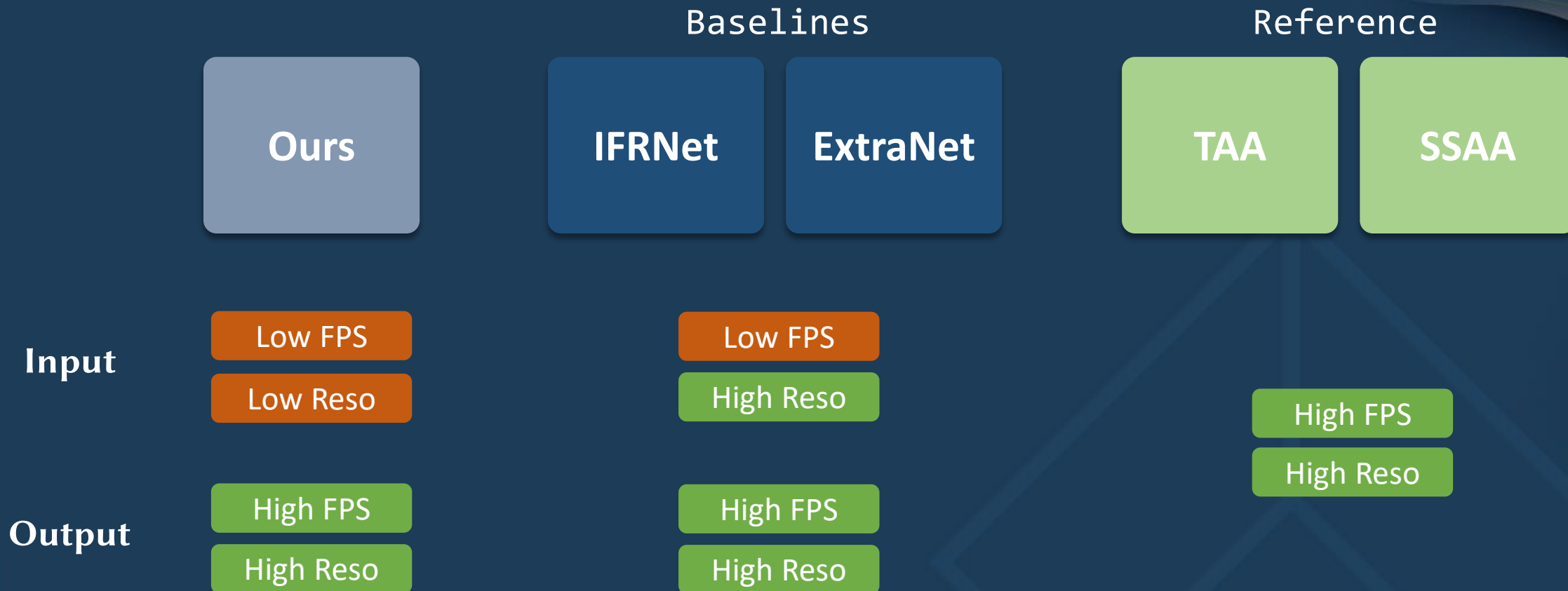
(2x)² Resolution

(540p -> 1080p)
(720p -> 1440p)
(1080p -> 2160p)

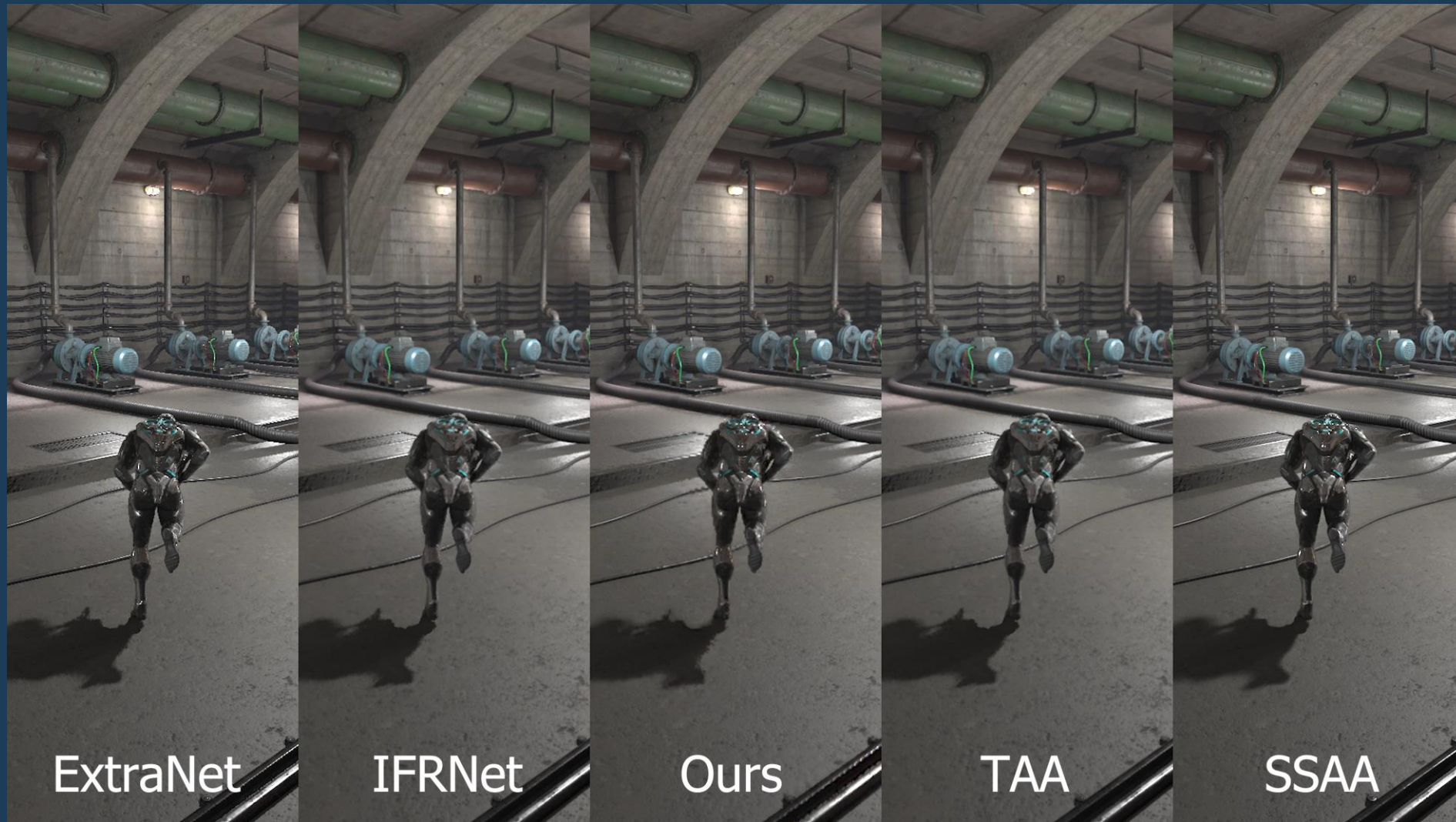
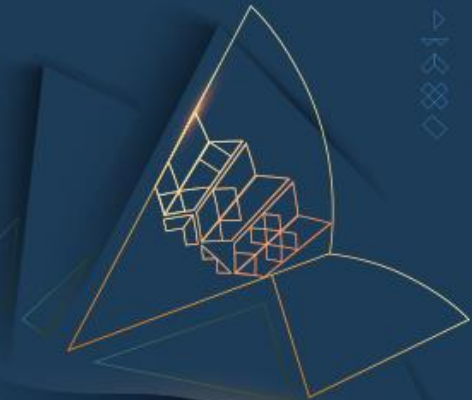
2x Frame Rate

(15 FPS -> 30 FPS)

(UNFAIR) Comparison with Frame Generation Methods



Comparison with Frame Generation Methods



Ours

IFRNet

ExtraNet

ExtraNet

IFRNet

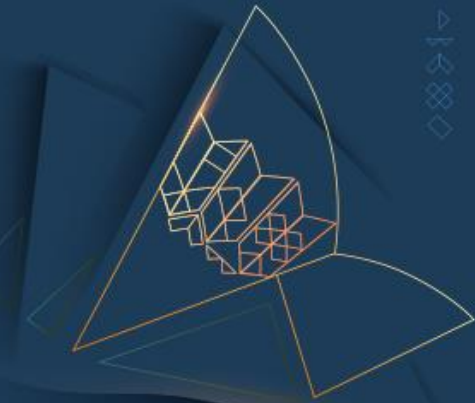
Ours

TAA

SSAA



Comparison with Frame Generation Methods



Ours

IFRNet

ExtraNet

ExtraNet

IFRNet

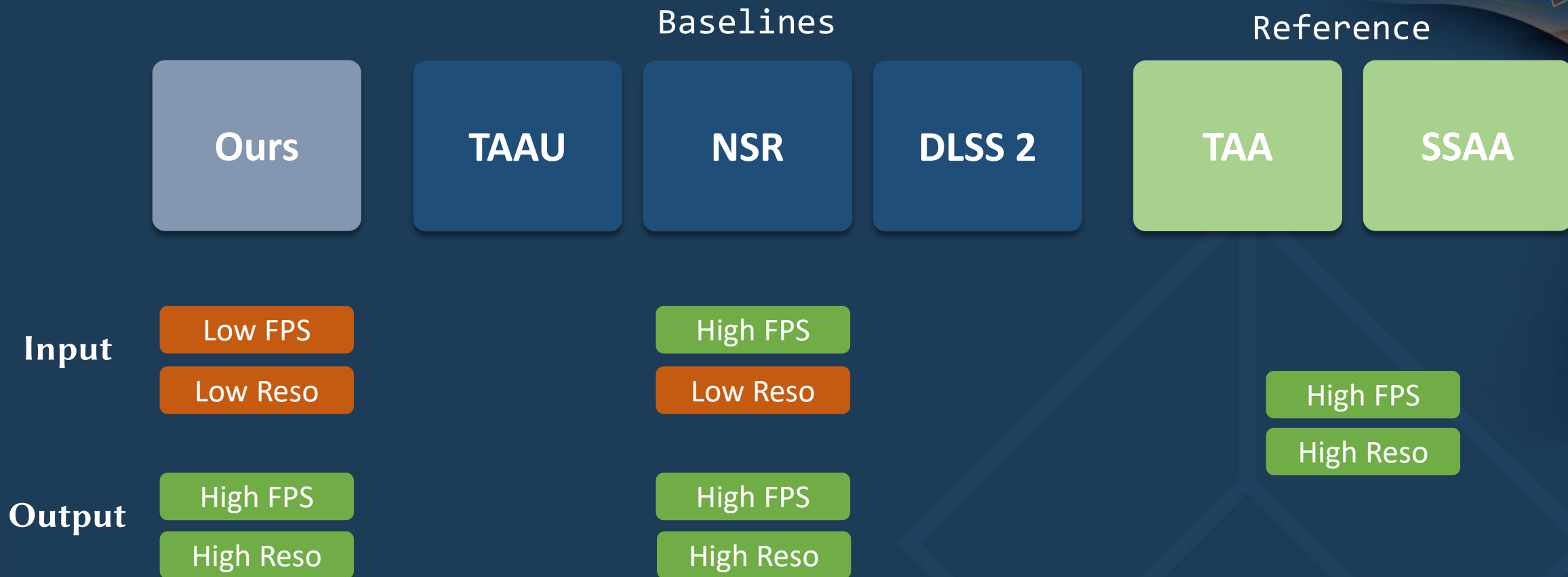
Ours

TAA

SSAA



(UNFAIR) Comparison with Super Sampling Methods



Comparison with Super Sampling Methods



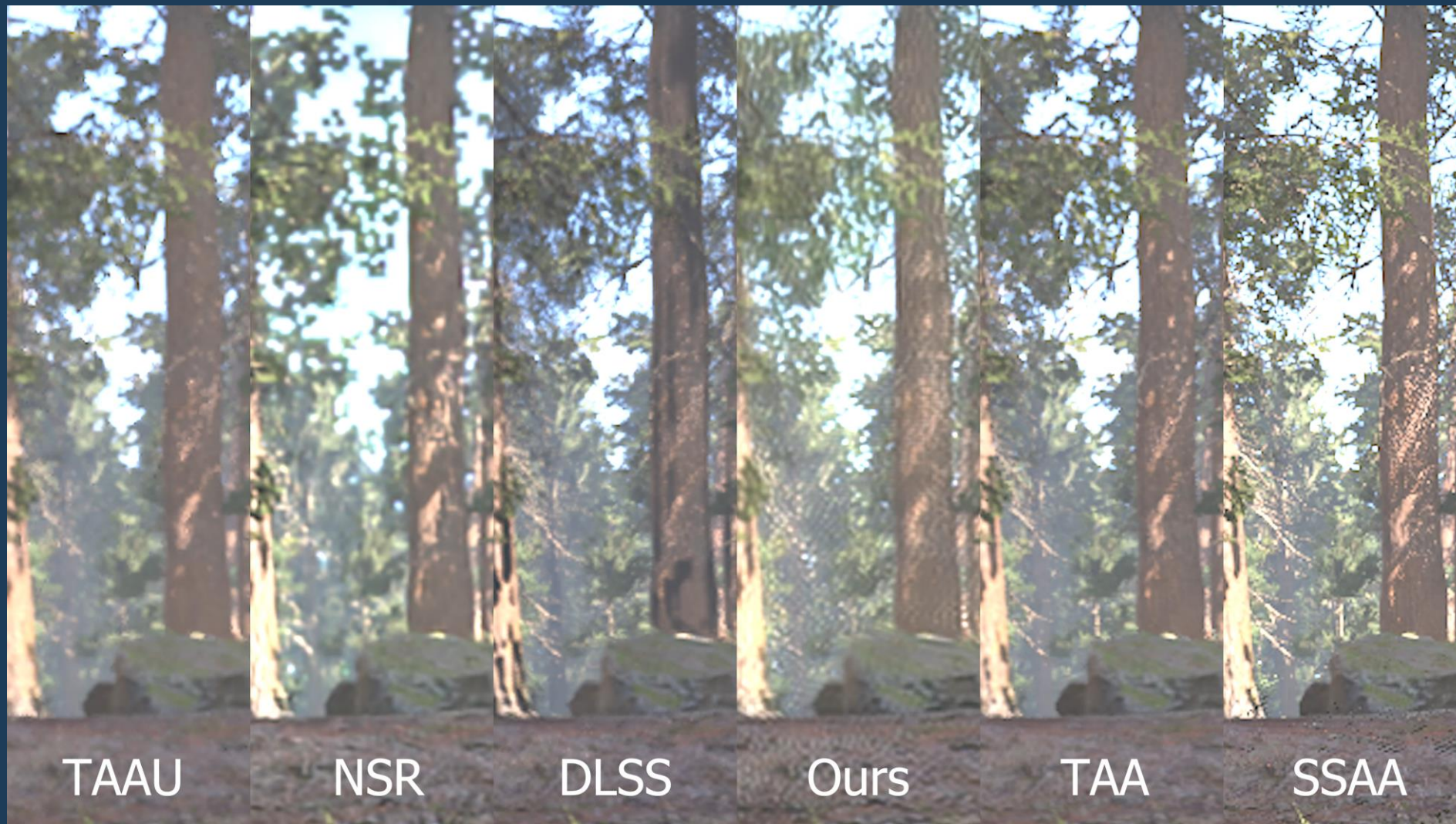
Ours

TAAU

NSR

DLSS 2

(UNFAIR) Comparison with Super Sampling Methods



Ours

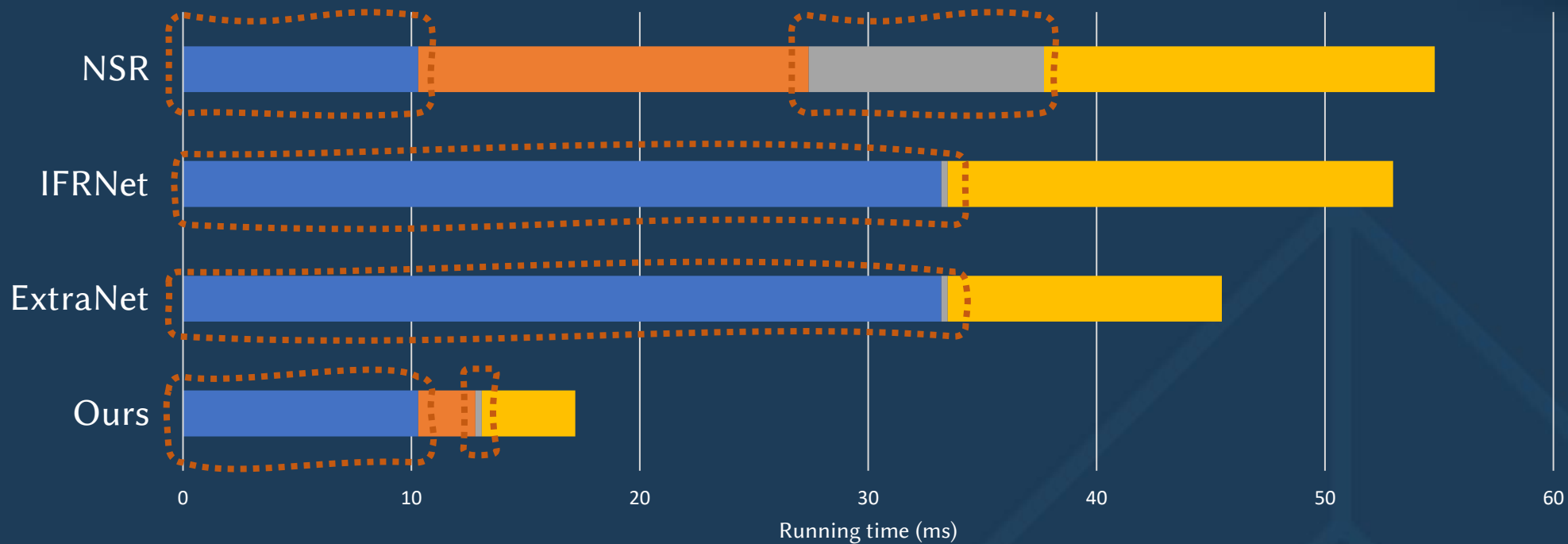
TAAU

NSR

DLSS 2

Performance

Running time of generating two consecutive frames

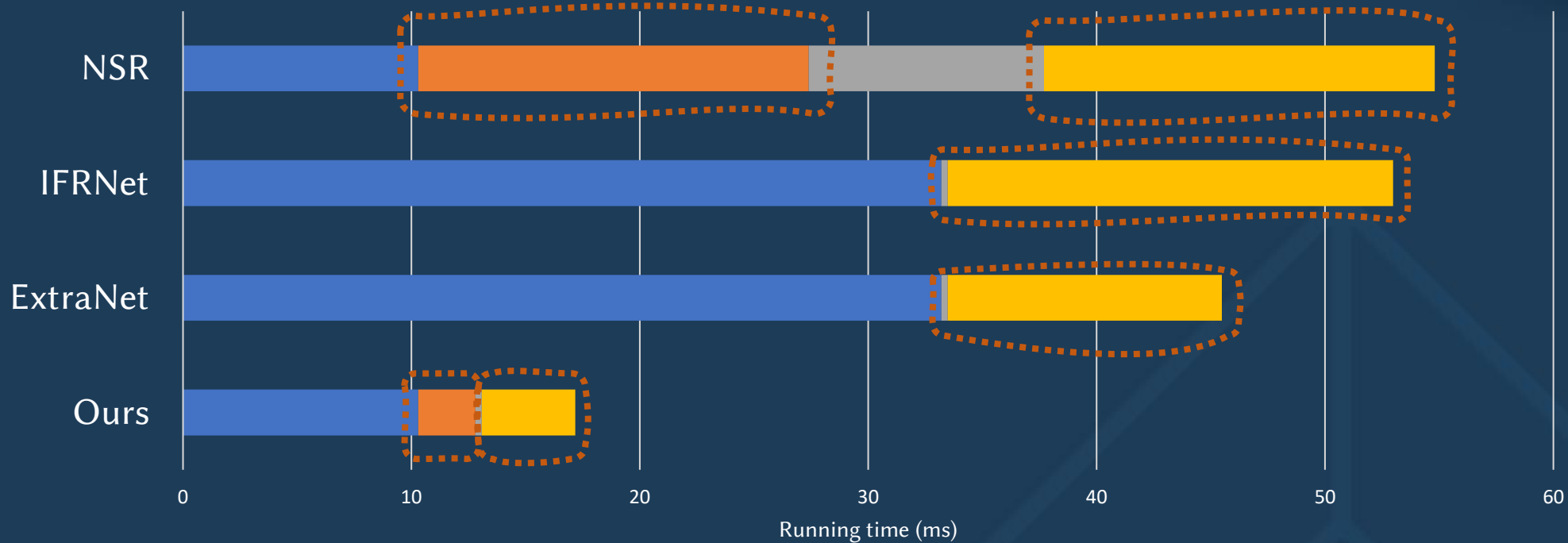


■ Rendering Time in Frame 1
■ Rendering Time in Frame 2

■ Module Time in Frame 1
■ Module Time in Frame 2

Performance

Running time of generating two consecutive frames



■ Rendering Time in Frame 1
■ Rendering Time in Frame 2

■ Module Time in Frame 1
■ Module Time in Frame 2

Summary

- Efficient warping method to handle disocclusion areas.
- Light-weight flow refinement module for shading correction.
- Joint pipeline for spatial super sampling and extrapolation.
- Achieve both better quality and performance.

	Super Resolution	Frame Generation	No Extra Latency
ExtraNet	✗	✓	✓
IFRNet	✗	✓	✗
NSR	✓	✗	
DLSS 2	✓	✗	
XeSS	✓	✗	
DLSS 3	✓	✓	✗
ExtraSS	✓	✓	✓

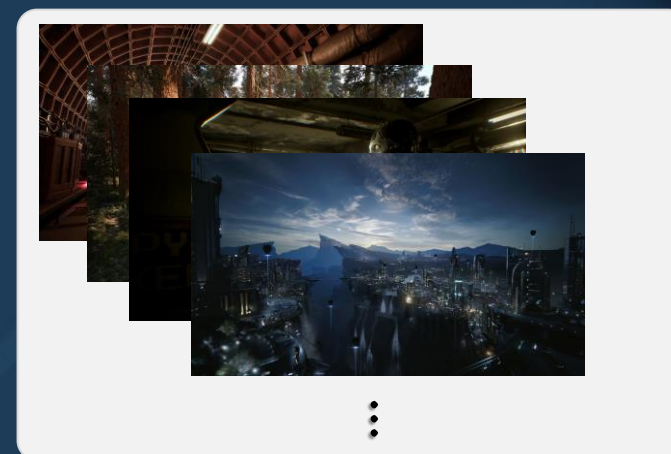
Limitations and Future work



Reduced-cost G-buffers



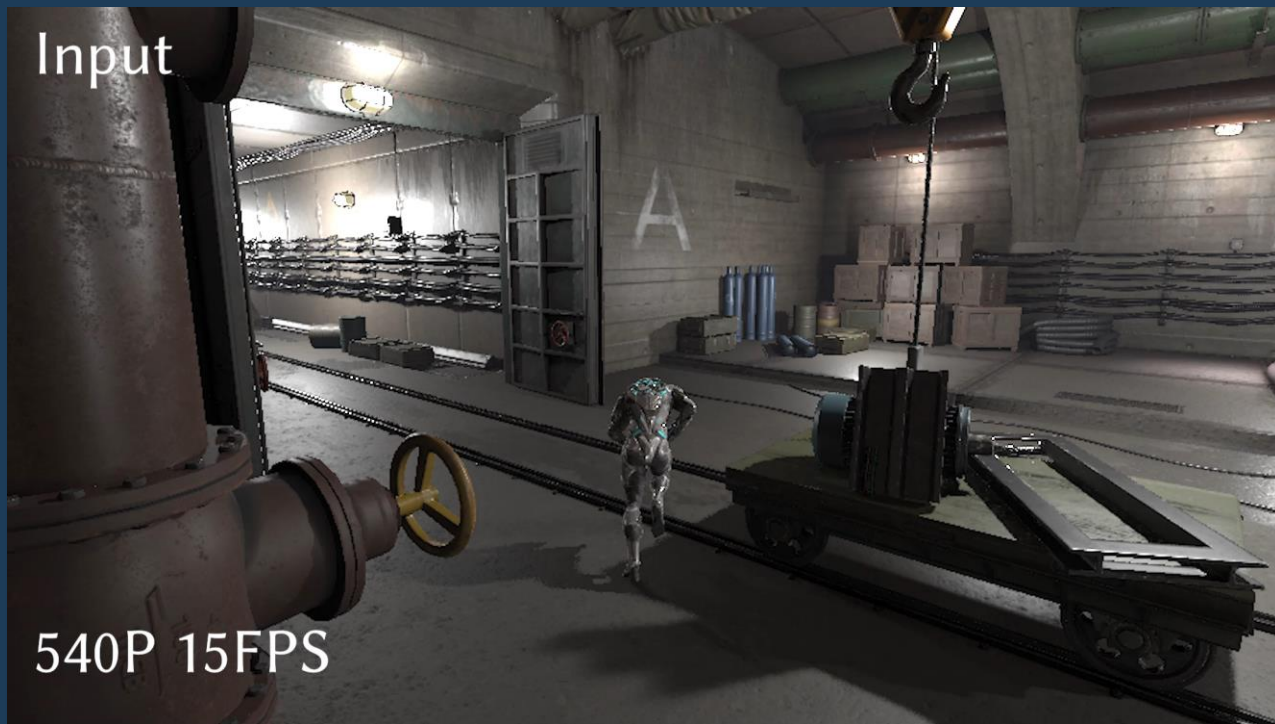
Flexible #Frames Extrapolation



Generalization



Project Page



Thank you!

