Learned HDR Image Compression for Perceptually Optimal Storage and Display

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Outline

- Introduction
- Method
- Experiments
- Summary

Introduction

Motivations

- Increased information in HDR impedes storage and transmission

- Directly displaying HDR images on LDR monitors causes significant information loss and quality degradation

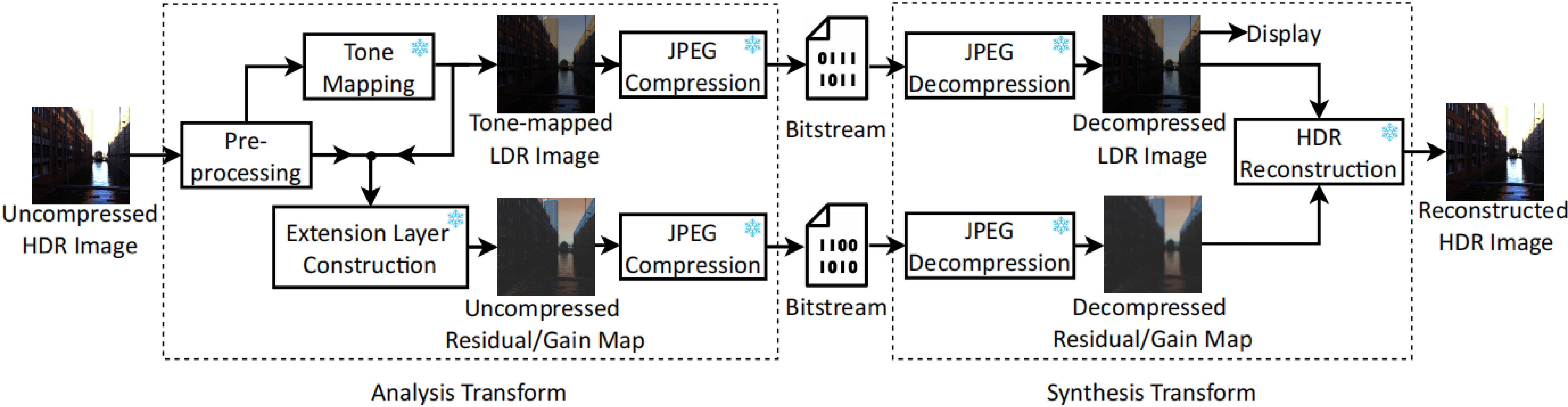
Introduction

Contributions

- ➢ Introduce a new HDR image compression problem
  - Considering both storage and display constraints
- ➢ Adopt two perceptually-aligned image quality metrics as loss functions
  - Normalized Laplacian pyramid distance (NLPD) [Laparra et al., 2016]
  - HDR-IQA as LDR-IQA [Cao et al., 2024]

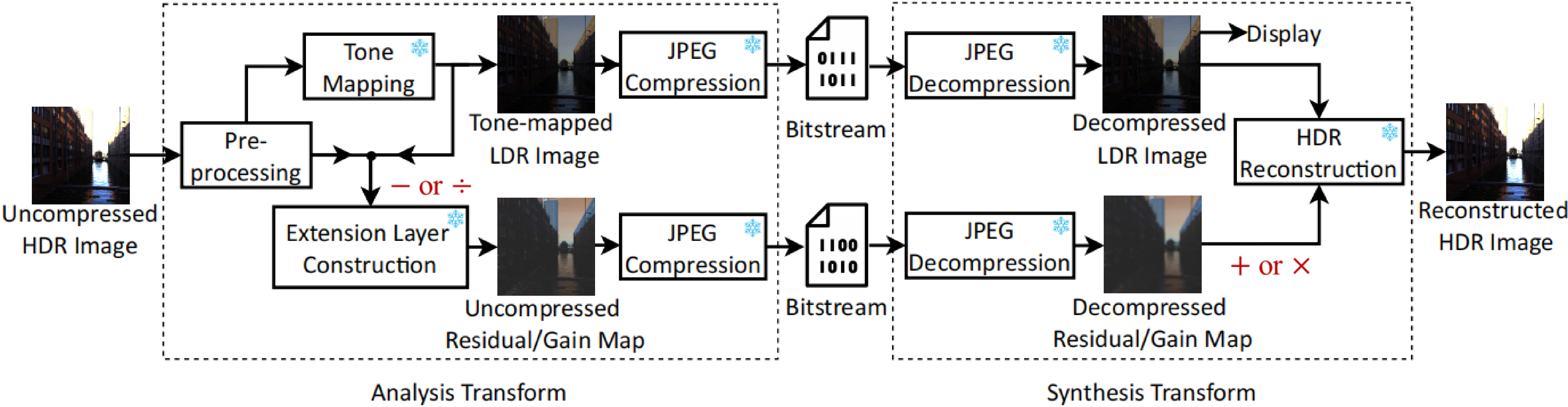
Traditional Methods

General diagram



Traditional Methods

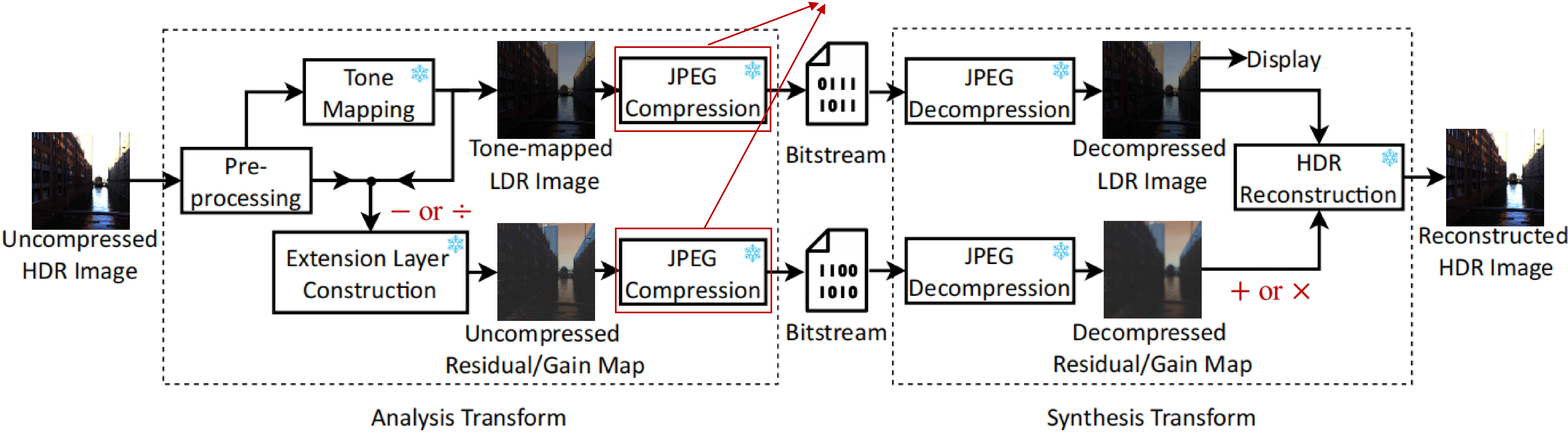
General diagram



Traditional Methods

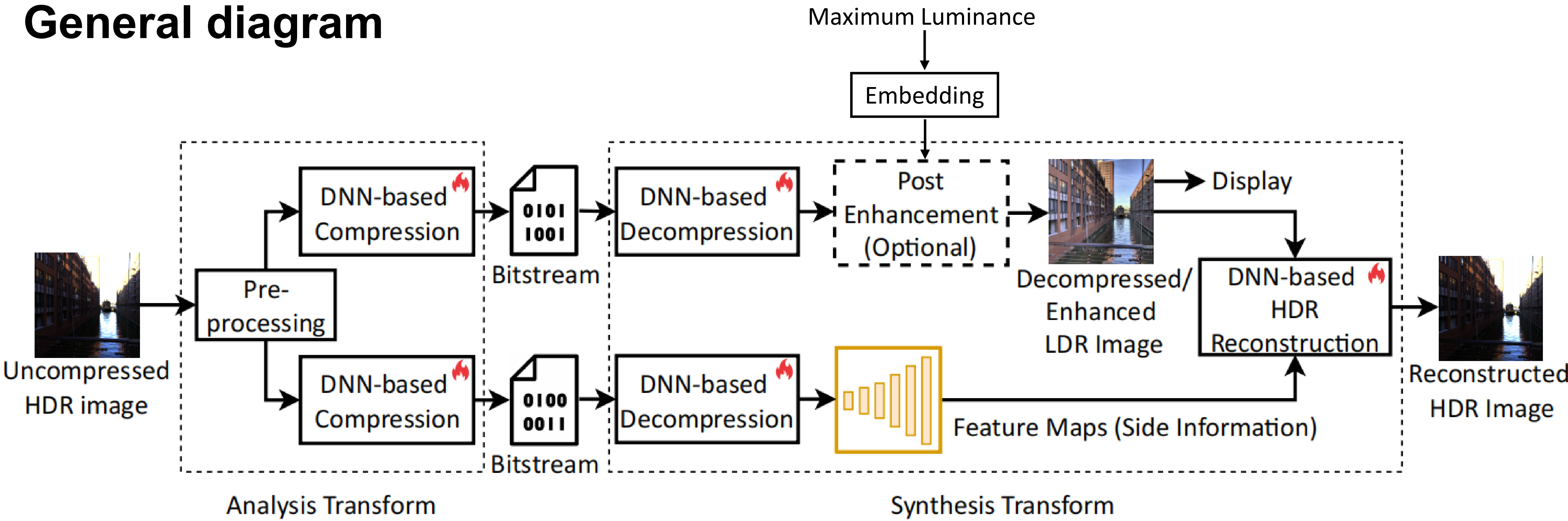
General diagram

Other image and video compression standards such as JPEG2000 and H.264



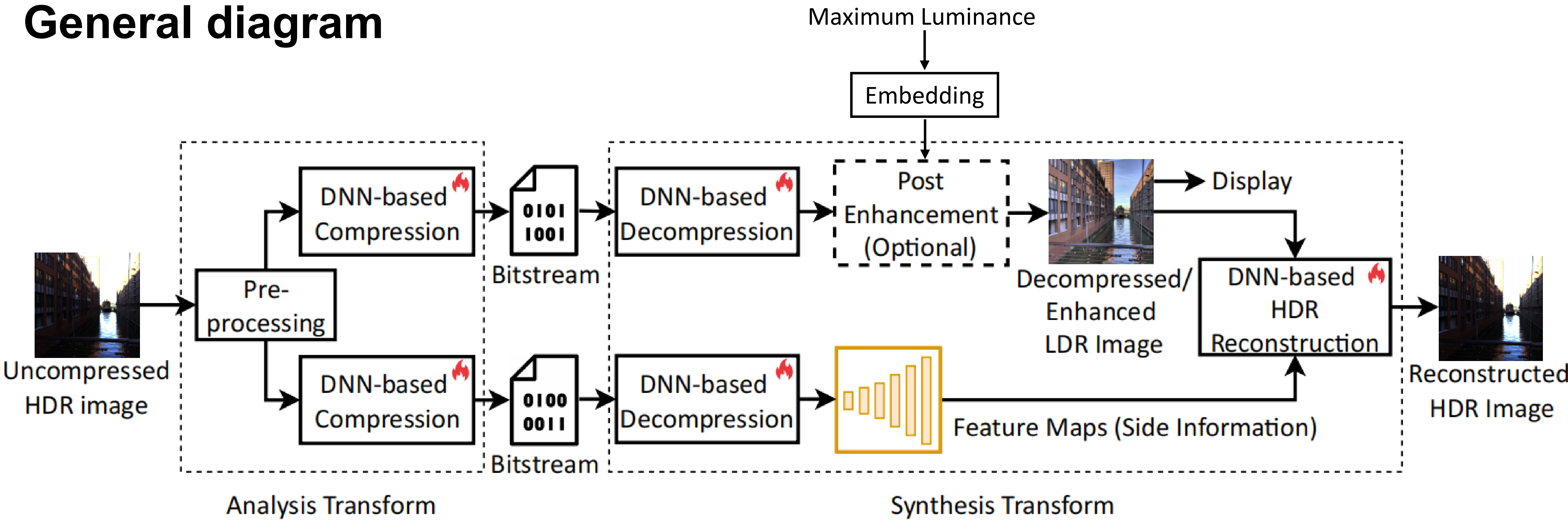
Proposed Method

General diagram



Proposed Method

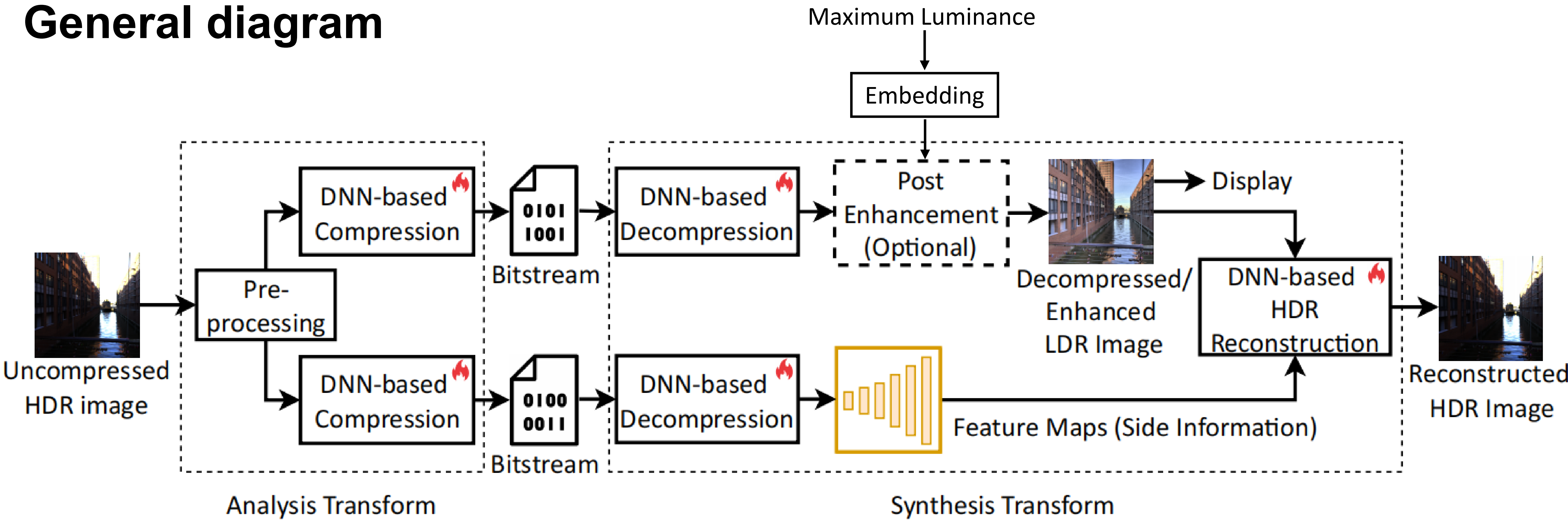
General diagram



- Learnable compression and decompression process

Proposed Method

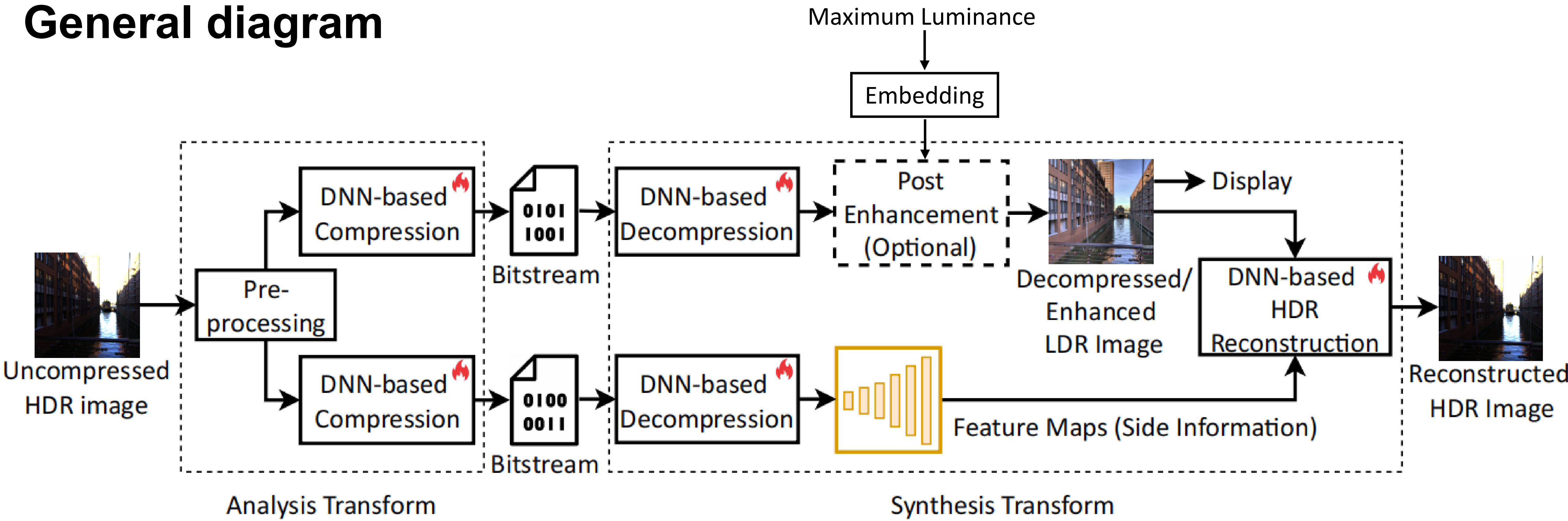
General diagram



- Learnable compression and decompression process
- Representation (feature maps) as side information

Proposed Method

General diagram



- Learnable compression and decompression process
- Representation (feature maps) as side information
- Side information independent of LDR images

Optimization Objective

Distortion function

- NLPD for LDR images

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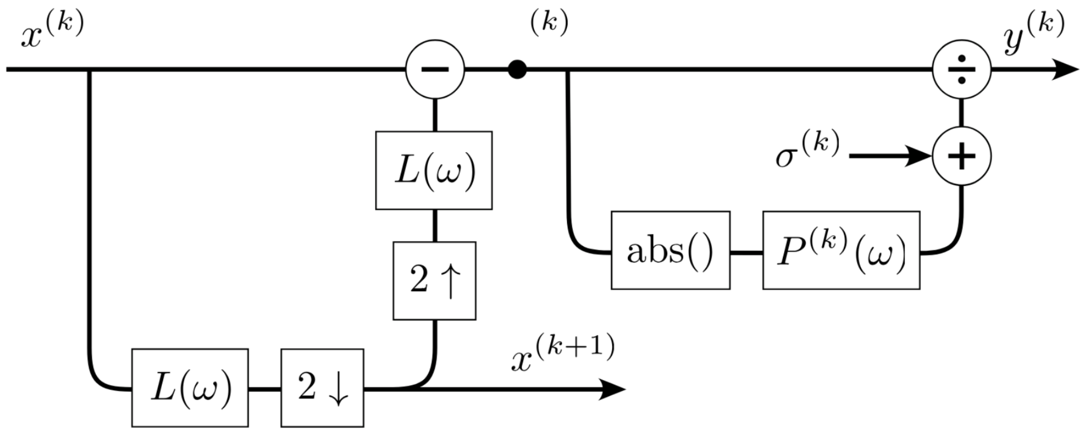
Distortion function

➢ NLPD for LDR images

- Models center-surround filtering and local gain control in the early visual system

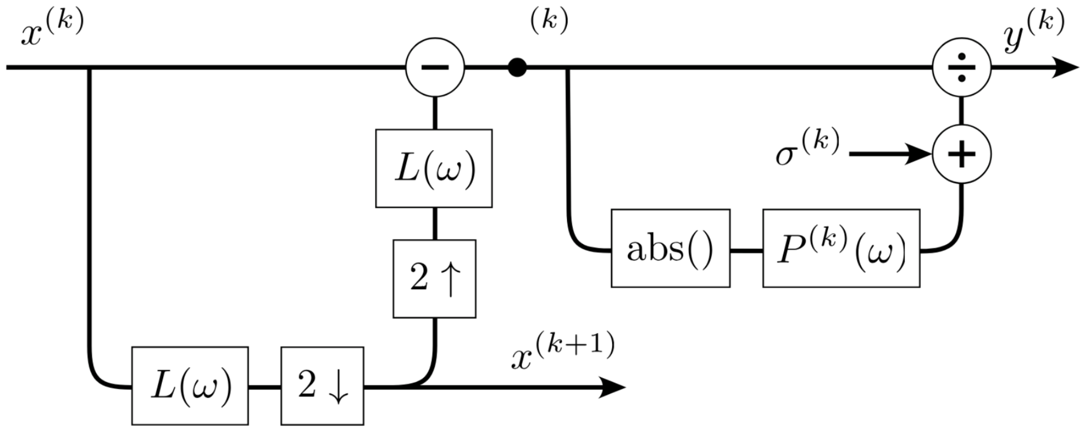


Optimization Objective

Distortion function

➢ NLPD for LDR images

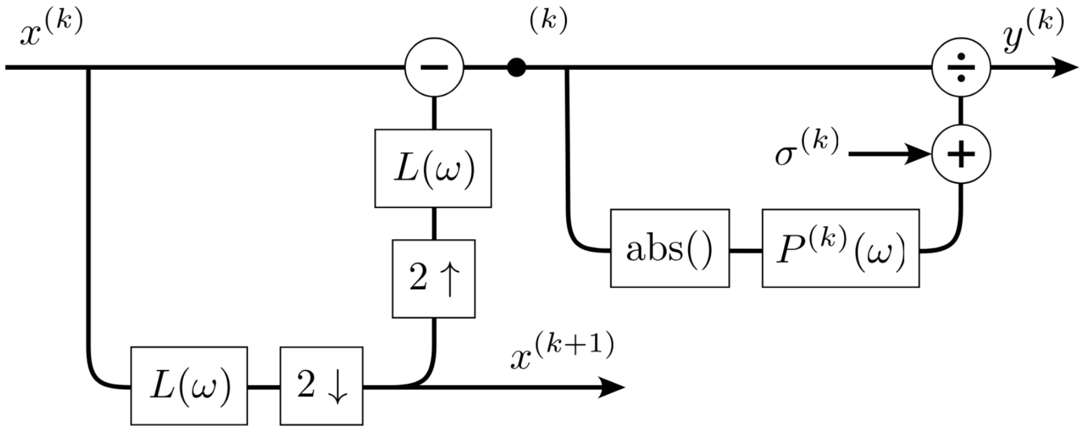
- Models center-surround filtering and local gain control in the early visual system
- Allows comparison of images with different dynamic ranges



Optimization Objective

Distortion function

- NLPD for LDR images
  - Models center-surround filtering and local gain control in the early visual system
  - Allows comparison of images with different dynamic ranges
  - Is effective in optimizing image rendering algorithms with various display constraints



Optimization Objective

Distortion function

- HDR-IQA as LDR-IQA HDR images

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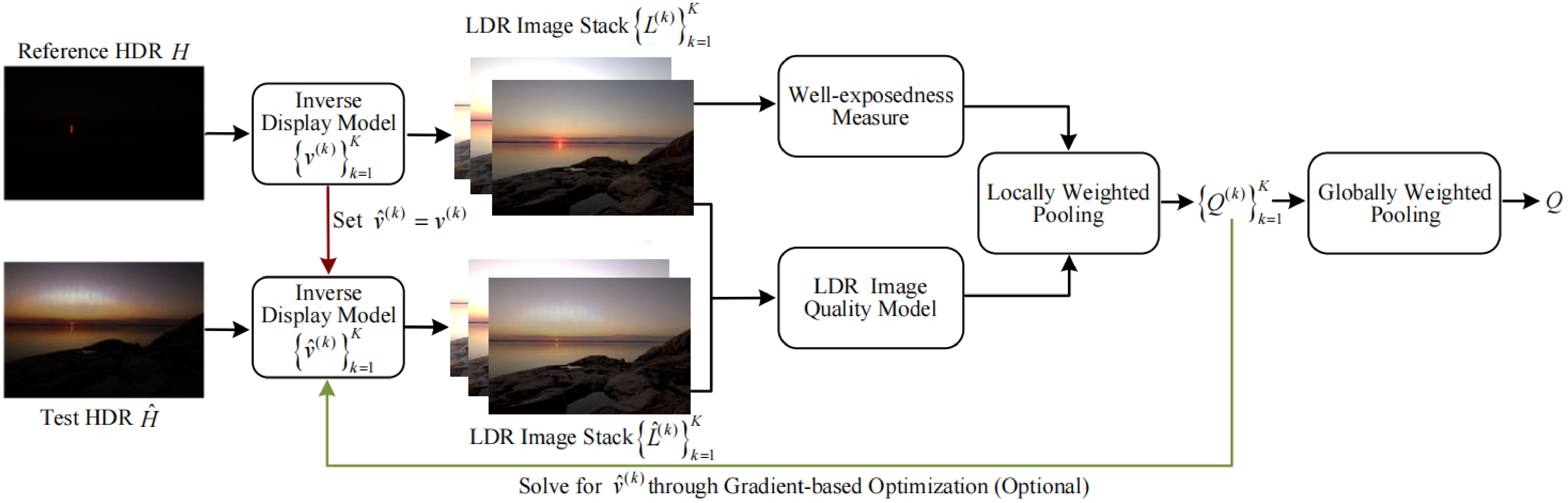
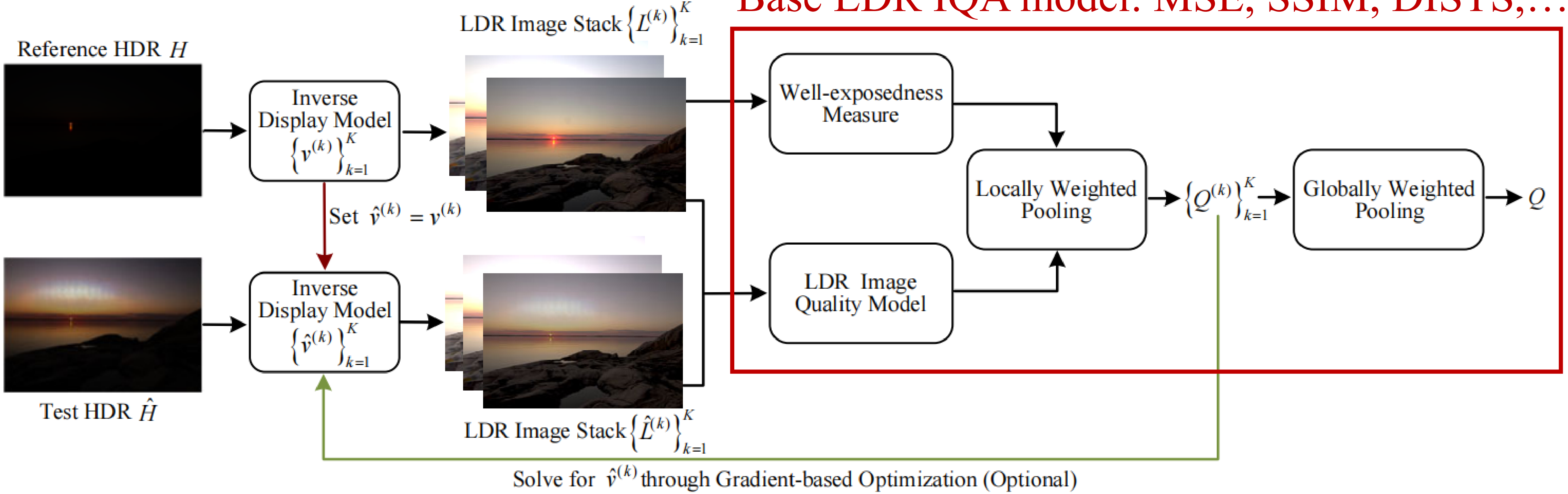


Optimization Objective

Distortion function

- ➢ HDR-IQA as LDR-IQA HDR images

Base LDR IQA model: MSE, SSIM, DISTS,…



Experiments

Datasets

- ➢ We use panoramic HDR images from Poly Haven
  - 3, 880 images for training, and 780 images for testing

Competing Methods

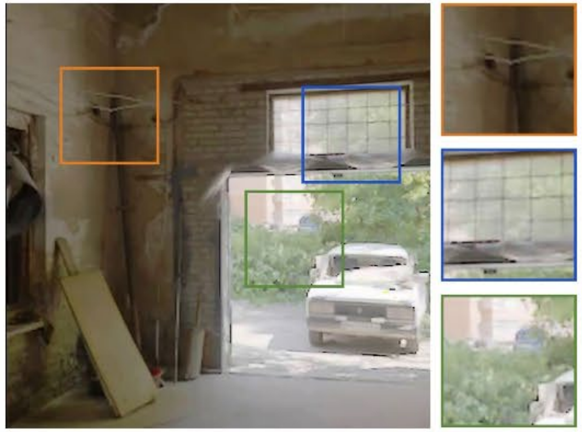
- ➢ Nine HDR image compression methods for comparison

Visual Results

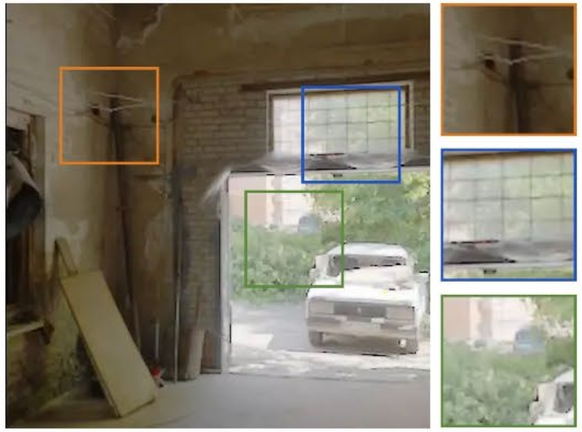
- LDR

JPEG-HDR (0.75 bpp)

Boschetti10 (0.77 bpp)



Mai11 (0.81 bpp)



TMO+WebP (0.75 bpp)

TMO+BPG (0.76 bpp)

JPEG-XT (0.75 bpp)

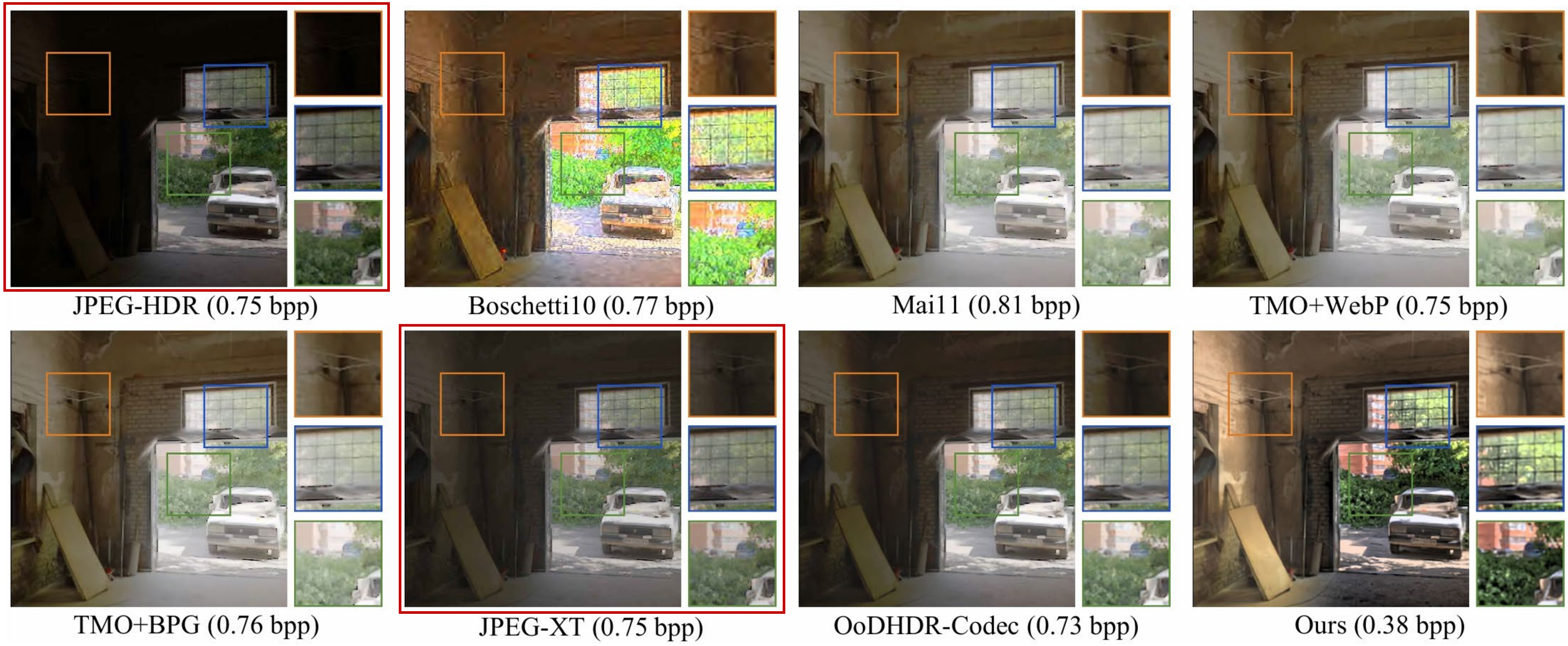
OoDHDR-Codec (0.73 bpp)

Ours (0.38 bpp)

Visual Results

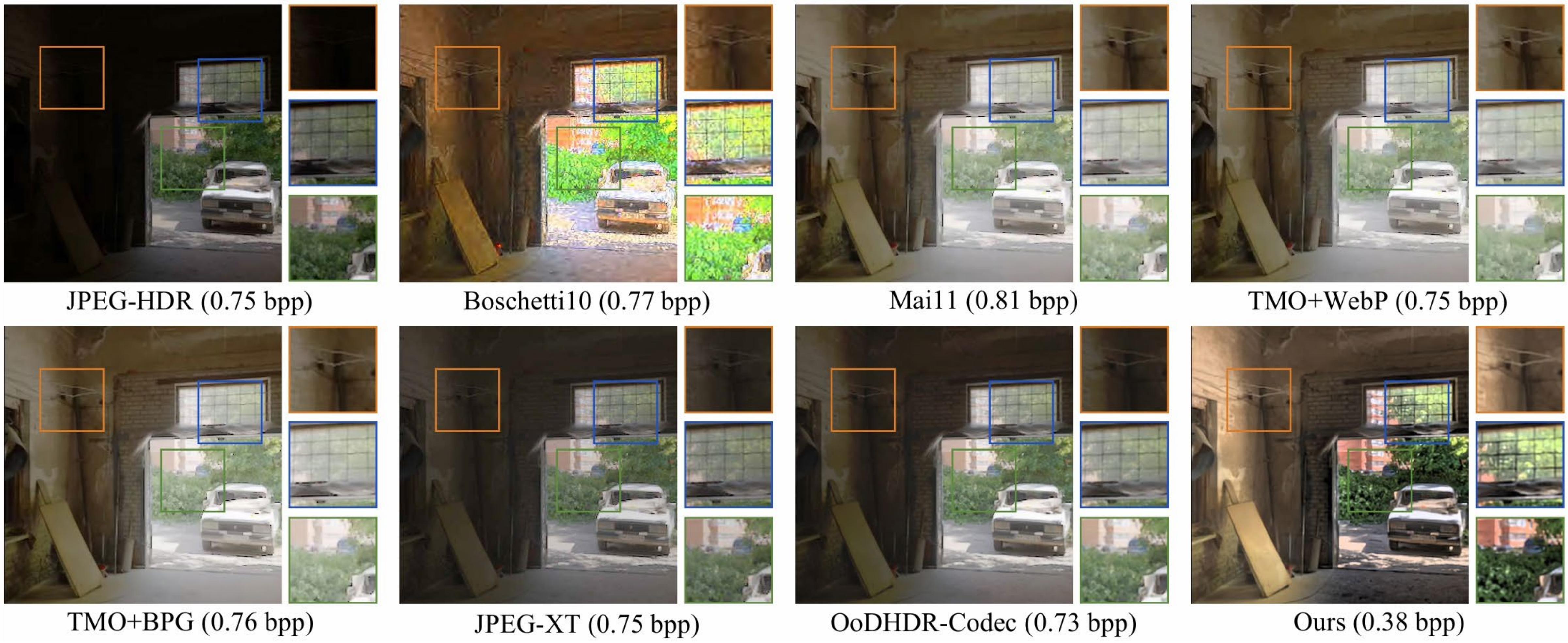
➢ LDR

- Detail loss in under-exposure areas
- Blocking artifacts



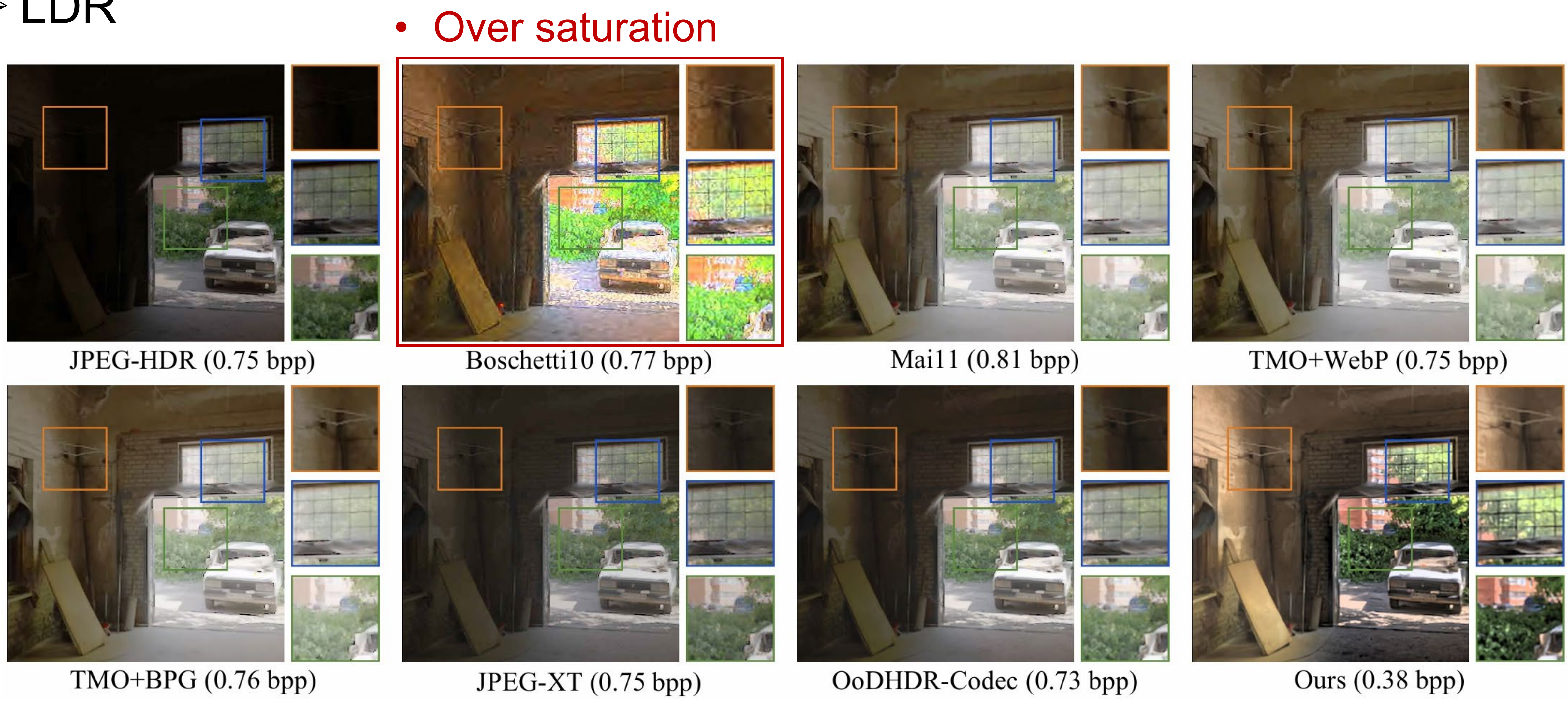
Visual Results

➢ LDR



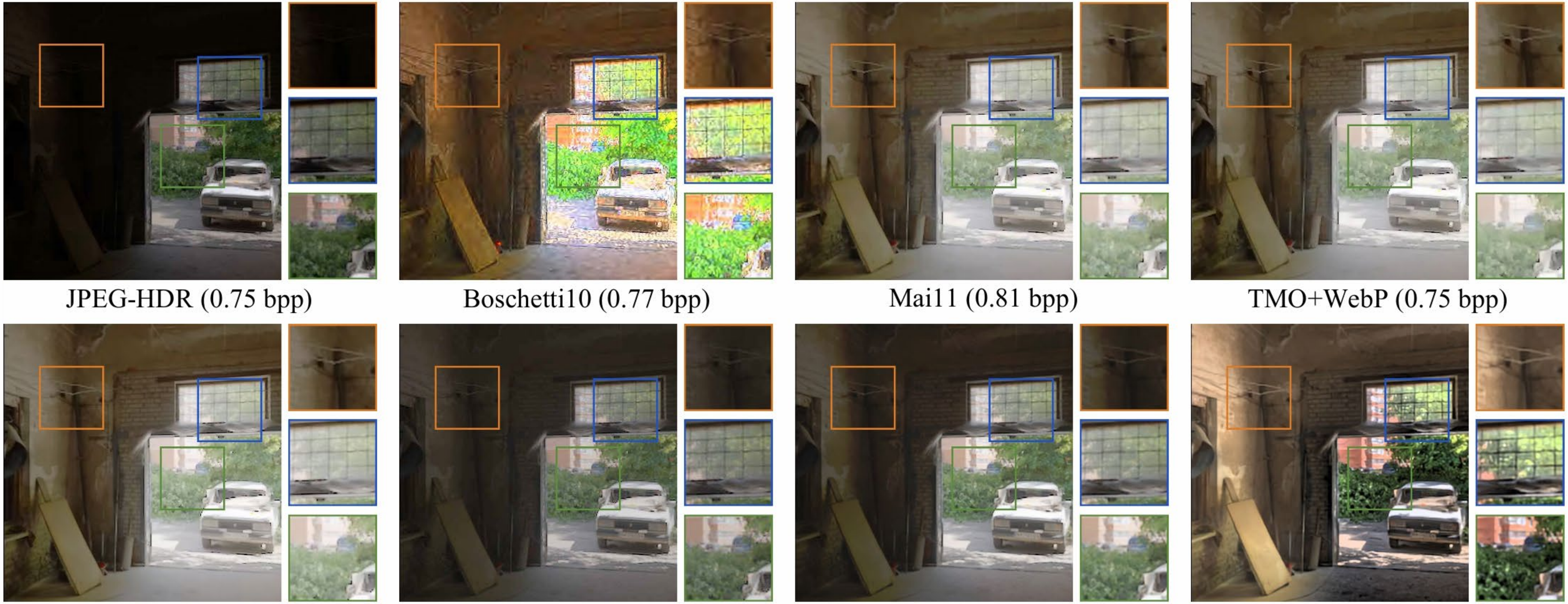
Visual Results

- LDR



Visual Results

- LDR



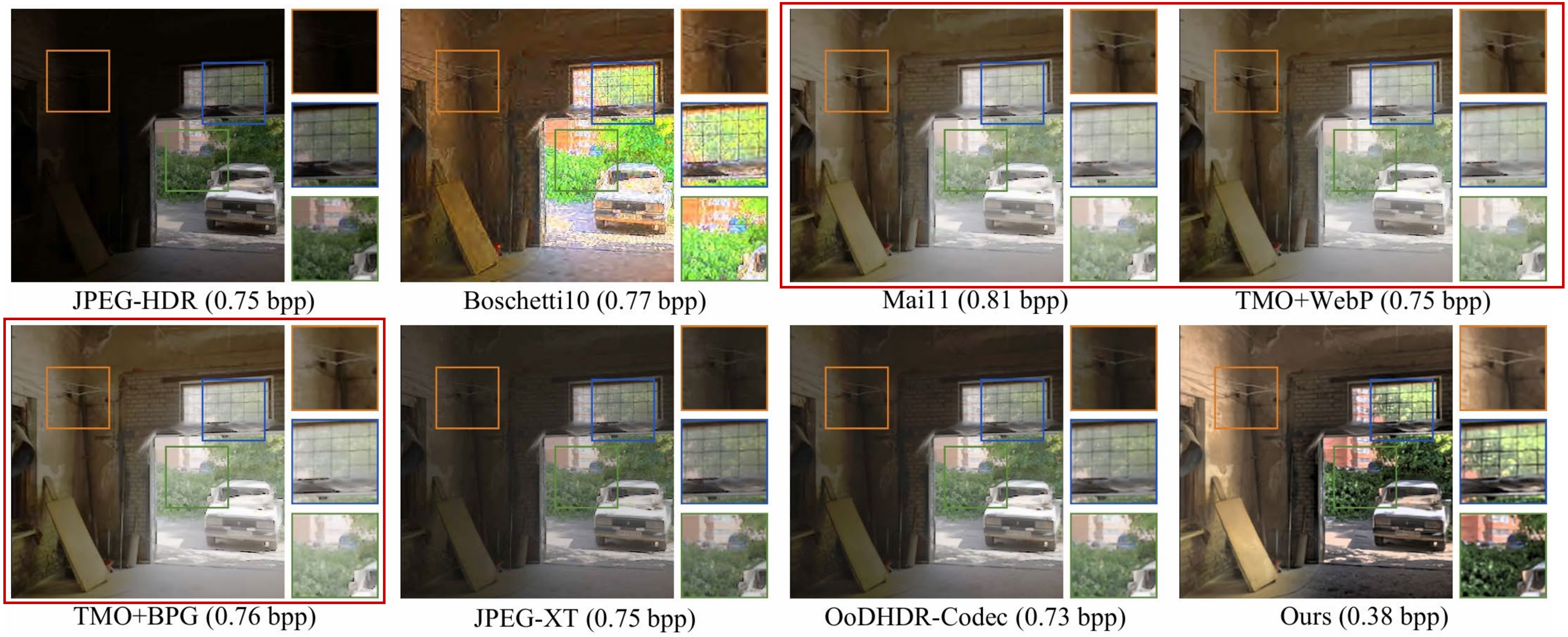
JPEG-HDR (0.75 bpp) | Boschetti10 (0.77 bpp) | Mai11 (0.81 bpp) | TMO+WebP (0.75 bpp)

TMO+BPG (0.76 bpp) | JPEG-XT (0.75 bpp) | OoDHDR-Codec (0.73 bpp) | Ours (0.38 bpp)

Visual Results

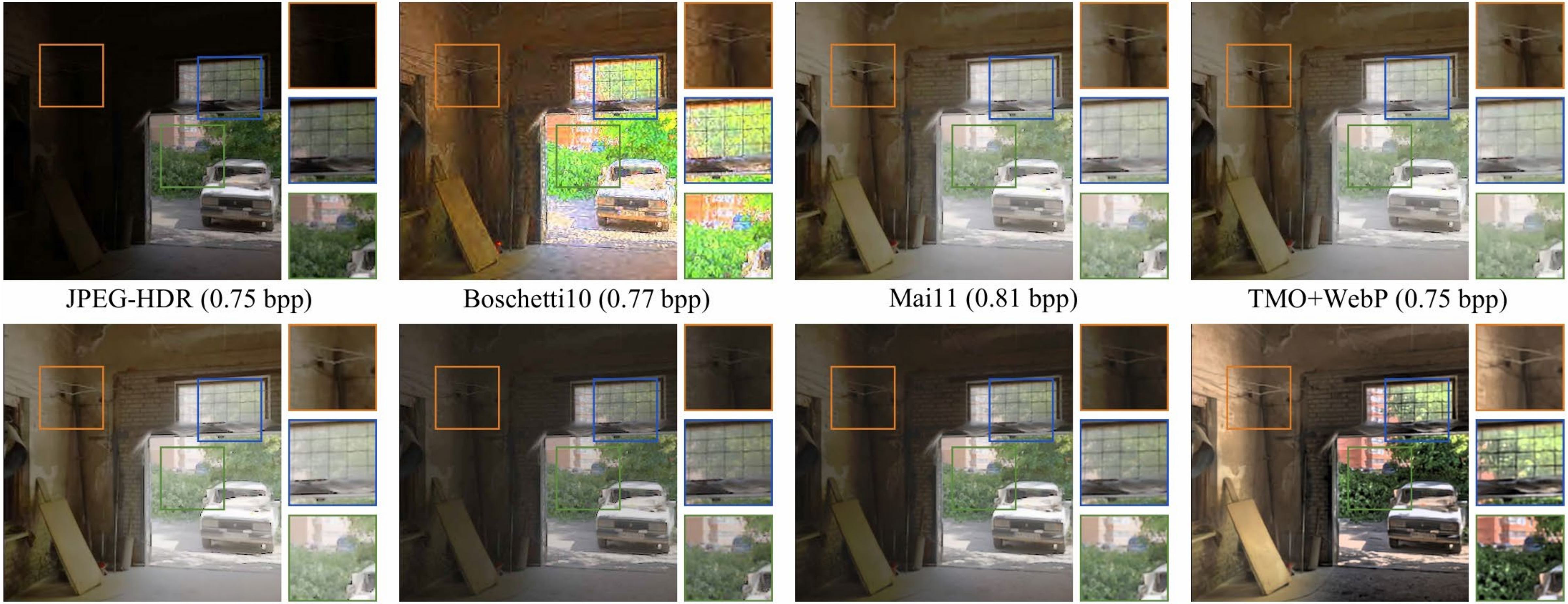
➢ LDR

- Detail loss
- Low color saturation



Visual Results

- LDR



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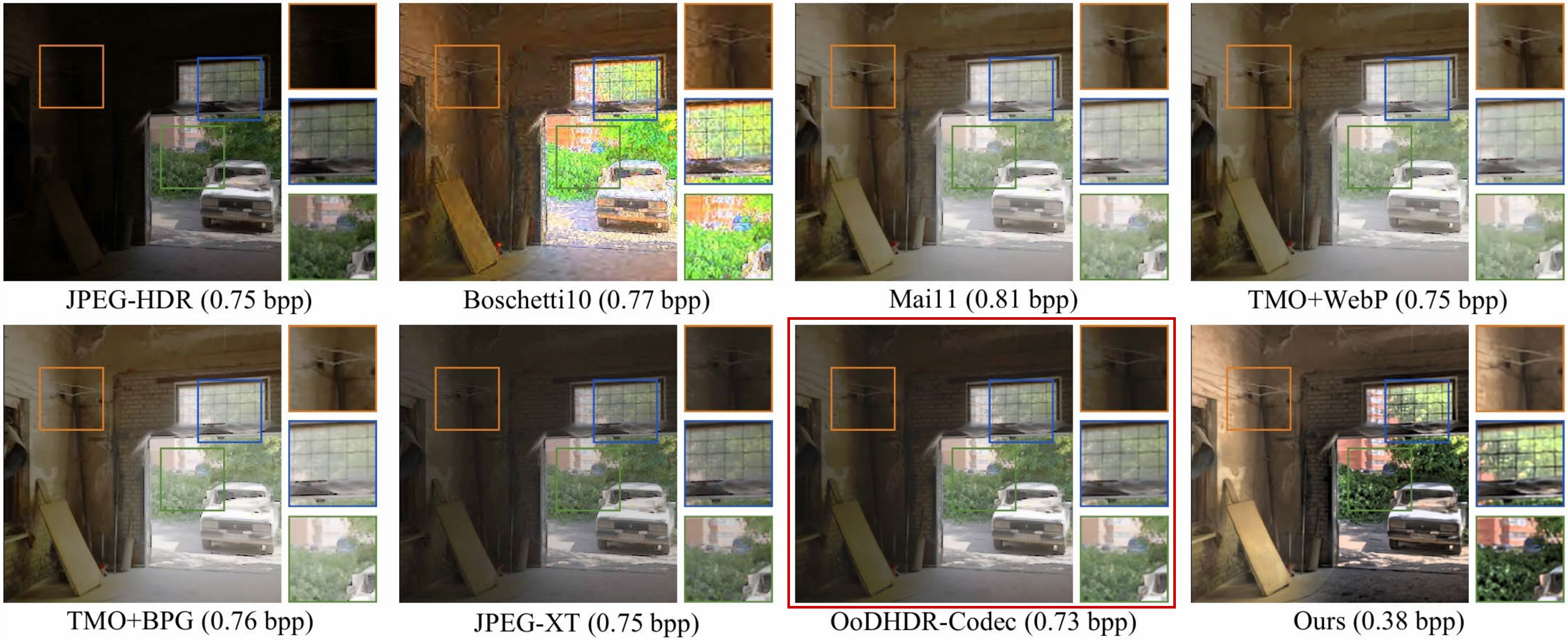
Visual Results

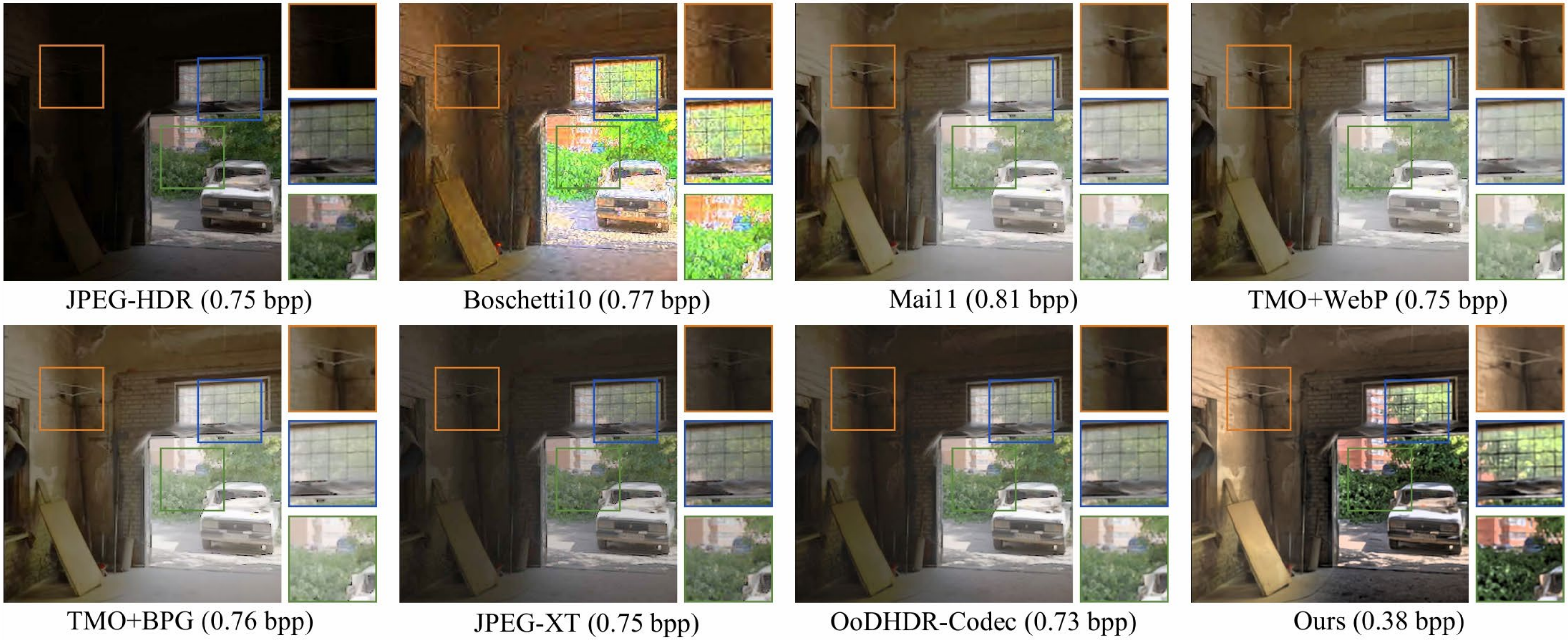
➢ LDR



- Detail loss in low-exposed regions

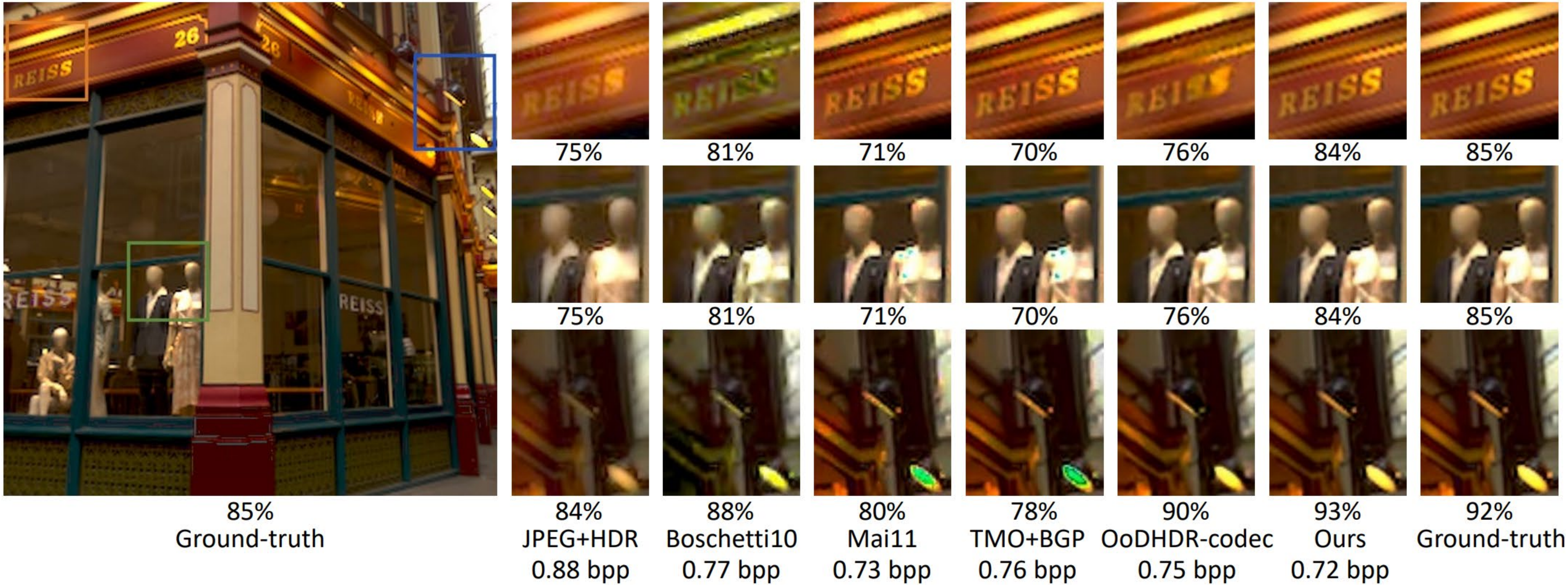
Visual Results

- LDR



Visual Results

➢ HDR



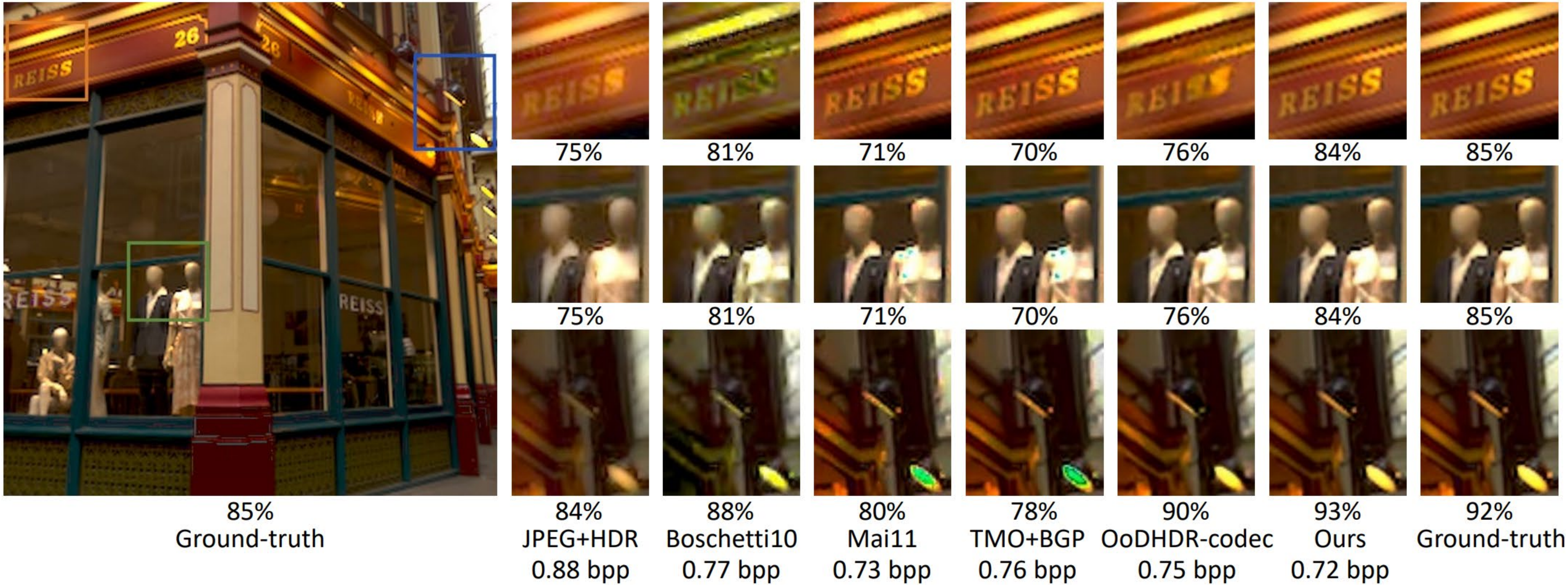
Visual Results

➢ HDR

- Blocking
- Blurring

Visual Results

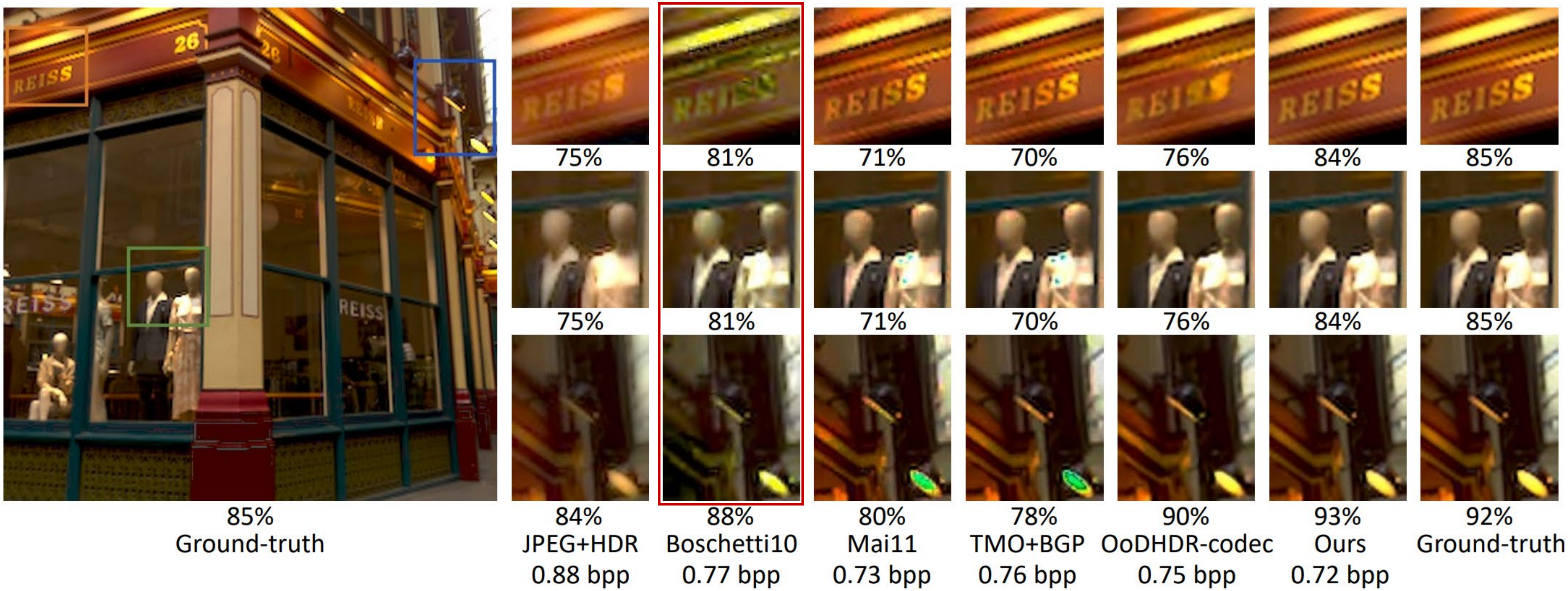
➢ HDR



Visual Results

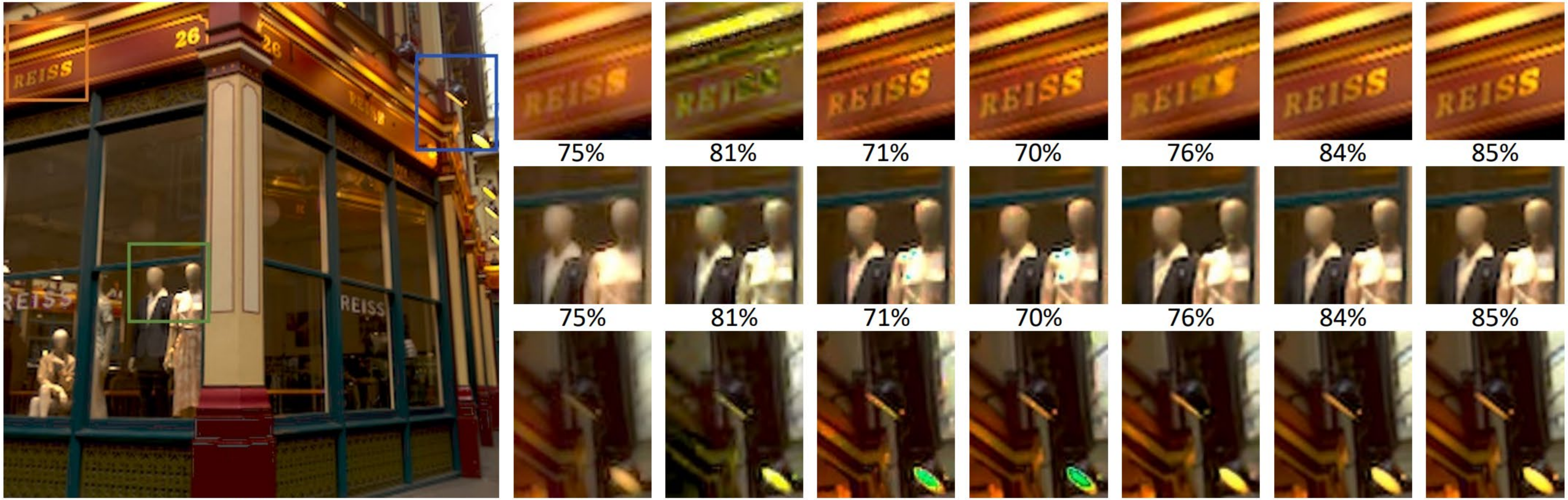
➢ HDR

- Texture loss
- Color cast



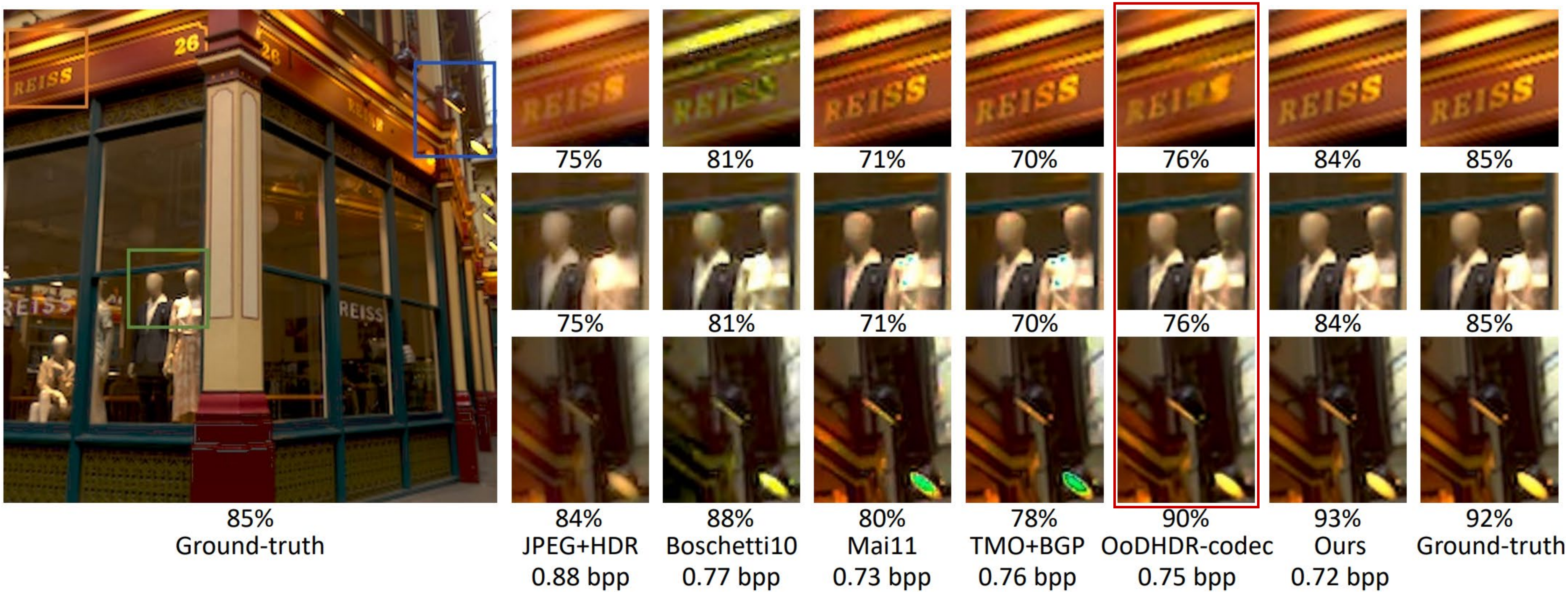
Visual Results

- HDR



Visual Results

- HDR



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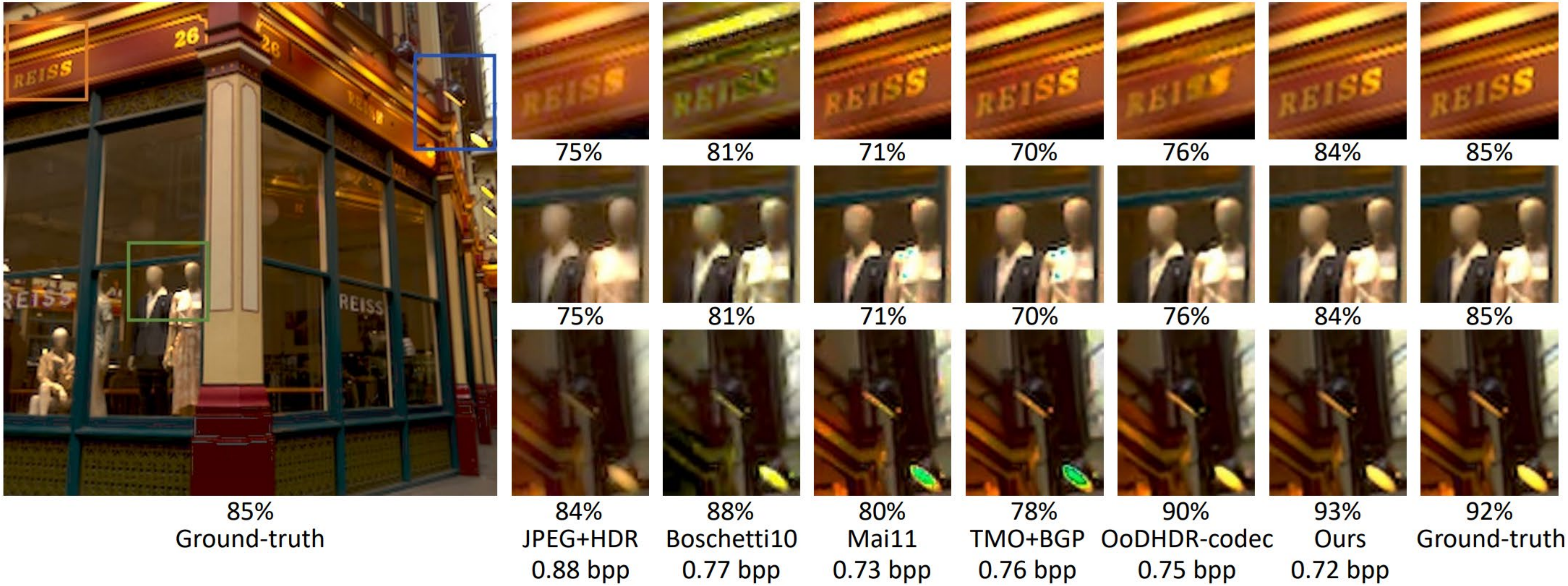
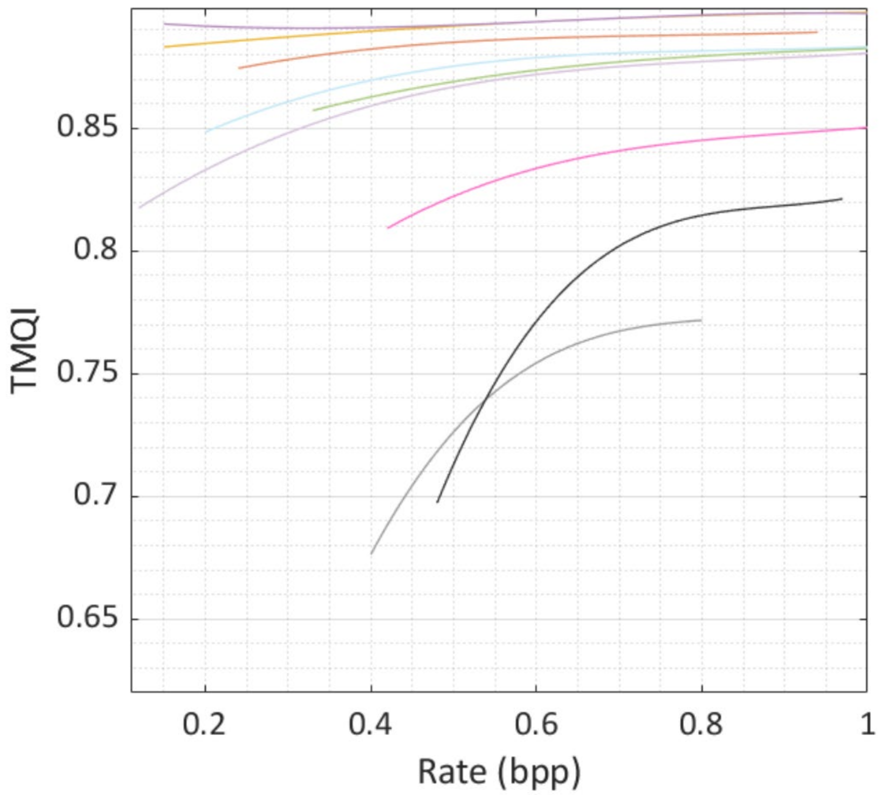
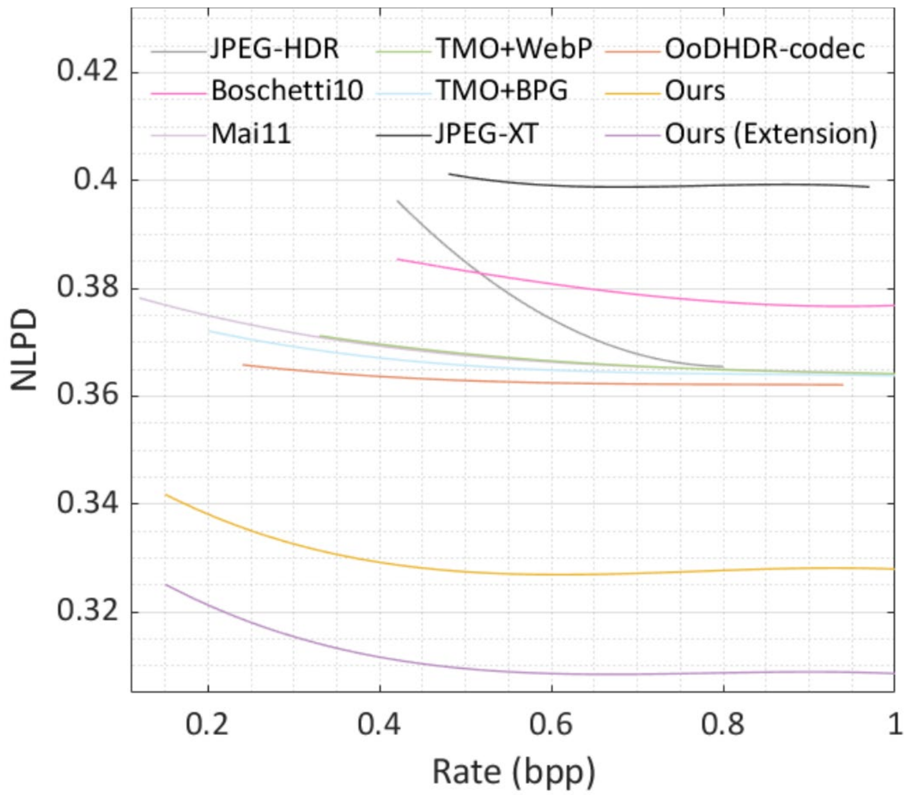


Quantitative Evaluation

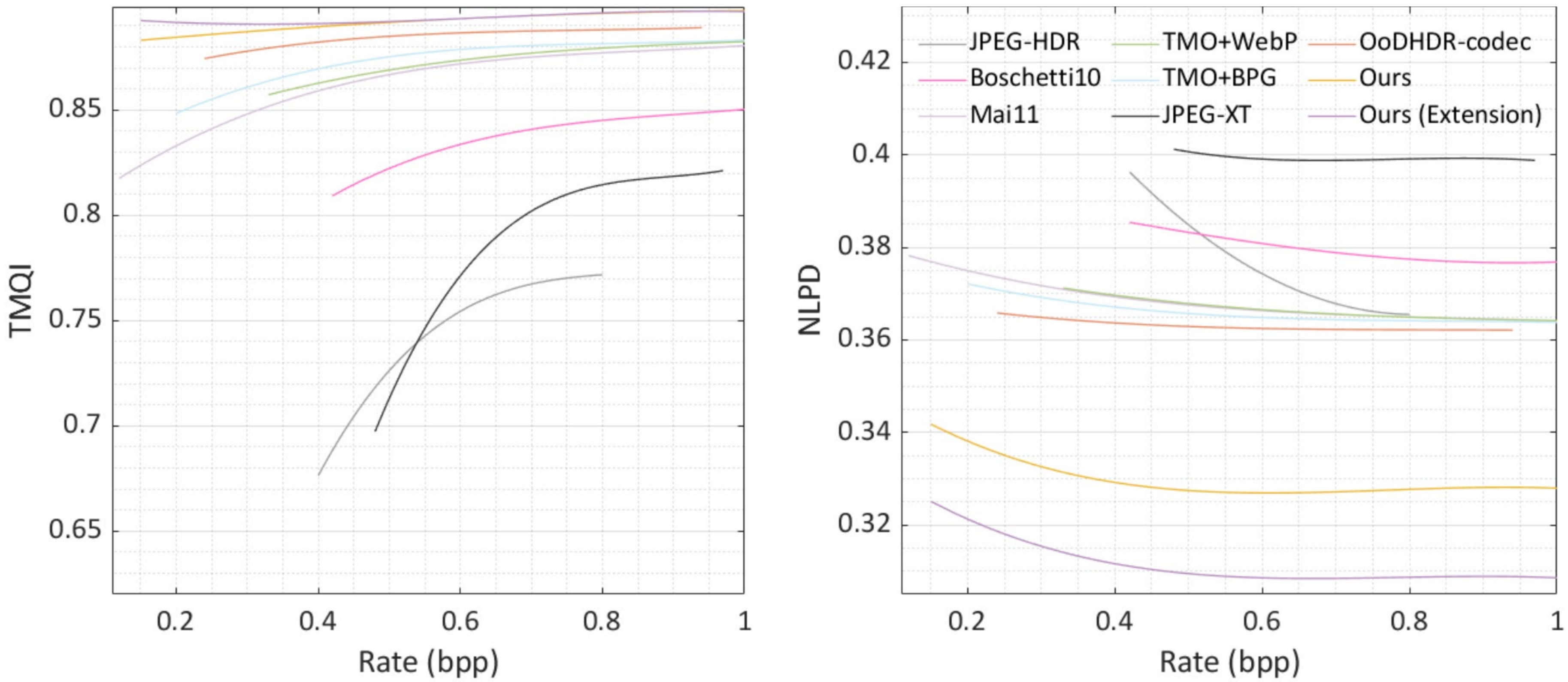
➢ LDR





Quantitative Evaluation

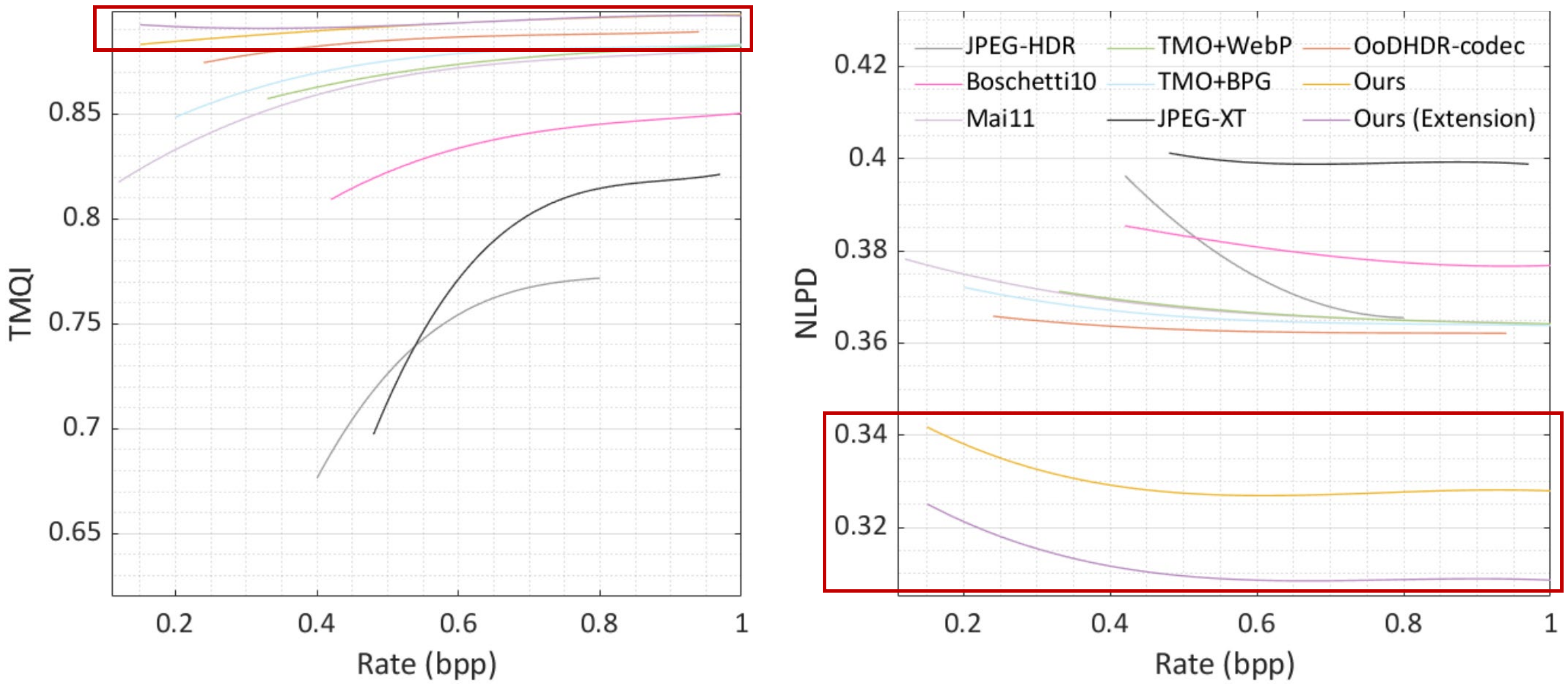
➢ LDR



- Higher TMQI and lower NLPD mean better quality

Quantitative Evaluation

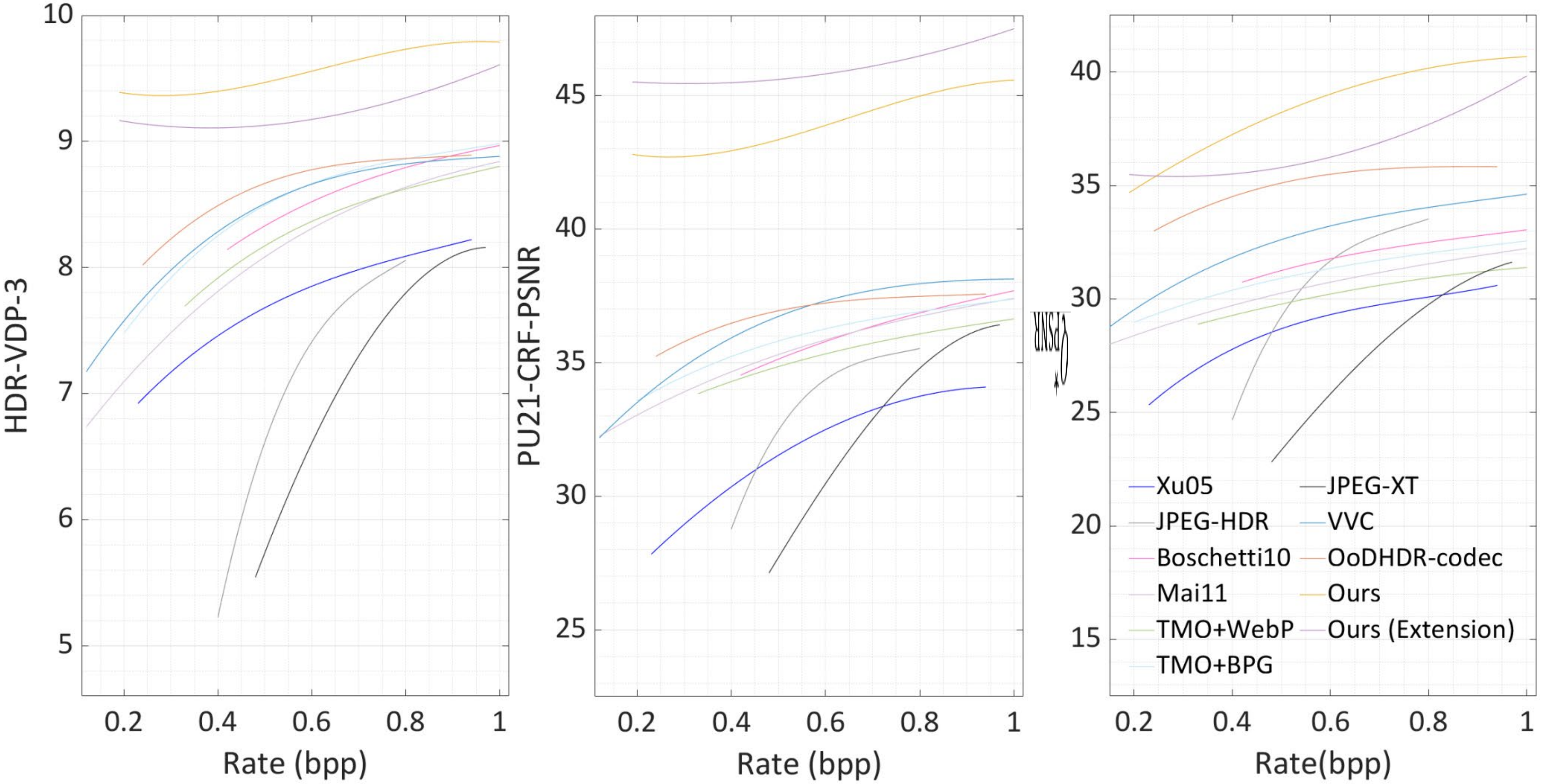
➢ LDR



- Higher TMQI and lower NLPD mean better quality
- Our method and its extension consistently deliver the best values

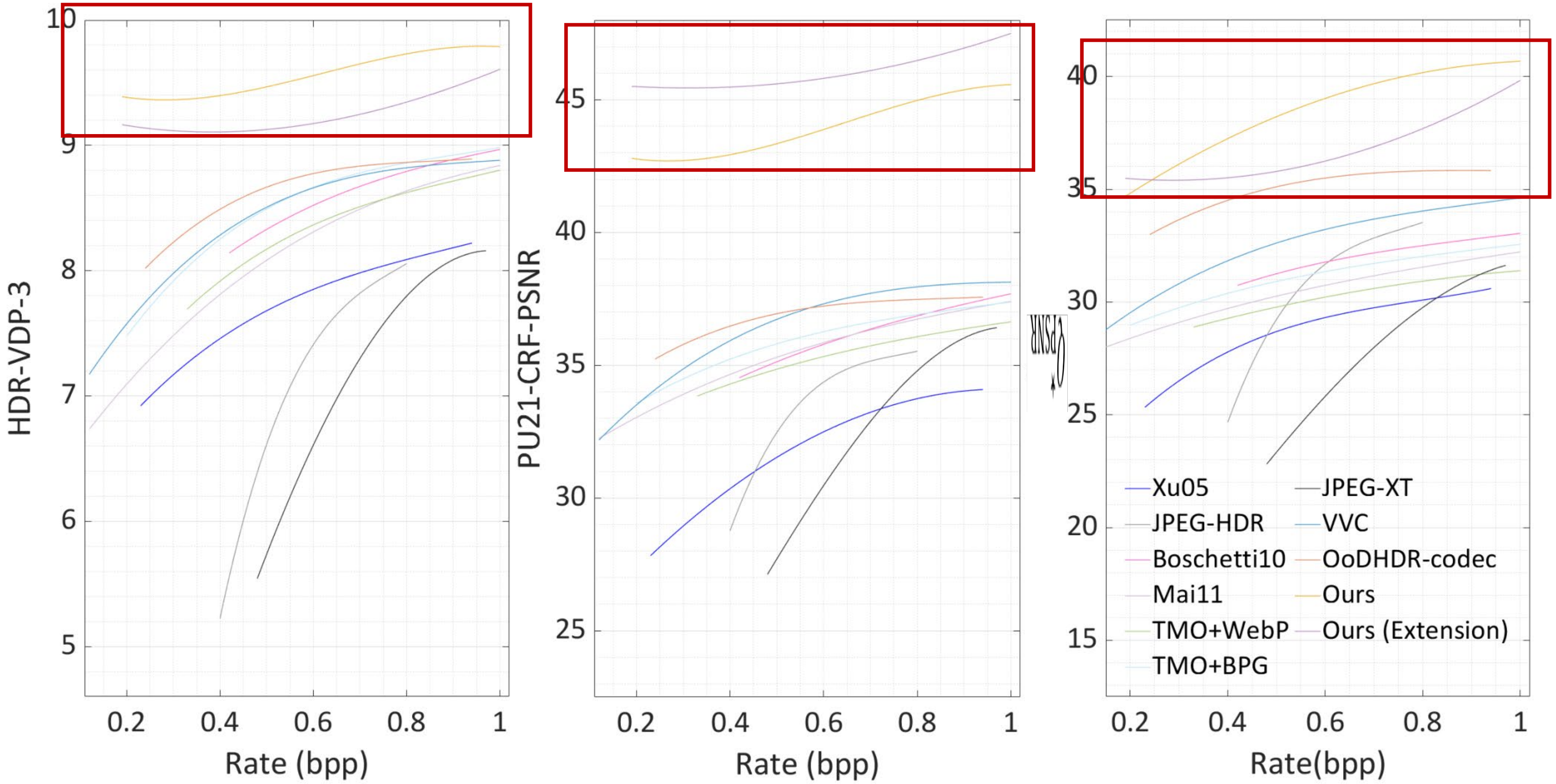
Quantitative Evaluation

➢ HDR



Quantitative Evaluation

➢ HDR



- Our methods outperform other methods, particularly at relatively low bit rates

Summary

Summary

- We have presented an end-to-end optimized HDR image compression system for perceptually optimal storage and display

- The proposed method prioritizes perceptual optimization by adopting two perceptually aligned image distortion measures

Thanks for your attention!