Artifact-free High Dynamic Range Imaging for Dynamic Scenes using

Robust Patch-Based HDR Reconstruction

DIP PROJECT

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Team : cut-copy-paste

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High Dynamic Ranging (HDR)

- For a scene, dynamic range refers to ratio between the brightest and darkest parts (intensity) of the scene.

- The Dynamic Range of real world scenes with direct sunlight or shadows can be quite high ratios of 100,000 : 1 are common in the natural world.

- HDR imaging : Generating images with a greater range of luminance levels than which can be achieved by taking only a single photograph with a fixed exposure.


WHY HDR IMAGES?

Low Dynamic Range Vs High Dynamic Range

Standard Dynamic Range

High Dynamic Range

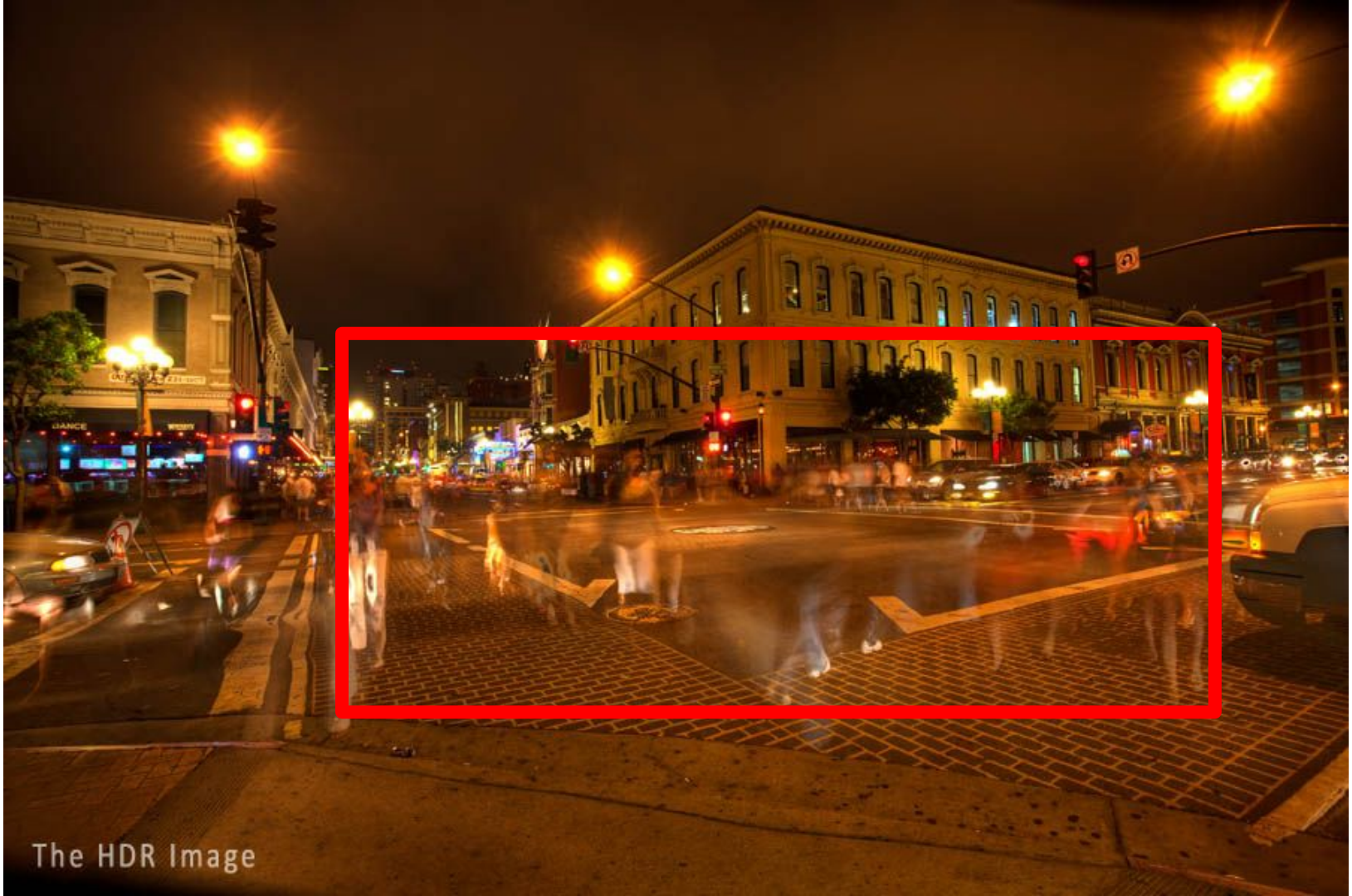

OFF
ON

What happens when we capture Dynamic Scenes?

Dynamic Scenes : Scenes involving motion



Motion Blur


The HDR Image

AIM

HDR imaging that is robust to camera/scene motion.

Previous Work

- Common approach in HDR imaging of a scene -
  Take sequential LDR images at different exposure levels and merge them into an HDR image.
  But this suffers from artifacts for scenes with significant motion.

- There are two major kind of approaches to remove motion artifacts for sequential HDR imaging.
  - Algorithms that reject ghosting artifacts
  - Algorithms that align the different exposures

Possible Approaches

- Algorithms that reject ghosting artifacts

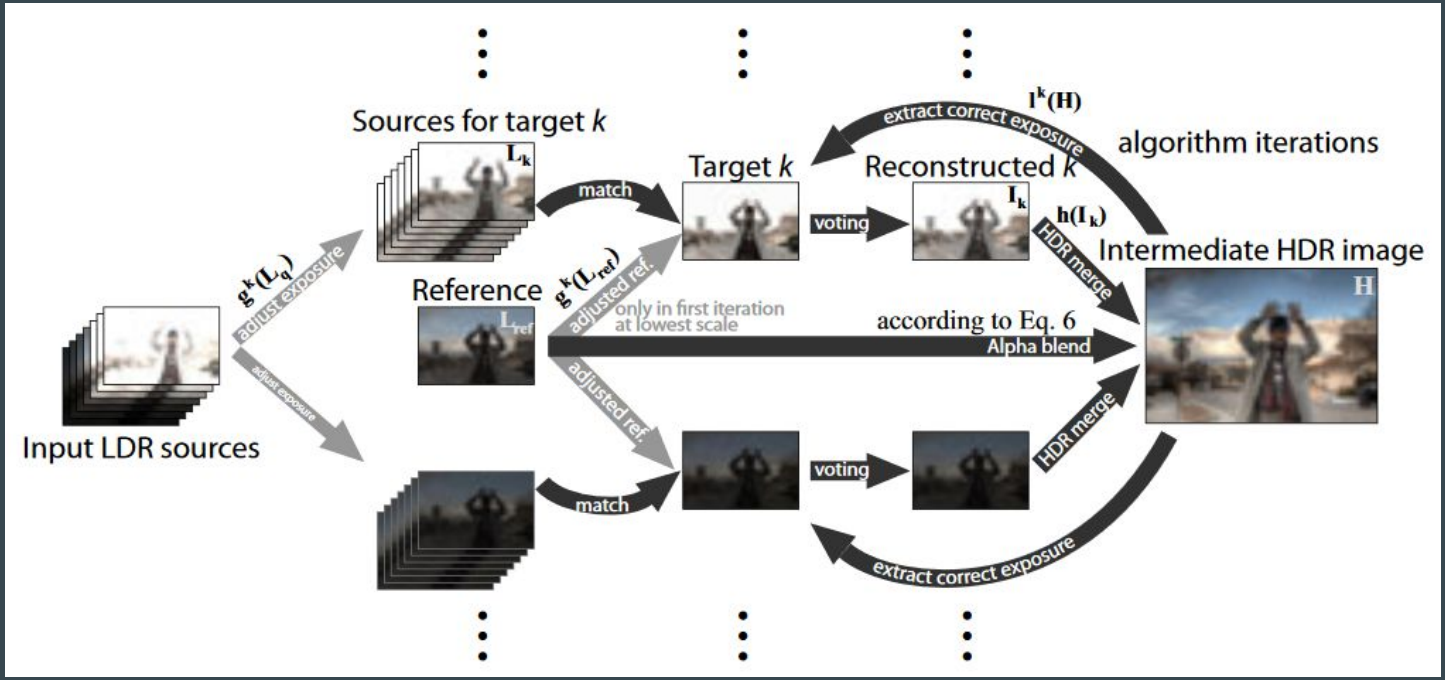
  These techniques try to identify ghosted pixels and only use information from a subset of exposures in the ghosted locations.
- Algorithms that align the different exposures

  These approaches try to align the different LDR exposures before merging them into the final HDR image.

  Current state-of-the-art method: *Zimmer et al. [2011]*. They used a optical flow based method to minimize their proposed energy function.

System Model

System Description



Inner core algo which solves the HDR synthesis equation

HDR Synthesis Equation

$$E(H) = \sum_{p \in \text{pixels}} \Big[\alpha_{\text{ref}_{(p)}} \cdot \left(h(L_{\text{ref}})_{(p)} - H_{(p)} \right)^2 + \left(1 - \alpha_{\text{ref}_{(p)}}\right) \cdot E_{\text{MBDS}}(H \mid L_1, \ldots, L_N) \Big].$$

MBDS

$$E_{\mathrm{MBDS}}(H \mid L_1, \ldots, L_N) =$$

$$\sum_{k=1}^{N} \mathrm{MBDS}\big(l^k(H) \mid g^k(L_1), \ldots, g^k(L_N)\big),$$

$$\mathrm{MBDS}(T \mid S_1, \ldots, S_N) = \frac{1}{N} \sum_{k=1}^{N} \sum_{P \in S_1, \ldots, S_N} w_k(P) \min_{Q \in T} d(P, Q) +$$

$$\frac{1}{|T|} \sum_{Q \in T} \min_{P \in S_1, \ldots, S_N} d(Q, P), \qquad (9)$$

Patch-based HDR image reconstruction algorithm

/ Stage 1 – optimize for $I_1, \ldots, I_N$ in Eq. 4 */*
for exposure $k = 1$ to $N, k \neq$ ref **do**
  $I_k \leftarrow \text{SearchVote}(I_k \mid g^k(L_1), \ldots, g^k(L_N))$
  $I_k \leftarrow \text{Blend}(I_k, l^k(H))$
end for

/ Stage 2 – optimize for H in Eq. 4 */*
$\tilde{H} \leftarrow \text{HDRmerge}(I_1, \ldots, I_N)$ [Eq. 5]
$H \leftarrow \text{AlphaBlend}(h(L_{\text{ref}}), \tilde{H})$ [Eq. 6]
/ extract the new image targets for the next iteration */*
$\{I_1, \ldots, I_N\} \leftarrow \{l^1(H), \ldots, l^N(H)\}$

Search and vote solves for patches to minimise E_{MBDS}.

$$\tilde{H}_{(p)} \leftarrow \frac{\sum_{k=1}^{N} \Lambda(I_{k_{(p)}}) h(I_k)_{(p)}}{\sum_{k=1}^{N} \Lambda(I_{k_{(p)}})}.$$

$$H_{(p)} \leftarrow \alpha_{\text{ref}_{(p)}} \cdot h(L_{\text{ref}})_{(p)} + (1 - \alpha_{\text{ref}_{(p)}}) \cdot \tilde{H}_{(p)}.$$

Results

Input LDR image stack

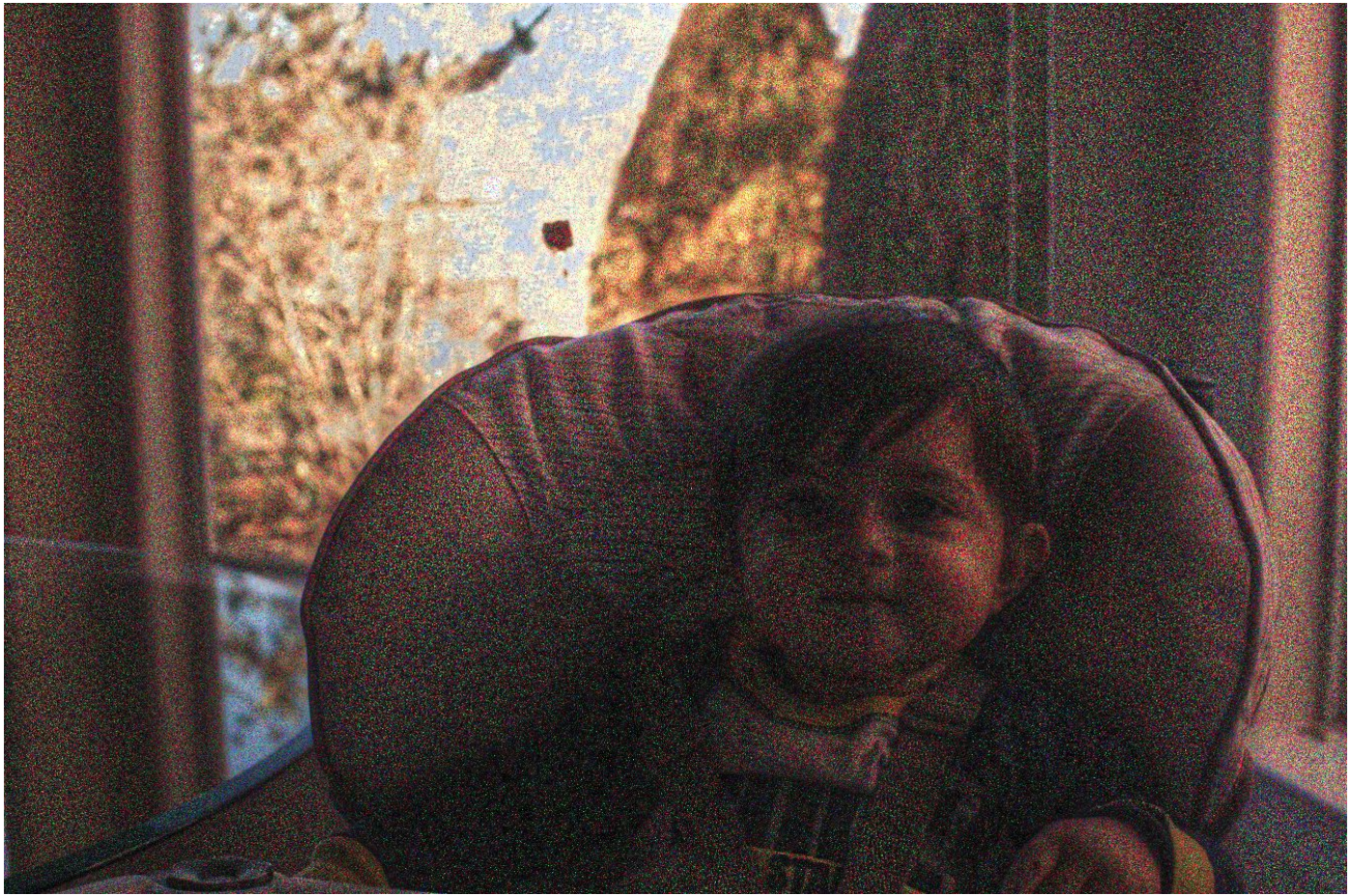
Final HDR Image

FAILURE CASES

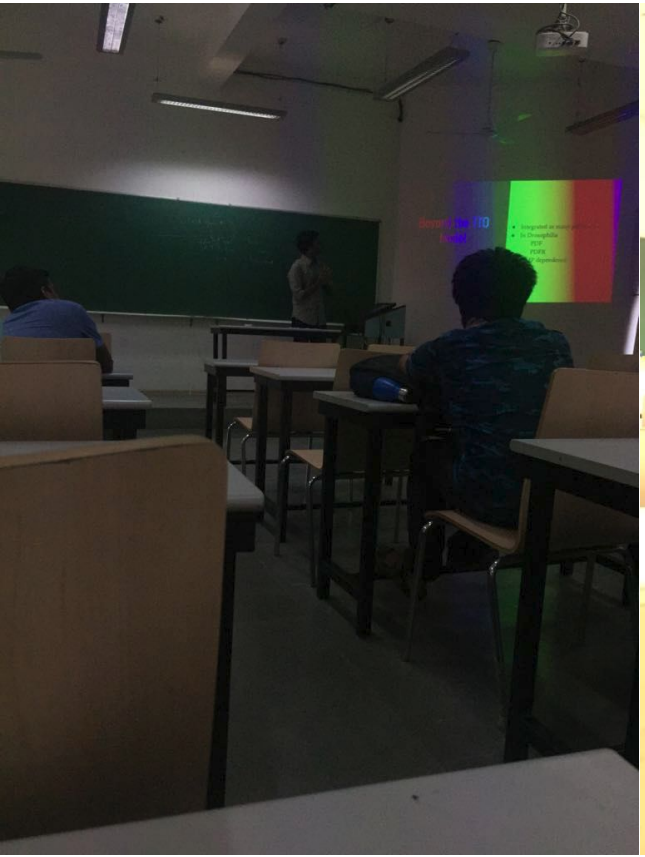
Our Result

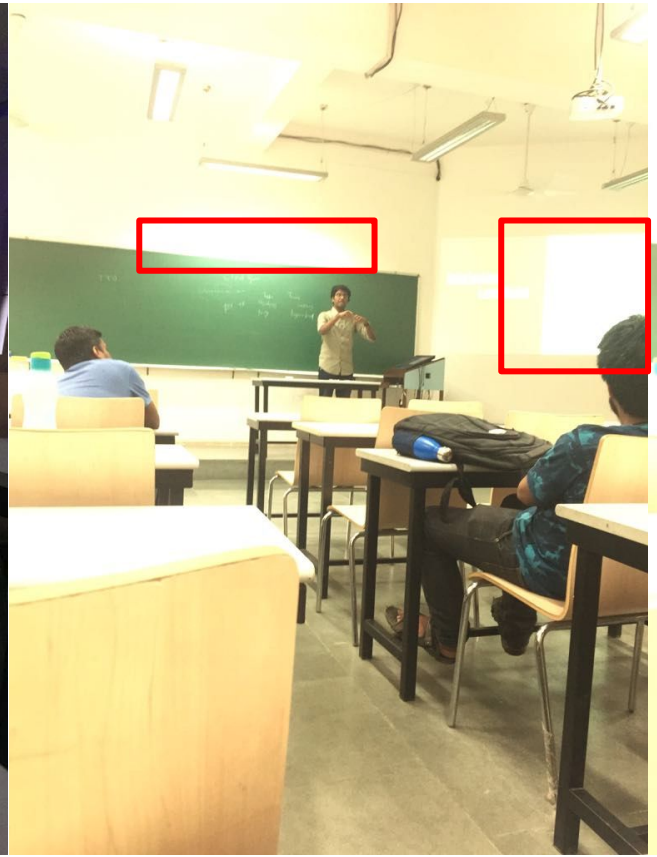
HDR Tone mapped Image

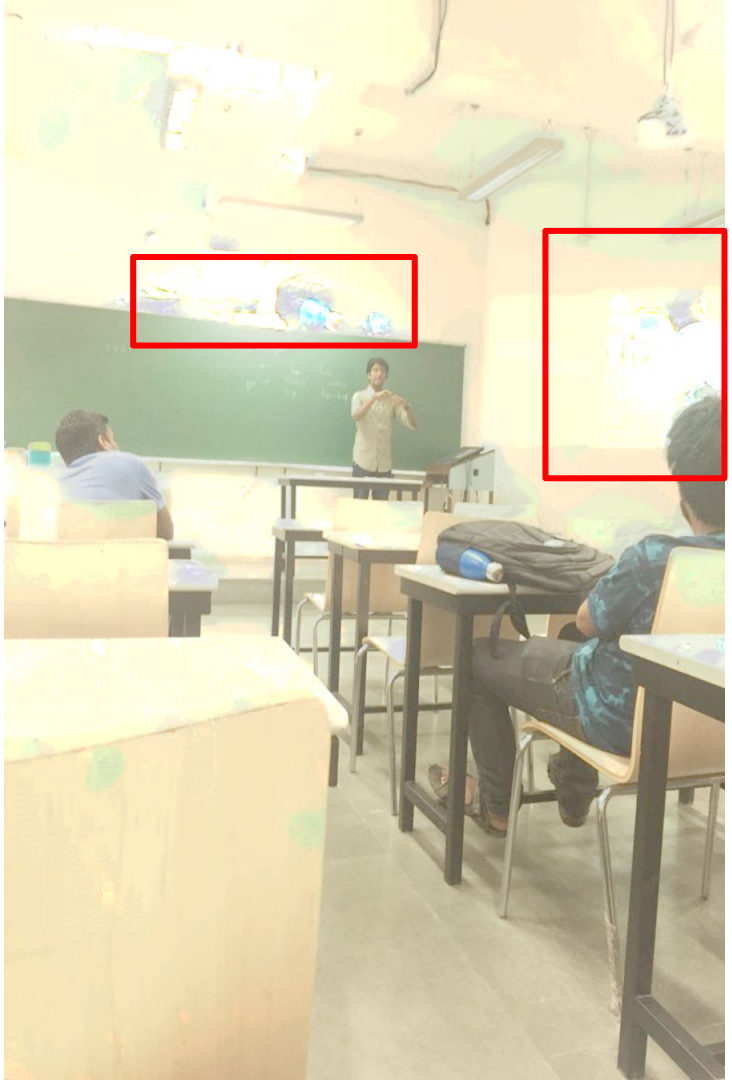
Noisy HDR Image



Implementation on our own Dataset (Generalisation)







Reason behind failure cases

*Reference Image being the central foundation for the HDR final image.

*Pixel Reconstruction going wrong due to insufficient valid information across all the exposures.

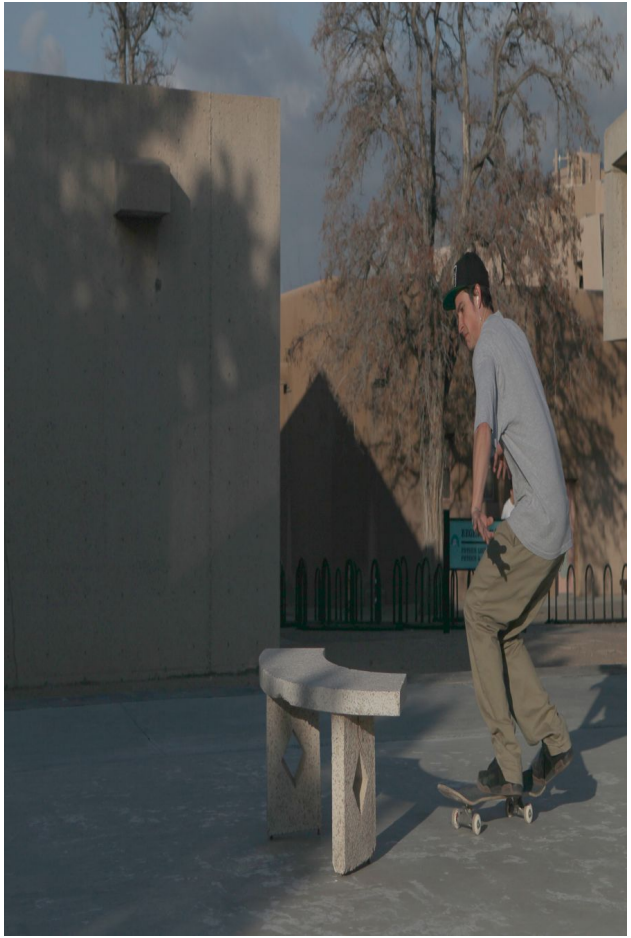
More Results

Output HDR image

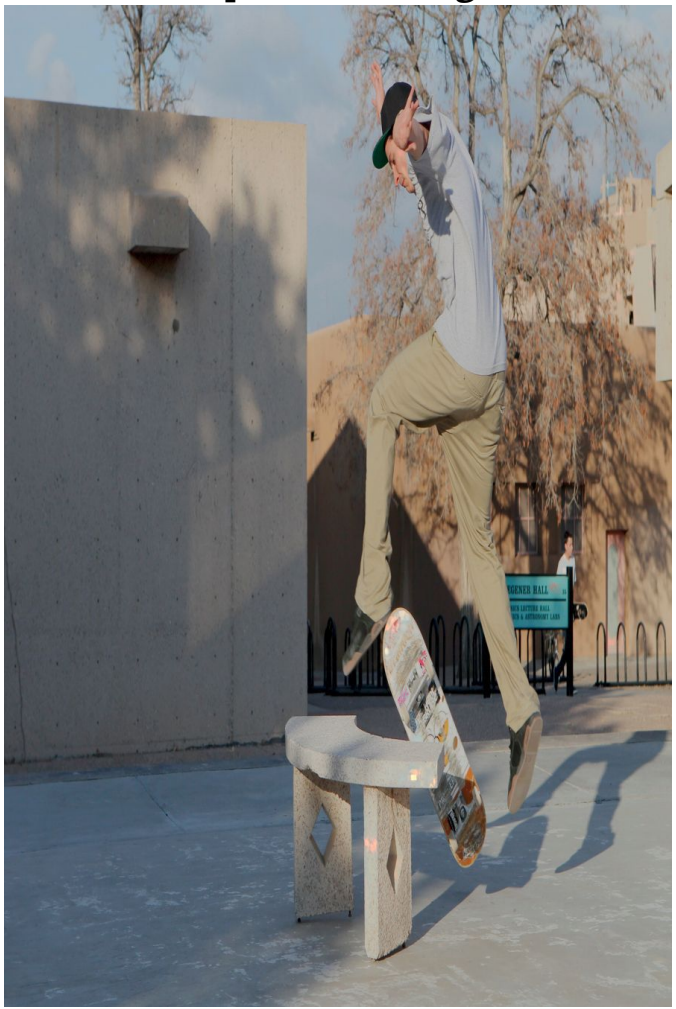


Output HDR image

Output HDR image



Output HDR image



THANK YOU!

Any Questions?