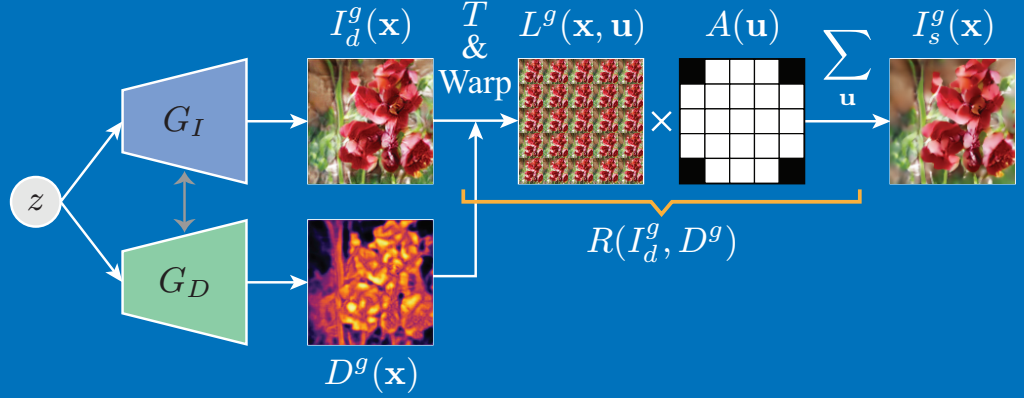
Project page

Unsupervised Learning of Depth and Depth-of-Field Effect from Natural Images with Aperture Rendering Generative Adversarial Networks

Takuhiro Kaneko



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Overview

Unsupervised learning of depth and DoF effect from natural images

Unlabeled natural images

Training data

AR-GAN

Training

Deep DoF *Shallow DoF* *Depth*

Generated data

- No ground-truth depth
- No paired data
- No pretrained model

$$G : z \mapsto (I_d^g, I_s^g, D^g)$$

Positioning of research

Fully unsupervised 3D representation learning

Only a collection of unlabeled natural images are available for training

Viewpoint-aware

Learn 3D representation using ***viewpoint*** cues

HoloGAN
[Nguyen-Phuoc+2019]

Szabó et al.
[Szabó+2019]

RGBD-GAN
[Noguchi+2020]

Unsup3d
[Wu+2020]

Viewpoint change

HoloGAN

Inapplicable to a viewpoint-biased dataset

(e.g., Oxford Flowers dataset)

Positioning of research

Fully unsupervised 3D representation learning

Only a collection of unlabeled natural images are available for training

Focus-aware

Learn 3D representation using ***focus*** cues

Applicable to a viewpoint-biased dataset if the dataset includes various DoF images

Training data

(e.g., Oxford Flowers dataset)

Training

Deep DoF *Shallow DoF* *Depth*

AR-GAN

[ours]

Positioning of research

Fully unsupervised 3D representation learning

Only a collection of unlabeled natural images are available for training

Viewpoint-aware

Learn 3D representation using ***viewpoint*** cues

HoloGAN
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RGBD-GAN
[Noguchi+2020]

Unsup3d
[Wu+2020]

AR-HoloGAN
[ours]

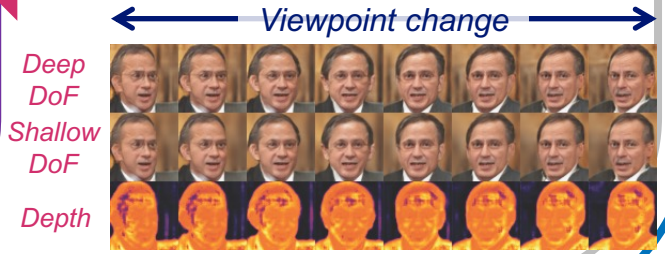
Compatible

AR-RGBD-GAN
[ours]

Focus-aware

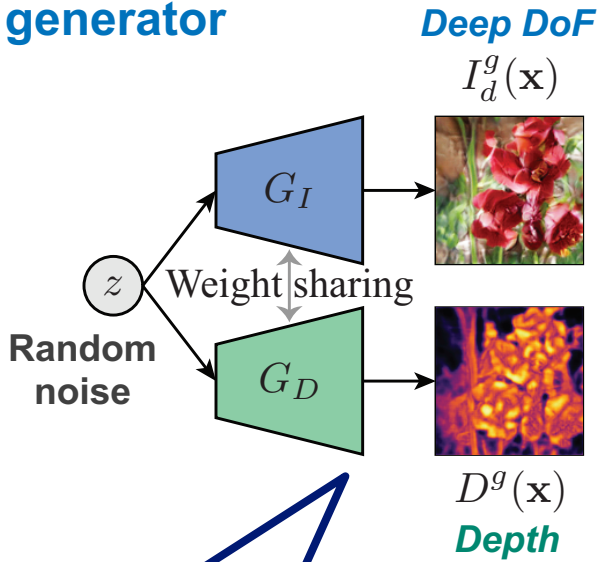
Learn 3D representation using ***focus*** cues

AR-GAN
[ours]



Overall pipeline 1/3

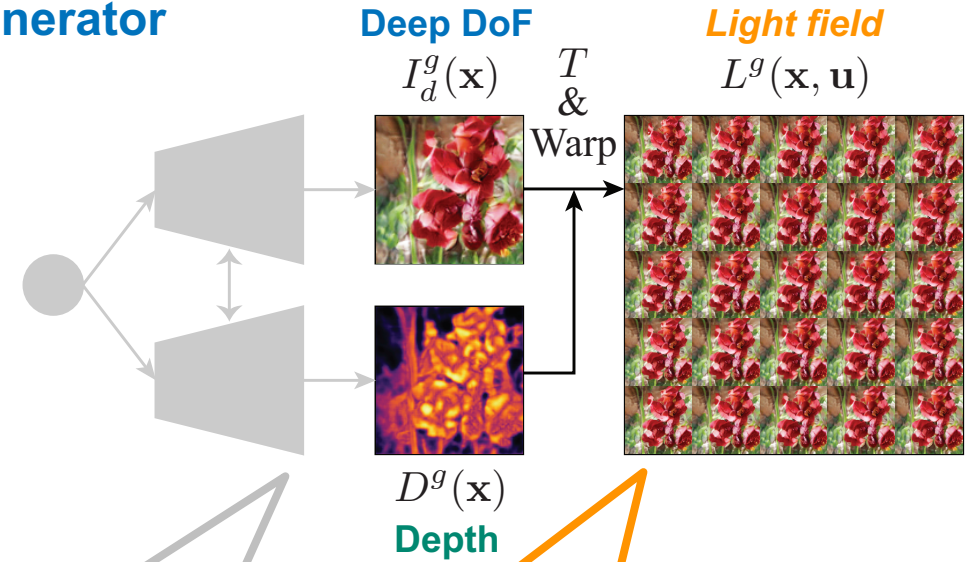
AR-GAN generator



1. Generate pair of ***deep DoF image*** and ***depth*** from **random noise**

Overall pipeline 2/3

AR-GAN generator

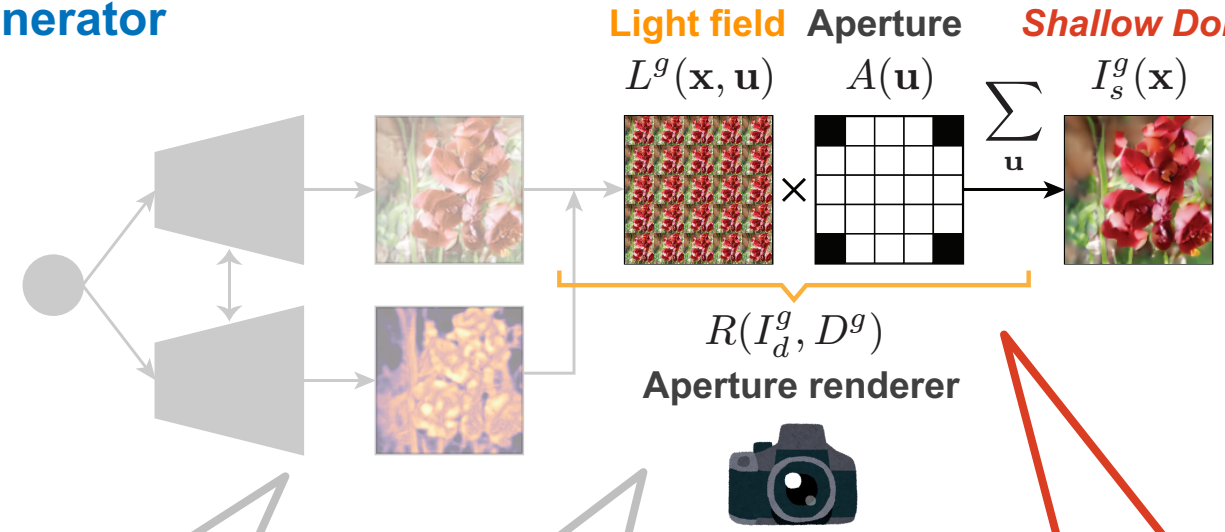


1. Generate pair of ***deep DoF image*** and ***depth*** from **random noise**

2. Simulate ***light field*** by warping **deep DoF image** based on **depth**

Overall pipeline 3/3

AR-GAN generator



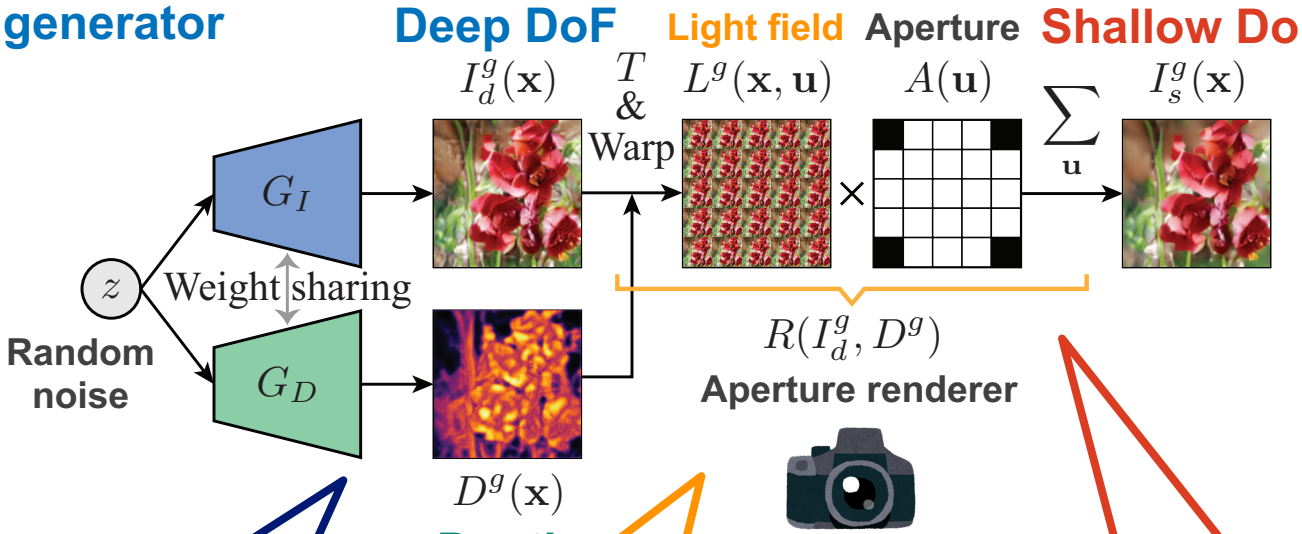
1. Generate pair of ***deep DoF image*** and ***depth*** from **random noise**

2. Simulate ***light field*** by warping **deep DoF image** based on **depth**

3. Render ***shallow DoF image*** by integrating **light field** using **aperture**

Aperture renderer [Srinivasan+2018]

Overall pipeline



1. Generate pair of ***deep DoF image*** and ***depth*** from **random noise**

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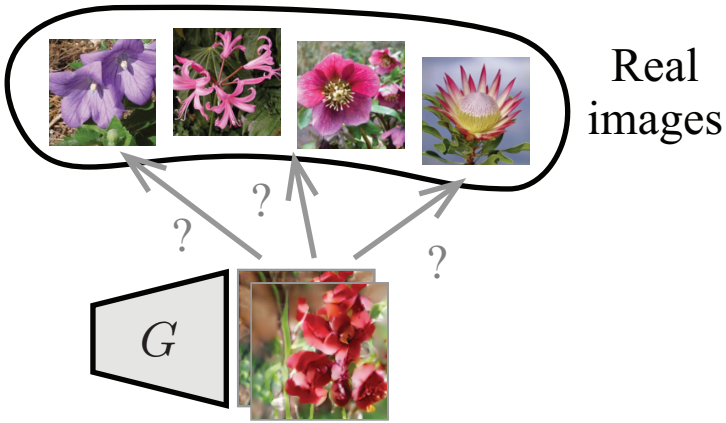
Aperture renderer [Srinivasan+2018]

Standard learning (baseline)

Learn real image distribution without any constraints

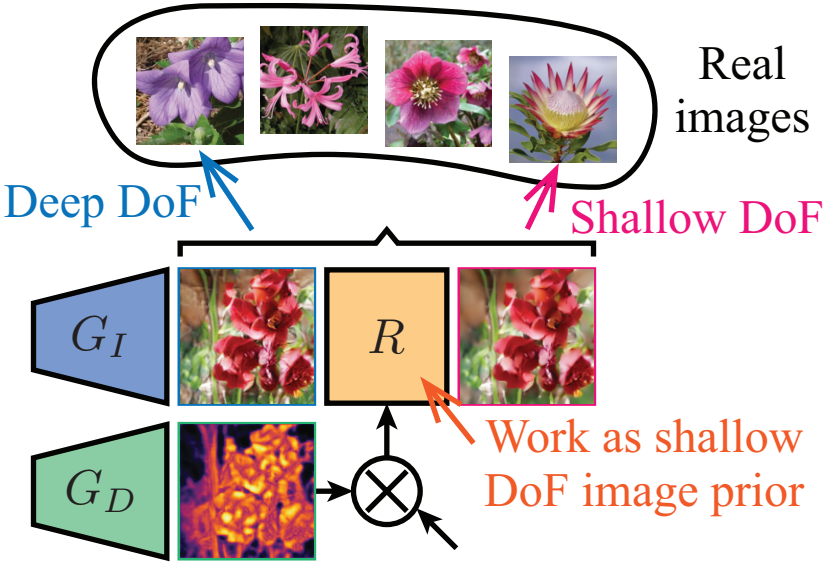


Standard learning (baseline)

$$\mathcal{L}_{\mathrm{GAN}} = \mathbb{E}_{I^r}[\log C(I^r)] + \mathbb{E}_z[\log(1 - C(G(z)))]$$

DoF mixture learning (proposed)

Learn real image distribution while generating diverse DoF images

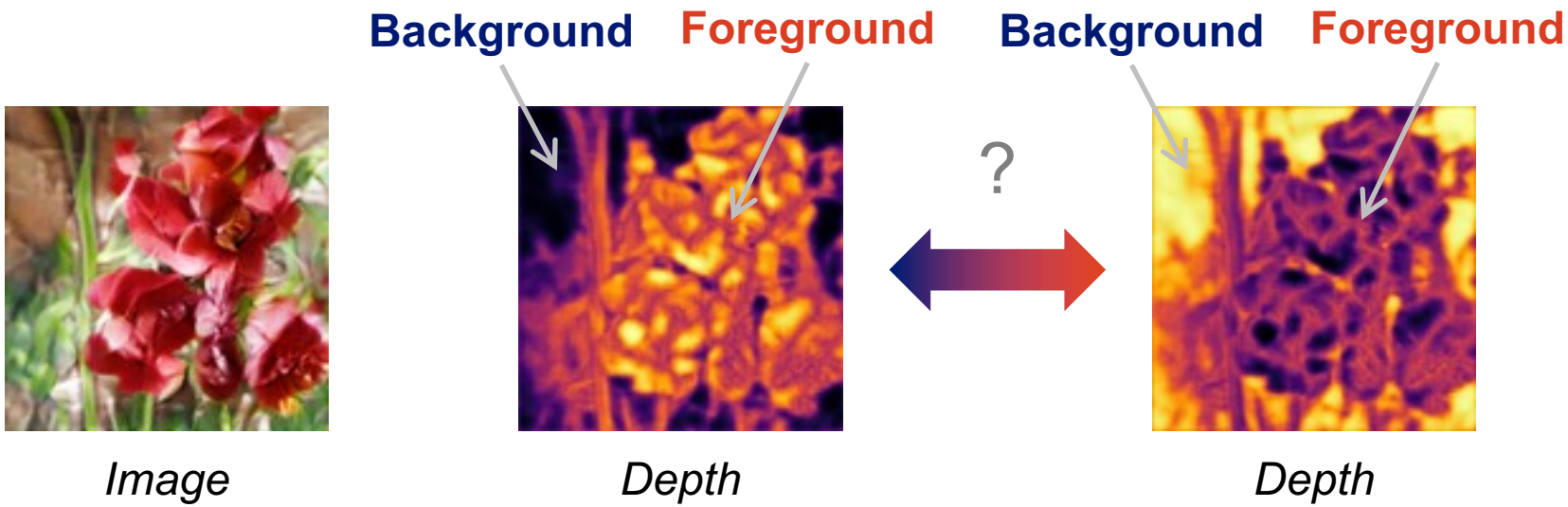


DoF mixture learning (proposed)

$$\mathcal{L}_{\text{AR-GAN}} = \mathbb{E}_{I^r}[\log C(I^r)] + \mathbb{E}_{z,s}[\log(1 - C(R(G_I(z), sG_D(z))))]$$

Difficulty in unsupervised learning

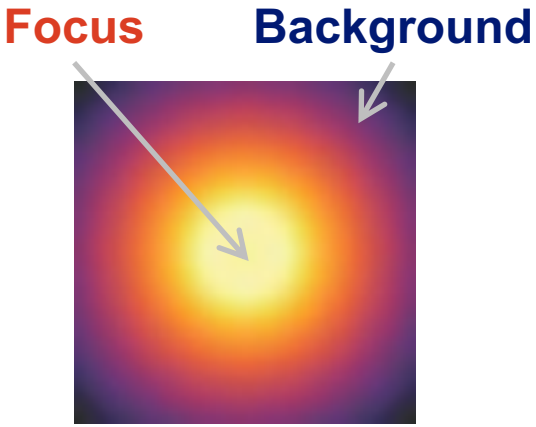
Ambiguity between fore/background blur



Center focus prior

Solve ambiguity between fore/background blur by providing prior

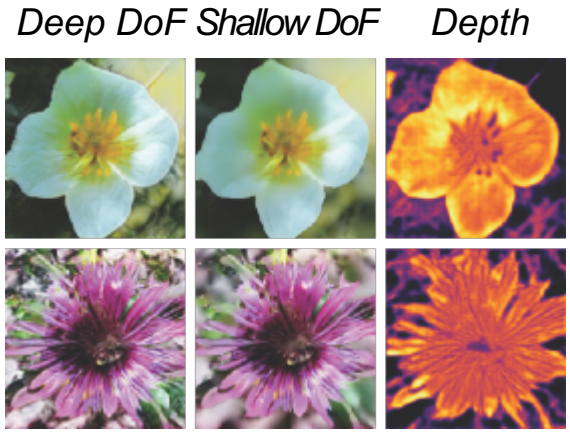
Examples of center focused images



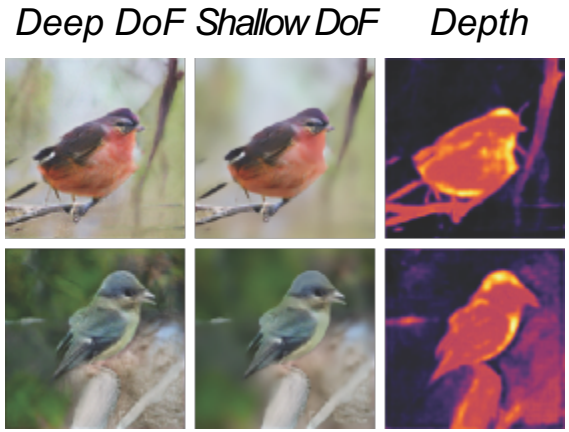
Center focus prior

Examples of generated data

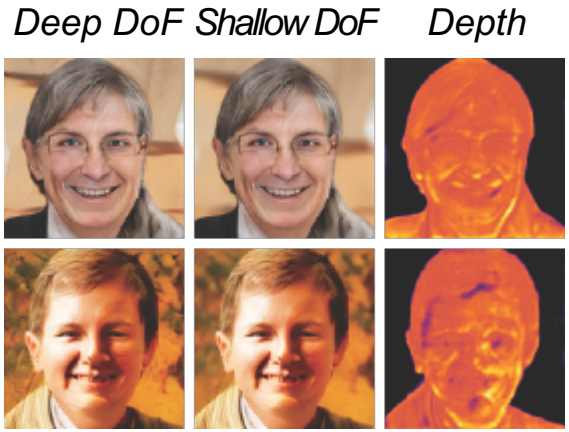
Examples of data generated from AR-GAN



Generated data
[Oxford Flowers]



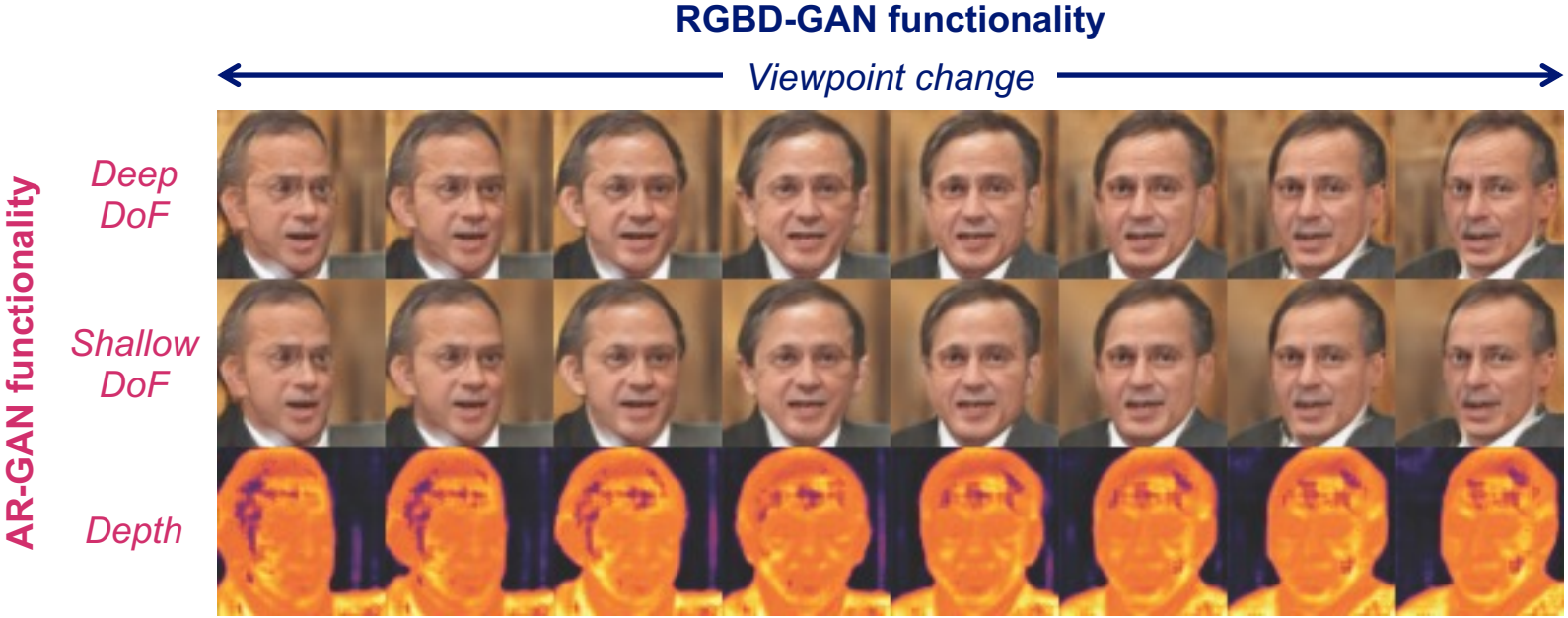
Generated data
[CUB-200-2011]



Generated data
[FFHQ]

Portability analysis

Examples of data generated from AR-RGBD-GAN (AR-GAN + RGBD-GAN)



Generated data
[FFHQ]

RGBD-GAN [Noguchi+2020]

Application in shallow DoF rendering

NTT

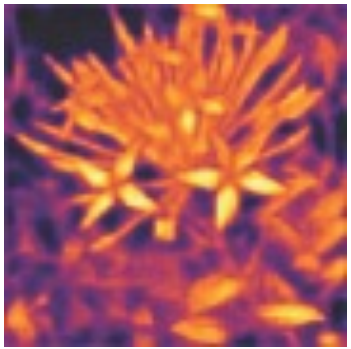
Learn shallow DoF renderer (Deep DoF → Shallow DoF) using generated data

Deep DoF

Input
(iPhone photo)

Shallow DoF

Depth



AR-GAN-DR
(proposed)

W/ ***no*** supervision

Shallow DoF

CycleGAN
(baseline)

W/ ***set-level*** supervision

Deep or shallow DoF

iPhone photo and CycleGAN [Zhu+2017]

Project page

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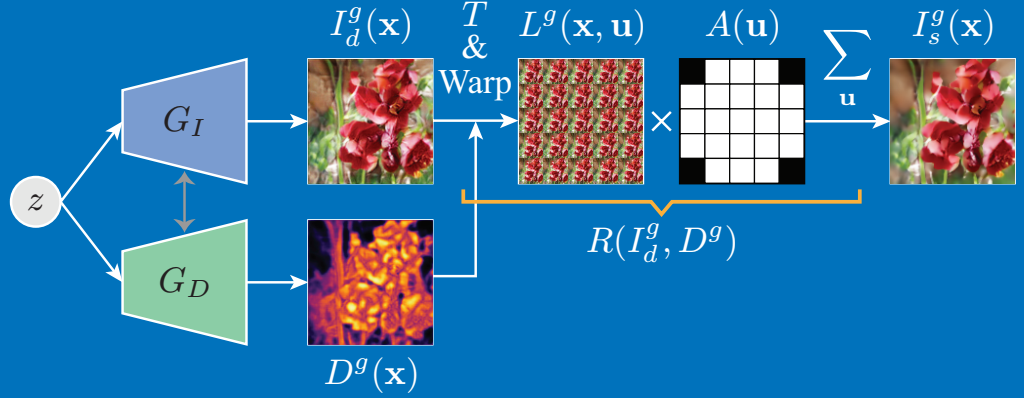

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