Digital Image Processing Final Project Proposal

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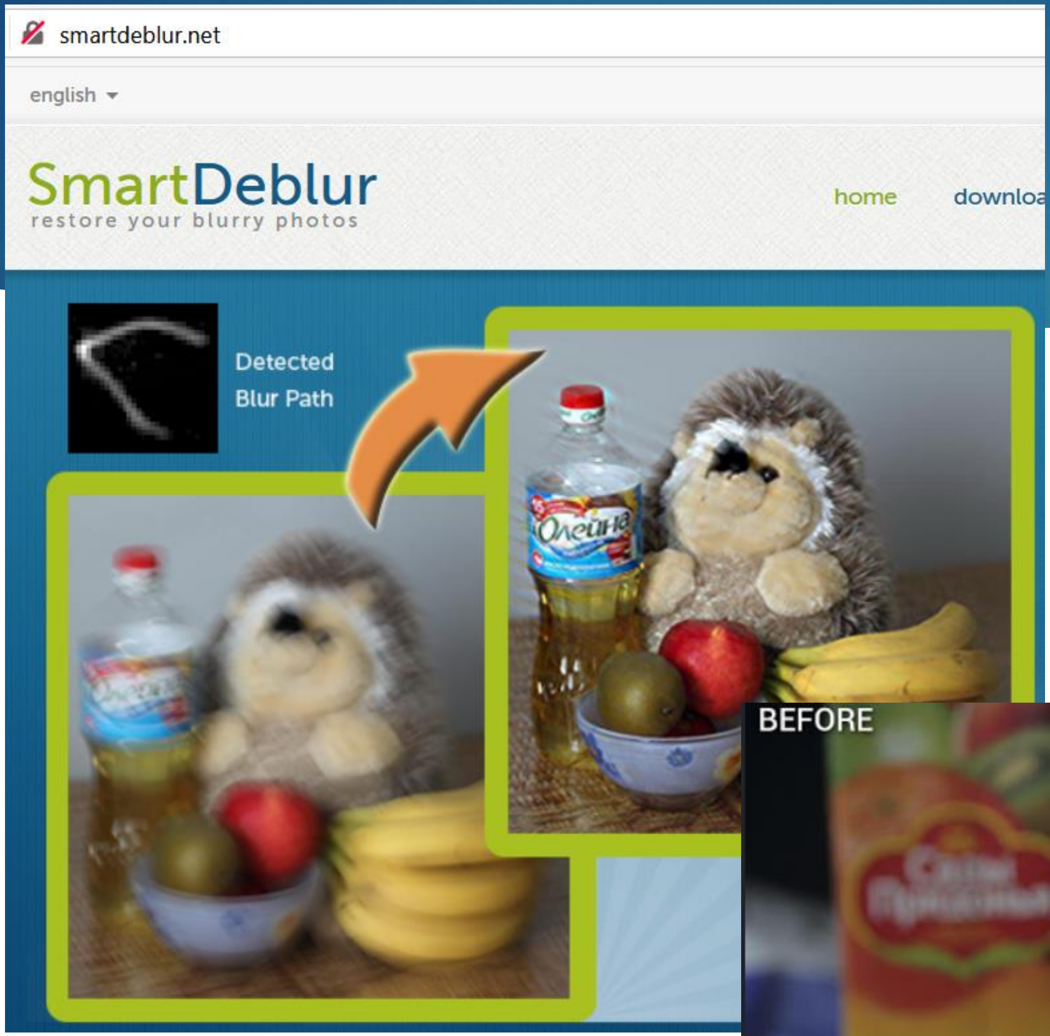
Preface


smartdeblur.net
english
SmartDeblur
restore your blurry photos
home
Detected
Blur Path


BEFORE
AFTER
Сады
Придонья

DeblurGAN-v2 Paper

Introduction

Image Deblurring

- Progress of GANs

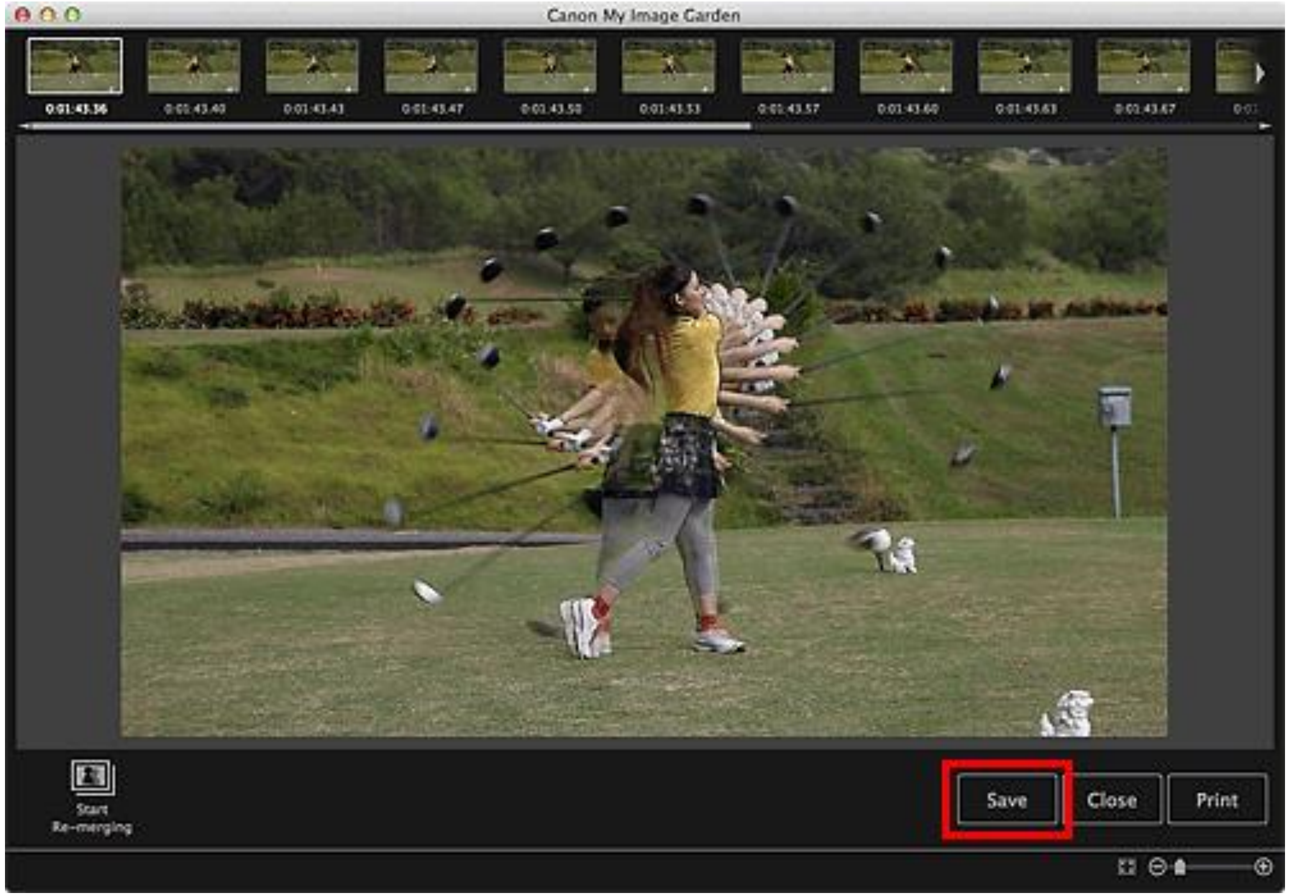
$$I_B = k(M) * I_S + N,$$

- **The project is focused in three main parts :**

1. Generate blurred images
2. A method to deblur
3. A novel method to quantify how good is a deblurred algorithm

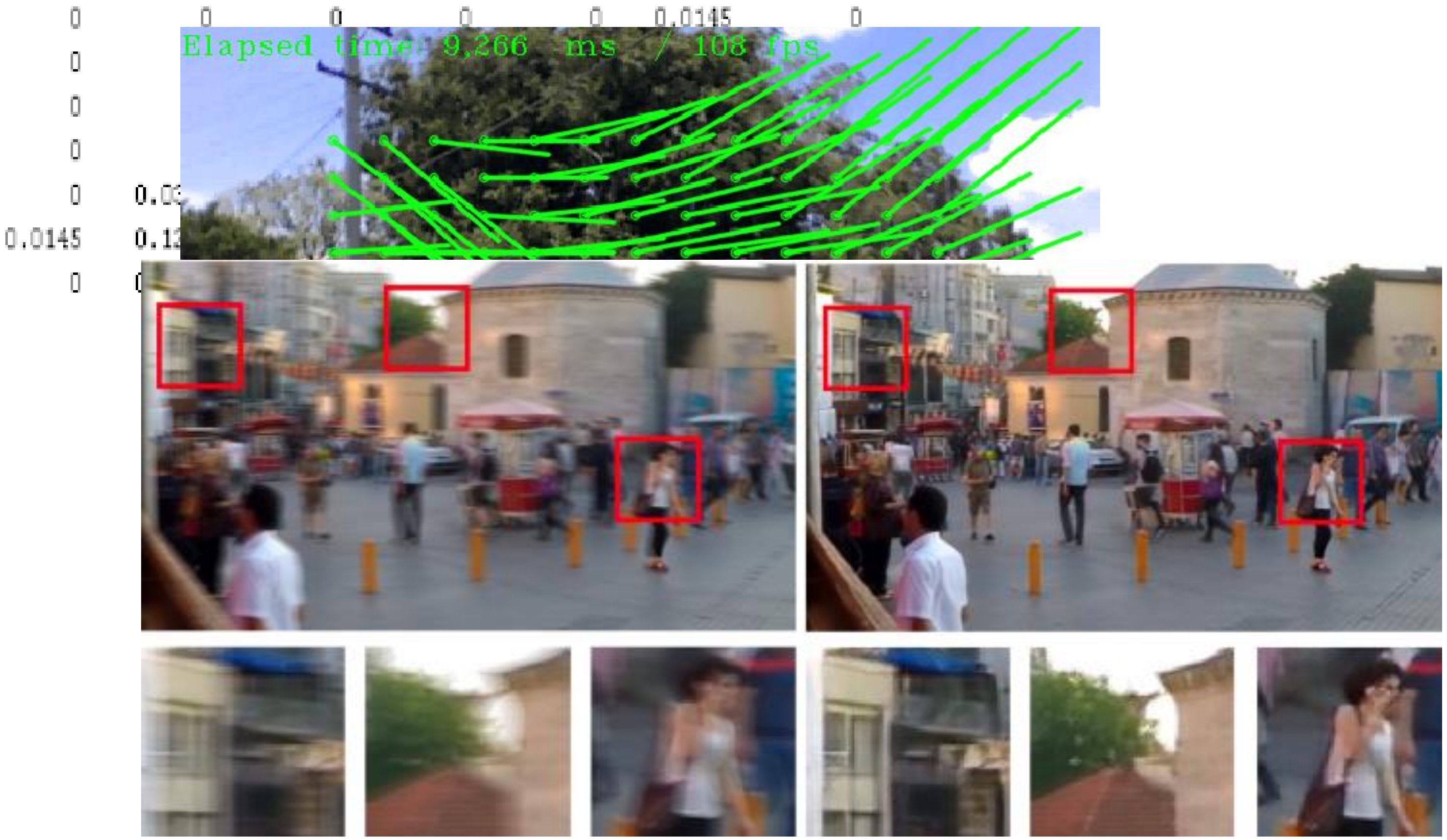
Blurred Image Generation

- Difficult to Dataset
- Take from video
- Convolving sharp images
- A novel method



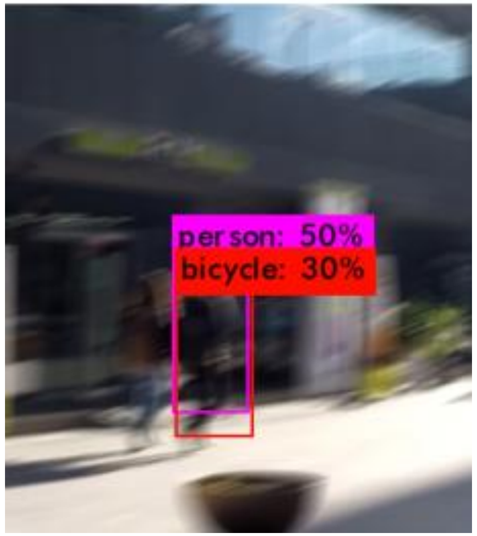
Deblurring Methods

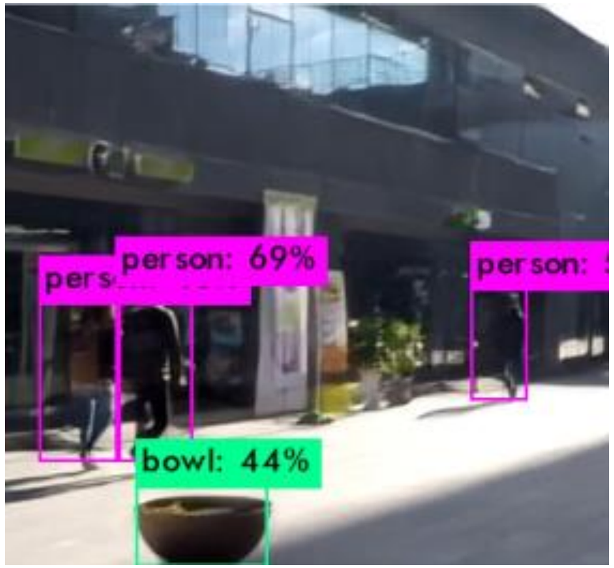
- Estimate the blur kernel
- Obtain the motion flow estimation
- Perform blind kernel-free image deblurring



Deblurring Algorithm Performance

- Run an object detection benchmark on yolo

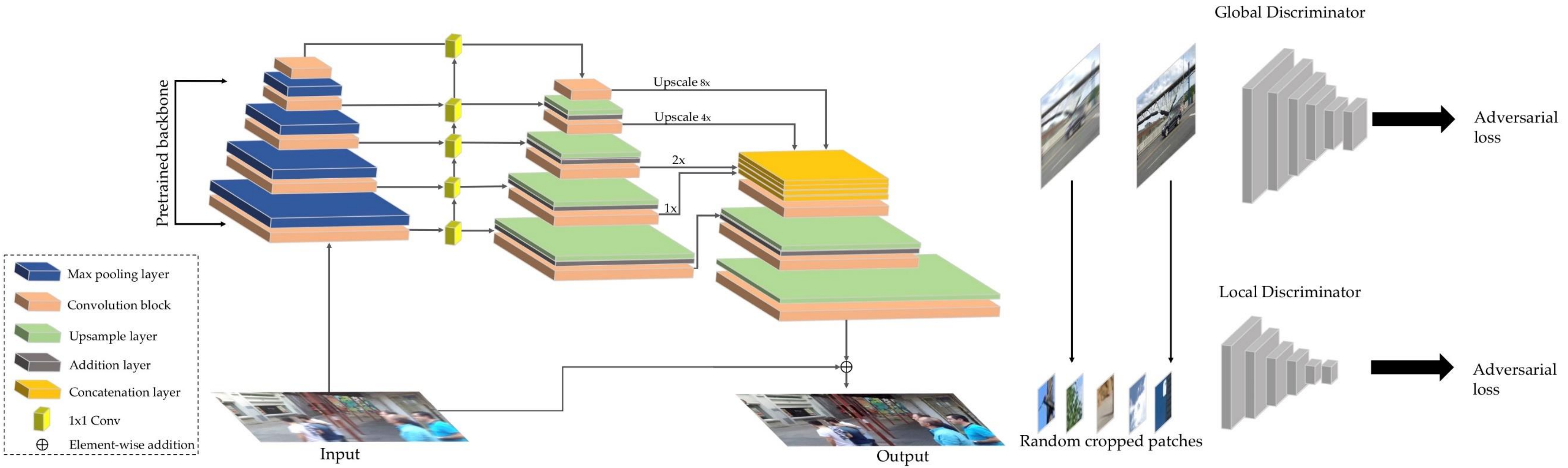




Architecture

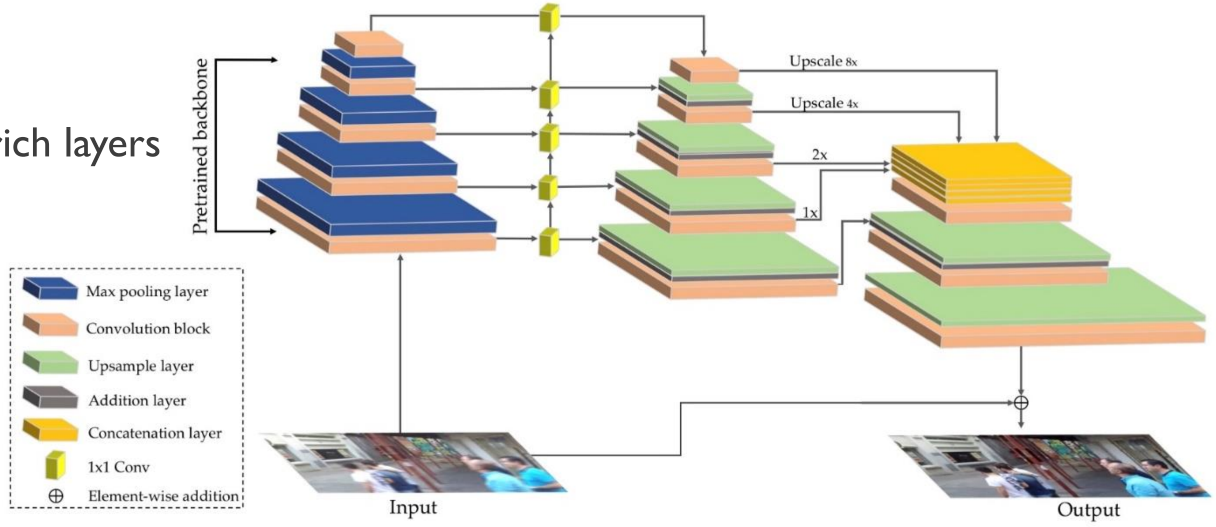
Feature Pyramid Deburring

"A lighter-weight alternative to incorporate multi-scale features"
-Kupyn et al.



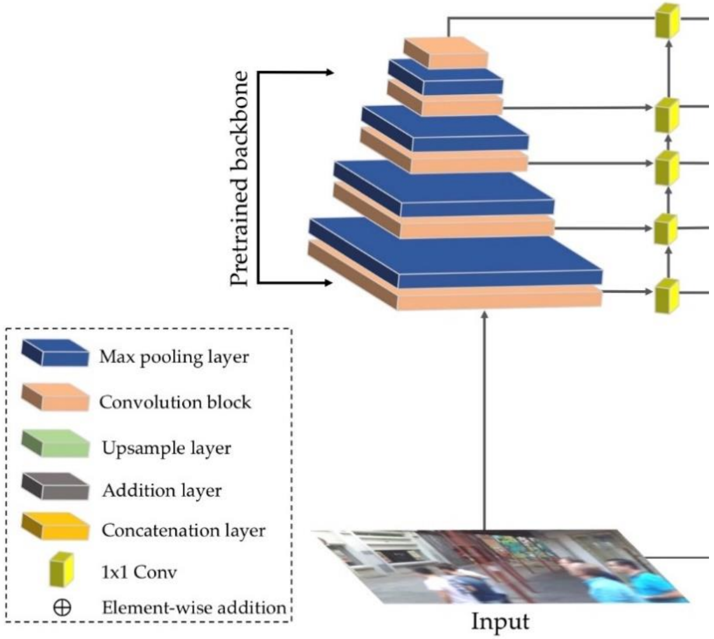
Feature Pyramid Deburring

- Bottom-up pathway
  - Convolutional network for feature extraction
  - Down sampling of special resolution
  - Semantic context information is extracted and compressed
- Top-down pathway
  - Reconstruction of higher special resolution from semantic rich layers
- Lateral Connections
  - Supplement high-resolution details and help localize objects



Backbones

- Inception-ResNet-v2
  - Pursues strong deburring performance
- MobileNet-v2
  - For mobile on device enhancement
- MobileNet-DSC
  - Replaces all normal convolution in the full network
  - Extremely Light-weight
  - Efficient Deburring



Generative adversarial networks

- Two player minimax game Discriminator and Generator
  - Goal is to capture the real data distribution

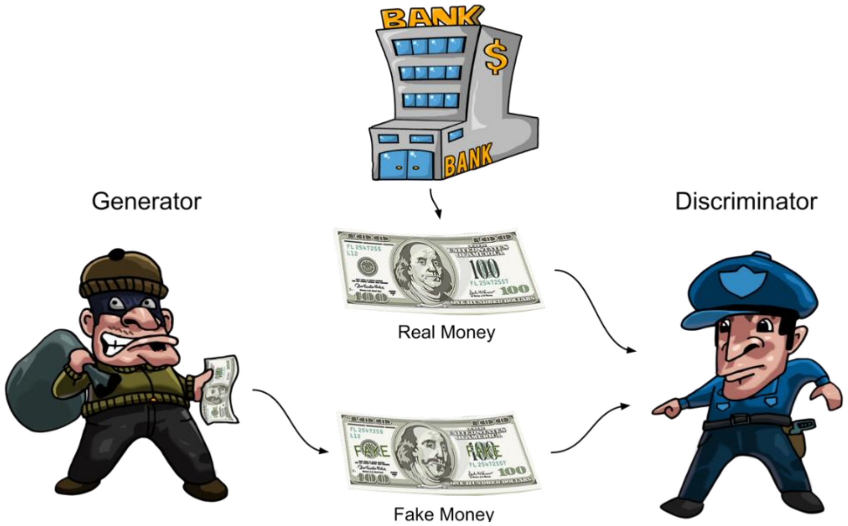
$$\min_G \max_D V(D,G) = \mathbb{E}_{x\sim p_{data}(x)}\left[\log D(x)\right] + \mathbb{E}_{z\sim p_z(z)}\left[\log(1-D(G(z)))\right]$$

- Least Square GANs Discriminator
  - Loss function that provides smoother and non-saturation gradient

$$\min_D V(D) = \frac{1}{2}\mathbb{E}_{x\sim p_{data}(x)}\left[(D(x)-1)^2\right] + \frac{1}{2}\mathbb{E}_{z\sim p_z(z)}\left[D(G(z))^2\right]$$

$$\min_G V(G) = \frac{1}{2}\mathbb{E}_{z\sim p_z(z)}\left[(D(G(z))-1)^2\right]$$

- Relativistic GAN
  - Estimates probability that given real data is more realistic than random fake sampled data

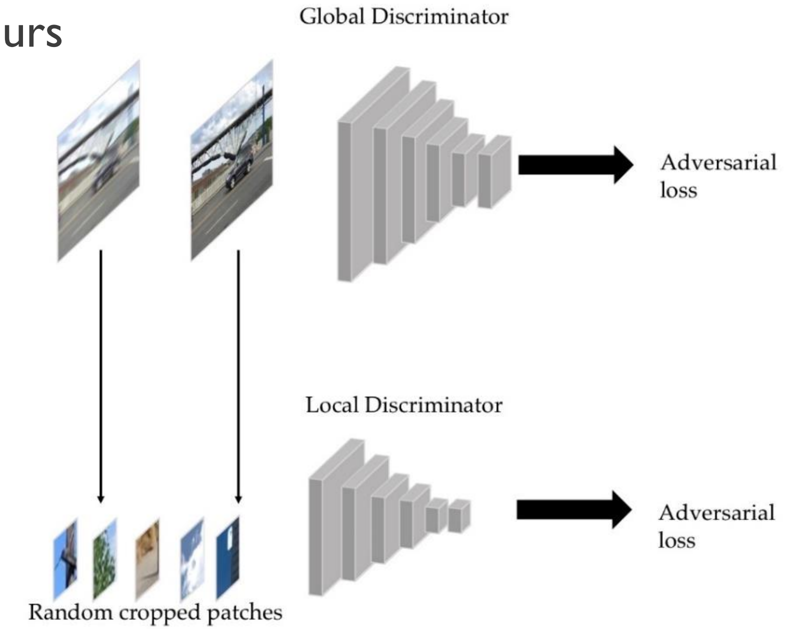


Double-Scale RaGAN-LS Discriminator

- Double Scale Discriminators to handle larger and more heterogeneous blurs
  - Local branch
    - Operates on patch levels
    - Produces sharper results
  - Global branch
    - Feed on full input image
    - Better performance for highly non-uniform blurs
- Losses

$$L_D^{RaLSGAN} = \mathbb{E}_{x \sim p_{data}(x)}\left[(D(x) - \mathbb{E}_{z \sim p_z(z)} D(G(z)) - 1)^2\right] + \mathbb{E}_{z \sim p_z(z)}\left[(D(G(z)) - \mathbb{E}_{x \sim p_{data}(x)} D(x) + 1)^2\right]$$

$$L_G = 0.5 * L_p + 0.006 * L_X + 0.01 * L_{adv}$$



Training Datasets

- GoPro:
  - GoPro Hero 4 camera
  - 240 fps video sequences
- DVD:
  - Multiple Devices
  - 71-real world videos sequences at 240 fps
- NFS:
  - iPhone 6 and iPad Pro
  - 75 videos with high frame rate
  - Youtube Videos

Experimental Evaluation

Quantitative Evaluation

- Evaluation metrics: PSNR and SSIM, inference efficiency

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

Quantitative Evaluation

- Second best in some tests, but fastest by far; several order of magnitudes

Table 1: Performance and efficiency comparison on the GoPro test dataset, All models were tested on the *linear* image subset.

	Sun *et al.* [43]	Xu *et al.* [51]	DeepDeblur [33]	SRN [45]	DeblurGAN [21]	Inception-ResNet-v2	MobileNet	MobileNet-DSC
PSNR	24.64	25.10	29.23	**30.10**	28.70	29.55	28.17	28.03
SSIM	0.842	0.890	0.916	0.932	0.927	**0.934**	0.925	0.922
Time	20 min	13.41s	4.33s	1.6s	0.85s	0.35s	0.06s	**0.04s**
FLOPS	N/A	N/A	1760.04G	1434.82G	678.29G	411.34G	43.75G	**14.83G**

Table 2: PSNR and SSIM comparison on the Kohler dataset.

Method	Sun [43]	DeepDeblur [33]	SRN [45]	DeblurGAN [21]	Inception-ResNet-v2	MobileNet	MobileNet-DSC
PSNR	25.22	26.48	26.75	26.10	26.72	26.36	26.35
SSIM	0.773	0.807	0.837	0.816	0.836	0.820	0.819

Table 3: Results on DVD dataset

	PSNR	SSIM	Inference Time	Resolution
WFA	28.35	N/A	N/A	N/A
DVD (single)	28.37	0.913	1.0s	960 x 540
DeblurGAN-v2 (MobileNet)	**28.54**	**0.929**	**0.06s**	1280 x 720

Visual Comparison

(a) Blurry (b) DeepDeblur [33]
(c) SRN [45] (d) DeblurGAN [21]
(e) DeblurGAN-v2 (Inception-ResNet-v2) (f) DeblurGAN-v2 (MobileNet)

Figure 7: Visual comparison on the Kohler dataset.

Ablation Study

- DeblurGAN (ResNet G, local-scale patch D, WGAN-GP + perceptual loss) modifications study:
  - Generator: adding FPN
  - Discriminator: adding global-scale
  - Loss: replacing WGANGP with RaGAN-LS and adding MSE term

Table 5: Ablation Study on the GoPro dataset, based on DeblurGAN-v2 (Inception-ResNet-v2).

	PSNR	SSIM
DeblurGAN (starting point)	28.70	0.927
+ FPN	29.26	0.931
+ FPN + Global D	29.29	0.932
+ FPN + Global D + RaGAN-LS	29.37	0.933
DeblurGAN-v2 (FPN + Global D + RaGAN-LS + MSE Loss)	**29.55**	**0.934**
Removing perceptual loss (replace 0.5 with 0 in L_G)	28.81	0.924

Final Project Proposal

DeblurGAN-v2(deo)

- Currently allows single image deblurring
- Make pipeline for video (blurring and) deblurring
- Evaluating deblurred video image quality to original

Original Video → Original Frames → Blurred Frames → Blurred Video → Blurred Frames → Deblurred Frames → Deblurred Video

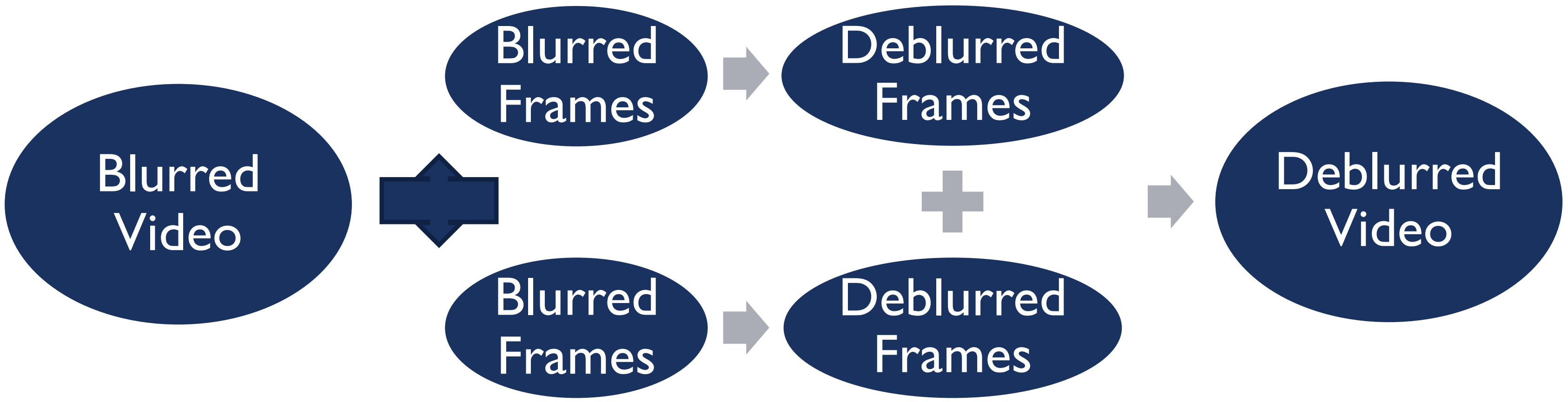
DeblurGAN-v2(deo)

- Alternative pipeline for naturally blurry video:
  - Low framerate
  - Lack of proper illumination
  - Camera movement

Original Blurred Video → Original Blurred Frames → Deblurred Frames → Deblurred Video

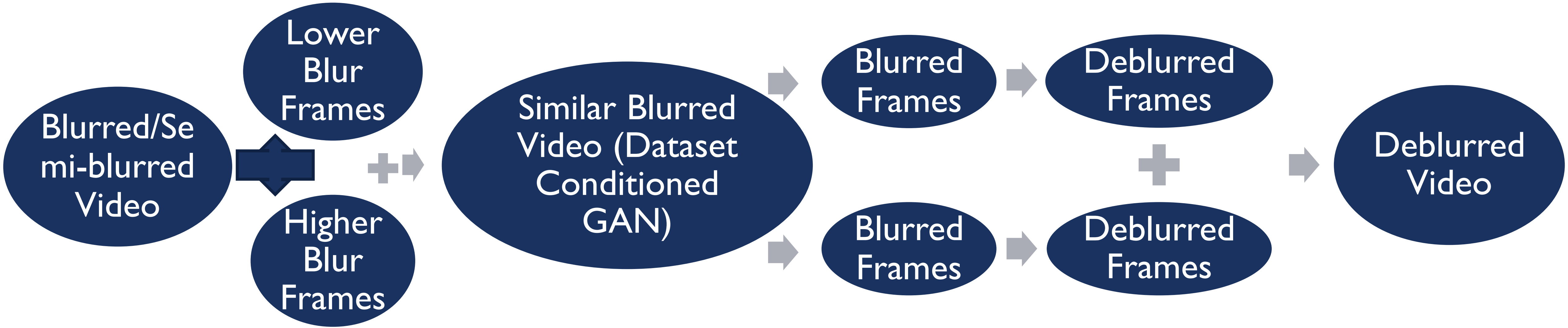
DeblurGAN-v2(deo)

- Other possible lines of improvement come from HPC (High-Performance Computing) side:
  - Parallel processing of frames for obtaining close to real-time deblurring



DeblurGAN-v2(deo)

- Even more ambitious (and advanced pipeline): fine-tuning network on the go with input video blur/deblurred image-pairs with high-learning rate/loss penalization for conditioning to new dataset



SupraFPS

- Super Resolution for FPS of videos: 30 FPS to 120 FPS (slow-motion)
- Naive/simple approach: linear/weighted interpolation of video frames

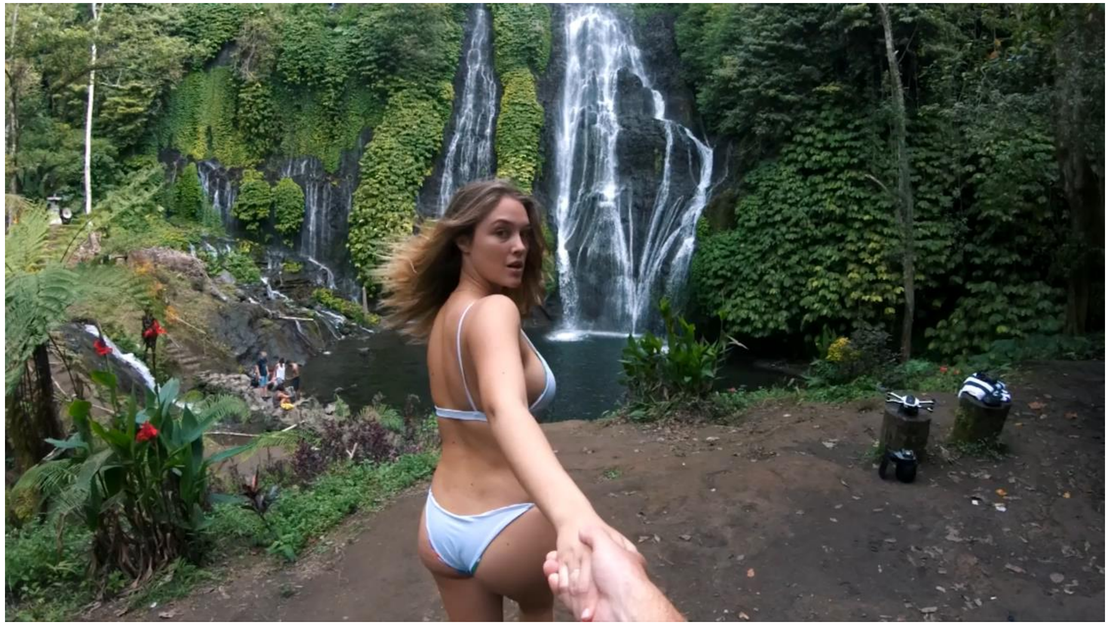
Original Video (FPS: X, time: t_1) → Original Frames → Interpolated /Blurry Frames → Deblurred Interpolated Frames → Slow-mo Video: (FPS: X, time: t_2)

*X: FPS of original video, t_1: duration in time (s) of original video, t_2 (t_2 > t_1): duration in time (s) of new video

fpsGAN

- More-advanced approaches: use kernel for motion estimation to get interpolated frames, CNNs

- GAN-boosted approach: fpsGAN
  - Real high FPS video, down-sample to low FPS pairs and use network to generate/learn difference between the real high FPS videos and the ones generated from our previous approaches
  - Use the results of fpsGAN (which are probably not that accurate) through deblurGAN-v2(deo) and compare to results through only fpsGAN



SupraFPS Advanced Pipeline

Real High-FPS and Synthetic High-FPS Videos

fpsGAN Training

fpsGAN Input: Low-FPS Video

fpsGAN Output: High-FPS Video

DeblurGAN-v2(deo) Deblurring

Deblurred-High-FPS (Final Output) Videos

References

- O. Kupyn, T. Martyniuk, J. Wu, and Z. Wang, "DeblurGAN-v2: Deblurring (Orders-of-Magnitude) Faster and Better," *arXiv:1908.03826 [cs]*, Aug. 2019.
- O. Kupyn, V. Budzan, M. Mykhailych, D. Mishkin, and J. Matas, "DeblurGAN: Blind Motion Deblurring Using Conditional Adversarial Networks," *arXiv:1711.07064 [cs]*, Apr. 2018.
- "PyTorch." [Online]. Available: https://www.pytorch.org. [Accessed: 07-Dec-2019].
- "NVIDIA Tesla P100: The Most Advanced Data Center Accelerator," *NVIDIA*. [Online]. Available: https://www.nvidia.com/en-us/data-center/tesla-p100/. [Accessed: 07-Dec-2019].
- "GoPro HERO6 Black: The Best Slow Motion Ever in 4K! - YouTube." [Online]. Available: https://www.youtube.com/watch?v=khPwinkQ52k. [Accessed: 07-Dec-2019].
- *TAMU-VITA/DeblurGANv2*. TAMU-VITA, 2019.