Deep Image Deblurring

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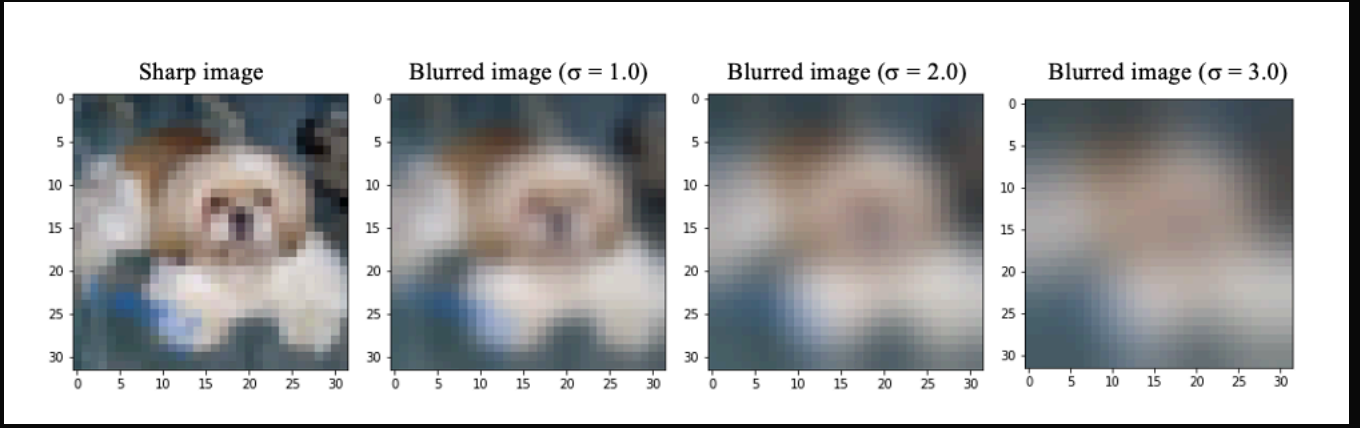
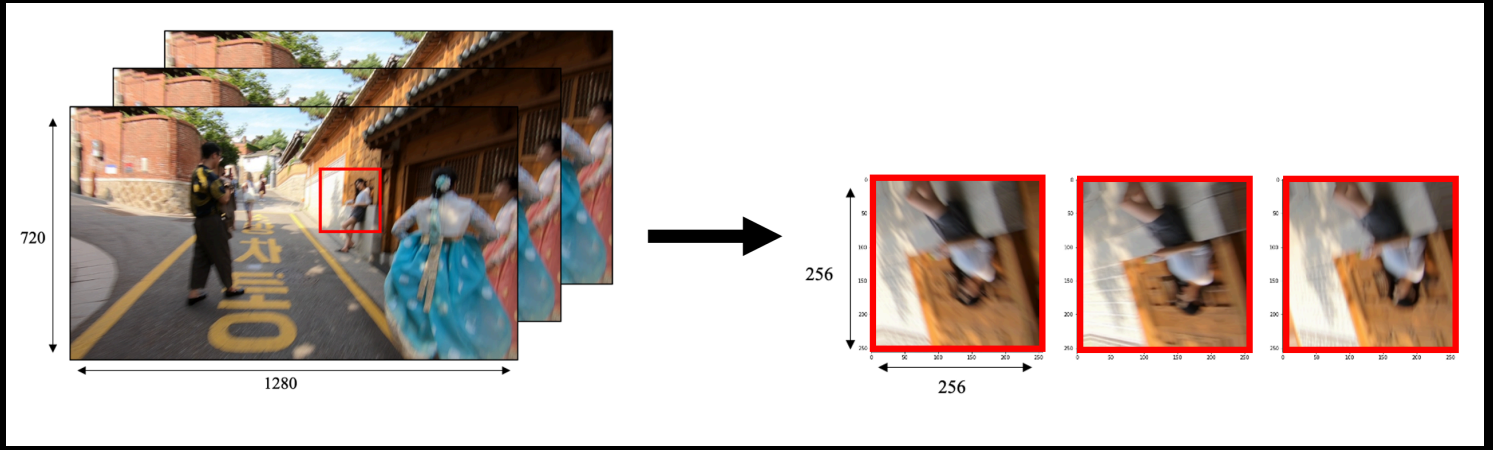
Datasets
CIFAR-10

- 60 000 images of resolution 32x32.
- **Preprocessing**
  - Every image was smoothed with a Gaussian Kernel $0 \leq rand(\sigma) \leq 3$
  - No data augmentation

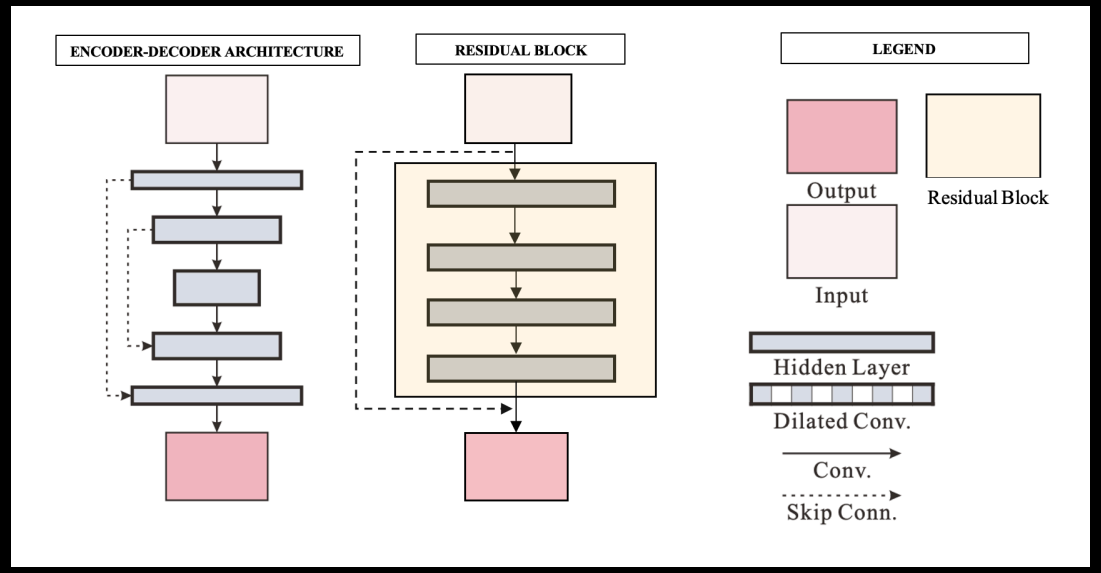


Datasets
REDS

- 300 videos with 100 images of resolution 720 × 1280 each
- **Preprocessing**
  - Random image **crops** of 256 x 256
  - Vary **brightness** by small amount for every image crop
  - **Flip** and rotate **images** at a 50 % rate each
  - Concatenation of previous and next frame, shifted up to 2 pixels to the opposite directions respectively



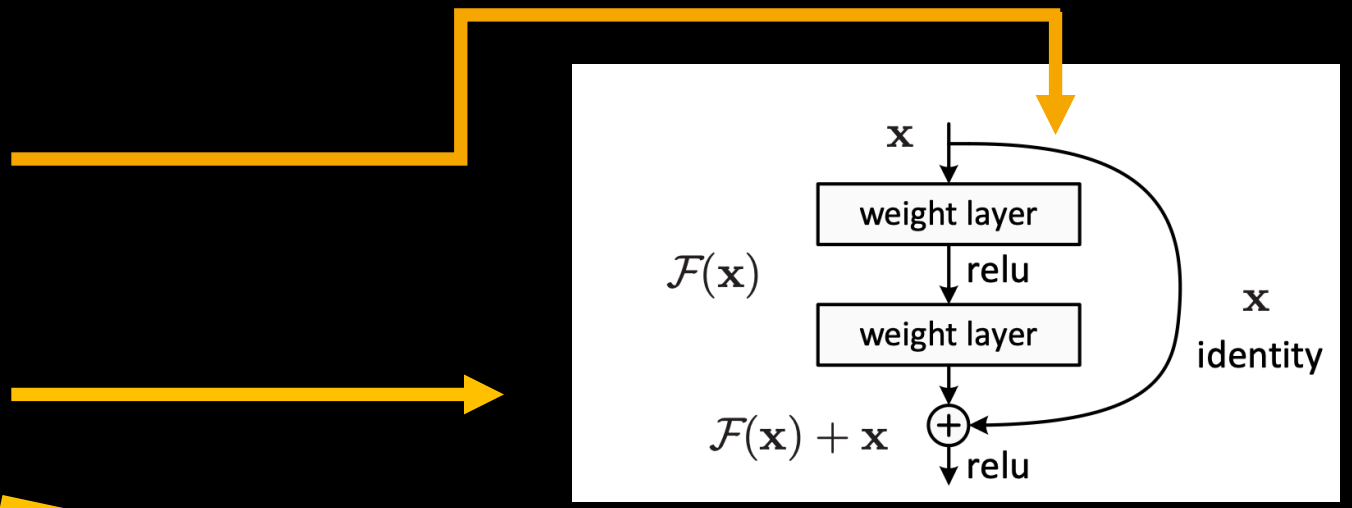
Basic ideas behind our architectures

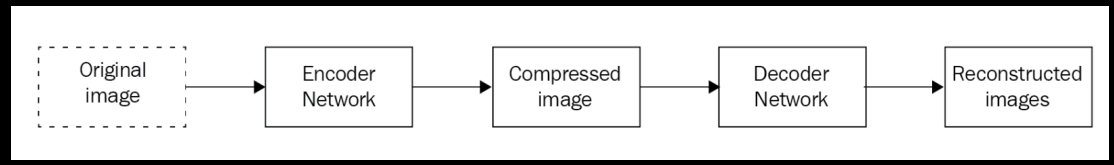


Basic ideas behind our architectures

Overview

- Skip Connections
  - Addition / Concatenation
  - Short / Long
- Residual Blocks
- Convolutional Autoencoders



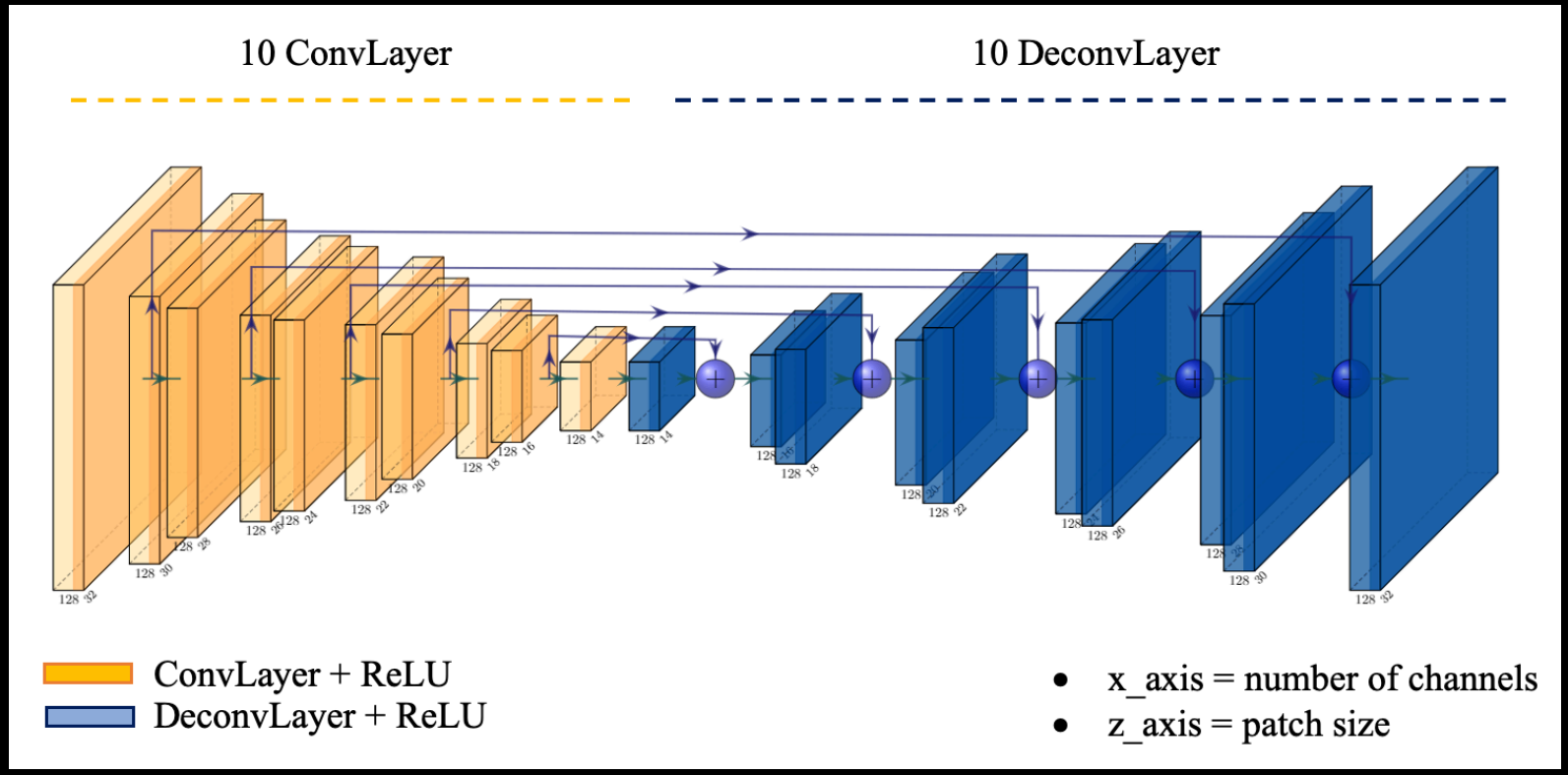


ARCHITECTURES

1. CARLO_NET

TESTED ONLY ON CIFAR-10

- **Convolutional Autoencoder** with the use of symmetric **skip connections.**
- **Skip connections**:
  - **faster training** + **better result**
  - **every 2 layers** from convolutional features maps to their mirrored deconvolutional feature maps
- **Activation:** ReLU
- **Input and Output:** input size can be arbitrarily, input and output have the same size
- **Kernel Size:** 3x3
- **Padding:** Valid (i.e. no padding)
- **Stride:** 1 (i.e no stride)

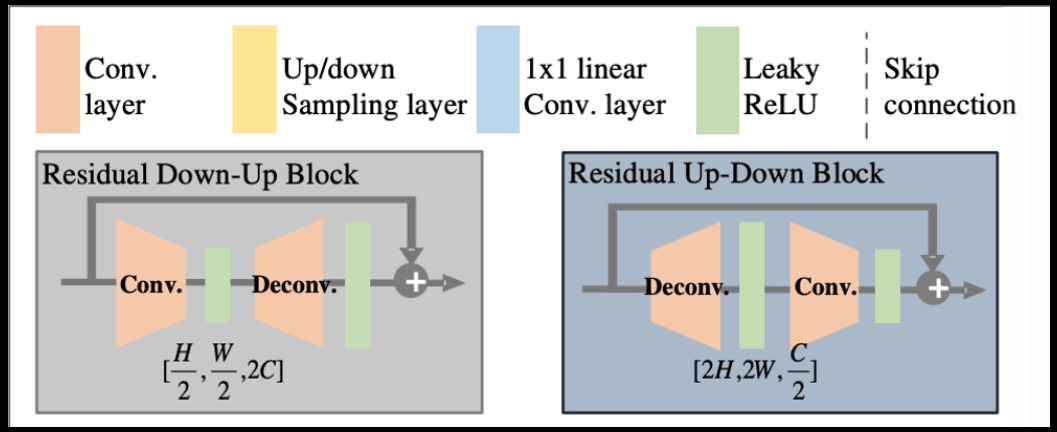


ARCHITECTURES

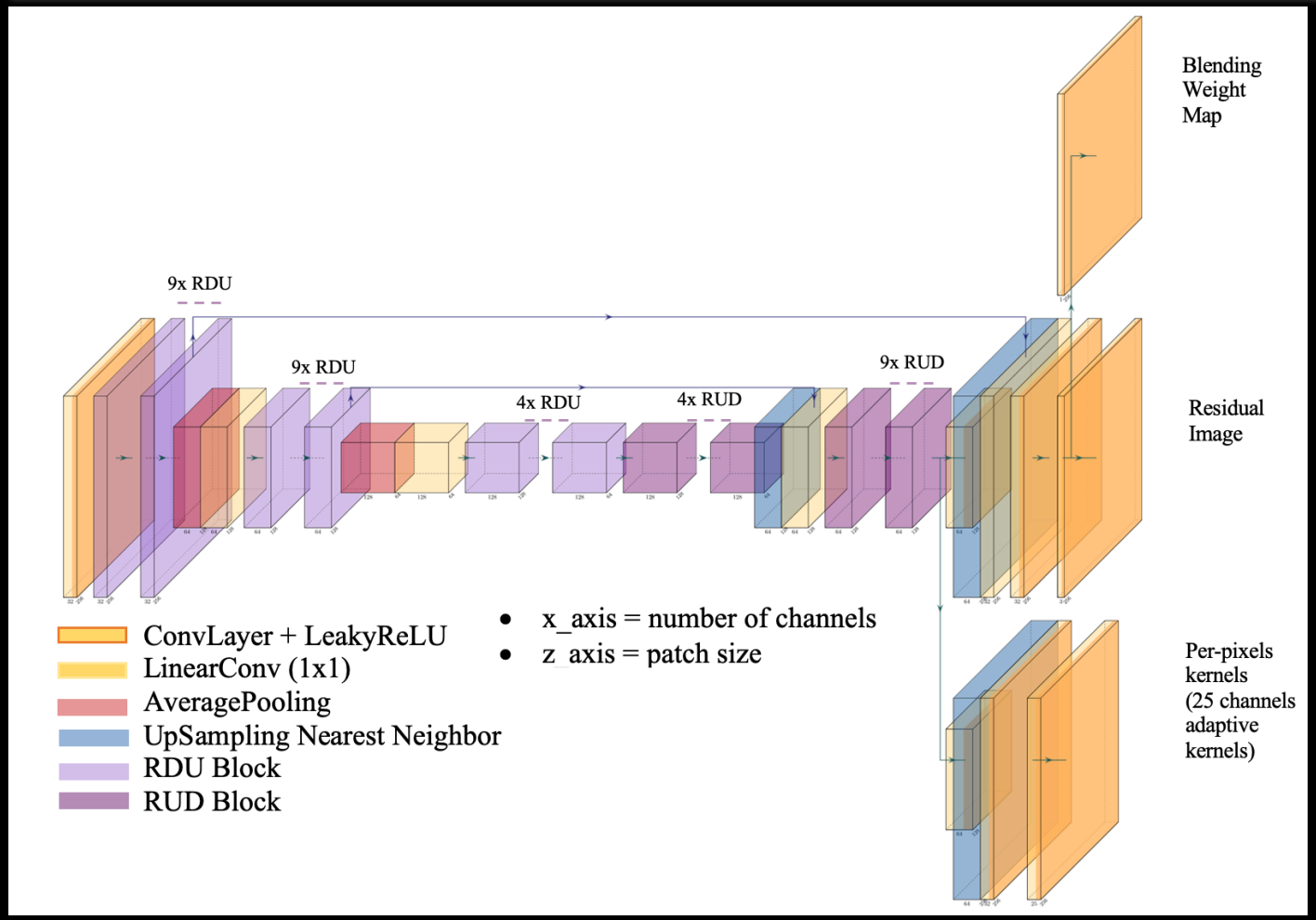
2. KAIST_NET

TESTED BOTH ON CIFAR-10 AND REDS

- **Convolutional Autoencoder** based on the idea of the U-Net architecture, where the covolution layers in the encoder and decoder parts are replaced with residual down-up and residual up-down blocks respectively.
- **Activation:** Leaky ReLU
- **Res Down-Up Block**:
  - Convolution 5x5, stride 2, padding same
  - Leaky ReLU
  - Deconvolution 4x4, stride 2, padding same
- **Res Up-Down Block**:
  - Deconvolution 4x4, stride 2, padding same
  - Leaky ReLU
  - Convolution 5x5 , stride 2, padding same



ARCHITECTURES
2. KAIST_NET - STRUCTURE



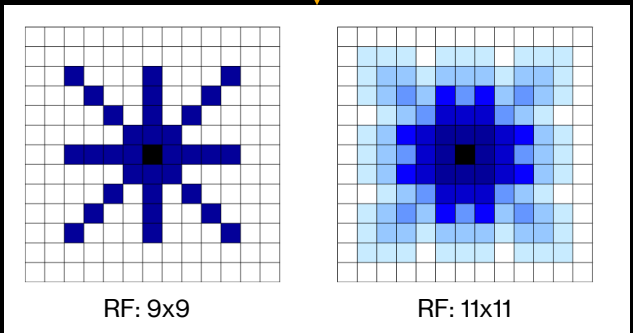
- **Output**
  - $L = w \cdot B \times K_d + (1 - w) \cdot R$
  - **Sum of:**
    - **Weighted residual RGB image *R***
    - **Adaptive convolution**
      - **25 channels adaptive kernels *K***
      - **Blurred image *B***
      - **Blending weight map *w***

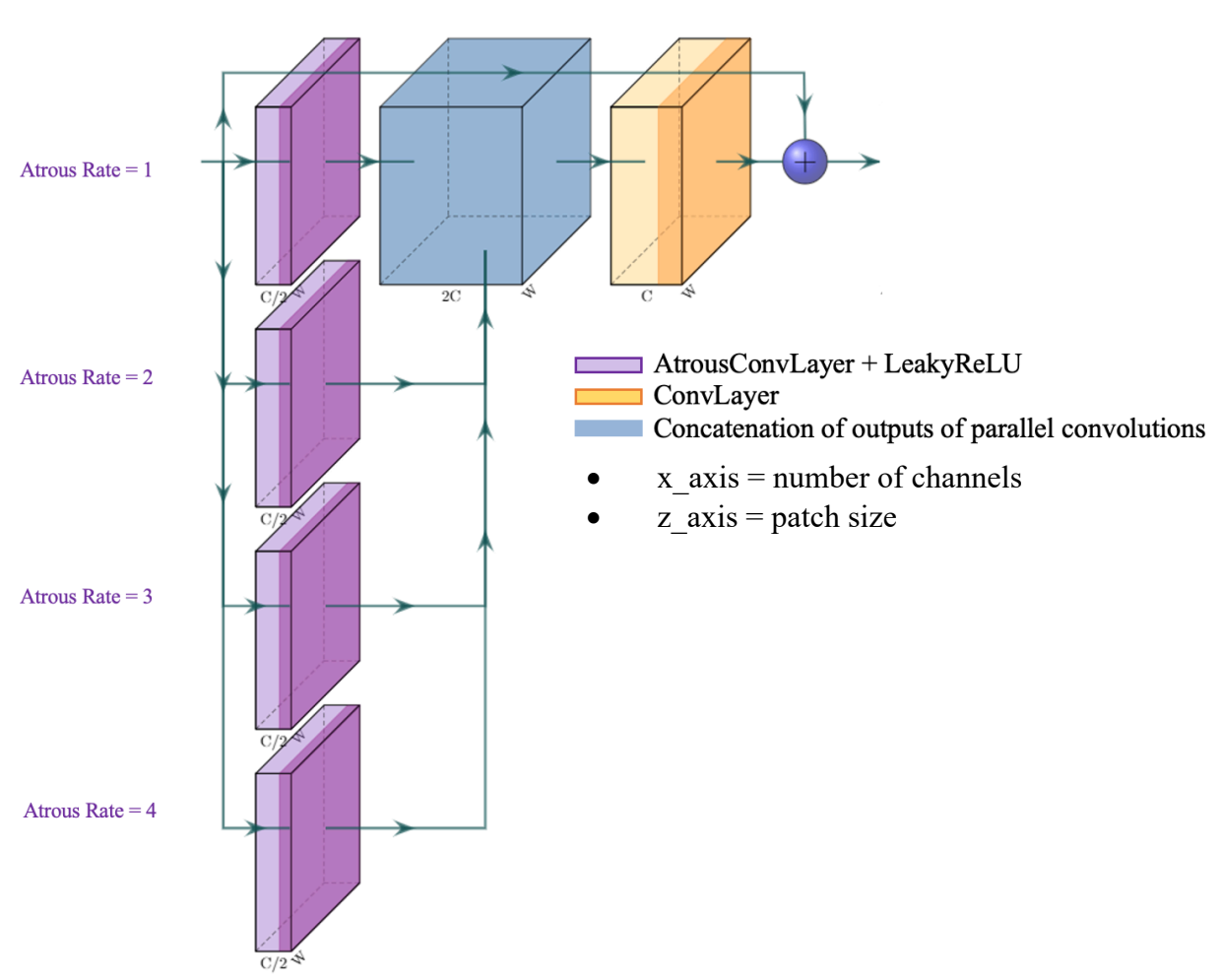
ARCHITECTURES

3. ATROUS_NET - Official network of our work

TESTED BOTH ON CIFAR-10 AND REDS

- **Convolutional network** based on the use of novel **Residual Blocks** composed **of Atrous (or dilated) convolutions**
- Every **Convolution** in this block has:
  - **Kernel Size:** 3x3
  - **Stride:** 1 (i.e no stride)
  - **Padding**: Same
- **Receptive field** of each Atrous Block : 11 x 11





ARCHITECTURES
3. ATROUS_NET : WHY USE ATROUS CONVOLUTIONS?

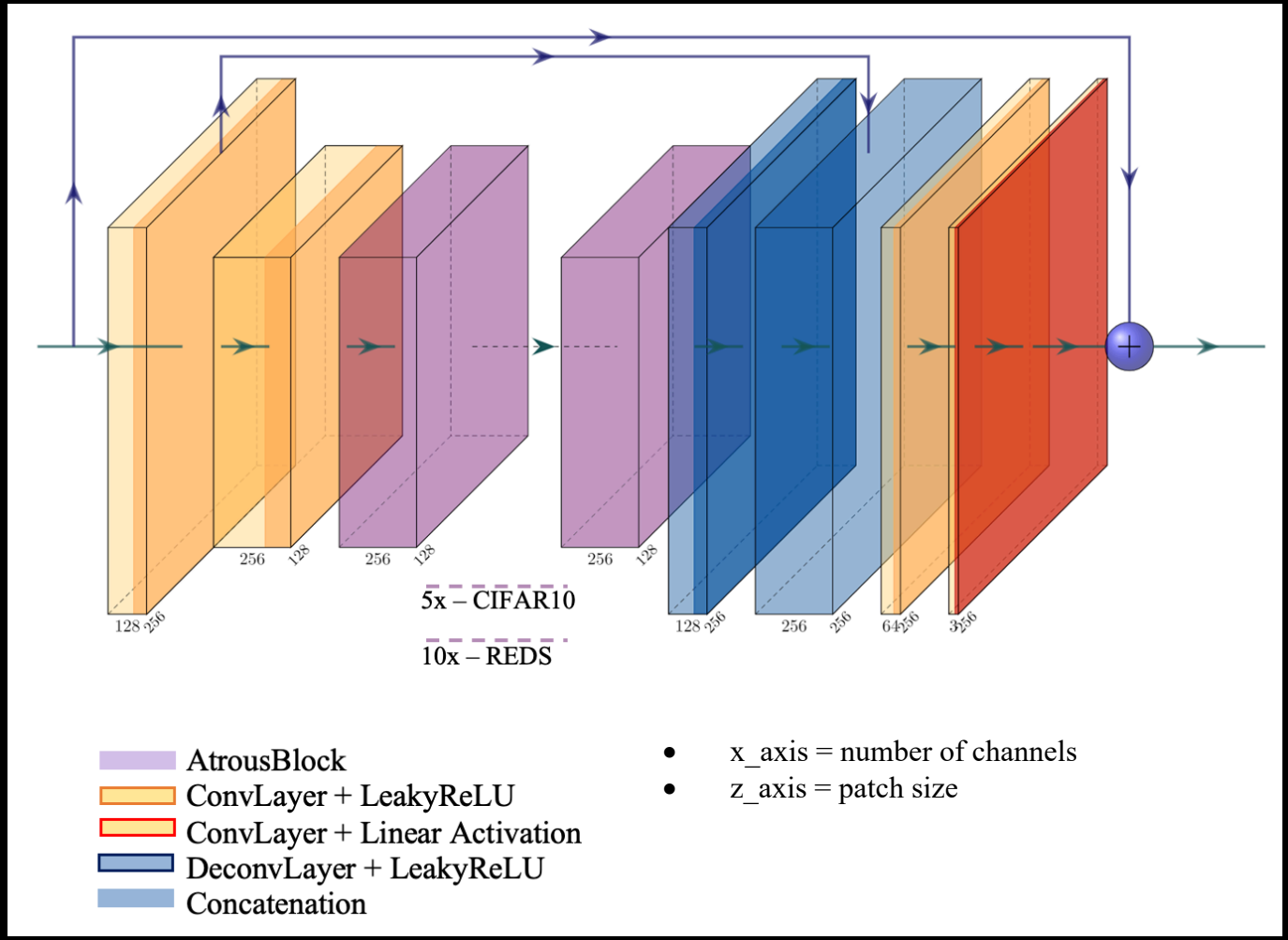
- Simulate a **multiscale approach without reducing spatial resolution**
  - by using 3x3 atrous convolutions at different dilation rates we can achieve a very wide receptive field at a much lower computational cost (w.r.t. a comparable standard convolution), without losing too much spatial resolution.

ARCHITECTURES

3. ATROUS_NET - STRUCTURE

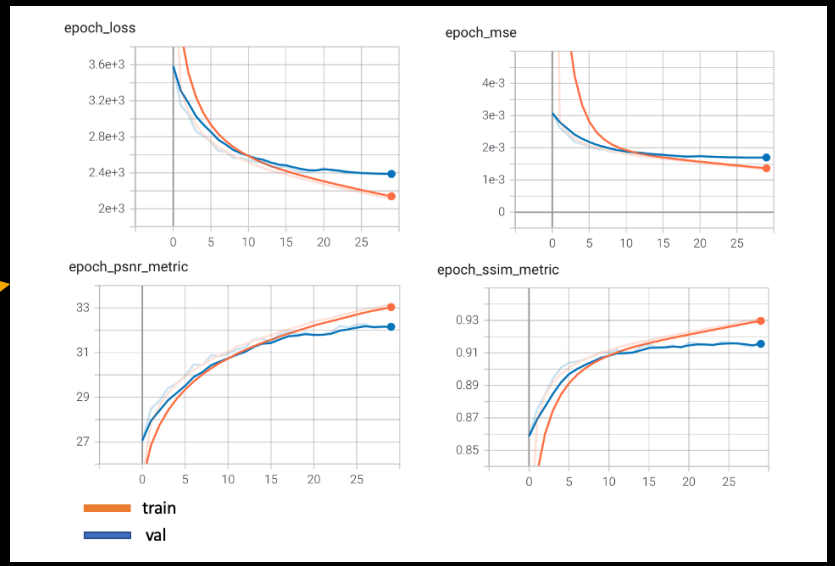
TESTED BOTH ON CIFAR-10 AND REDS

- **Inner structure**
  - **Convolution 9x9, padding same**
    - ➢ low-level features extraction
  - **Convolution 3x3, stride 2, padding same**
    - ➢ down-sampling
  - Series **of Atrous Blocks**:
    - **CIFAR-10**: 5 Residual Atrous Blocks
    - **REDS**: 10 Residual Atrous Blocks
  - **Deconvolution 3x3** and **2 Convolutions 3x3, stride 2, padding same**
    - ➢ up-sampling
- **Output**: concatenation of blurred input image and residual image
- **Weight Initialization: He Initializer**



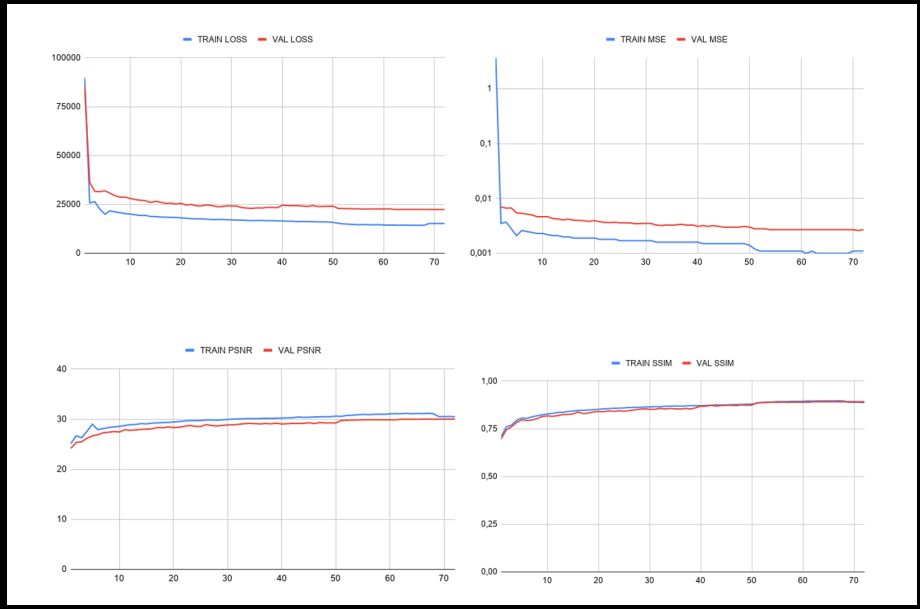
TRAINING
CIFAR-10

	BATCH SIZE	ITERATIONS	OPTIMIZER	LOSS
CARLO_NET	32	40	Adam	MSE/L2
KAIST_NET	32	30	Adam	LAD/L1
ATROUS_NET	**32**	**29**	**Adam**	**LAD/L1**



TRAINING
REDS

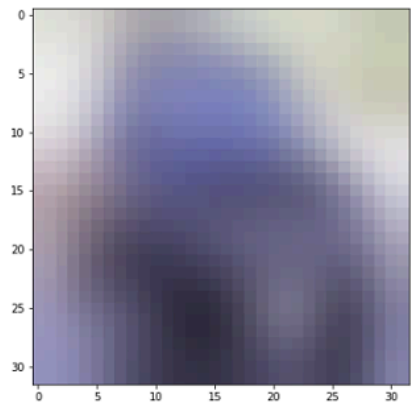
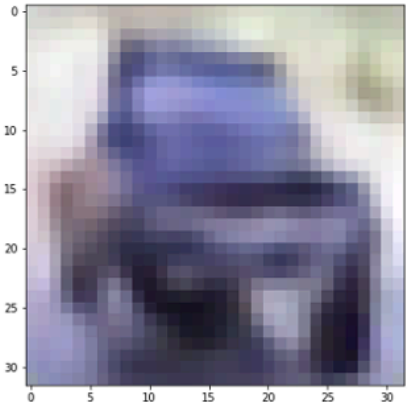
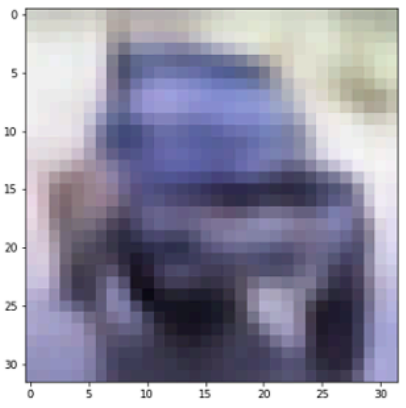
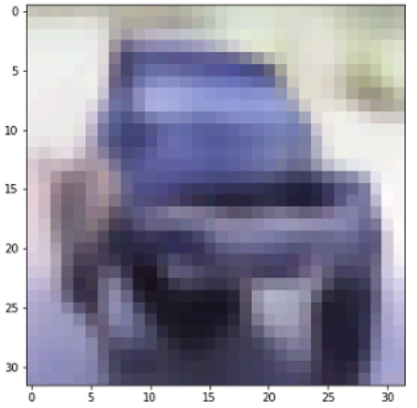
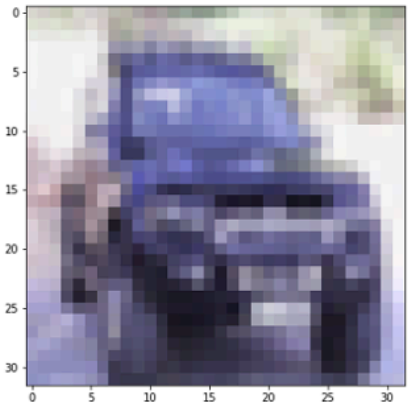
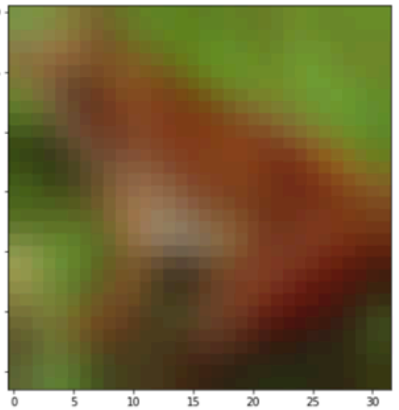
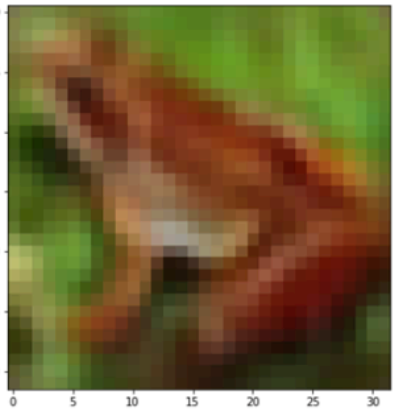
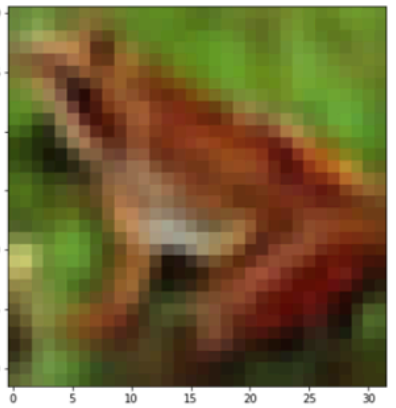
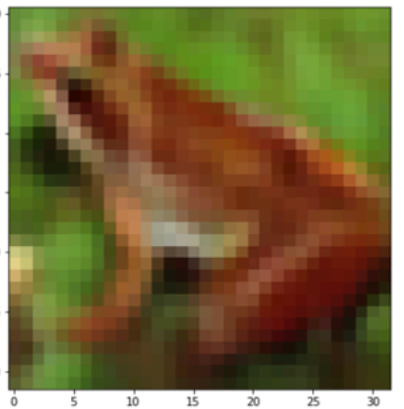
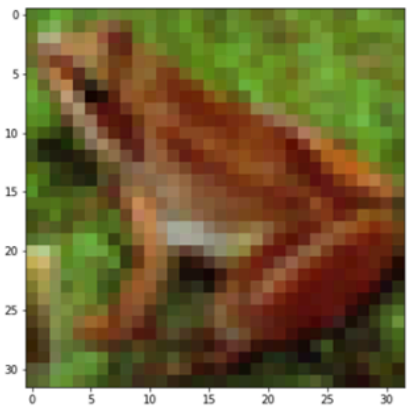
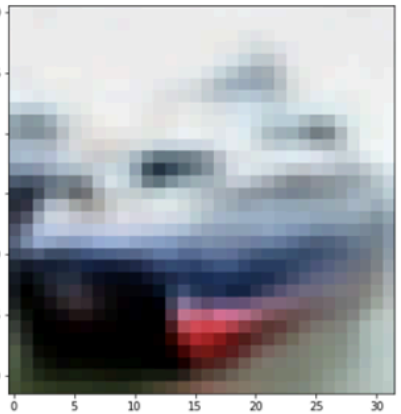
	BATCH SIZE	ITERATIONS	OPTIMIZER	LOSS
KAIST_NET	4	55	Adam	LAD/L1
ATROUS_NET	**4**	**71**	**Adam**	**LAD/L1**



EXPERIMENTAL RESULTS

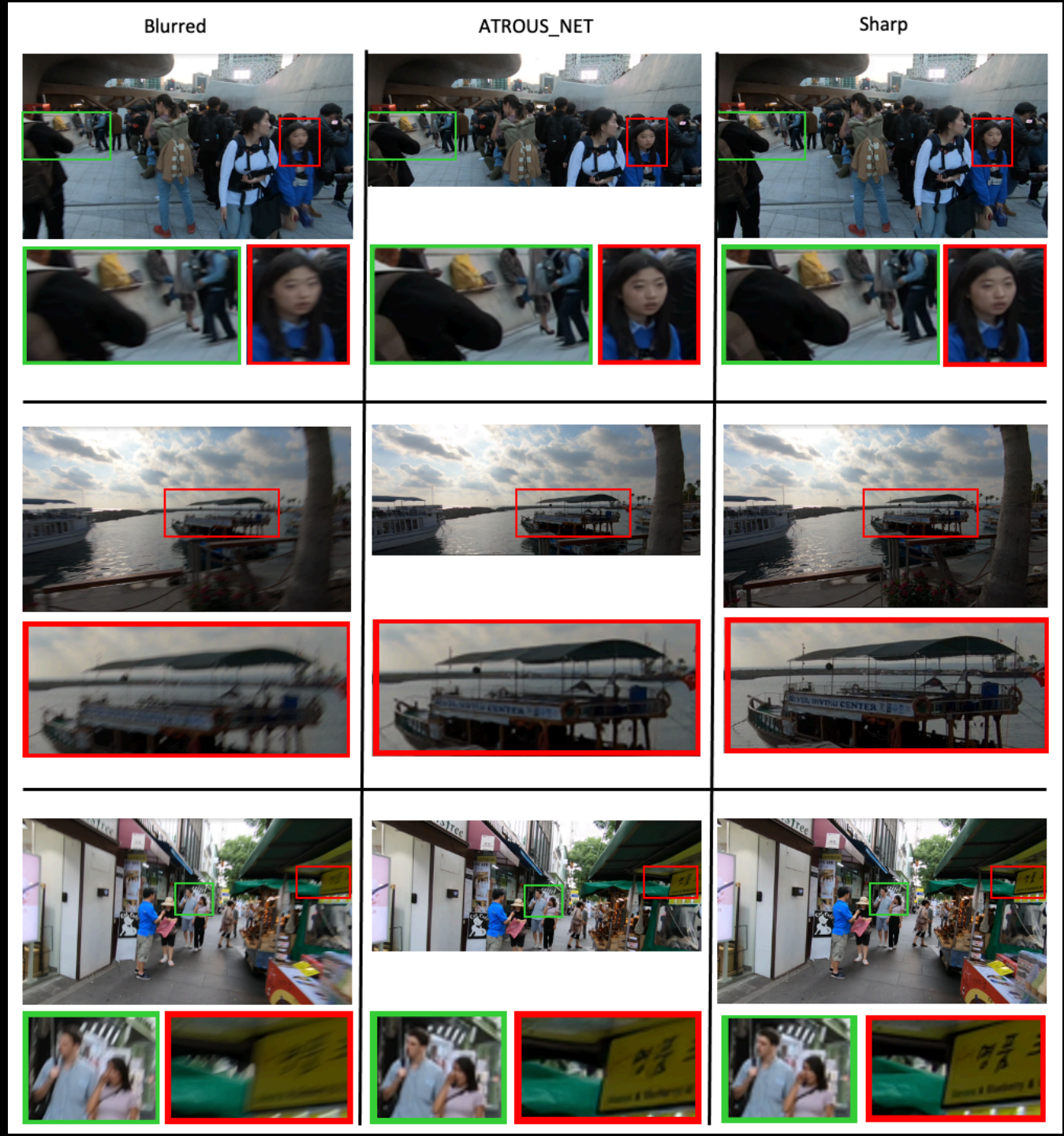
CIFAR-10

	CARLO_NET	KAIST_NET	ATROUS_NET	Baseline
SSIM	0.905	0.9012	**0.9237**	0.7127
PSNR	29.34	31.53	**33.61**	24.64
MSE [10^{-3}]	2.11	1.77	**1.50**	6.34

Blurred	CARLO_NET	KAIST_NET	ATROUS_NET	Sharp
				
				
				

EXPERIMENTAL RESULTS
REDS

	KAIST_NET	UniA Team	DeblurGAN – v2	ATROUS_NET	Baseline
SSIM	0.806	0.9412	0.8059	**0.9009**	0.7617
PSNR	28.70	34.44	28.92	**32.42**	27.048
MSE [10^{-3}]	2.42	----------	----------	**1.05**	3.88


Blurred
ATROUS_NET
Sharp

ROBUSTNESS BETA-TEST
ATROUS_NET ON GOPRO

- **Beta** because this test has been carried out without training ATROUS_NET on GoPro
- Although the network is not trained on GoPro, we can say that **it still manages to slightly remove the noise present in the images**