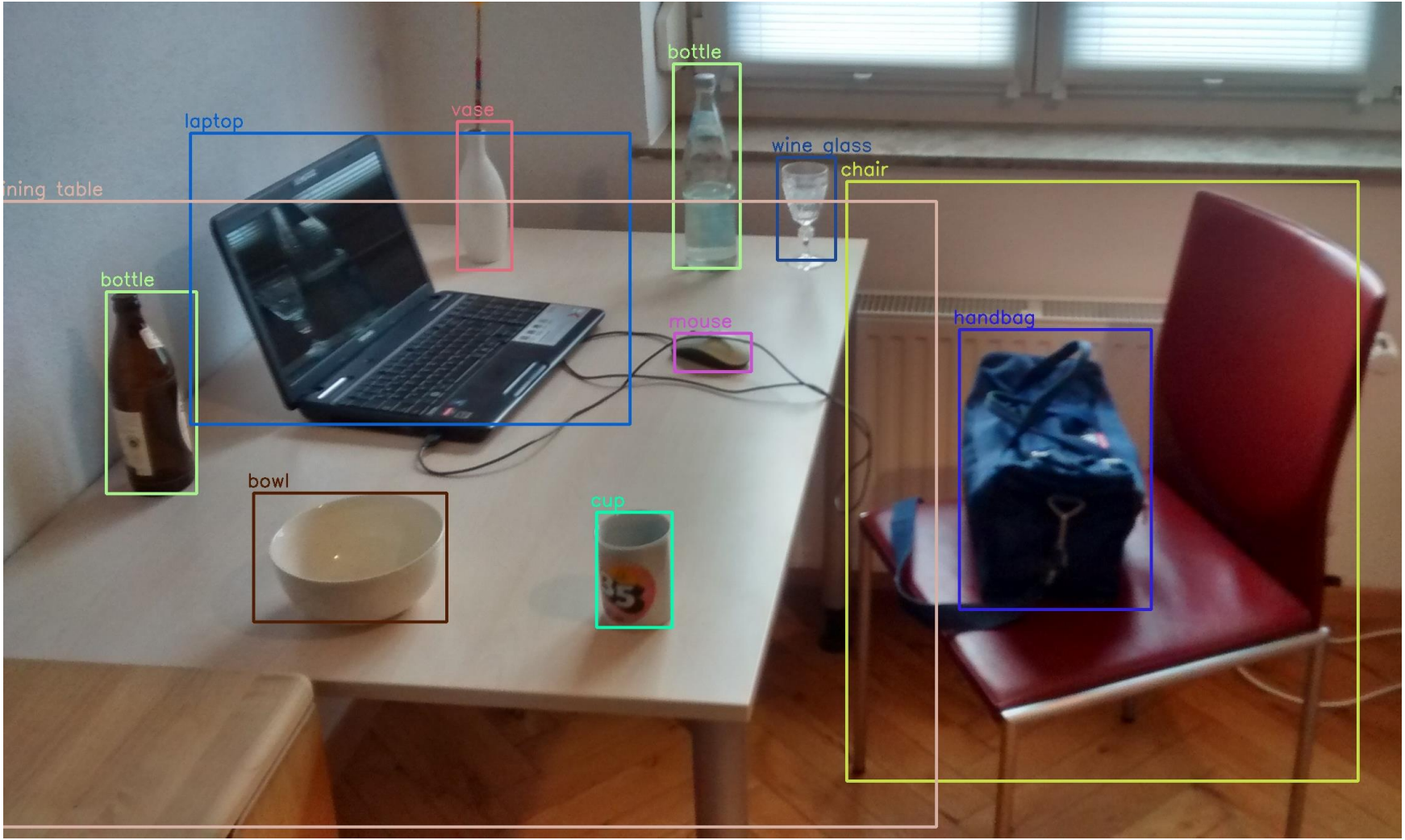
RESTORING IMAGES

By Felix Zhang


bottle
vase
laptop
wine glass
chair
ining table
bottle
mouse
handbag
bowl
cup

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IMPORTANT TERMS & CONCEPTS

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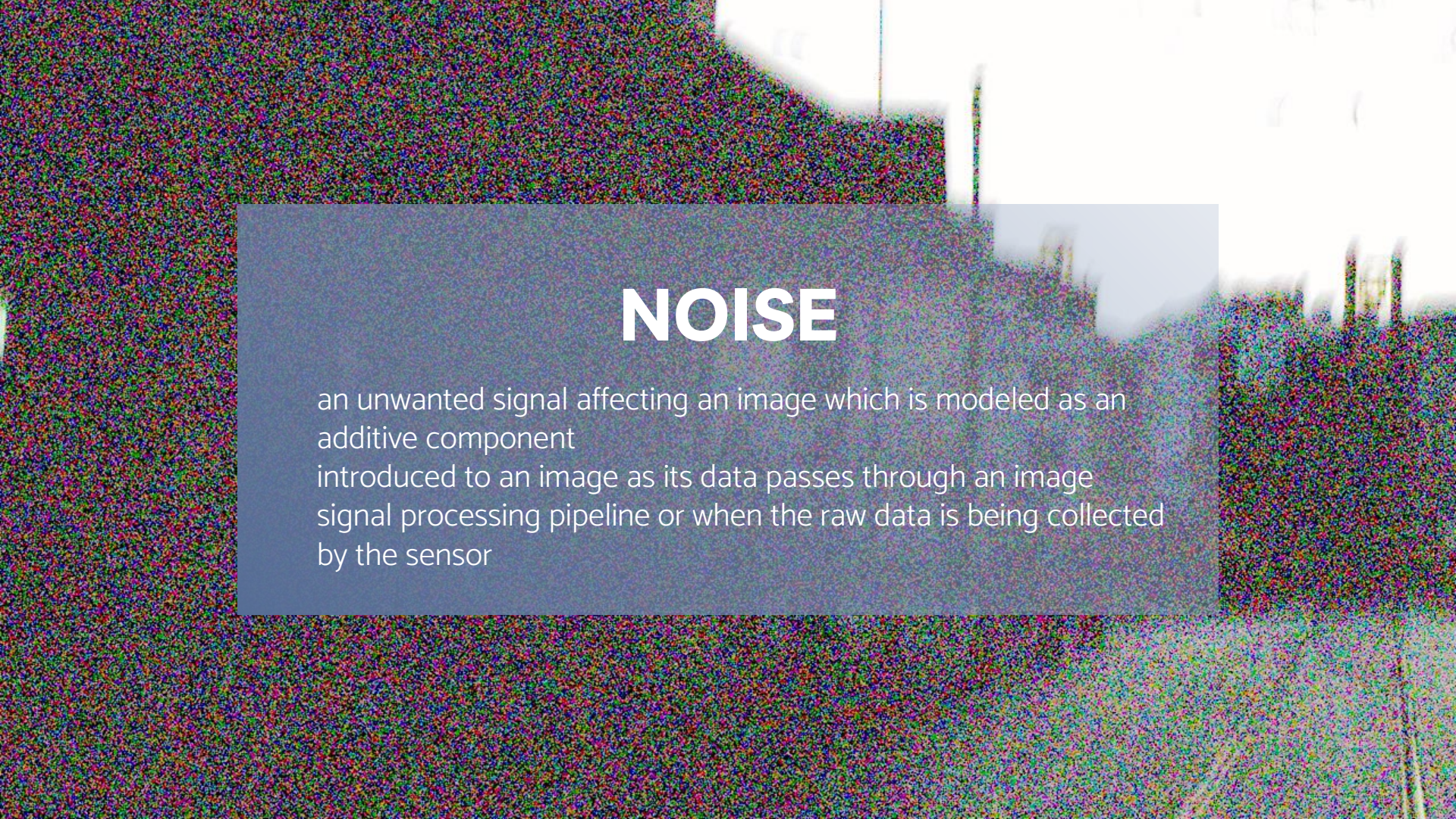
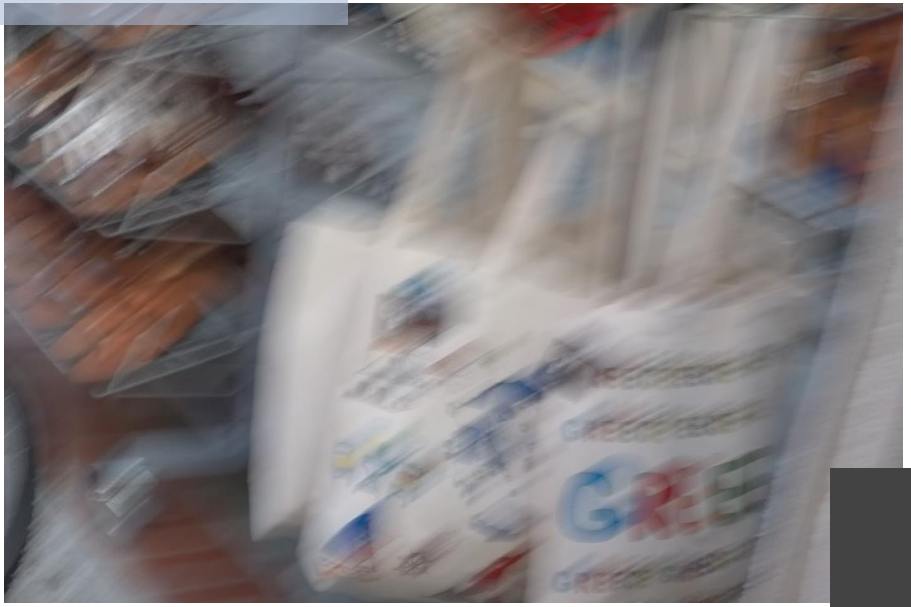


NOISE

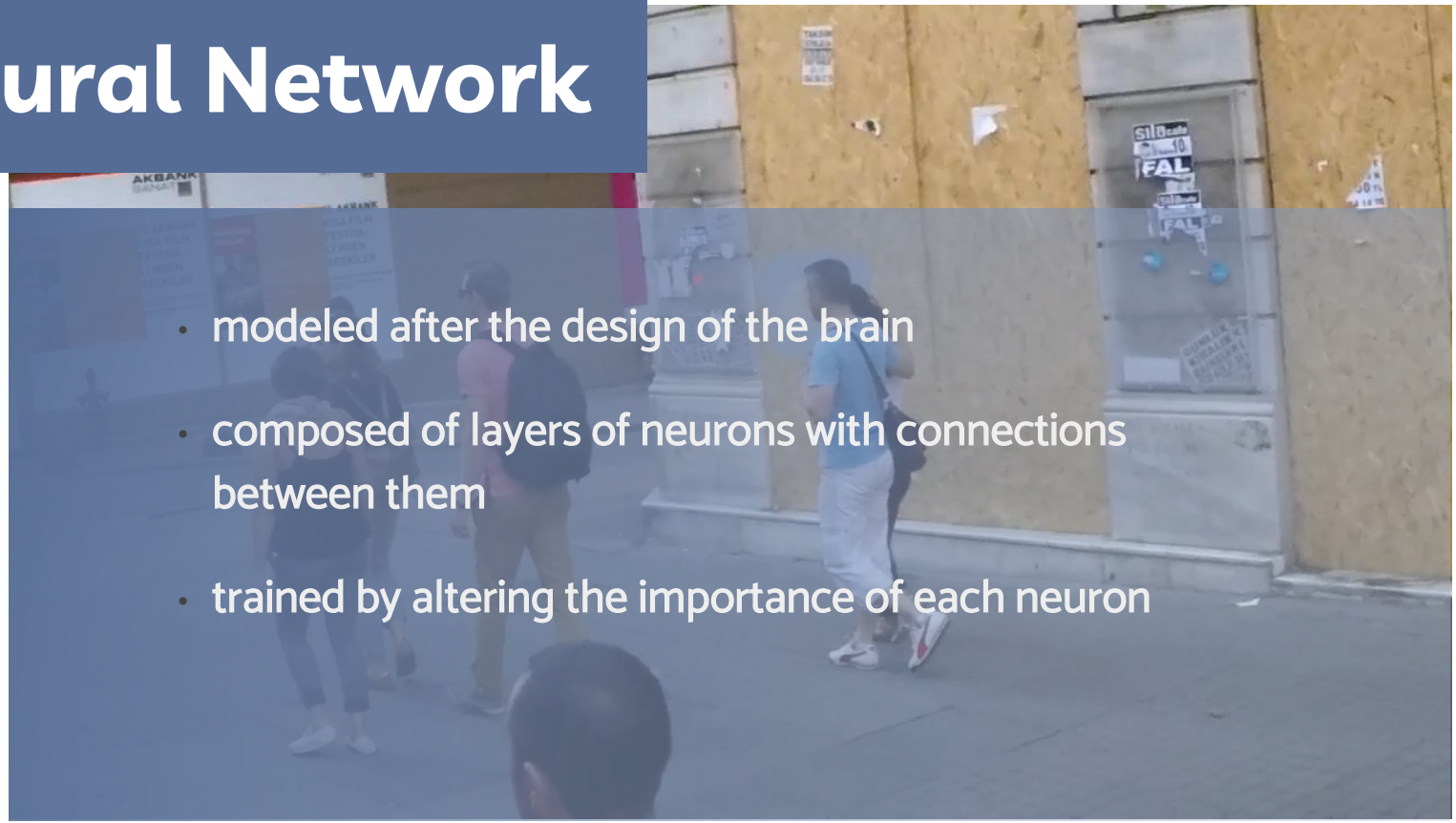
an unwanted signal affecting an image which is modeled as an additive component
introduced to an image as its data passes through an image signal processing pipeline or when the raw data is being collected by the sensor



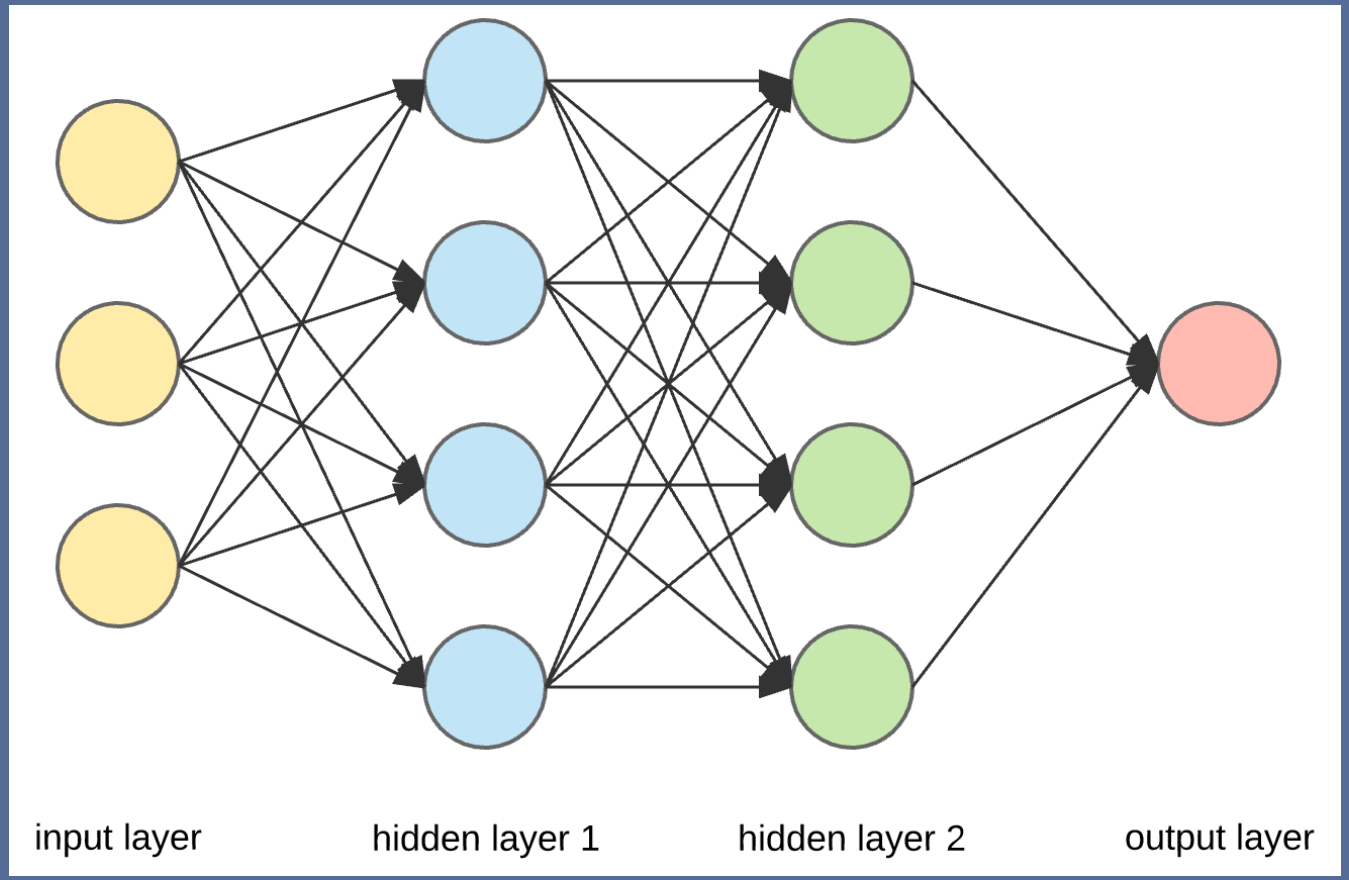
BLUR

Blur is a form of degradation that occurs when a sensor's pixel averages light from different regions.
It occurs when either an object in frame or the camera itself moves as an image is being taken.

Neural Network

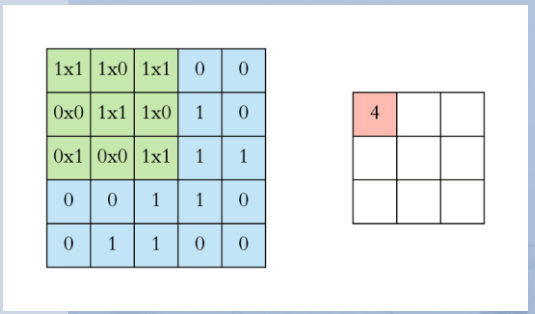


- modeled after the design of the brain
- composed of layers of neurons with connections between them
- trained by altering the importance of each neuron


input layer
hidden layer 1
hidden layer 2
output layer

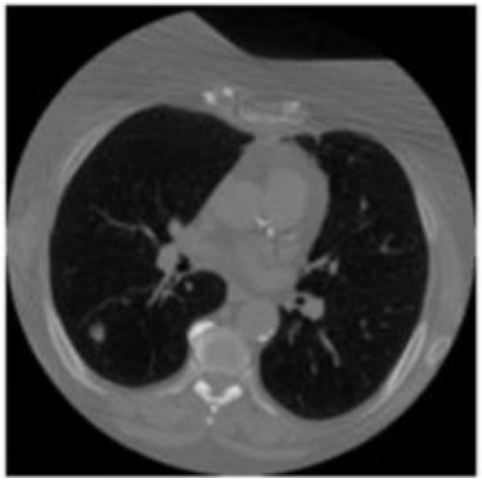
Convolution

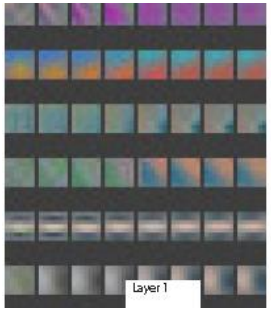
function that applies a filter over an image

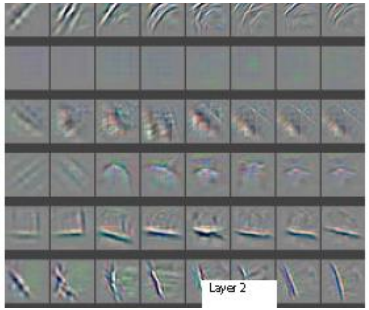


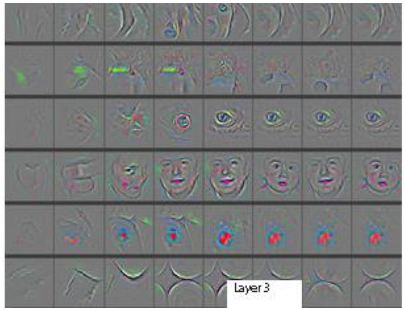
Examples

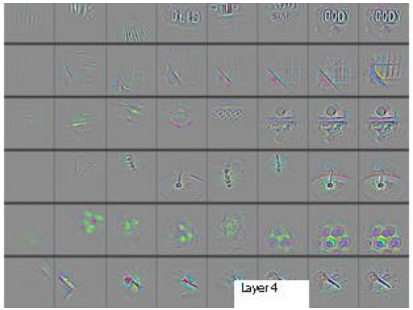
-1	0	-1
-2	0	2
-1	0	1

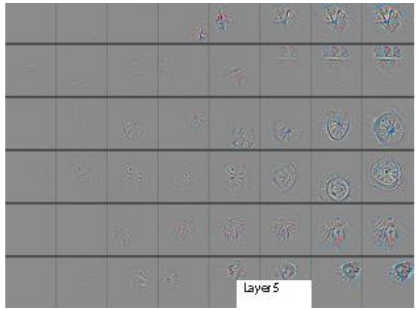










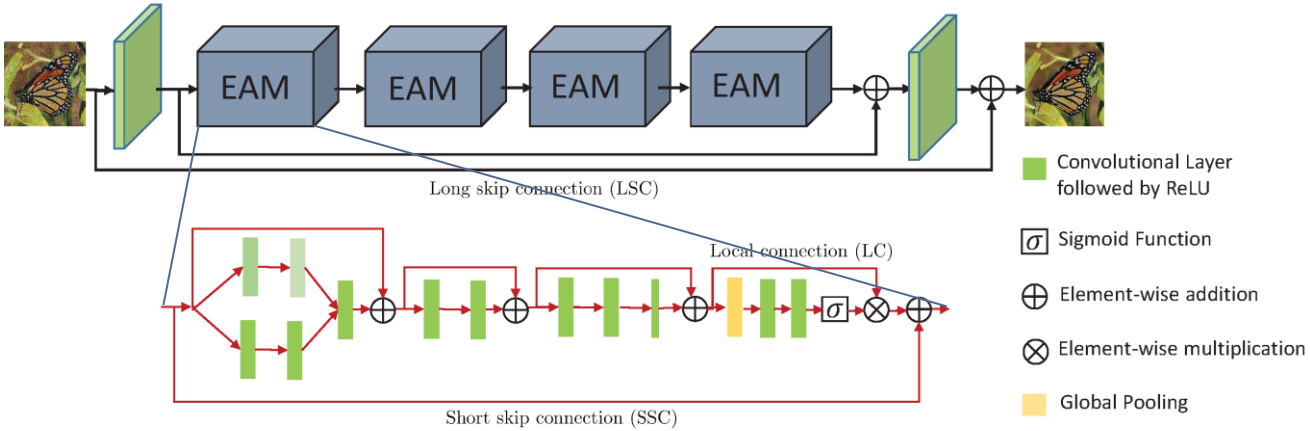


02

EXISITING MODELS

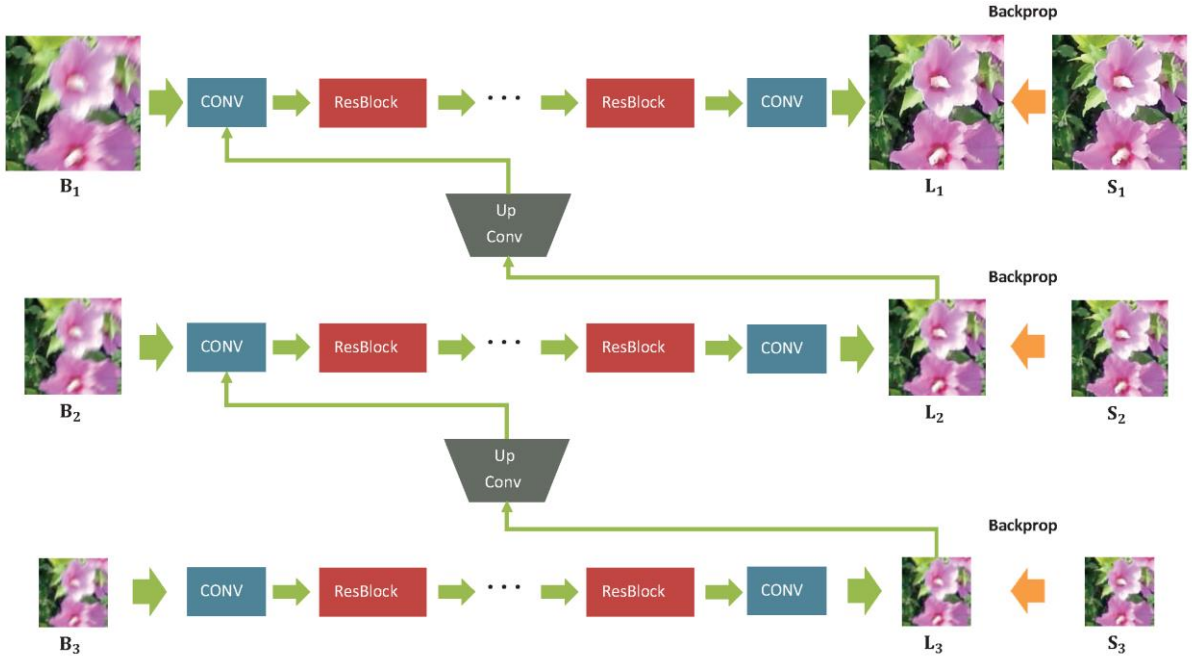
RIDNet

Anwar and Barnes



Solved a problem with earlier denoising architectures that required a noise estimation subnetwork to feed into a non-blind denoising one. This was done by creating an end-to-end neural network architecture.

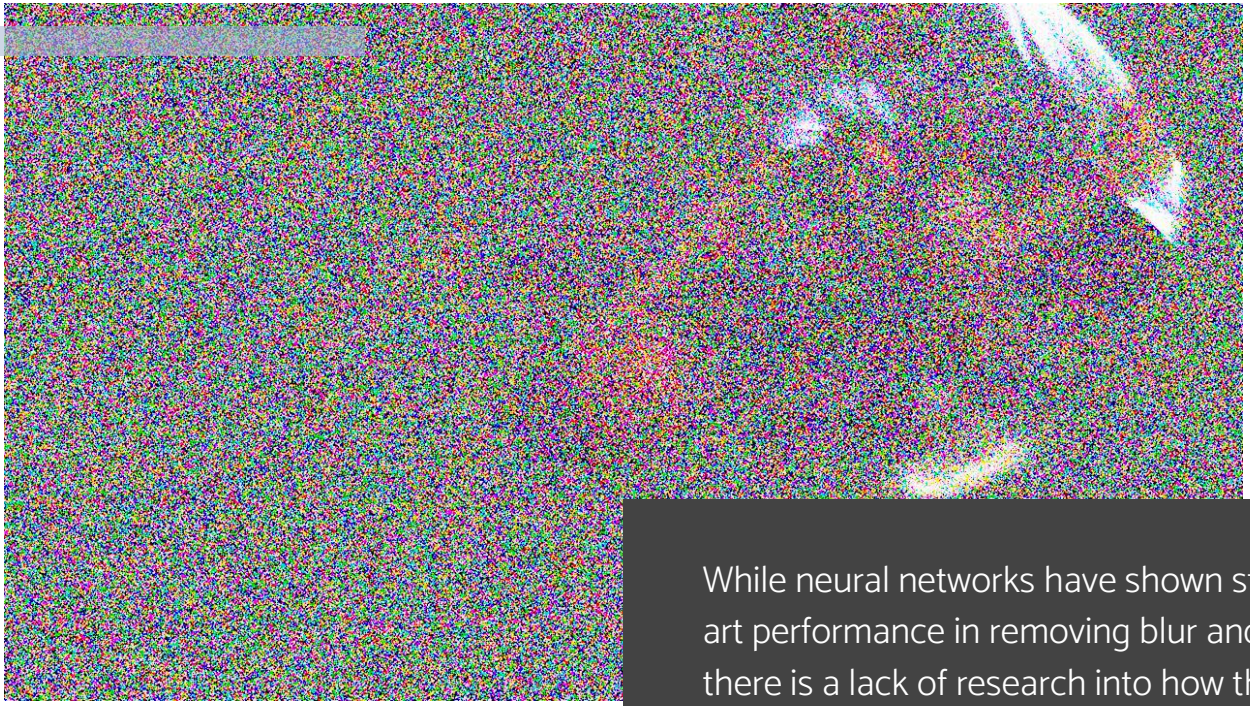
RIDNet relies upon a feature learning residual to identify the features within an image before passing them to the reconstruction layer



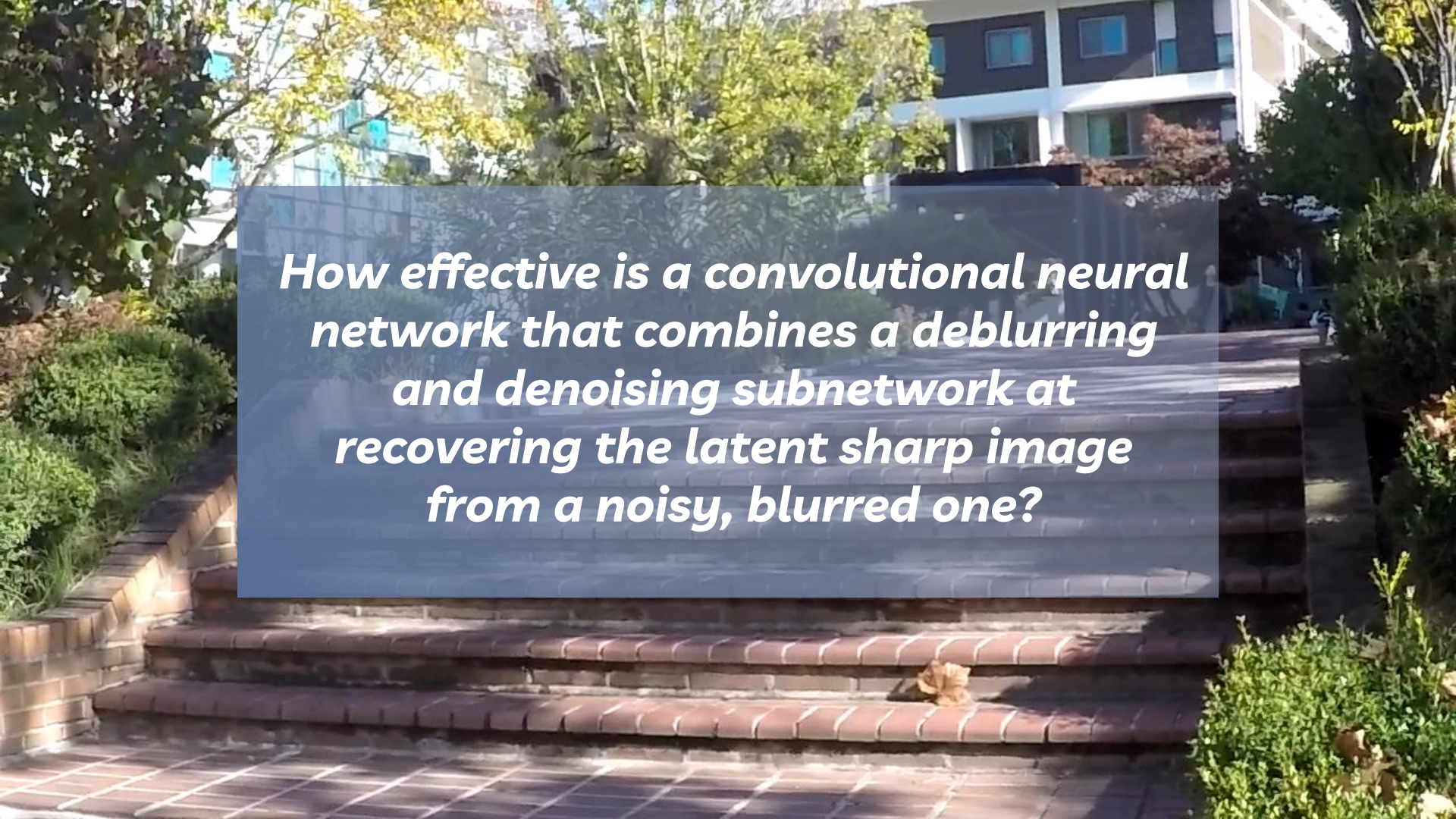
DeepDeblur
Nah et al.

Previous deblurring architectures relied upon accurate blur kernel estimation which raises the problem of non-uniformity. This was addressed in DeepDeblur by introducing a multi-scale architecture to progressively determine the sharp image. Their model relies upon identifying the structural features of an image at different sizes.

GAP IN RESEARCH



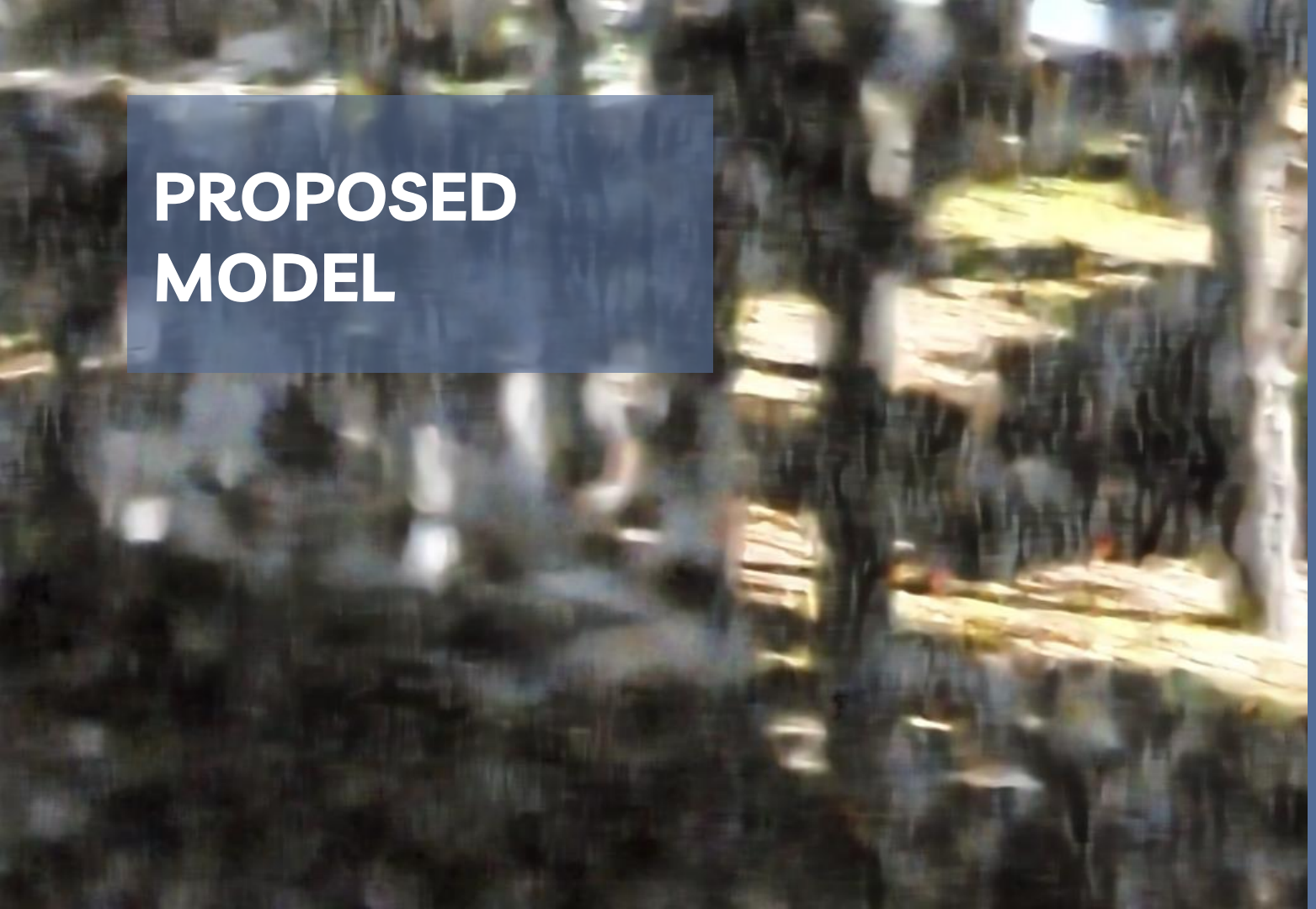
While neural networks have shown state-of-the-art performance in removing blur and noise, there is a lack of research into how they perform when used in conjunction to recover an image that is affected by both blur and noise.


How effective is a convolutional neural network that combines a deblurring and denoising subnetwork at recovering the latent sharp image from a noisy, blurred one?

HYPOTHESIS

combining the two models will prove more effective than utilizing only a denoising or deblurring neural network to restore an image

the distortion left after the restoration process to be significantly less than the sum of the individual networks



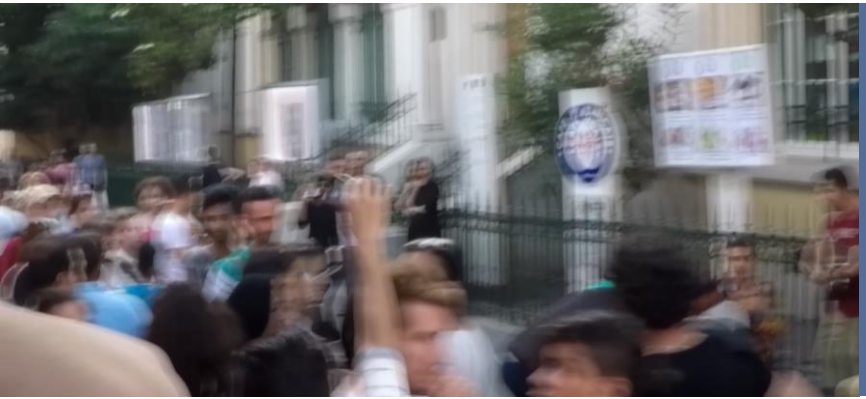
PROPOSED MODEL

03

MODEL OUTLINE

DENOISING

composed of a feature extraction, feature learning residual, and reconstruction component



DEBLURRING

employs a multi-scale network architecture consisting of a Gaussian pyramid structure

04

METHODOLOGY

PROCEDURE

STEP 1	Implment the proposed model in Python
STEP 2	Train the proposed model on a set of images from the GOPRO dataset
STEP 3	Test the proposed model, RIDNet, and DeepDeblur on a testing dataset
STEP 4	Calculate an average PSNR and SSIM value for the output images

TECHNICAL SPECIFICATIONS

An AMD Ryzen 3600 CPU and Nvidia RTX 3070 GPU were used to train and test the models

Neural network architectures were implemented in Python 3.8 using PyTorch 1.7.1 and CUDA 11.0

The models were tested on a modified version of the GOPRO dataset

MODIFIED DATASET

image with synthetic noise added with a program that imitates an image processing pipeline

sharp image used as the reference point

EVALUATION METRICS

PSNR

The peak signal-to-noise ratio index (PSNR) was chosen due to its widespread usage in the field and its incorporation of mean squared error which allows it to measure absolute error between images

SSIM

The structural similarity index measure (SSIM) was chosen for its focus on measuring the relative similarity of two images, with the goal of mimicking the visual quality perception of humans

LIMITATIONS

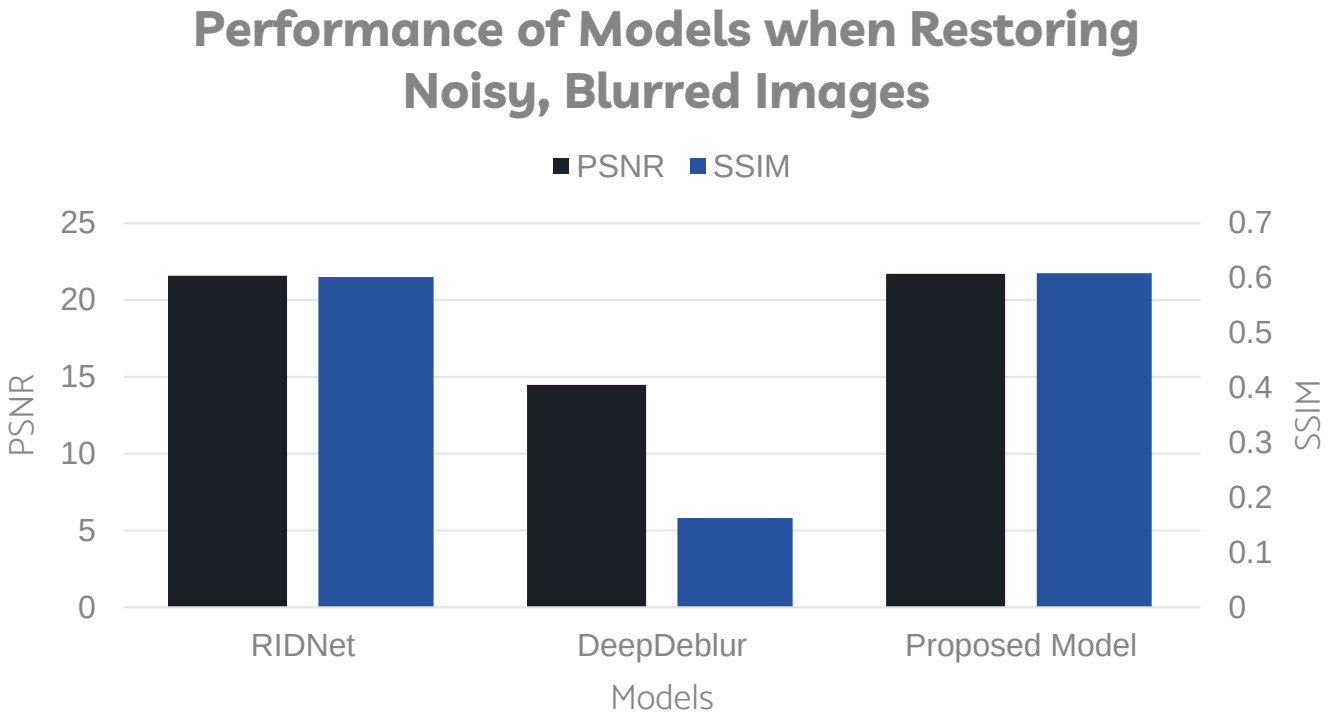
Other combinations of denoising and deblurring neural network architectures were unable to be trained and tested

Unable to construct an additional training and testing dataset of real-life noisy, blurred images

RESULTS & ANALYSIS

04

QUANTITATIVE RESULTS



Metrics	RIDNET	DeepDeblur	Proposed Model
PSNR	21.573	14.479	21.706
SSIM	0.602	0.163	0.609

LOW BLUIR
LOW NOISE

Input

Proposed Model

RIDNet

DeepDeblur

HIGH BLUIR
LOW NOISE

Input

Proposed Model

RIDNet

DeepDeblur

LOW BLUIR
HIGH NOISE

Input

Proposed Model

RIDNet

DeepDeblur

HIGH BLUIR
HIGH NOISE

Input

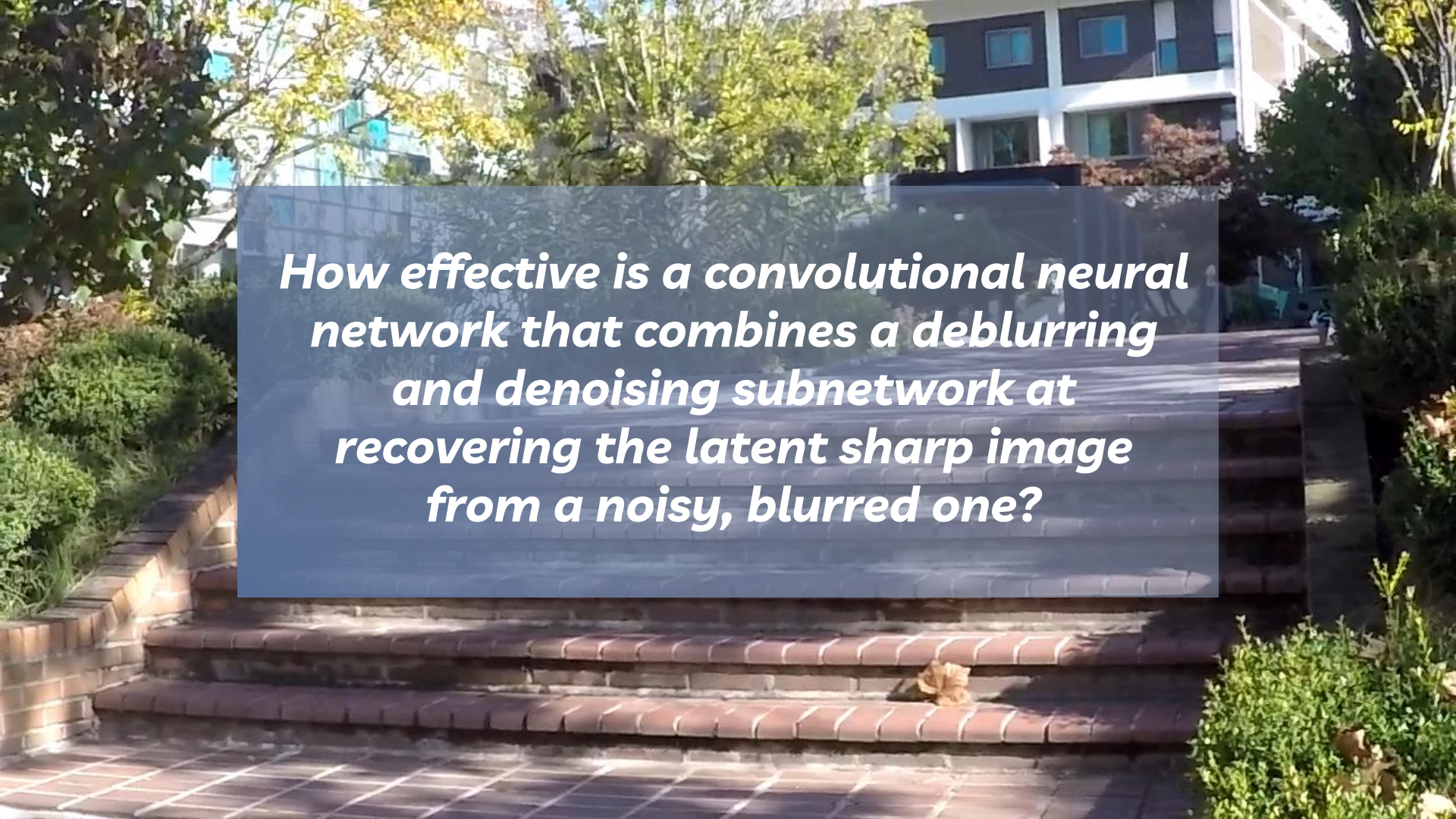
Proposed Model

RIDNet

DeepDeblur

DISCUSSION

05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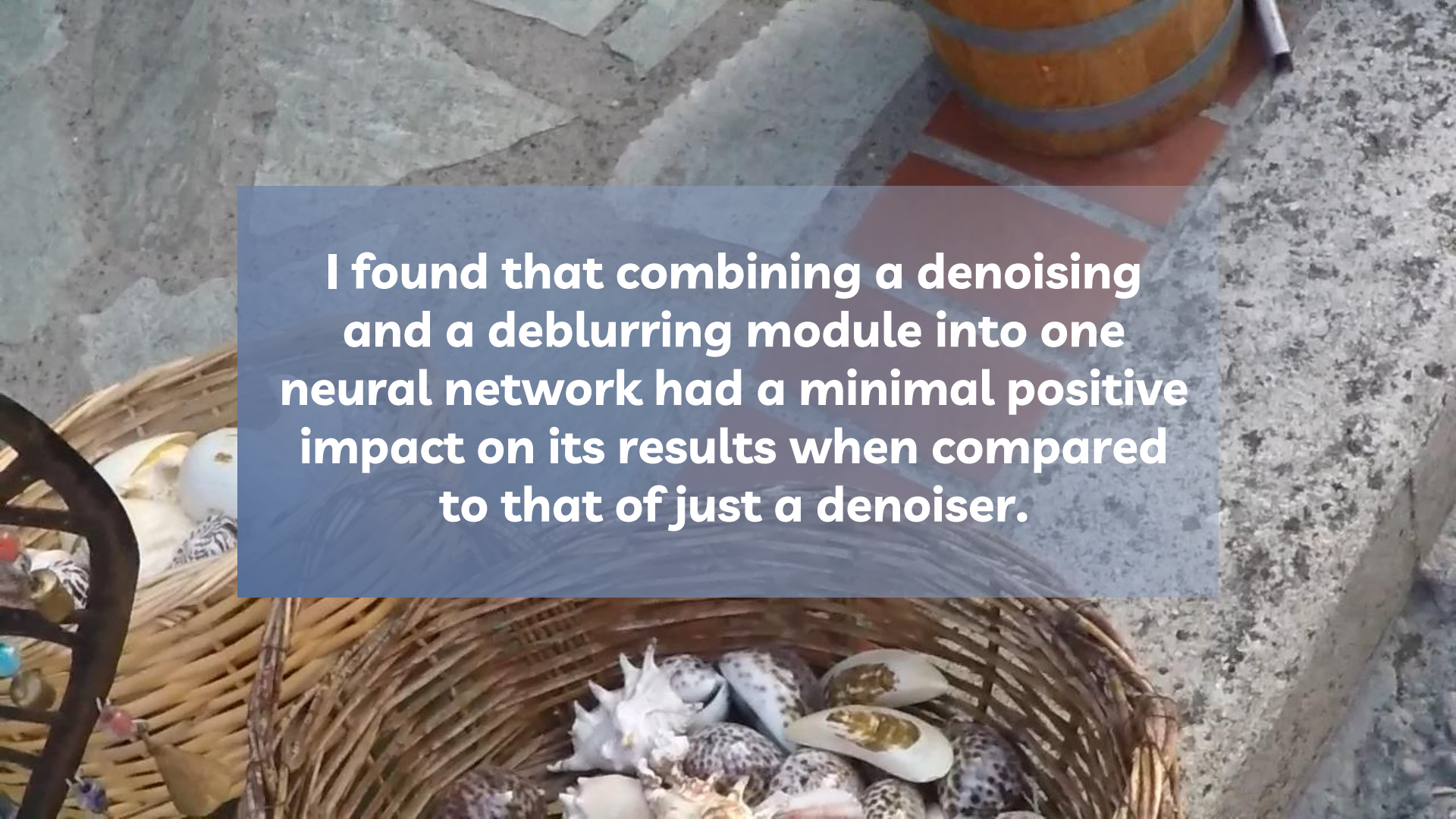
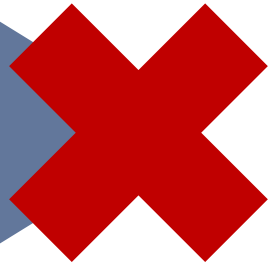


I found that combining a denoising and a deblurring module into one neural network had a minimal positive impact on its results when compared to that of just a denoiser.

HYPOTHESIS

combining the two models will prove more effective than utilizing only a denoising or deblurring neural network to restore an image

the distortion left after the restoration process to be significantly less than the sum of the individual networks



IMPLICATIONS

PREPROCESSOR

Used to perform preprocessing on the input images for an object recognition network trained on a clean dataset

INTERNET OF THINGS

Employed by devices on the “internet of things” and in autonomous vehicles

RESTORATION

Increase quality of images taken in low-light situations or with long exposure times

FUTURE RESEARCH

COMBINATION

Investigate other combinations of deblurring and denoising networks

ARCHITECTURE

Explore other possible architectures, specifically an end-to-end framework

DISTORTION

Investigate the use of other image restoration networks in conjunction with one another


Thanks!

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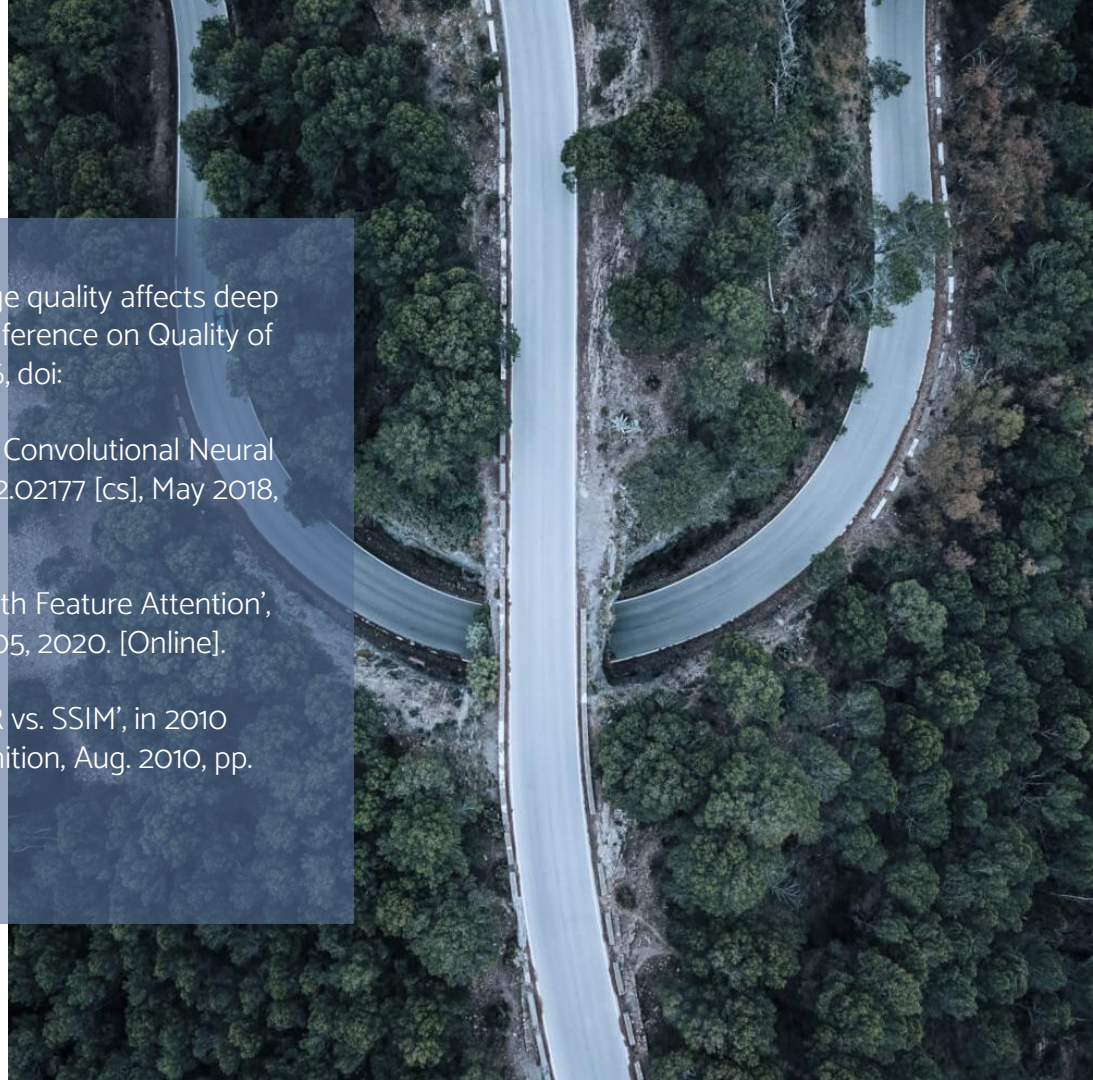

Image Sources

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https://medium.com/@ksusorokina/image-classification-with-convolutional-neural-networks-496815db12a8
https://eg.bucknell.edu/~cld028/courses/379-FA19/NN/convTF-Walk-Thru.html
https://www.researchgate.net/figure/An-example-of-edge-detection-using-a-Sobel-filter-Left-The-kernel-of-a-Sobeloperator_fig6_334205989
Visualizing and Understanding Convolutional Networks

RESTORING IMAGES

By Felix Zhang