Mech 19118 TEO LIM FONG

B.Eng. Mechatronics

# Removal of Rain using WAVELET CYCLEGAN

## INTRODUCTION

The wavelet method has recently been developed to enhance image quality through noise removal resulting in images with enhanced resolution.

Wavelet CycleGan is a novel algorithm created for rain removal and preservation of colors of the images in HSV color space. Wavelet CycleGan consist of two stages – frequency sub bands and residual rain removal. Frequency sub bands focuses on different location of frequency information which enhances the structure of the images and retain the original color. Residual rain removal focuses on removing the rain.

Frequency sub bands can be obtained by applying DWT (Discrete Wavelet Transform) to the luminance(V) channel, where human vision is sensitive to luminance changes. After applying DWT, four coefficients will be obtained – LL (low-low), LH(low-high), HL(high-low), HH(high-high). These coefficients contains frequency information of different locations which is ideal for training in Convolutional Neural Network (CNN). It will be reconstructed back using IDWT (Inverse Discrete Wavelet Transform) and converted back to RGB channel. CycleGan is then used to remove most of the rain.

The proposed solution removed rain more efficiently, preserved the color of the images. Additionally, both quantitative comparison & qualitative analysis are much better than the existing solution – CycleGAN.

## Objective

Create and implement novel algorithm,
Wavelet CycleGAN to:

- Remove rain efficiently
- Retain the original color of the images
- Achieve a lower NIQE (Naturalness Image Quality Evaluator)

## METHOD

## Training Dataset

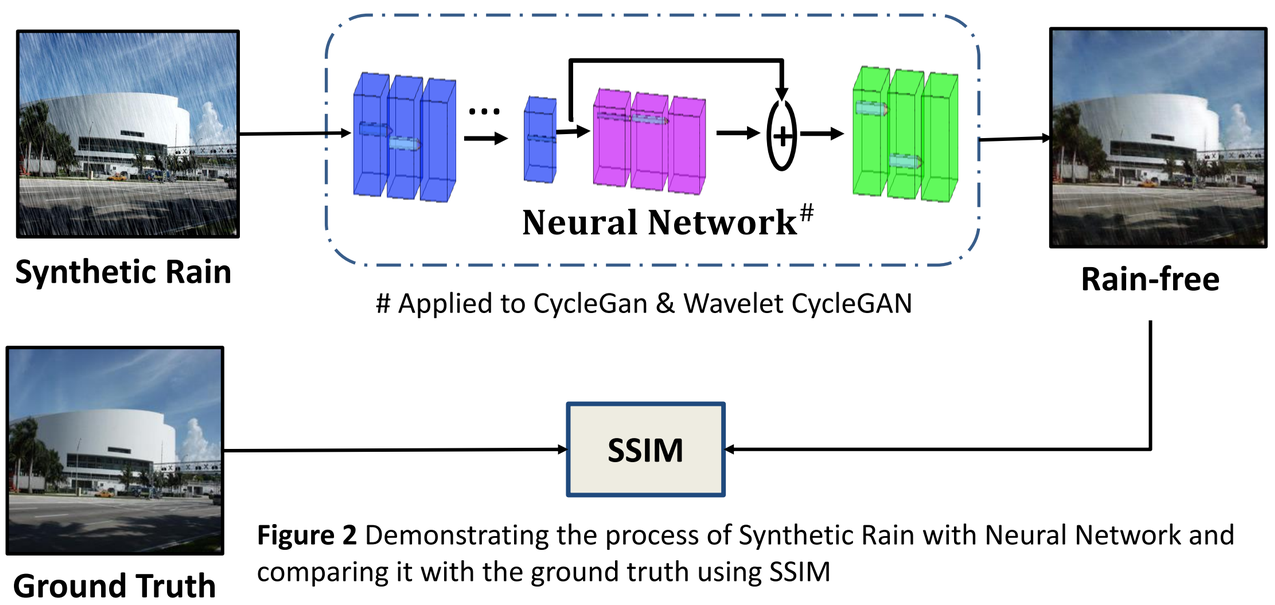


**Figure 2** Demonstrating the process of Synthetic Rain with Neural Network and comparing it with the ground truth using SSIM

| | ID CGAN | CycleGan | Wavelet CycleGan |
|---|---|---|---|
| SSIM | 0.8133* | 0.8980 | 0.908 |

SSIM(Structural Similarity Index) quantifies image quality degradation by processing synthetic rain on the ground truth. SSIM also measures the perceptual difference between rain-free images and the ground truth. Wavelet CycleGAN evidently achieves superior quantitative results when compared to other algorithms as shown in **Table 1**.

**Table 1.** Quantitative Comparison between the different algorithms using the synthetic data set

* Lai Meng Tang, Li Hong Lim, and Paul Siebert (2018) Removal of Visual Disruption Caused by Rain using Cycle-Consistent Generative Adversarial Networks

## Testing Dataset

NIQE (Naturalness Image Quality Evaluator) is an image comparison without any dependency (ground truth).

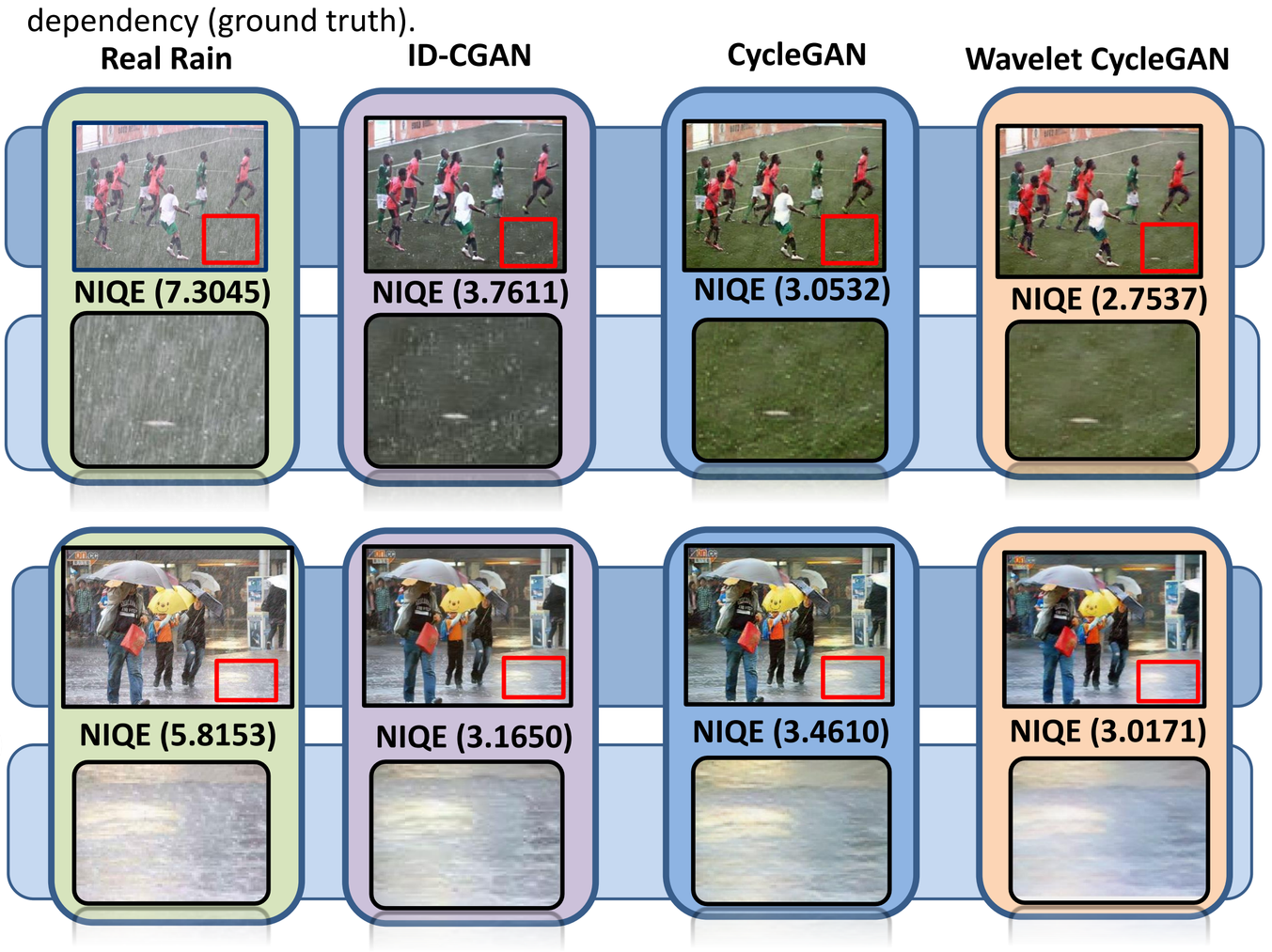


**Figure 3** Qualitative Analysis using real rain images

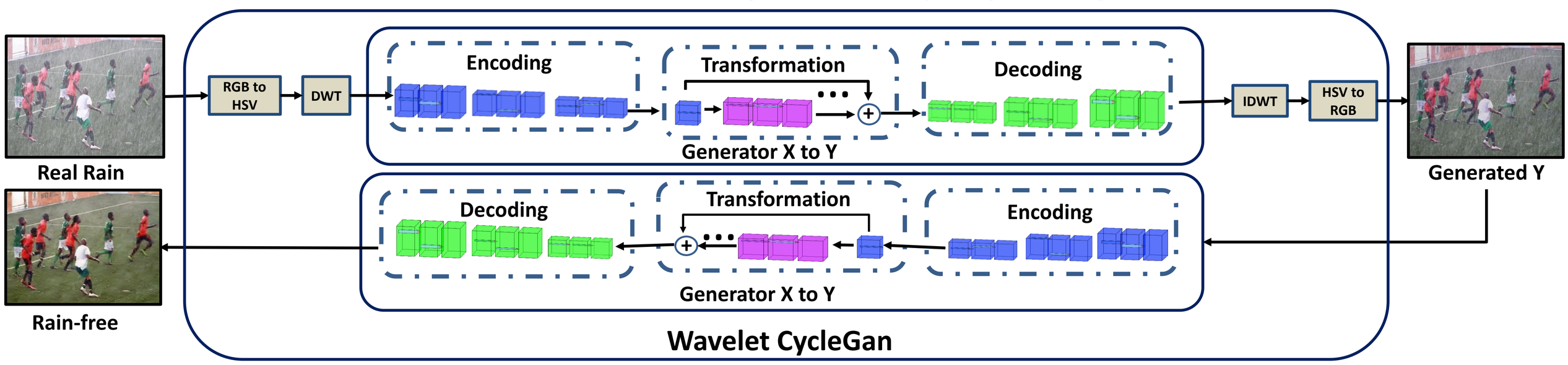


**Figure 1** Wavelet CycleGan Convolutional Neural Network

Supervisors (Singapore): Mr Tang Lai Meng
Supervisor (Glasgow): Dr. Liu Xiao Lei

SINGAPORE INSTITUTE OF TECHNOLOGY

University of Glasgow