VGG 16 Architecture

→ One of the most preferred CNN architecture developed by Simonyan and Zisserman by 2014

→ It has 16 convolutional layers.

→ VGG 16 is preferred as it has a very uniform architecture.

→ It has huge number of parameters (ie) it has 138 million parameters which is certainly difficult to handle.

Structure

I/P

↓

Conv 1-1 Conv 1-2 Pooling
conv 2-1 conv 2-2 Pooling
conv 3-1 conv 3-2 conv 3-3 Pooling
conv 4-1 conv 4-2 conv 4-3 Pooling
Conv 5-1 Conv 5-2 conv 5-3 Pooling

dense

dense

dense

⇓

O/P

No	Convolution	O/P dimension	Pooling	O/P dimension
layer 1 & 2	64 channel 3 x 3 kernel	224x224x64	Max pool Stride = 2, 2x2 size	112x112x64
layer 3 & 4	128 channel of 3x3 kernel	112x112x128	Stride = 2 size 2x2	56x56x128
layer 5,6,7	256 channel of 3x3 kernel	56x56x256	stride = 2 size = 2x2	28x28x258
layer 8,9,10	512 channel of 3 x 3 kernel	28x28x512	stride = 2 size 2x2	14x14x512
layer 11,12,13	512 channel of 3 x3 kernel	14x14x512	stride = 2 size 2x2	7x7x512

→ The first layer might be an input layer which could be passed into the function as argument. The function then returns a reference to the final layer in the block, the pooling layer, that could be connected to a flatten

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layer and subsequent layers for making a classification prediction.

Tropical Cyclone Intensity Estimation Using VGG

Tropical Cyclone

→ It is one of the costliest disaster.

→ A tropical cyclone is an intense circular storm that originates over warm tropical oceans. It is also called a hurricane or a typhoon. It is characterized by low atmospheric pressure and heavy rain and its winds exceeds 119 km (74 miles) per hour.

Formation

→ Once the wind speed increases to 36 km (23 miles) per hour, the storm is classified as a tropical depression.

→ If the circulation continues to intensify and the wind speeds exceed 63 km (39 miles) per hour, then the system is called a tropical storm.

→ Once the maximum wind speeds exceeds 119 km (74 miles) per hour, the storm is classified as tropical cyclone.

Conditions

1] The temp of surface layer of ocean water must be 26.5° (80° F) or warmer, and this warm layer must be atleast 50 meters (150 feet) deep.

2] A preexisting atmospheric circulation must be located near the surface warm layer.

3] The atmosphere must cool quickly with height to support the formation of deep convective clouds.

4] The middle atmosphere must be relatively humid at a height of about 5000 meters (16000 feet) above the surface.

5] The developing system must be atleast 500 km (300 miles) away from Equator.

6] The wind speed change slowly with height through the troposphere - no more than 10 meters (33 feet) per sec b/w surface and altitude of about 10,000 mtrs (33000 feet)

Research Paper

⇒ First of all, they used 5 kt interval estimation of wind speed with data available from Naval Research Laboratory. Now it extends by using 1 kt interval, and using real-time Geo-stationary Operational Environmental Satellite Imagery, performing extensive evaluation and building and deploying a production system.

Training dataset

i) Identify HURDAT2 storm intensity, time, location (latitude, longitude of storm center).

ii) Create a bounding box around storm using start and end date time of storm

iii) Use bounding box and time to download GOES-8, 10, 11, 12, 13, 16.

iv) Create a padding of +/- 5 degree from center of storm on both latitude and longitude.

v) Match HURDAT 2 wind speed to the closest file if there is not an exact match in time.

vi) Interpolate location information and wind speed (1 hr interval)

vii) Apply random rotation, random shear, zoom on training data to create more training samples.

Using this training dataset, design a deep learning model for objective estimation of tropical cyclone intensity using CNN.

→ This model inputs training samples at 5kt speed intervals and outputs a maximum wind speed at 1 kt resolution. however, model precision cannot exceed the 5kt resolution of i/p training data.

Performance Matrix

i) Mean Absolute Error = $\frac{1}{n} * \Sigma |x_p - x_t|$

ii) Root mean Squared Error = $\sqrt{\frac{1}{n} * \Sigma (x_p - x_t)^2}$

iii) Bias => $\frac{1}{n} * \Sigma (x_p - x_t)$

iv) Relative Root Mean Squared Error

$$(RRMSE) = \frac{\sqrt{\frac{\Sigma (x_p - x_t)^2}{n-1}}}{x_p}$$

x_p => predicted intensity.

x_t => actual intensity n → no. of samples

In CNN model, variation of VGG 16 architecture is used to estimate. This model includes 4 convolutional layer where each layer is followed by max pooling layer and A dense layers is included. which uses linear activation.

Model Hyper parameters :-

i) Learning rate of 1e-5
ii) Batch size - 60
iii) ReLU - Activation function
iv) Pooling with overlaps
v) Adaptive Moment Estimation (Adam) optimizer

⇒ It includes tracing the CNN's final intensity back to original image to discover which pixel contributed most to the classification by using Class Activation Map (CAM).

→ this model is extensively evaluated and systematically transitioned to production by comparing features identified in CAMS to Dvorak Techniques.

→ CNN is learning the desired cloud features for classification, particularly at higher intensities.