# Computer vision approach for quality inspection of steel sheets

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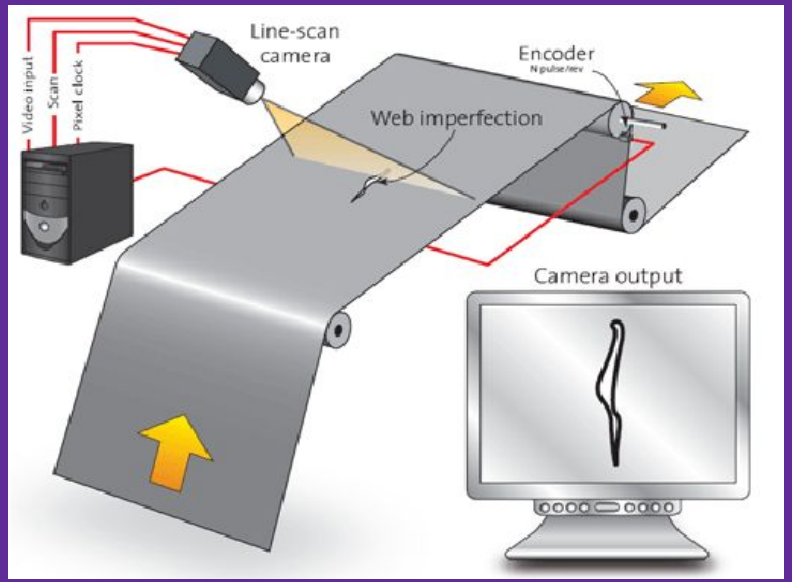
# Introduction

To predict the location and type of defects in steel using deep learning.

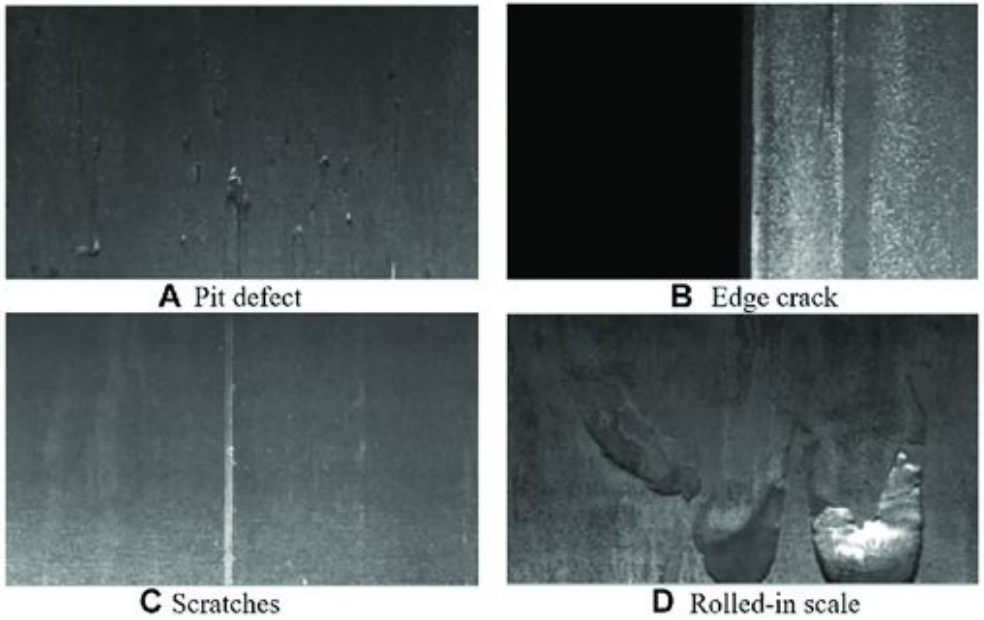
Business problem : Efficiency in Steel Production.

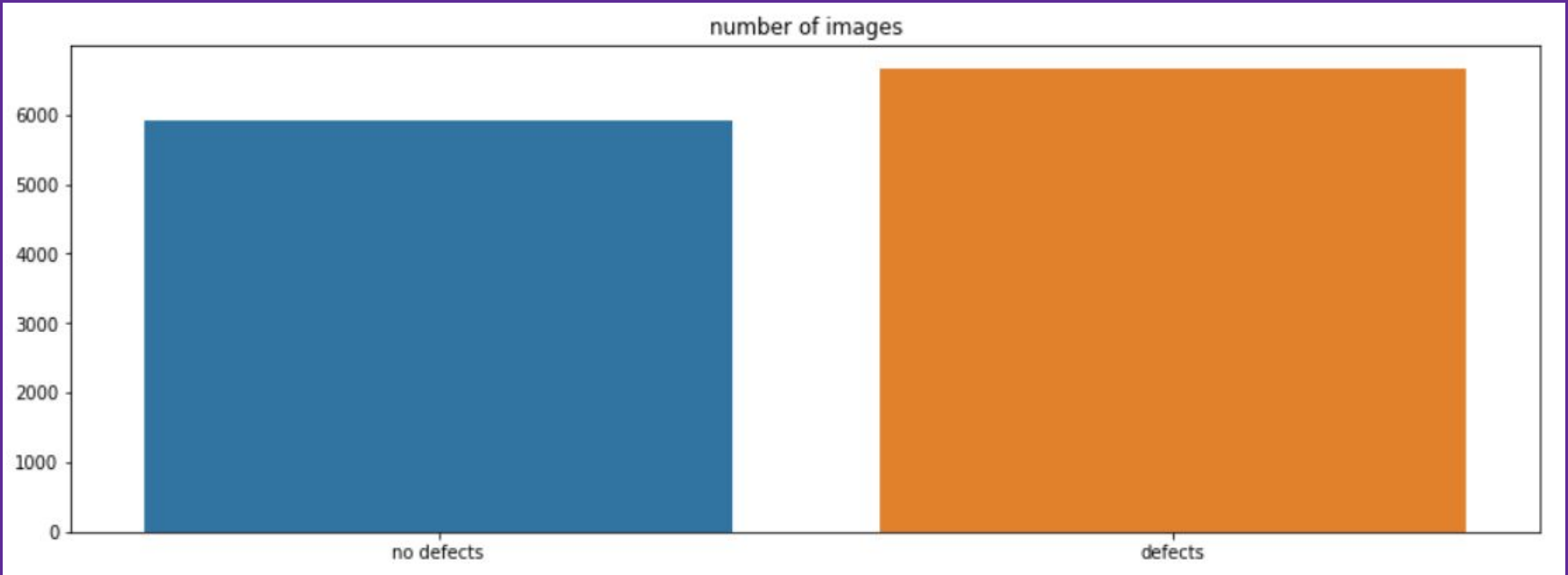
Working :



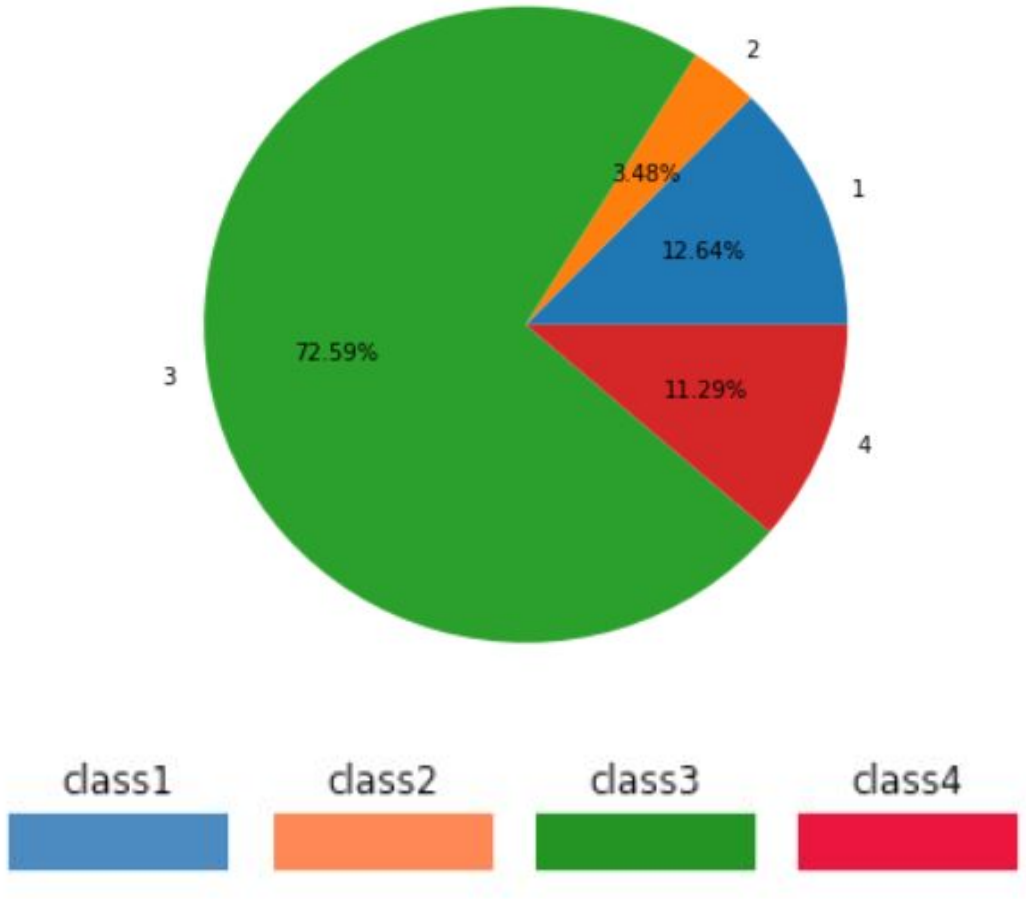
# Data Visualisation

Data is classified into four types of defects in steel.



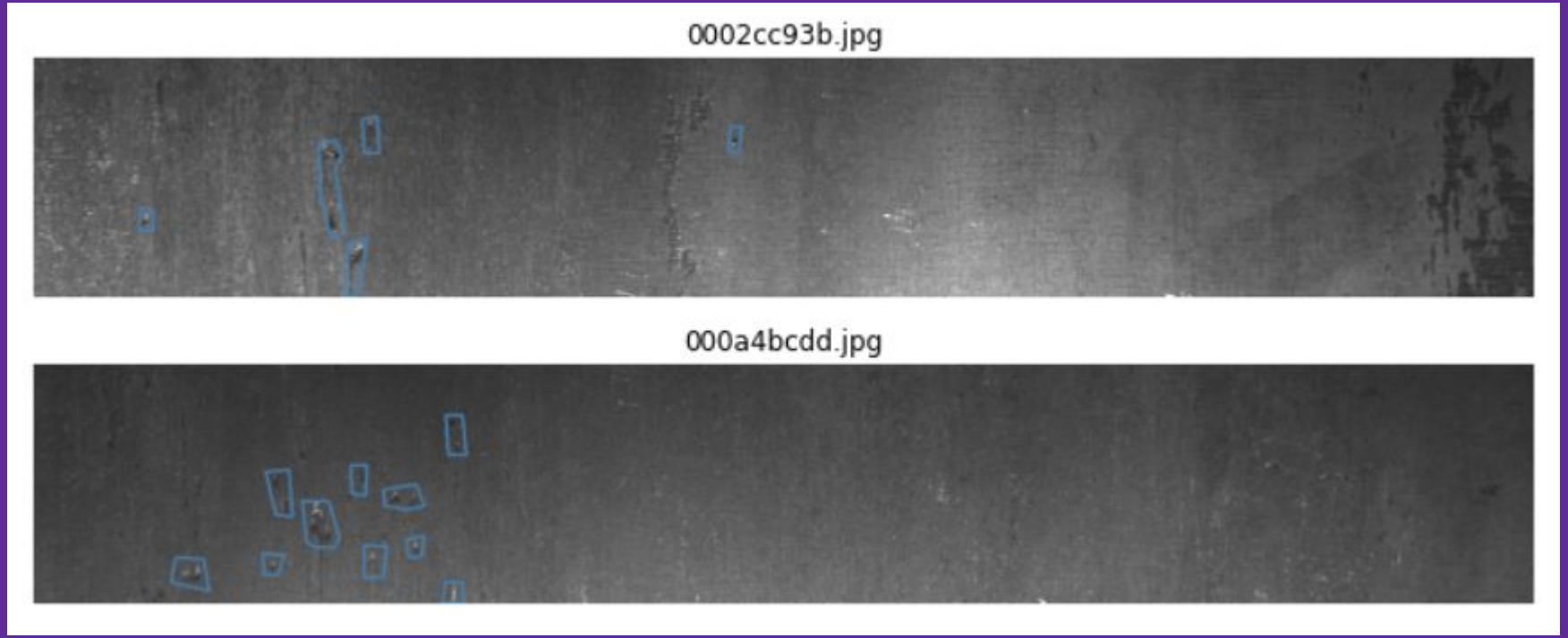



The number of images with no defects : 5912
The number of images with defects : 6666



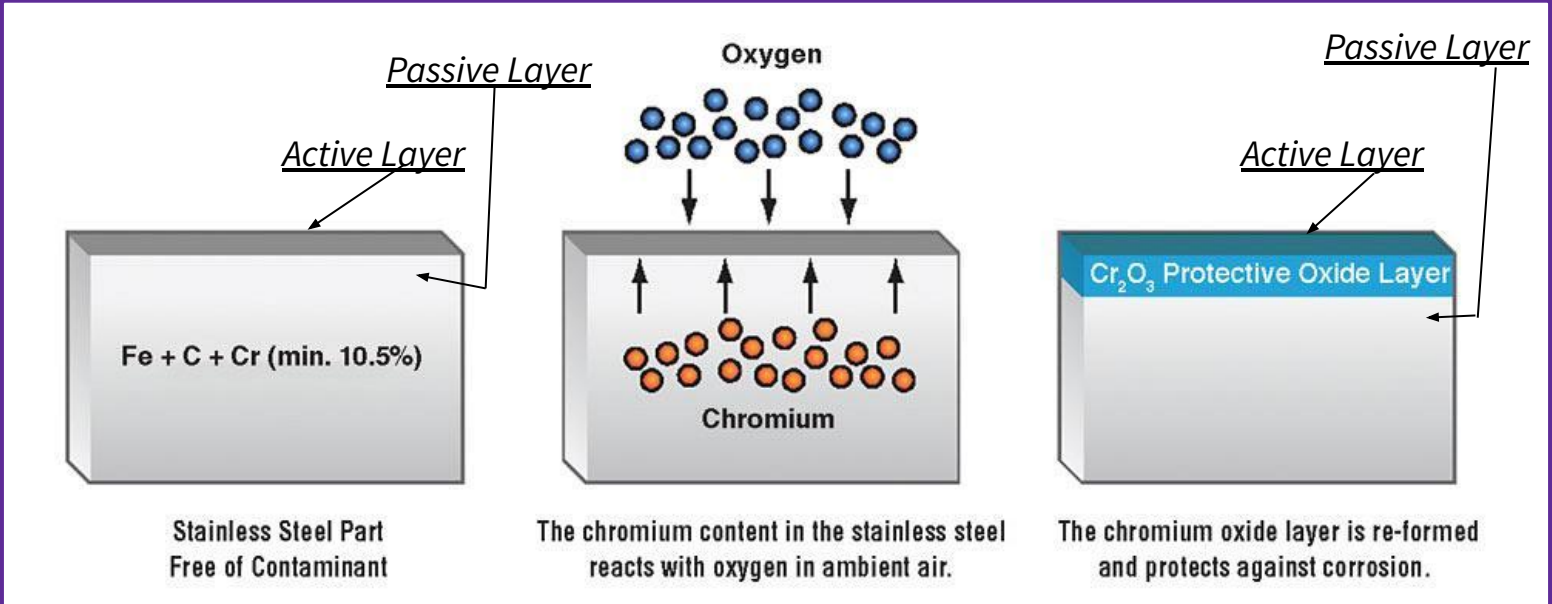

***A pie diagram*** of the defects is plotted as shown and ***palettes*** containing the ***labels*** for each class are shown in the ***output*** for ***representation*** purpose wherein,

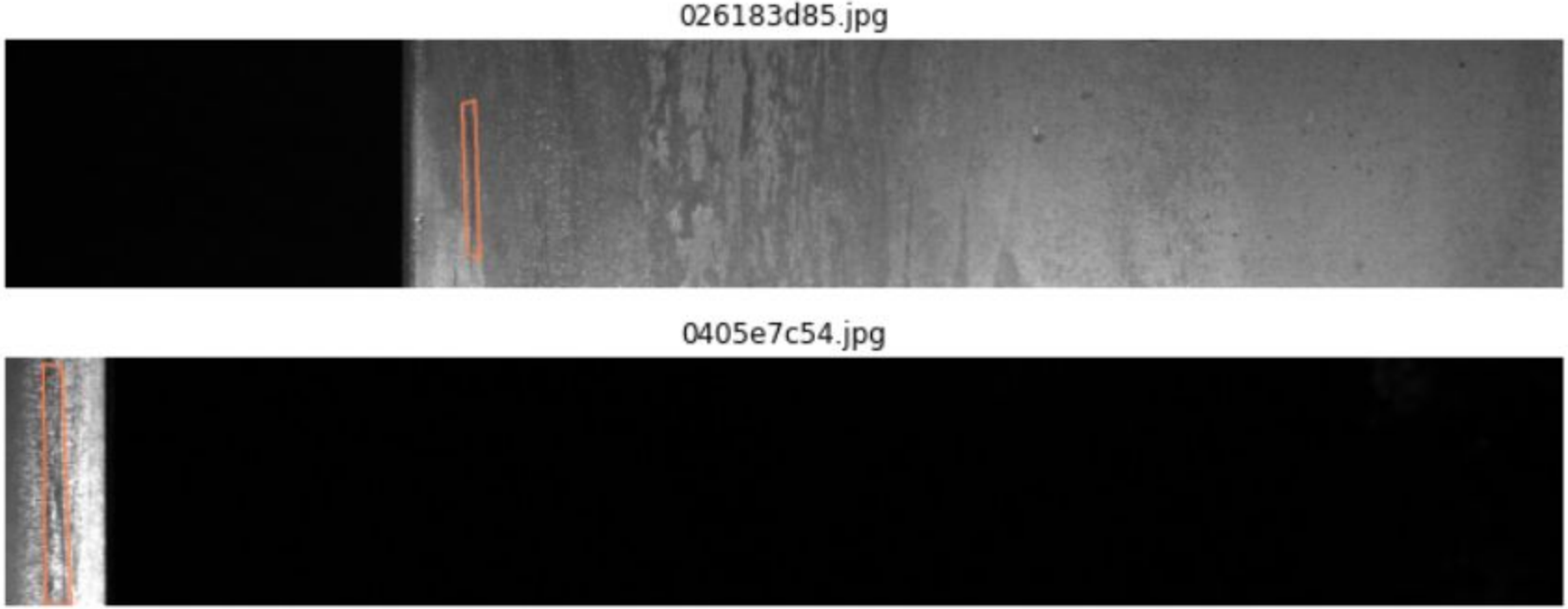
***Class 1 = 12.64%***
***Class 2 = 3.84%***
***Class 3 = 72.59%***
***Class 4 = 11.29%***




***Class 1*** defects annotated with ***Blue Contour*** around ***Pit defect***

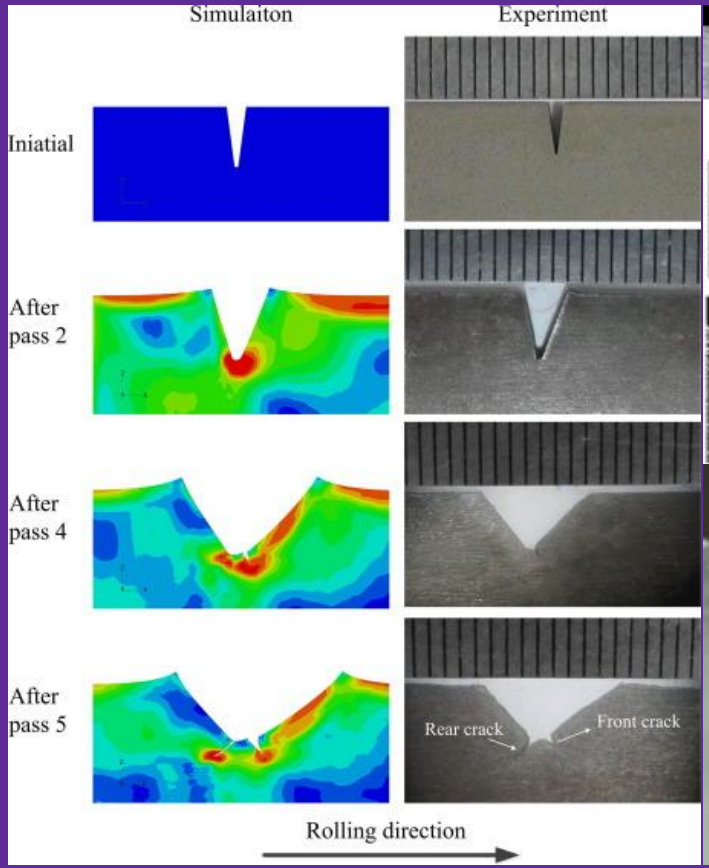
# What is Pit Defect?

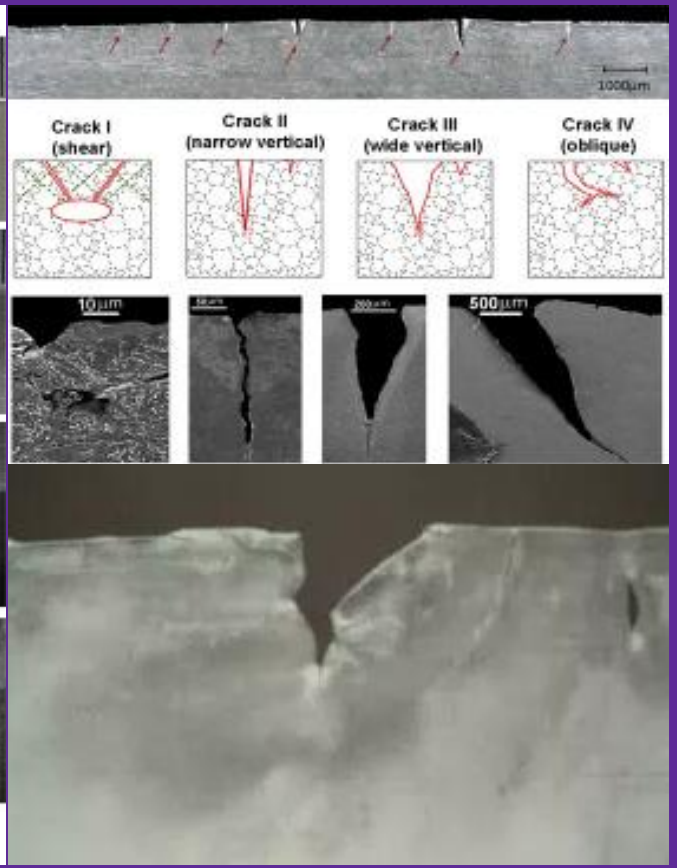


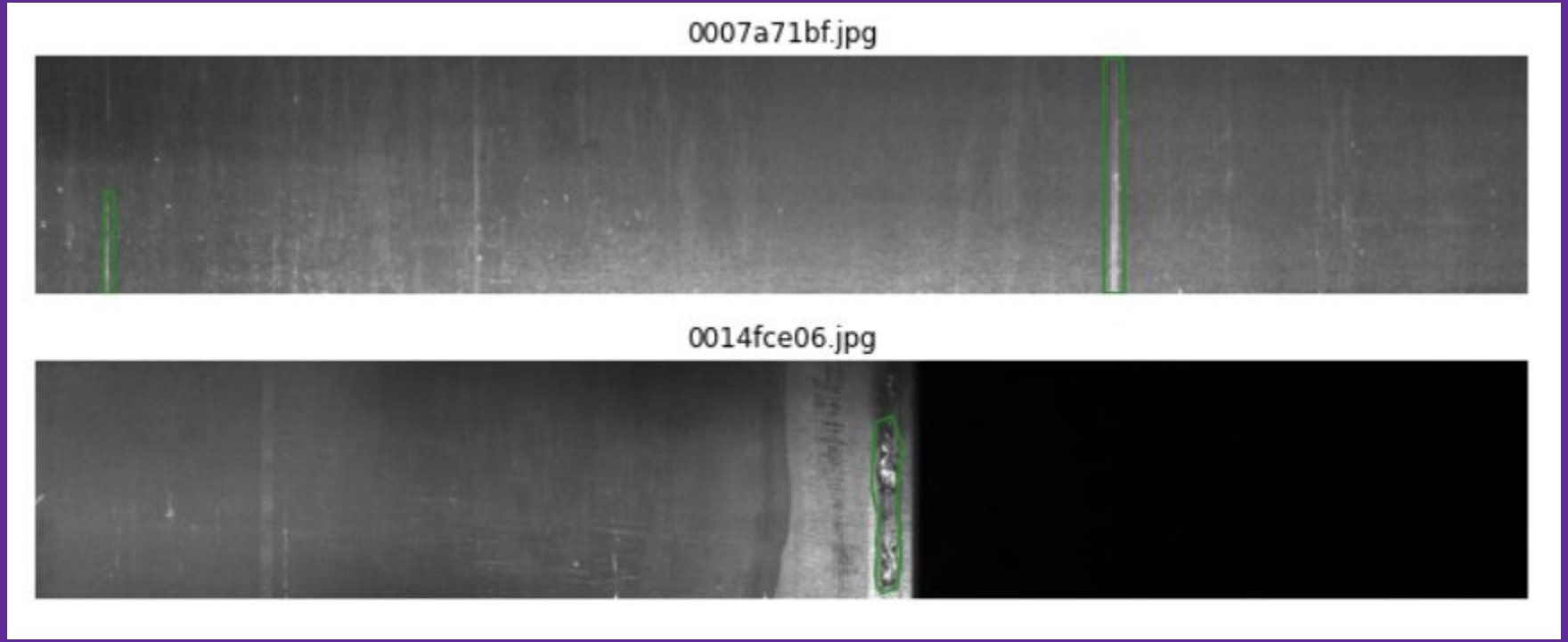



*Class 2* defects annotated with Orange Contour around *Edge Crack defect*

# *What is Edge Crack Defect?*

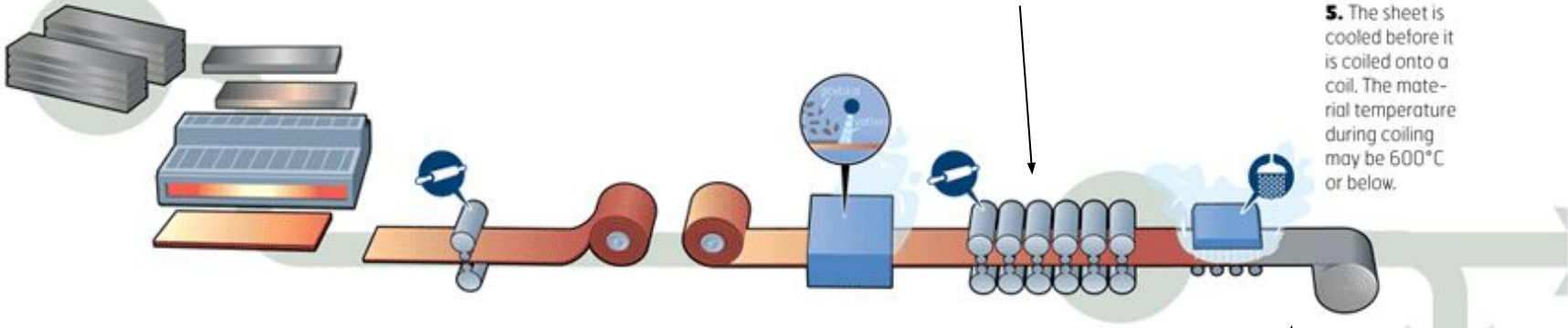





***Class 3*** defects annotated with Green Contour around ***Scratches defect***

# *What is Scratches Defect?*



**1.** The slabs are heated in slab furnaces to the correct rolling temperature of about 1,250°C.

**2.** In the roughing mill, the slab thickness of 220 mm is reduced to 30 mm. The steel is coiled and increases in length from 11 meters to a coil with 80 meters of heavy plate.

**3.** The plate is cleaned to remove millscale in several stages during hot rolling.

**4.** The hot rolling mill is a wide strip mill that can roll the whole width of the slab in one pass through the six stands.

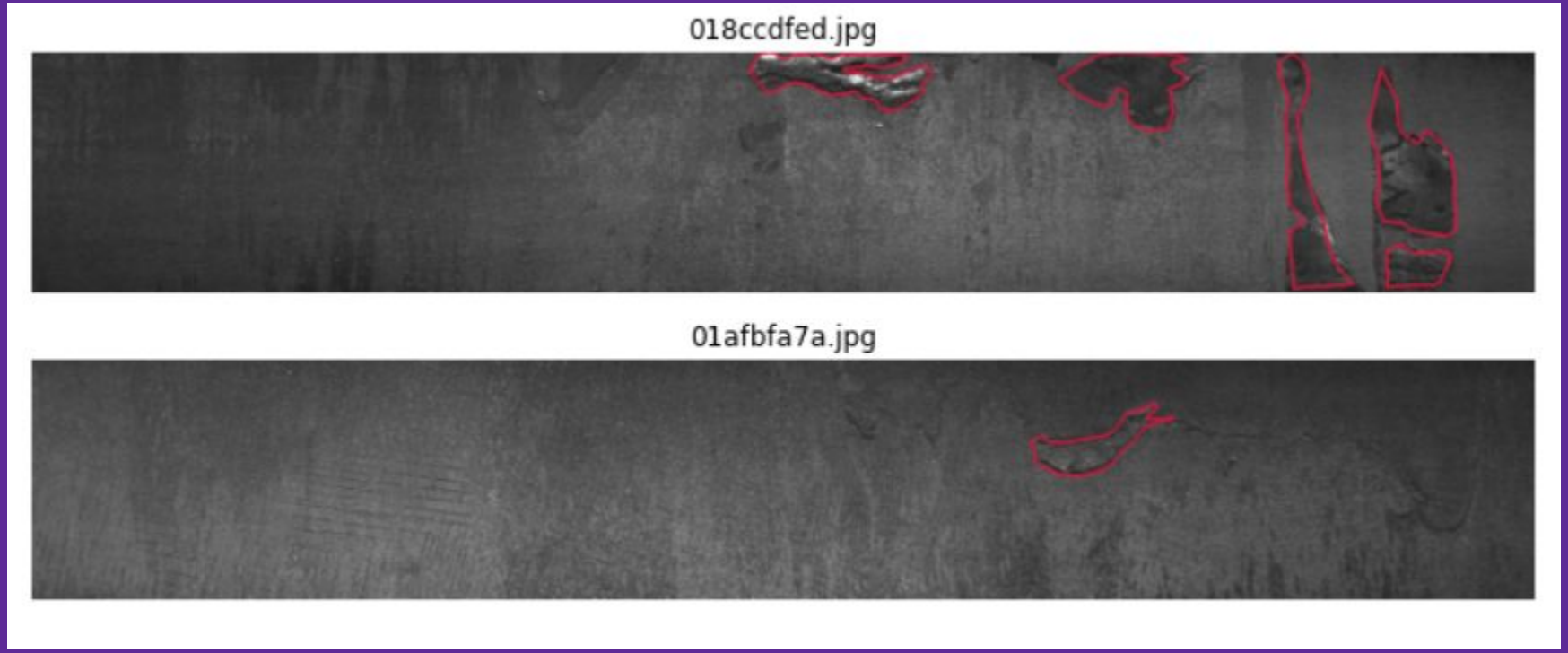
Extreme forces are applied to the rolls that roll the steel to a thickness of between 16 mm and 1.8 mm. The rolling speed is 120 km/h at the end of the hot rolling mill.

If the sheet is rolled down to a thickness of 2 mm, the sheet will have grown in length from 80 meters to 1,300 meters.

**5.** The sheet is cooled before it is coiled onto a coil. The material temperature during coiling may be 600°C or below.

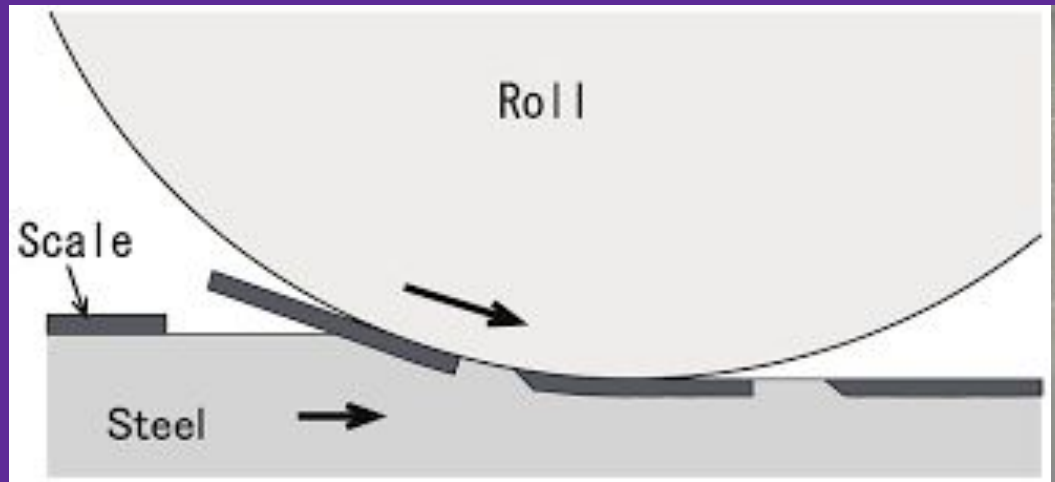
**6.** Hot rolled sheet steel is sold in coils or cut to length.

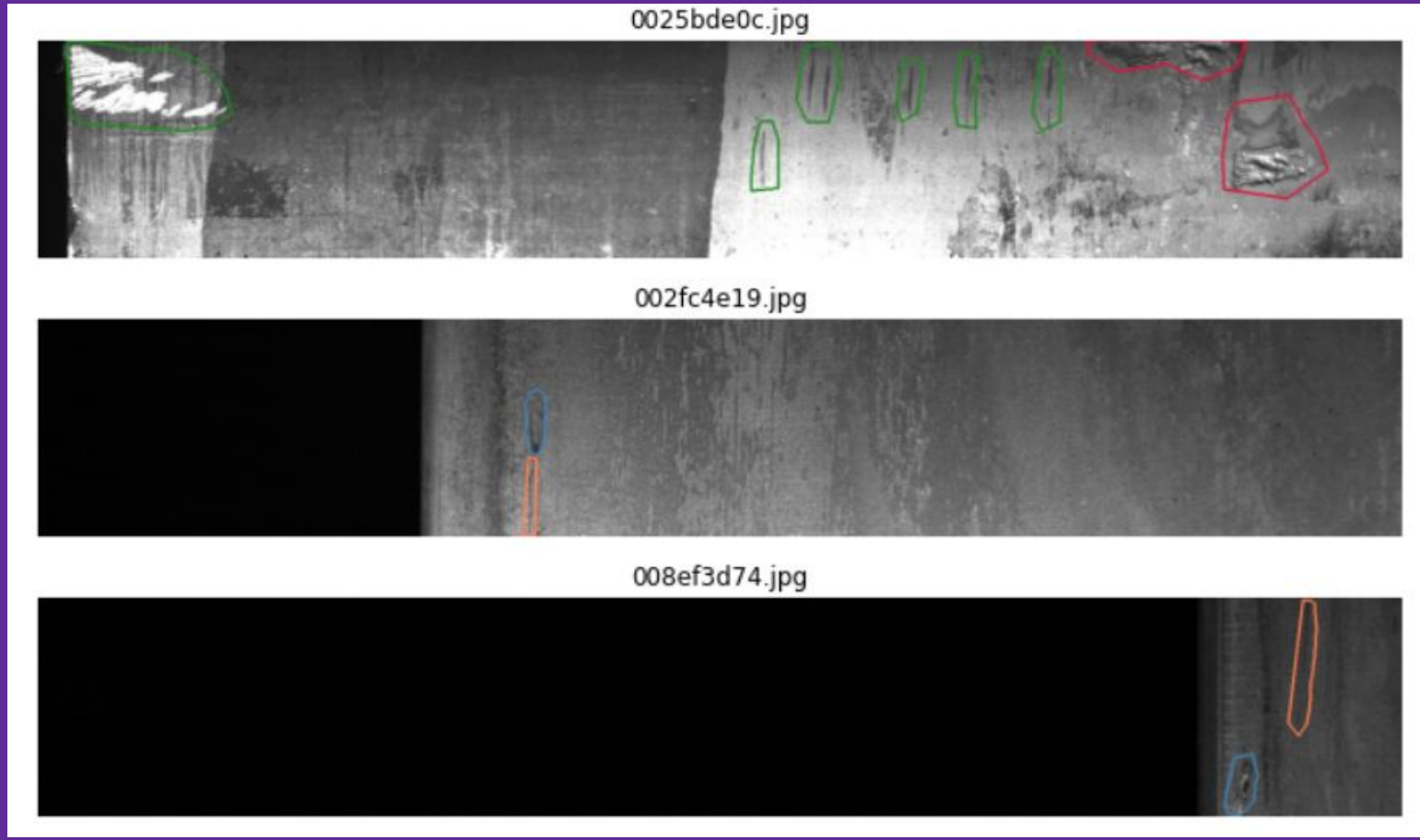
*Source: SSAB (www.ssab.com)*




***Class 4*** defects annotated with Red Contour around ***Rolled in Scale defect***

# *What is Rolled in Scale Defect?*




***Multi class defects*** are detected which contain class 1, 2, 3 and 4.

# Data Pre-Processing

***Run length Encoding (RLE):*** It is used to encode the location of foreground objects in segmentation. It is a method of reducing the file size of an image

***What is an image mask?***

It is used to recover a portion of an image of a specified colour. It is similar to thresholding

***Rle to Mask:***

- The ***rle2mask*** function is used to obtain the conversion.
- The height and width of the image is specified in order to create a one dimensional array.
- After the 1-D mask is obtained, it's dimension is converted to the dimensions of the image using the reshape function followed by transpose.

# DATA PRE-PROCESSING

## DATA AUGMENTATION

- Data augmentation is a technique of increasing the data available for training models, without actually collecting new data.
- It improves the performance and output of the model

ORIGINAL IMAGE

HORIZONTAL FLIP

VERTICAL FLIP

# Performance Metrics

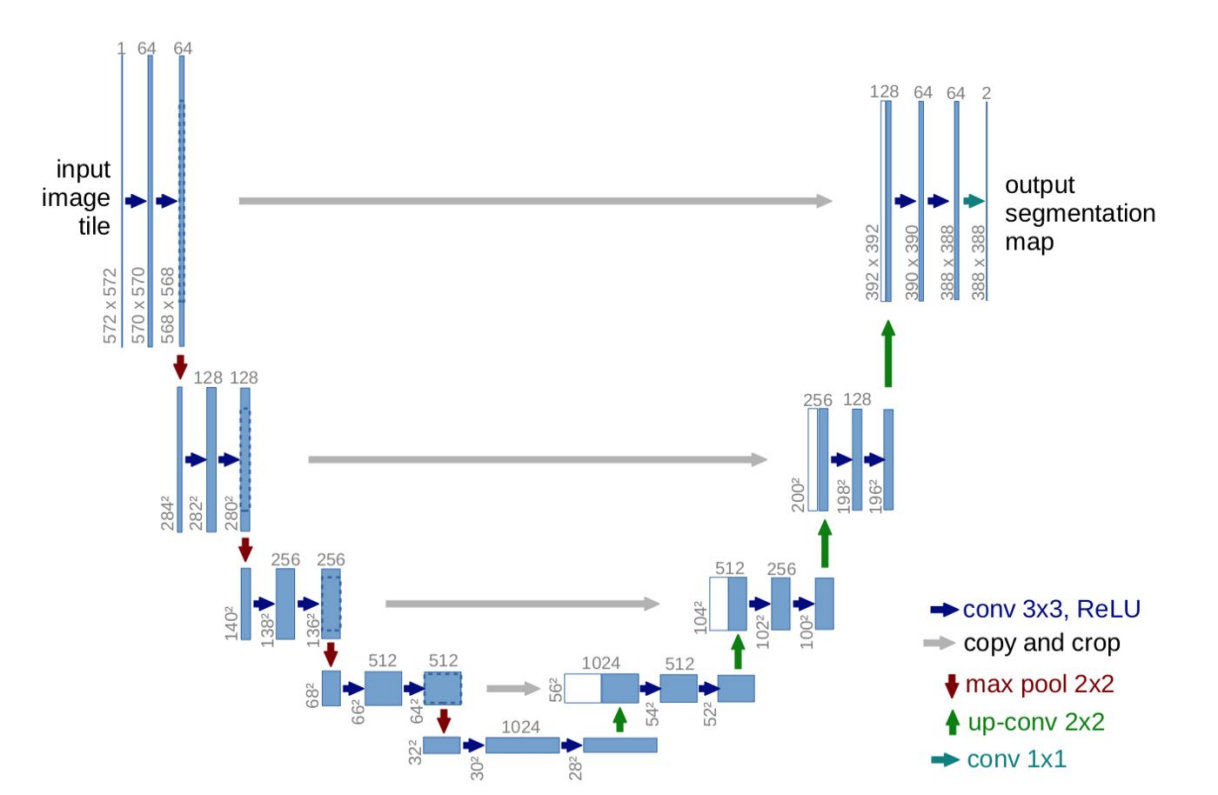
- **The dice coefficient can be used to compare the pixel-wise agreement between a predicted segmentation and its corresponding ground truth .**

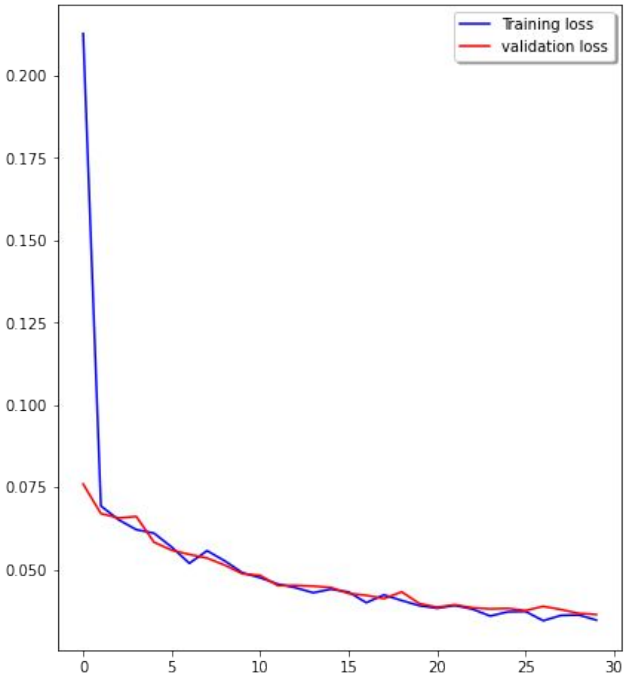
  **Formula :**

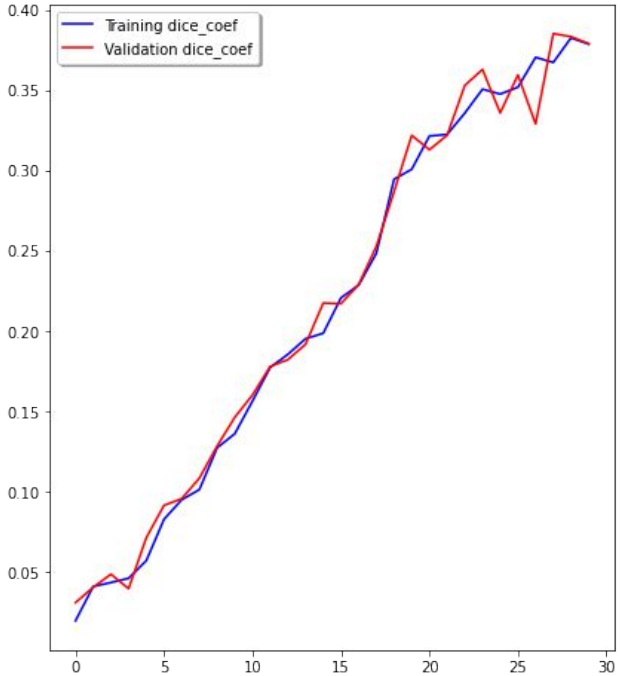
$$\frac{2 \times (\text{Intersection} + \text{smooth})}{(\text{Sum of True value}) + (\text{Sum of predicted value})}$$

- **Binary Cross Entropy loss (BCE) : Measures the loss of a segmentation model whose output is a probability between 0 and 1.**
- **Dice Loss : 1 - Dice Coefficient**
- **BCE dice loss = BCE loss + Dice loss**

# UNET Architecture




Training loss
validation loss
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0
5
10
15
20
25
30

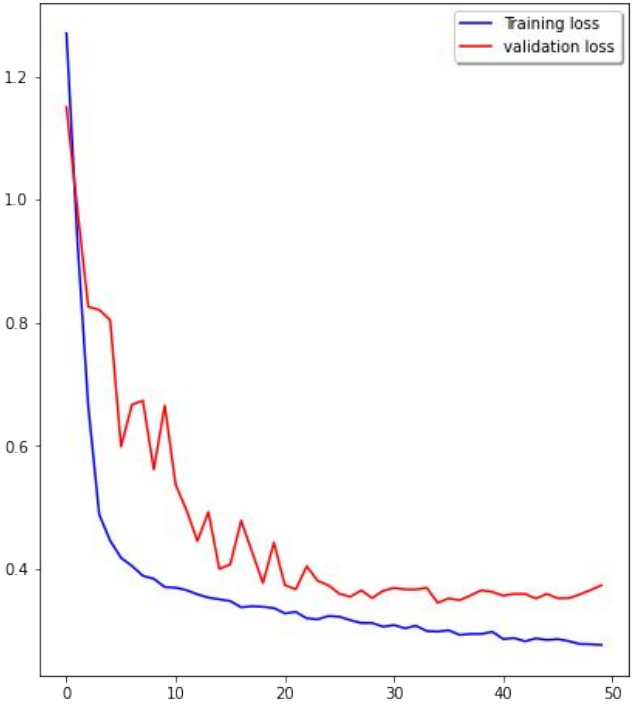

Training dice_coef
Validation dice_coef
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
5
10
15
20
25
30

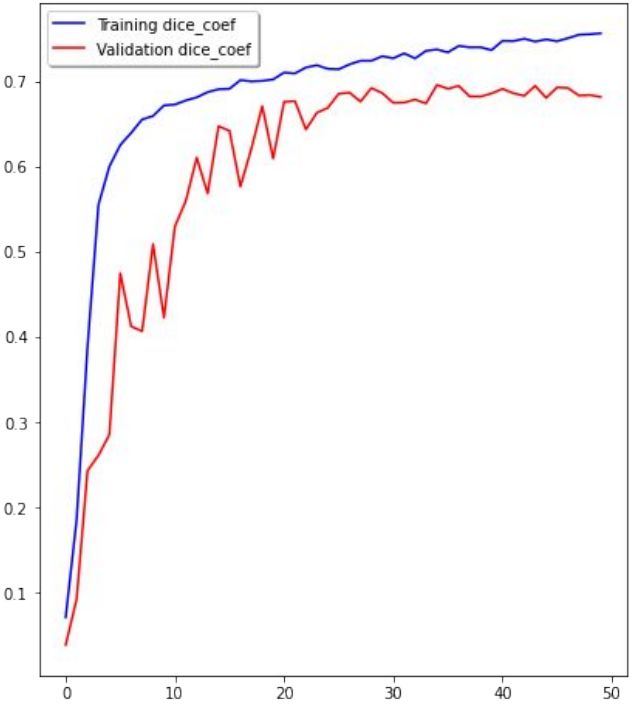
## PRE TRAINED

| Input | Operator | $t$ | $c$ | $n$ | $s$ |
|---|---|---|---|---|---|
| $224^2 \times 3$ | conv2d | - | 32 | 1 | 2 |
| $112^2 \times 32$ | bottleneck | 1 | 16 | 1 | 1 |
| $112^2 \times 16$ | bottleneck | 6 | 24 | 2 | 2 |
| $56^2 \times 24$ | bottleneck | 6 | 32 | 3 | 2 |
| $28^2 \times 32$ | bottleneck | 6 | 64 | 4 | 2 |
| $14^2 \times 64$ | bottleneck | 6 | 96 | 3 | 1 |
| $14^2 \times 96$ | bottleneck | 6 | 160 | 3 | 2 |
| $7^2 \times 160$ | bottleneck | 6 | 320 | 1 | 1 |
| $7^2 \times 320$ | conv2d 1x1 | - | 1280 | 1 | 1 |
| $7^2 \times 1280$ | avgpool 7x7 | - | - | 1 | - |
| $1 \times 1 \times 1280$ | conv2d 1x1 | - | k | - | |

## MOBILENET V2 UNET

- Less parameters due to which it is easy to train.
- It converges much faster than non pretrained model.
- Pretrained encoder helps to achieve high performance as compared to non pretrained model.


Training loss
validation loss
1.2
1.0
0.8
0.6
0.4
0
10
20
30
40
50


Training dice_coef
Validation dice_coef
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
10
20
30
40
50

# *HYPER PARAMETERS USED*

| Hyper parameters | UNET | Pretrained Mobilenet V2 UNET |
|---|---|---|
| Batch size | 8 | 8 |
| Epochs | 30 | 50 |
| Optimizer | Adamax | Adamax |
| Loss | BCE dice loss | BCE dice loss |
| Callback functions | Model checkpoint | Model checkpoint |
| | ReduceLRonPlateau | ReduceLRonPlateau |