TRANSMISSION STRUCTURES ADVANCED ANALYTICS AND MACHINE LEARNING ALGORITHMES

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What is Traditional data analytics and machine learning analytics?

What are analytics?

Analytics is the efficient analysis of data. It is used for the discovery and interpretation of important patterns in data and applying these data patterns toward effective decision-making.

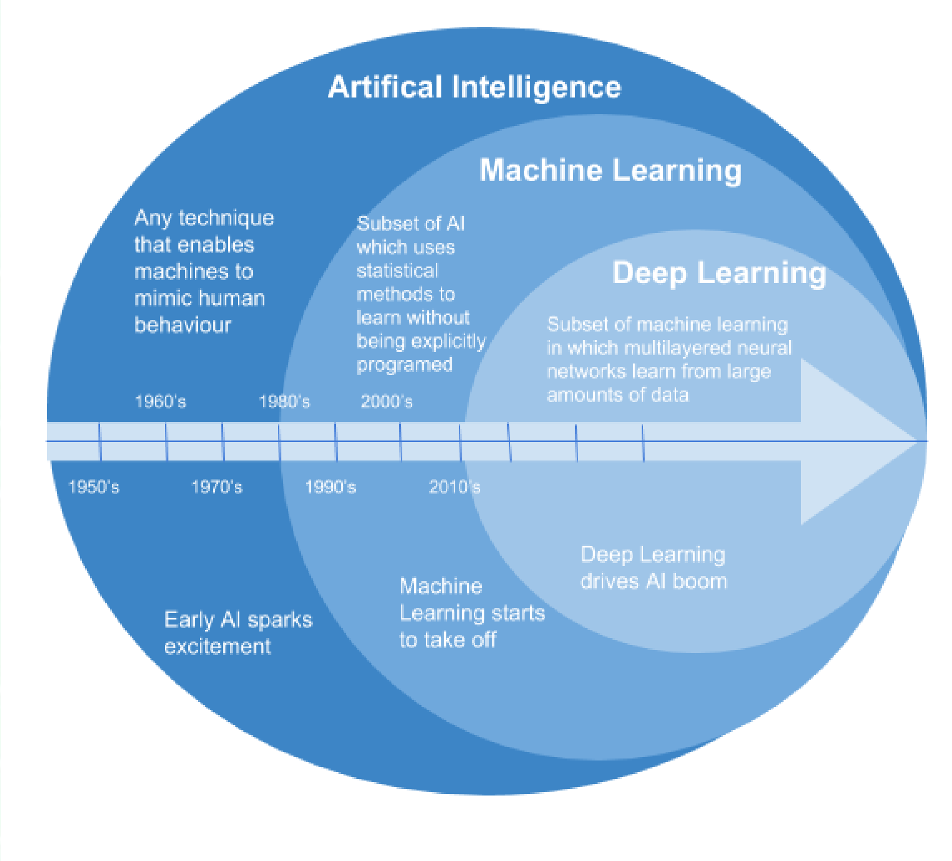
Traditional data analytics platforms typically revolve around dashboards.

Dashboards are constructed of visualizations and pivot tables that illustrate trends and pareto, for example. Construction of dashboards is labor-intensive, time-consuming, and often frustrating. The limitations of this process have paved the way for machine learning to take hold in analytics.

Machine learning analytics is an entirely different process.

Machine learning automates the entire data analysis workflow to provide deeper, faster, and more comprehensive insights.

Machine Learning (ML)

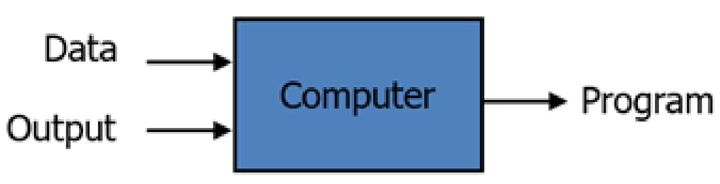


https://towardsdatascience.com/what-is-artificial-intelligence-all-about-anyway-b57c7eb75f5f

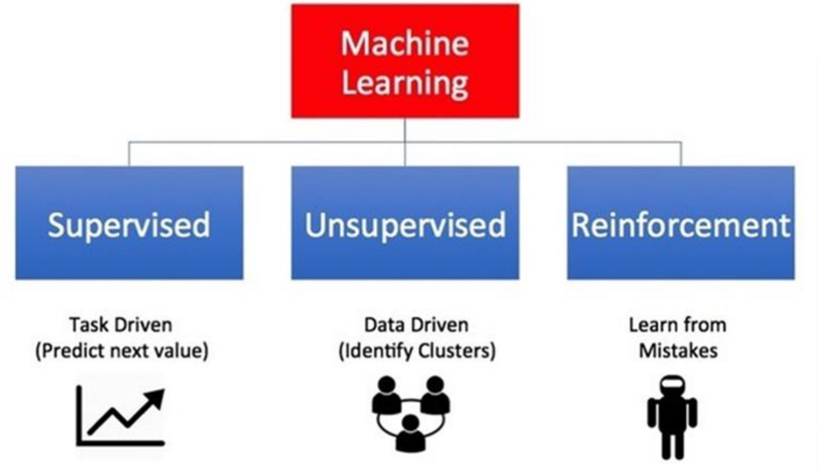
ML is a subfield of artificial intelligence (AI) that provides computers with the ability to learn from data. It is the study of computer algorithms that can improve automatically through experience and by using data. ML algorithms use training data to build models to make predictions or decisions without being explicitly programmed.

Traditional Programming

Machine Learning Programming



Types Of Machine Learning



Supervised learning (≈ 70% of all ML algorithms)

– Given: training data + desired outputs (labels)

Algorithms: linear regression, multiple regression, logistic regression, decision tree, random forest, K-nearest neighbor, neural networks, deep learning, etc.

Unsupervised learning (≈28% of ML algorithms)

– Given: training data (without desired outputs)

Algorithm: K-means for clustering

Reinforcement Learning

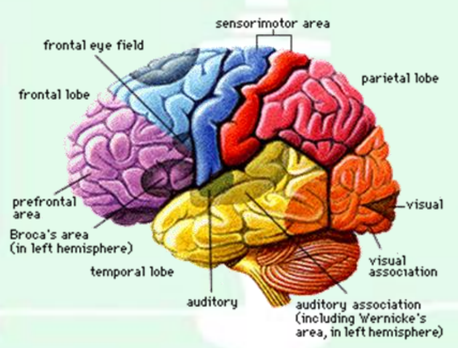
Application: Robots, games, process control

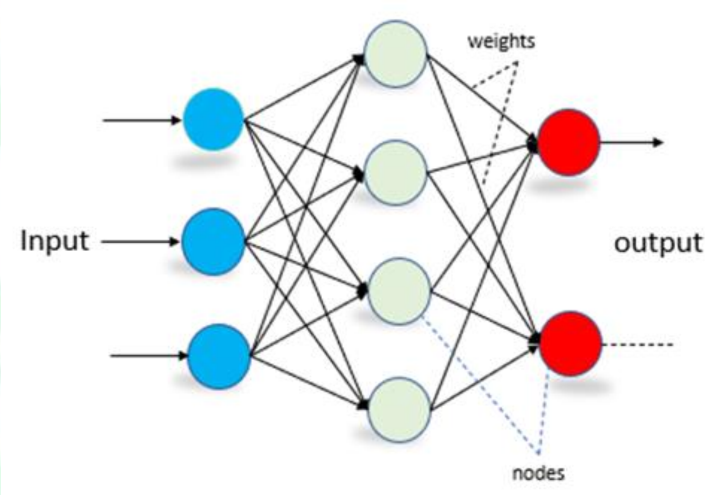
Algorithms: TD-Gammon, Atari 2600, Alpha Go

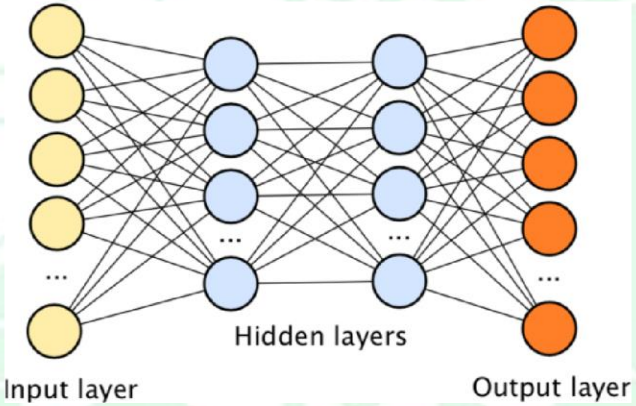
Why Machine Learning (ML)?

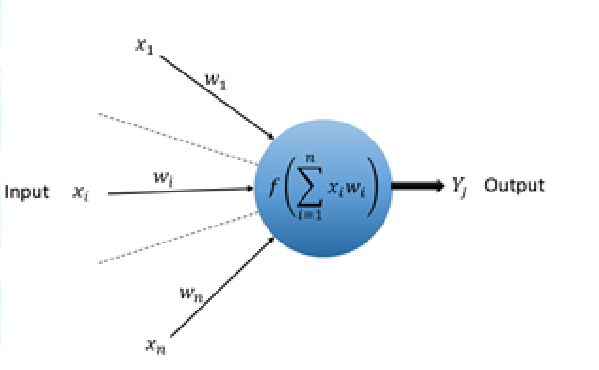
1. According to recent study, ML algorithms are expected to replace 25% of the jobs across the world, in the next 10 years.
2. With rapid growth of big data and availability of programming tools like C#, Python, and R – ML is gaining mainstream presence for data scientists.
3. ML applications are highly automated and self-modifying which continue to improve over time with minimal human intervention as they learn with more data.

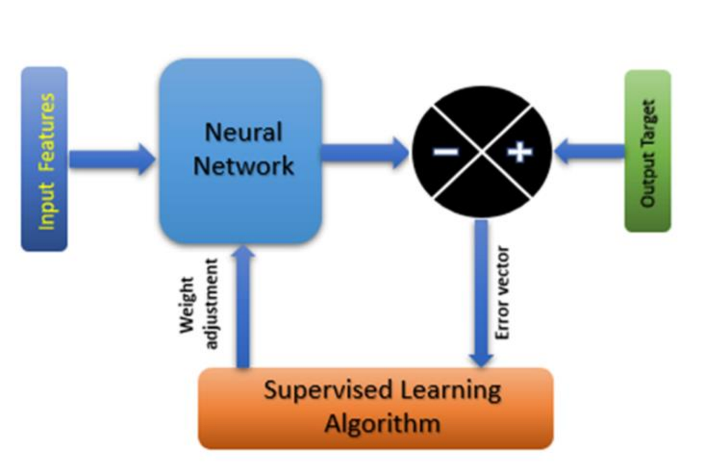
Artificial Neural Networks - How they work?









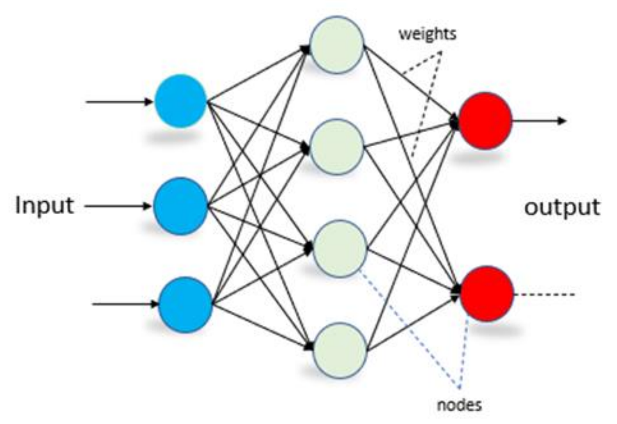


Backpropagation

Training the Network - Supervised learning

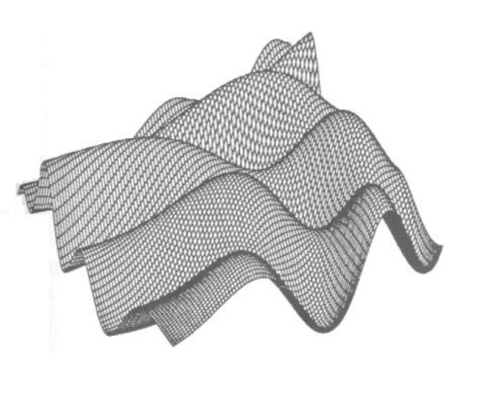
Calculating the weights in backpropagation learning algorithm

Back-propagation algorithm employs gradient descent to attempt to minimize the squared error between the network output values and the target values for these outputs.



Backpropagation

- Requires training set (input / output pairs)
  - Starts with small random weights
  - Error is used to adjust weights (supervised learning)



Calculating the weights in backpropagation learning algorithm

Derivation of the back-propagation rule for one training set:

$$E_d(\vec{w}) \equiv \frac{1}{2}\sum_{k}^{outputs}(t_k - O_k)^2$$

Where, E_d is the total error, o_k is the network output, and t_k is target (desired) output

Gradient descent:

$$\Delta w_{ji} = -\eta \frac{\partial E_d}{\partial w_{ji}}$$

Where, η is the learning rate (assumed 1) and w_{ij} the weight associated with the i^{th} input to unit j

Using the chain Rule

$$\frac{\partial E_d}{\partial w_{ji}} = \frac{\partial E_d}{\partial net_j}\frac{\partial net_j}{\partial w_{ji}} = \frac{\partial E_d}{\partial net_j} x_{ji}$$

Where x_{ji} the i^{th} input to unit j

Calculating the weights in back-propagation learning algorithm

Similarly,

$$\frac{\partial E_d}{\partial net_j} = \frac{\partial E_d}{\partial O_j}\frac{\partial O_j}{\partial net_j}$$

But,

$$net_j = \sum_i w_{ji} x_{ji}$$

And,

$$\frac{\partial E_d}{\partial O_j} = \frac{1}{2}\frac{\partial}{\partial O_j}\sum_k^{outputs}(t_k - O_k)^2 = -(t_j - O_j)$$

$$\frac{\partial O_j}{\partial net_j} = \frac{\partial \sigma(net_j)}{\partial net_j} = O_j\,(1 - O_j)$$

Where σ is the Sigmoid – Logistic activation function

Calculating the weights in back-propagation learning algorithm

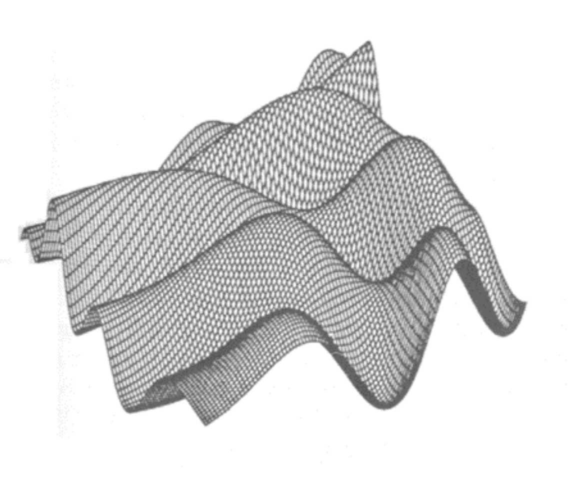
Weight adjustment can be written as follows:

$$\Delta w_{ji} = -\eta \frac{\partial E_d}{\partial w_{ji}} = \eta \left(t_j - O_j\right) O_j \left(1 - O_j\right) x_{ji}$$

The modified weight is:

$$w'_{ji} = w_{ji} + \Delta w_{ji}$$

The process is repeated until Δw_{ji} is minimized.



Gradient descent on error landscape

TRAINING THE ANN FOR IMAGE PROCESSING AND ANALYSIS

Proposed Model for Image Analysis and Corrosion Assessment

The RGB color model

The RGB is an additive color model in which Red, Green, and Blue light are added together in various ways to reproduce a broad array of colors. The name of the model comes from the initials of the three additive primary colors, red, green, and blue. We use this model because the three wavelengths of the RGB primaries correspond to the signals that are transmitted from the eye the brain. We see in RGB.

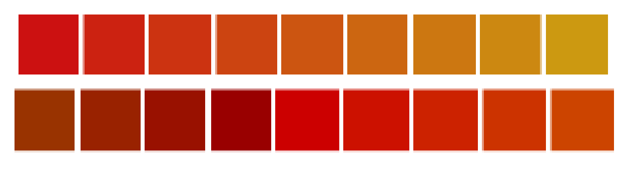
The main purpose of the RGB color model is for sensing, representation, and display of images in computers. For instance, if three colors are mixed at full strength, the combined RGB result is white and if all the components are at zero the result is black. Mixing red and green at full strength will results in Yellow, and so on.

Image Recognition: Color Categories

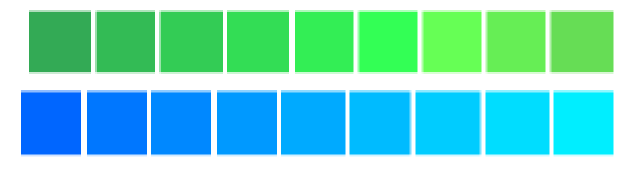
In order to recognize colors, first the image colors are divided into three categories:

Category A: Gray scale

Category B: Reddish



Category C: Others



Gray Scale:

Consists of black and gray regions

Reddish consists of corrosion colors: Orange, Brown, Red, Dark-Red, etc. and combinations of the reddish shades.

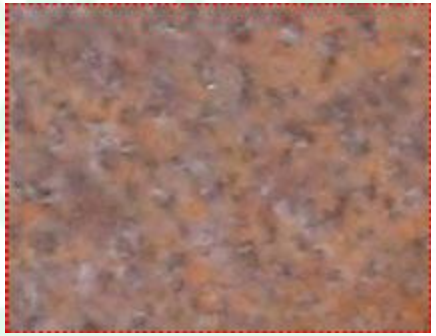
All other colors that don't have dominant R component in the RGB scale are either green or blue shades. These cannot be part of the steel structures. If the % of R component is less than 25%, the color is considered the other category

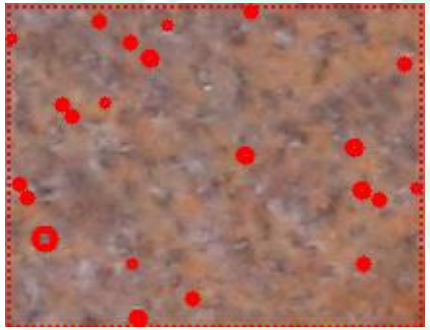
How the ANN recognize images?

1. The part of the image is divided into small grid or pixels (default 10,000). Each pixel is a sample of an original image; more samples typically provide more accurate representations of the original. The intensity of each pixel is variable. In color image, a color is typically represented by three component intensities such as red, green, and blue.
2. First, the ANN determine whether the grayscale parts of the image are gray or black. The ANN takes three inputs: R, G, and B components of the colors. It produces two outputs: one for black and one for gray. The output with highest value determines the color of the selected surface.
3. Similarly, reddish shades the inputs are three color components: R, G, and B. There are different outputs representing different shades of red: Yellow, Orange, yellow-brown, brown, brown-red, red, dark-red, etc.
4. All other colors that don't have dominant R component (i.e., less than 25%) in the RGB scale are either green or blue shades representing image background (i.e., vegetation or sky).
5. Each output takes value from 0 to 1. where 1 means that the color is present whereas 0 means that the color is not present.

Analysis of Pitting Corrosion

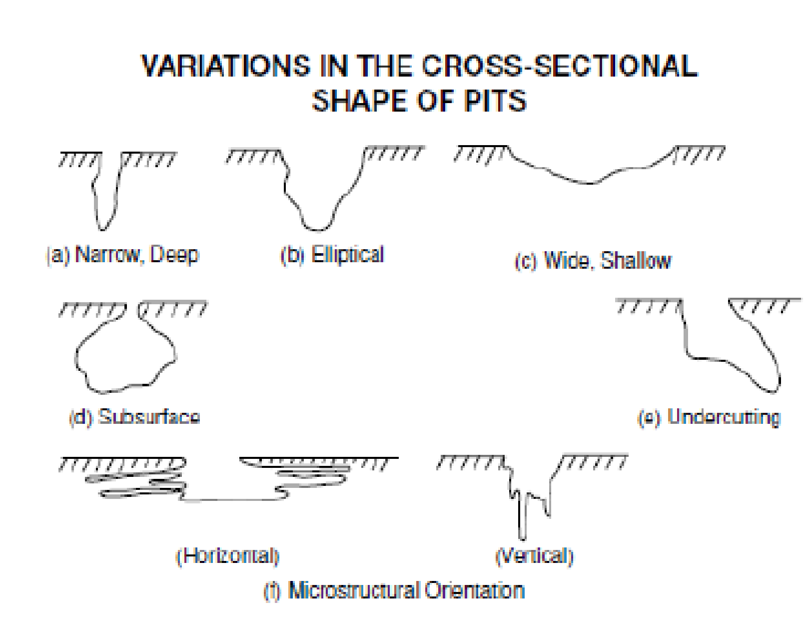
Pitting Analysis helps determines the pits density in the selected surface. Once the pits are identified, their density is determined. Based on the density, the thickness is approximated using the ASTM G64 standards.

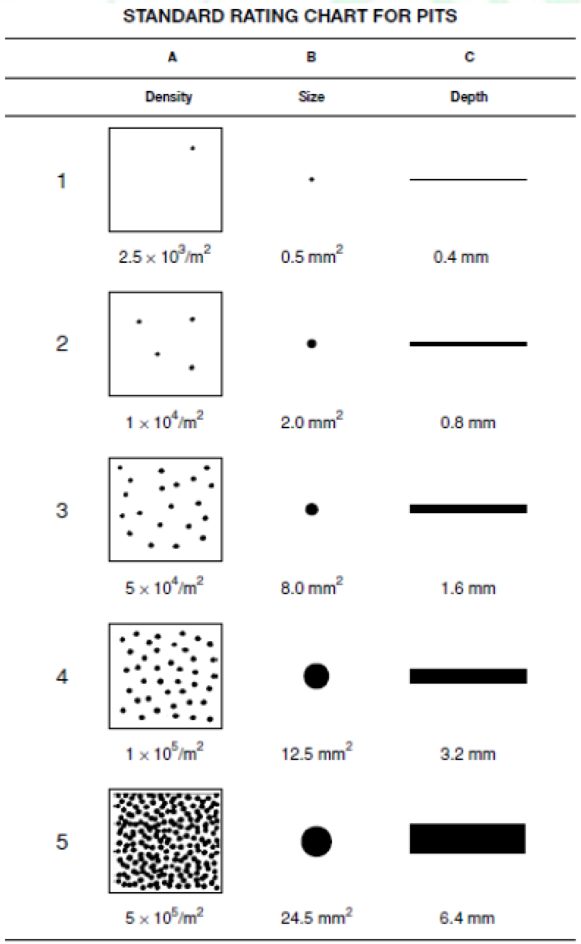




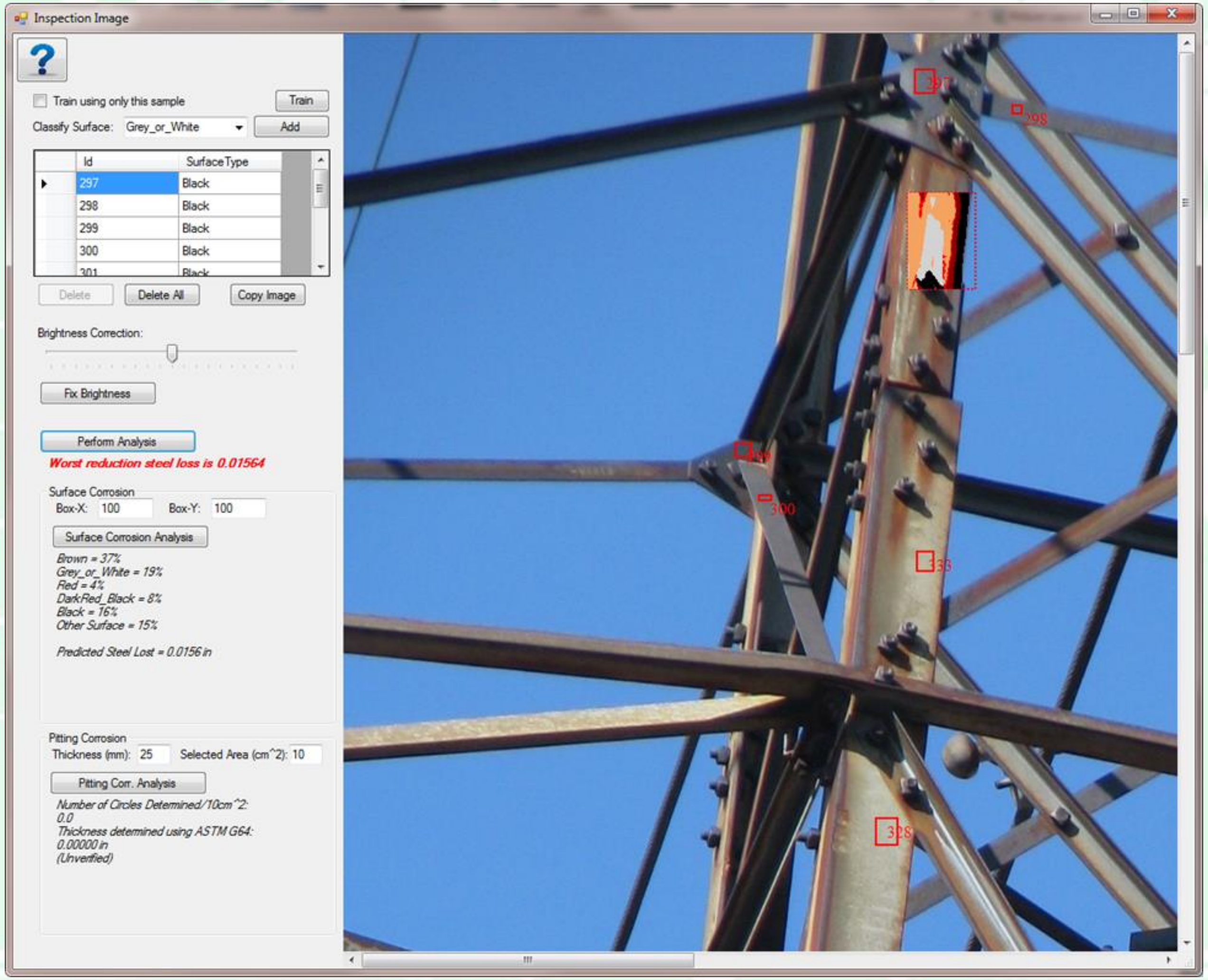
For pits identification, first binary image is constructed. The binary images take the value 1 (white) for positions where pits color is found else it takes value of 0 (black). For example, if red is the pits color, all the red areas in the image will be given a value of 1. Next, blobs are determined. These blobs are parts of images that are separated by black background. The shape of these blobs is determined. The small circular blobs are identified to be pits.

ASTM G46 (recommended practice to measuring pitting density and shape)





ANN – Analysis Results



ANN – Analysis Results

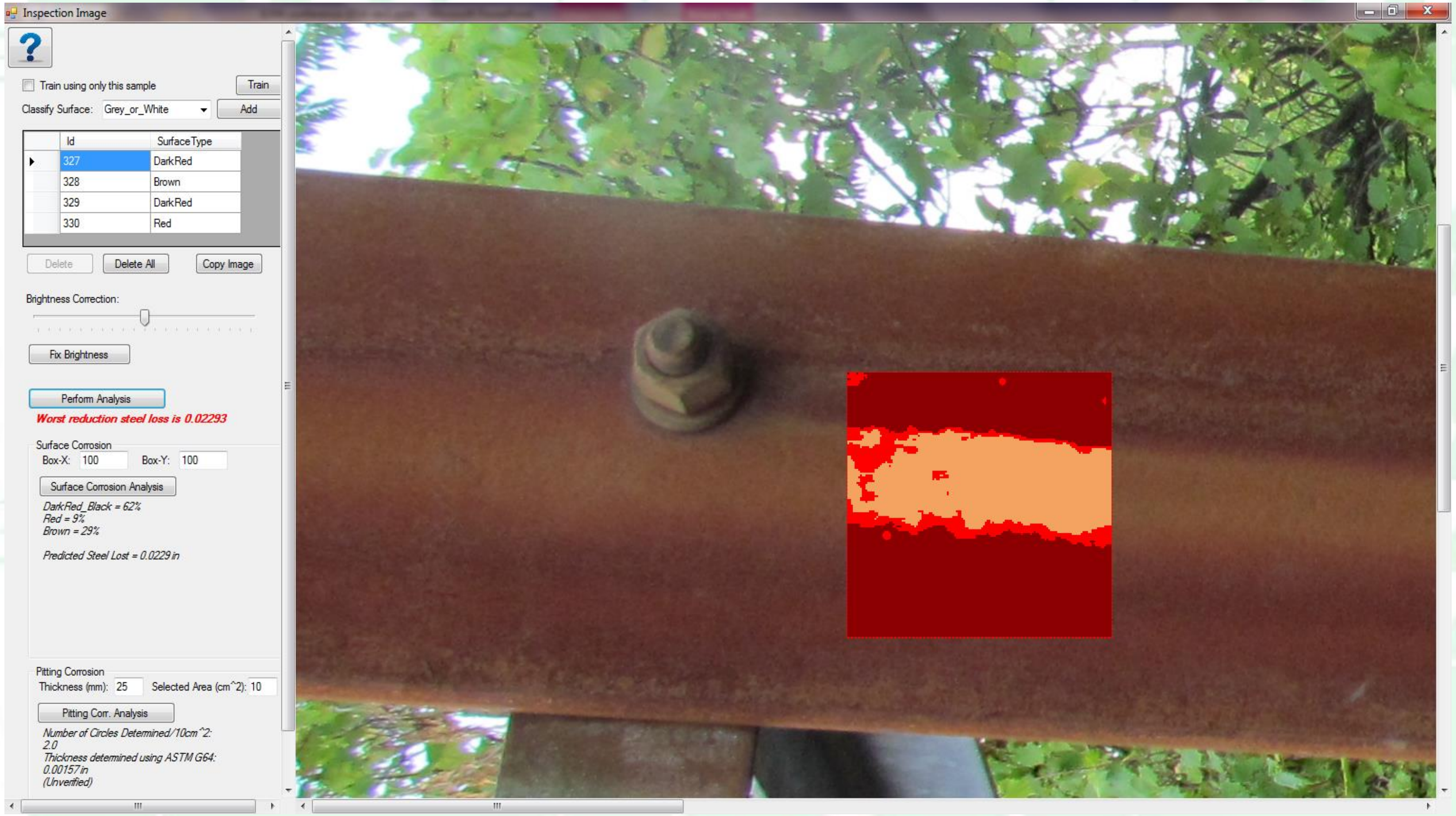


Image Recognition – Analysis Results

ANN – Analysis Results for surface corrosion:

Brown = 40%

Red = 25%

DarkRed_Black = 3%

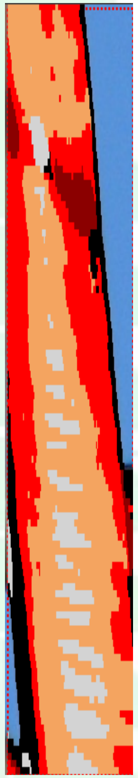
Grey_or_White = 8%

Other Surface (blue sky) = 15%

Predicted thickness reduction:

And the Predicted Reduction is 0.0375”(0.95mm)

Original Image



Colors recognized in the image

Environmental Effects

Recovering Intrinsic Images from a Single Image

Marshall F. Tappen, Willian T. Freeman, and Edward H. Adelson
MIT Artificial Intelligence Laboratory

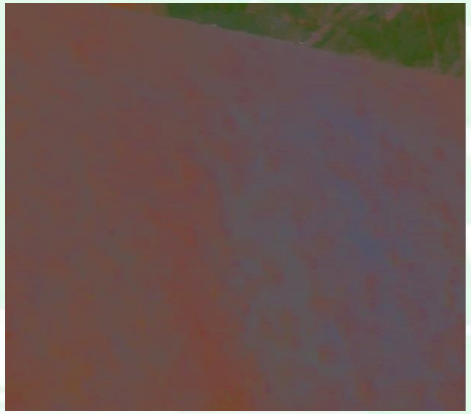
(a) Original Image (b) Shading Image (c) Reflectance Image

Shade removal algorithm - Original vs. Reflectance Images

Original

Reflectance

Original



Reflectance

Conclusions

- Using ANN for determination of corrosion type and severity will greatly enhance the accuracy of damage assessment of corroded steel towers by reducing cognitive type uncertainty inherit in visual inspection and damage assessment.

- The prediction of corrosion type and severity is very accurate when the image has no or minor illumination. Intrinsic images or reflectance images are independent of illumination effects, thus revealing the images' true color information, which are ideal for computer vision. Further work is underway to provide CMES with efficient algorithm for the removal of illumination effects from the images, thus increasing the accuracy of corrosion assessment regardless of the quality of the digital images.

Thank You - QUESTIONS ?????

Intelligence is not Substitute for Experience

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Experience is not Substitute for Intelligence