

# Practical Use of Advanced Image Processing System to Diagnose Residual Service Life of Galvanized Coatings

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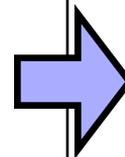
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# 1. Aim of Diagnosing Residual Service Life by Advanced Image Processing

Table-1 Comparison between conventional deterioration diagnosing manners and deterioration diagnosis by advanced image processing

Conventional deterioration diagnosis	Deterioration diagnosis by advanced image processing
<ul style="list-style-type: none"><li>• To evaluate deterioration levels visually at sites.</li><li>• color tones as same deterioration levels when comparing check points with deterioration samples.</li><li>• It is difficult to evaluate deterioration levels correctly under different photographing conditions.</li><li>• Variations in evaluating deterioration levels exist among individuals.</li><li>• It is impossible to evaluate check points corroded differently from deterioration samples.</li></ul>	<ul style="list-style-type: none"><li>• To take photos or videos at sites and to evaluate them at offices.</li><li>• To evaluate deterioration levels automatically by means of special analytical computer program.</li><li>• It is possible to evaluate exactly due to usage of corrected images.</li> <li>• It is possible to obtain identical evaluations through anybody.</li><li>• It is possible to evaluate check points even corroded differently from deterioration samples.</li></ul>



# Diagnostic Objects: Galvanized steel structures



## 2. Deterioration Diagnosis by Advanced Image Processing

### 2.1 Flow of Diagnosing Residual Service Life by Advanced Image Processing

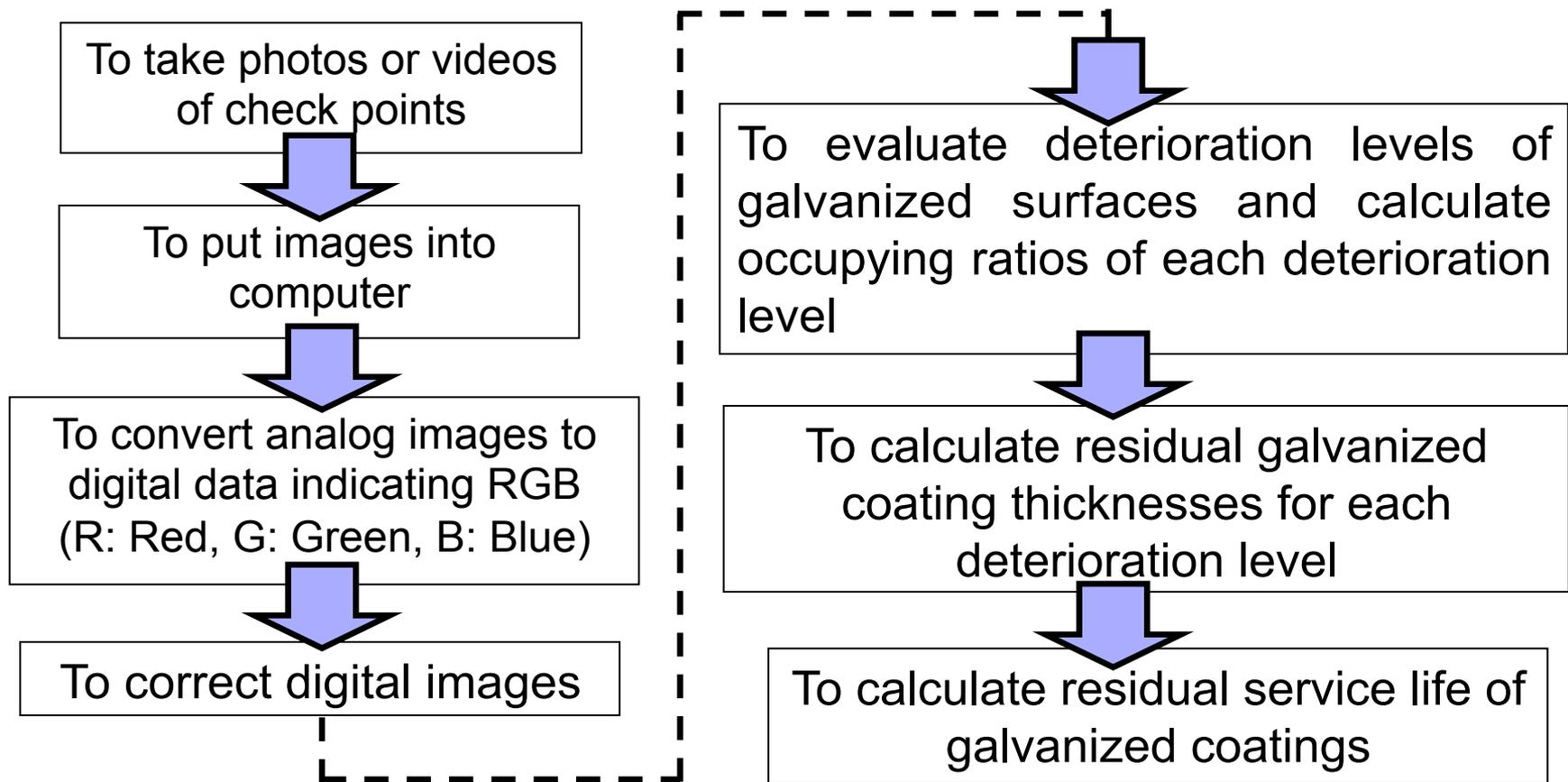


Figure-1 Flow of diagnosing deterioration by advanced image processing

## 2.2 Configuration of Advanced Image Processing System

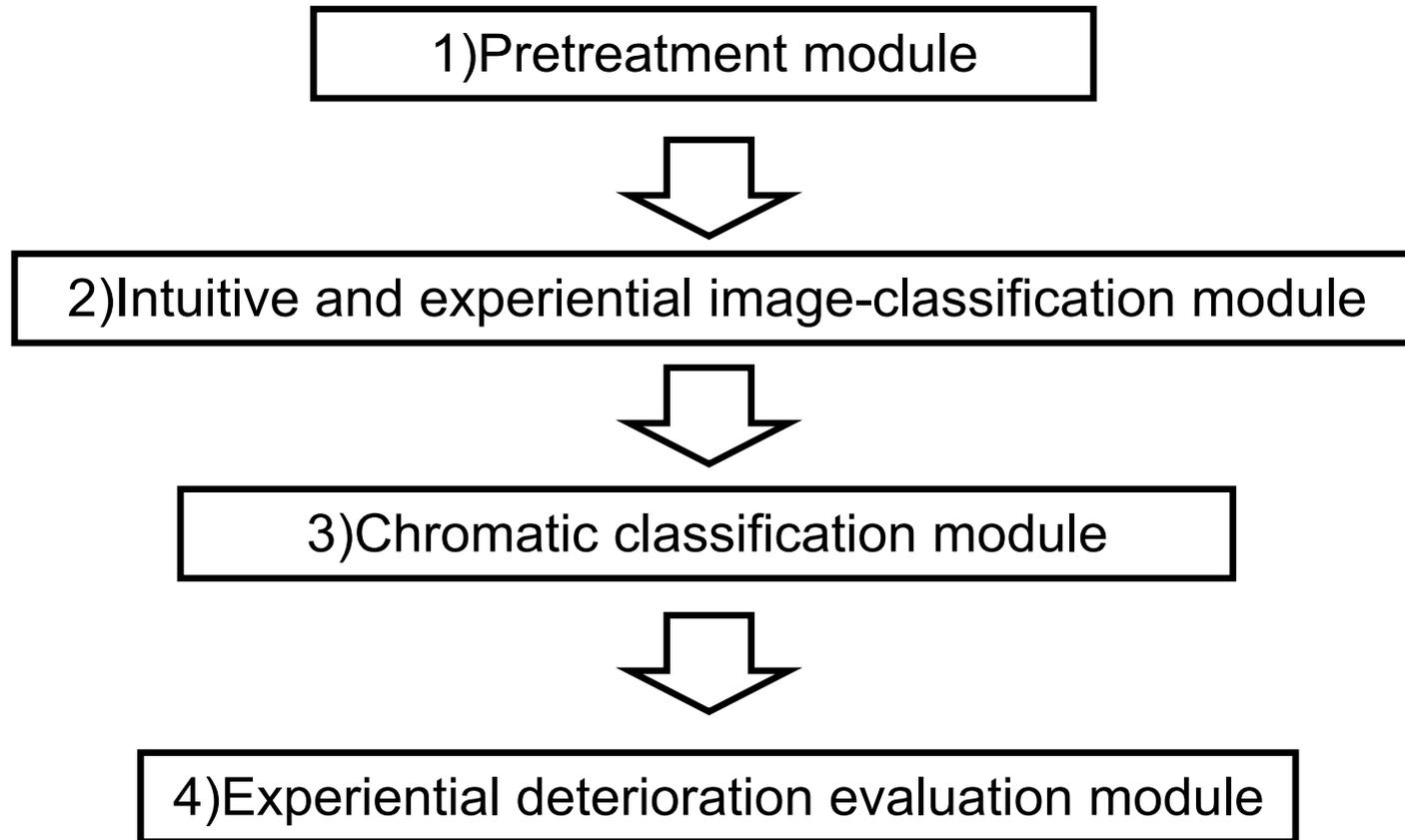


Figure-2 Configuration of Advanced Image Processing System

# 1) Pretreatment module

- Analog images are converted to digital data indicating RGB.
- Smoothing processing of images is performed for decrease the influence of the unexpected value.

## 2) Intuitive and experiential image-classification module

- When evaluating many images, they are classified intuitively depending on their photographed circumstances at first, and then judged to select their suitably corresponding evaluation patterns experientially.

### 3)Chromatic classification module

- In consideration of the whole image atmosphere, each image is divided into similar chromatic groups (i.e. chromatic grouping).

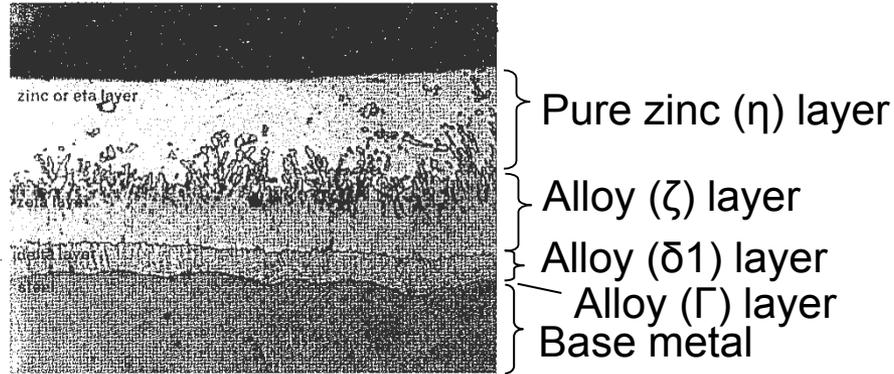
## 4) Experiential deterioration evaluation module

- Level of the deterioration of each chromatic group is evaluated experientially (i.e. experiential deterioration evaluation).

### 3. Definition of Evaluating Deterioration

- The advanced image processing system analyses color of galvanized surfaces by computer to evaluate the deterioration levels through using the property that galvanized surface color changes as the alloy layers expose.
- Levels of deterioration of galvanized surfaces are standardized according to Table-2 depending on exposure of the alloy layers.

Table-2 Definition of deterioration levels of hot dip galvanized surfaces



Deterioration levels	Deterioration of hot dip galvanized surfaces	Evaluation by advanced image processing
I	Normal condition keeping $\eta$ layer (pure zinc layer) with color of silver or gray	Blue
II	Slightly deteriorated condition where $\eta$ layer is corroded and $\zeta$ layer is locally exposed with white rust, stains and color of brown or dark brown partially	Light blue
III	Rather deteriorated condition where $\eta$ layer is corroded and $\zeta$ layer is wholly exposed with color of brown or dark brown	Yellow
IV	Very deteriorated condition where $\zeta$ layer is corroded, and $\zeta / \delta 1$ mixed or $\delta 1$ mixed layer is exposed with color of auburn or flecked auburn	Red
V	Extremely deteriorated condition where base metal is exposed with brown color and bumpy surfaces	Brown

## 4. Method of Calculating Residual Coating Thickness

- Upon evaluating the deterioration levels by the advanced image processing, residual coating thickness can be calculated according to Formula-(1) below, which indicates the relation between the deterioration levels and the coating thickness.

$$X = \alpha_i \cdot X_0 \quad \dots \dots (1)$$

$X$  : Calculated coatings thickness ( $\mu\text{m}$ )

$\alpha_i$  : Ratio of thickness reduced from initial  
galvanized coating in each deterioration level

$X_0$  : Initial galvanized coating thickness ( $\mu\text{m}$ )

- “ $\alpha_i$ ” shown below is the ratio of thickness reduced from initial galvanized coating in each deterioration level, which has been obtained through studying actually measured coating thicknesses of existing steel towers and sectional microstructure photos of their galvanized coatings.

# 5. Accuracy of Diagnosis by Advanced Image Processing

Table-3 Comparison of result of deterioration diagnosis by advanced image processing and actually measured data

Deterioration levels

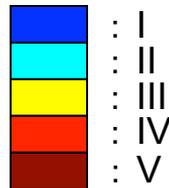


	Result of evaluation of deterioration levels	Calculated coating thickness (μm)	Occupying ration of each deterioration level (%)					Visual evaluation (Actual measured data)	Diagnosed image	Result treated by advanced image processing
			I	II	III	IV	V			
1	IV	16	0	30	30	40	0	IV 20μm or smaller		
2	IV	16	10	35	20	35	0	IV 20μm or smaller		
3	III	33	0	40	40	20	0	IV 35μm or smaller		
4	III	33	0	40	40	20	0	III - IV 40μm or smaller		
5	II	48	0	60	20	20	0	IV 45μm or smaller		
6	II	48	0	60	40	0	0	II - III 45μm or smaller		

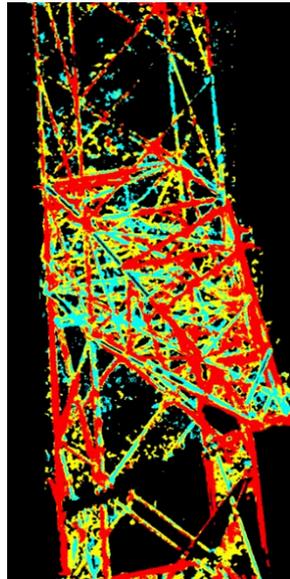
# 6. Example of Diagnosing Residual Service Life of Galvanized Coatings

## 1) Example of Diagnosing Residual Service Life of Galvanized Coatings on Steel Structures

Deterioration levels



Diagnosed image

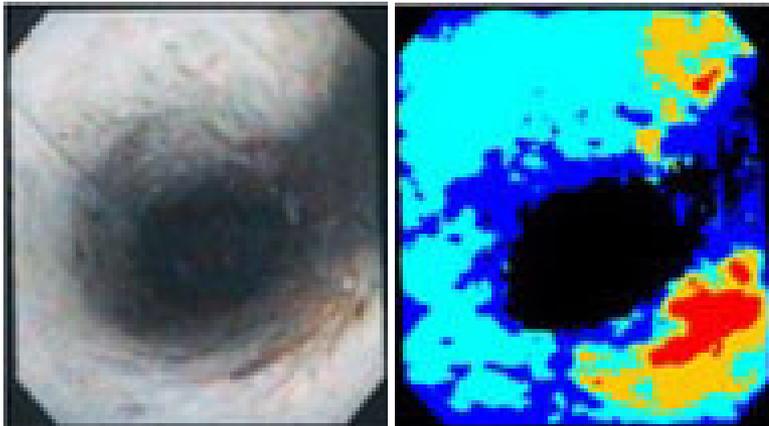
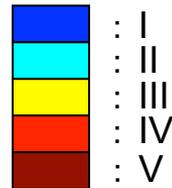


Result treated by advanced image processing

Results of diagnosis	
(1) Evaluation of deterioration levels	Evaluated as deterioration level IV, which is in the worst case.
(2) Occupying ratio of each deterioration level in the image diagnosis	I: -%, II: 20%, III: 38%, IV: 42%, V: -%
(3) Calculation of galvanized coating thickness	Calculated galvanized coating thickness when applying 550g/m <sup>2</sup> (76.4μm) as our in-house production standard I: -, II: 48μm, III: 33μm, IV: 16μm, V: -
(4) Diagnosis of residual service life of galvanized coatings	In consideration of the elapsed time (20 years) and deterioration level (IV) of diagnosed materials, their residual service life would be about 2 years.
(5) Countermeasure	It is recommended to immediately check out their deterioration in detail.

## 2) Example of diagnosing residual life of galvanized coatings in tubular steels

Deterioration levels



Diagnosed image

Result treated by advanced image processing

### Results of diagnosis

(1) Evaluation of deterioration levels

Evaluated as deterioration level IV, which is in the worst case.

(2) Occupying ratio of each deterioration level in the image diagnosis

I: 26%, II: 46%, III: 16%, IV: 12%, V: -%

(3) Calculation of galvanized coating thickness

Calculated galvanized coating thickness when applying 550g/m<sup>2</sup> (76.4μm) as our in-house production standard

I: 66μm , II: 48μm , III: 33μm, IV: 16μm, V: -

(4) Diagnosis of residual service life of galvanized coatings

In consideration of the elapsed time (36 years) and deterioration level (IV) of diagnosed materials, their residual service life would be about 3 years.

(5) Countermeasure

It is recommended to immediately check out their deterioration in detail.

## 7. Conclusion

- Outlines of the advanced image processing system and also examples of diagnosing residual service life are introduced.
- It has been thereby possible to evaluate photos objectively and quantitatively without evaluators' subjective views.
- It has furthermore become possible to evaluate deterioration levels of hot dip galvanized steel structures quantitatively and correctly even under different photographing conditions.
- It is our pleasure to contribute to reduction of maintaining costs for steel structures and to prolonging their service life through the diagnosis of deterioration of galvanized coatings by using the advanced image processing.