A JOINT CLASSIFICATION METHOD FOR TLS POINT CLOUD BY INTENSITY AND COLOR INFORMATION

Wang GUO, Xiaojun CHENG, Quan LI

College of Surveying and Geo-informatics
Tongji University
Shanghai China, 200092

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Outline

Problem

Method

Experiment

Summary

Problem

The TLS (Terrestrial laser scanner) is widely used in 3D modeling

TLS point cloud is massive, dispersed and unordered

We need a fast and accurate classification method

Problem

Previous Studies

Based on strongly varying density	(Hackel et al., 2016)
Based on neighborhood dimensionality	(Yang et al., 2013)
Based on the geometry and color information	(Ramiya & Nidamanuri, 2014)
Based on combining structure and context	(Kumari & Sreevalsannair, 2015)
Based on neighborhood selection & selecting feature	(Weinmann et al., 2015)
Based on feature similarity &semantic dependency.	(Zhang et al. 2015)

These methods are based on the **spatial features** of point cloud

- The logic and computation are complicated
- The difficulty increases with the complexity of the target shape

Spatial features is difficulty , but **physical properties ?**

Problem

Previous Studies

based on intensity information (Song et al., 2002)

Based on intensity information and elevation information (Charaniya et al., 2004)

Based on pseudo reflection image (Coren and Sterzai, 2006)

Based on color information

(Strom et al.,2010; Knopf,2011; Matti & Nebiker,2014; Luo et al.,2016)

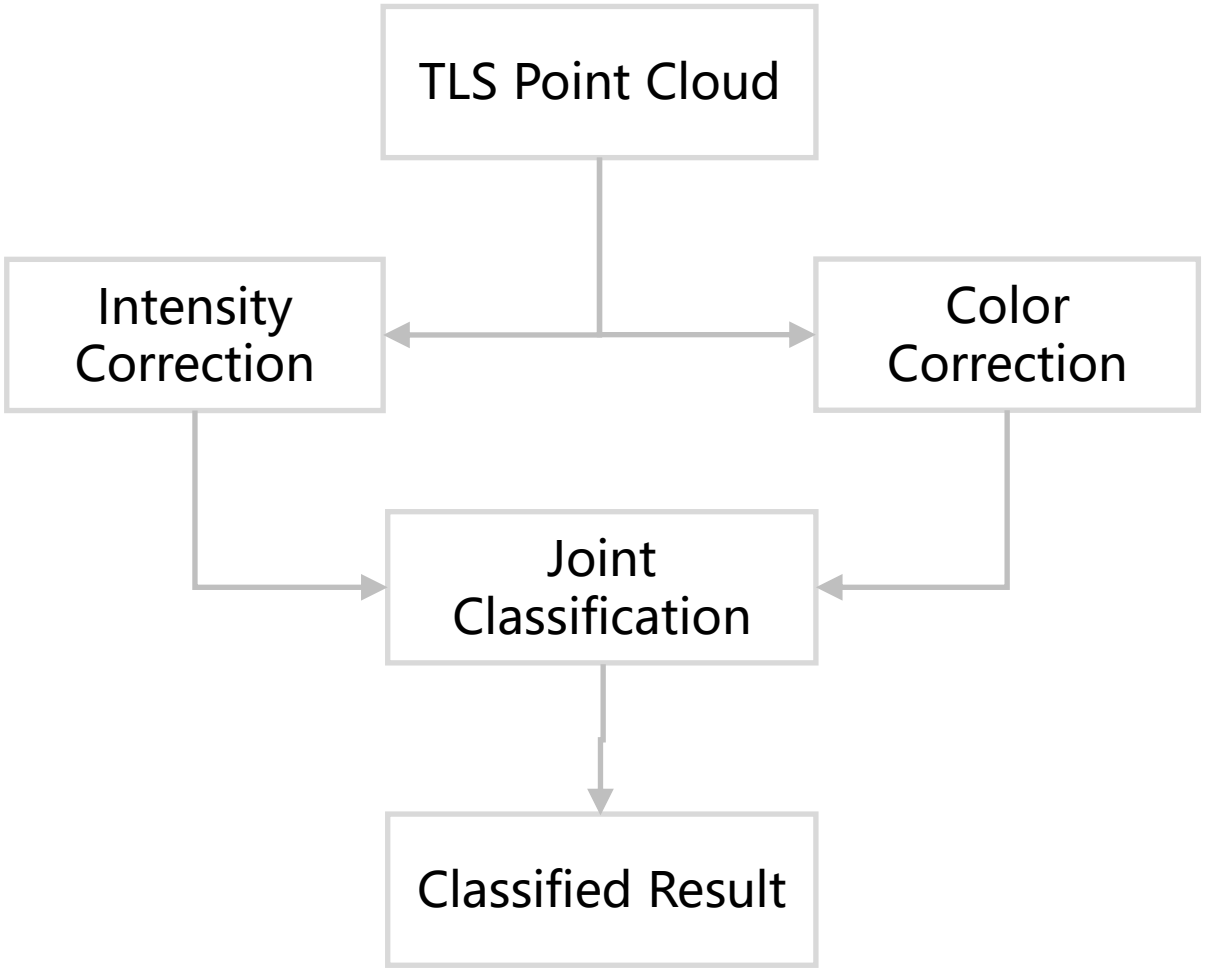
TLS original intensity data are inapplicable in directly retrieving

TLS intensity correction is not applicable and accurate

TLS can obtain the intensity and color information of the target surface

We want a classification method by **INTENSITY** and **COLOR**

Method


TLS Point Cloud
Intensity Correction
Color Correction
Joint Classification
Classified Result

Method

Intensity Correction

radar range equation: $$P_R = \frac{P_E D_R^2 \rho \cos\alpha}{4\pi R^2} \eta_{sys} \eta_{atm}$$

P_E,D_R,$\eta_{atm}$and η_{sys}can be assumed as constant, in TLS

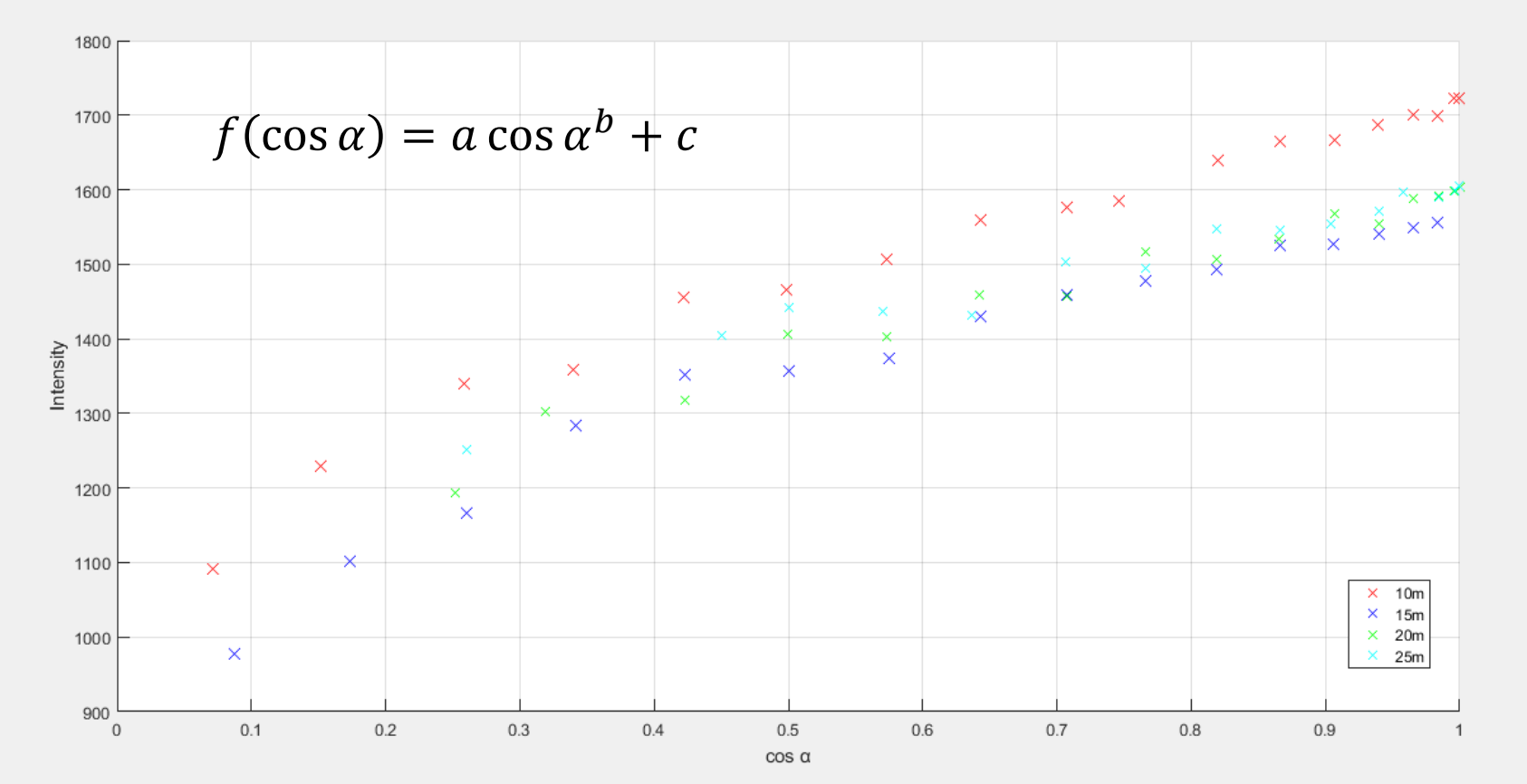
So, we can get:

$$P_R = \frac{C\rho \cos\alpha}{R^2} \qquad C = \frac{P_E D_R^2}{4\pi} \eta_{sys} \eta_{atm}$$

Distance and **incidence angle**
are important factors in intensity correction

Method

Incidence Angle Correction



The incidence angle correction $I_c = I - f(\cos\alpha) + f(\cos\alpha_c)$

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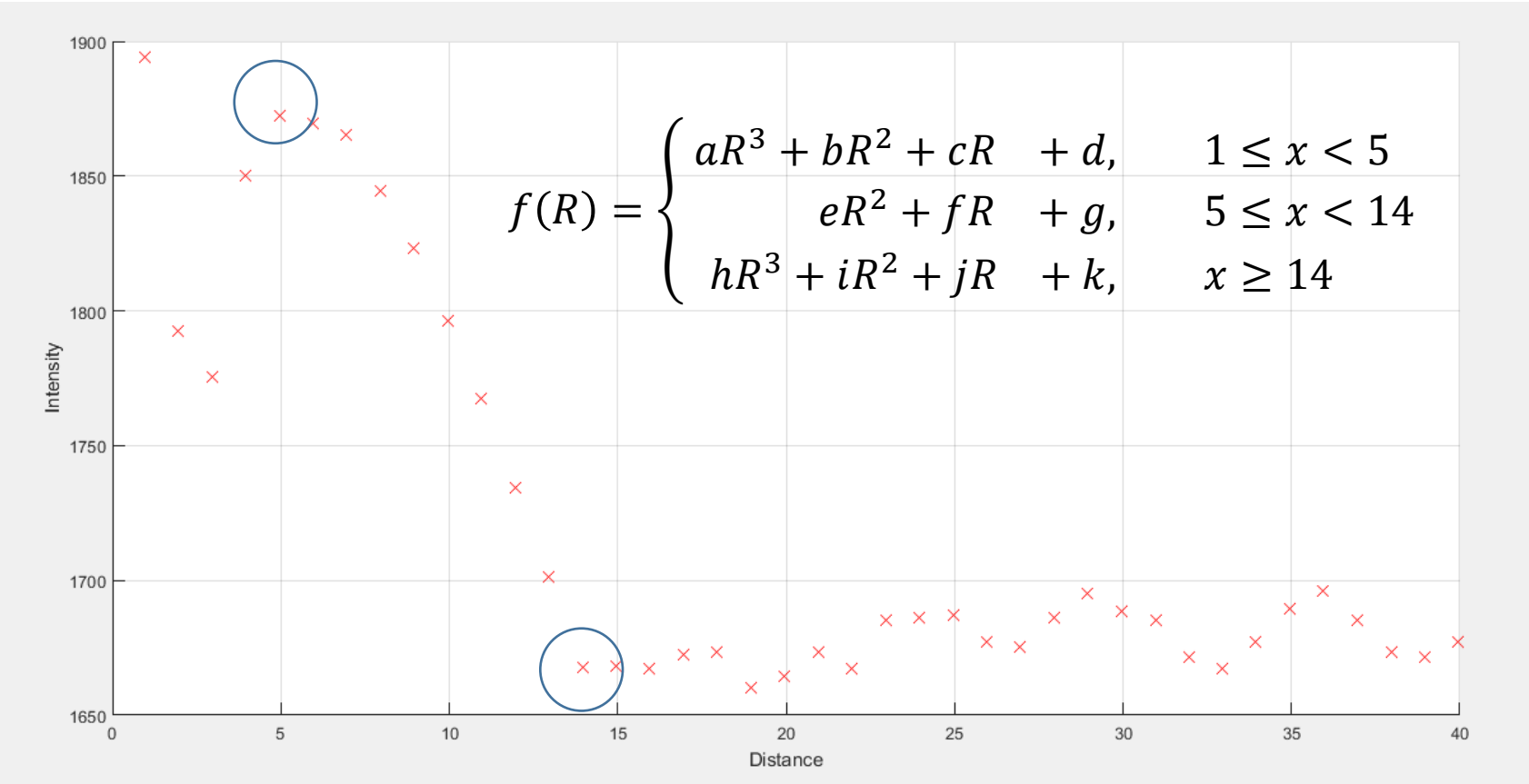
Method

Distance Correction



$$f(R) = \begin{cases} aR^3 + bR^2 + cR + d, & 1 \le x < 5 \\ eR^2 + fR + g, & 5 \le x < 14 \\ hR^3 + iR^2 + jR + k, & x \ge 14 \end{cases}$$

The incidence angle correction $I_c = I - f(R) + f(R_c)$

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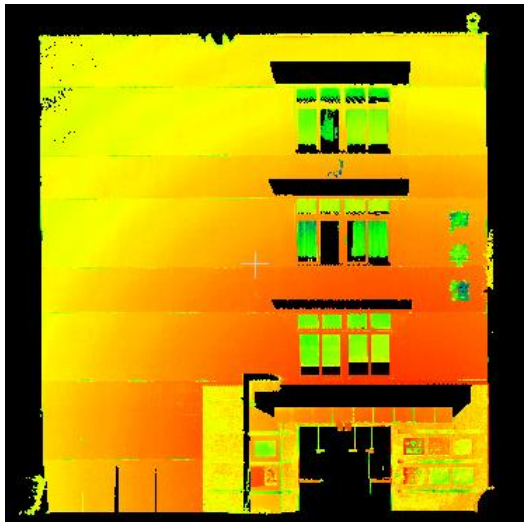
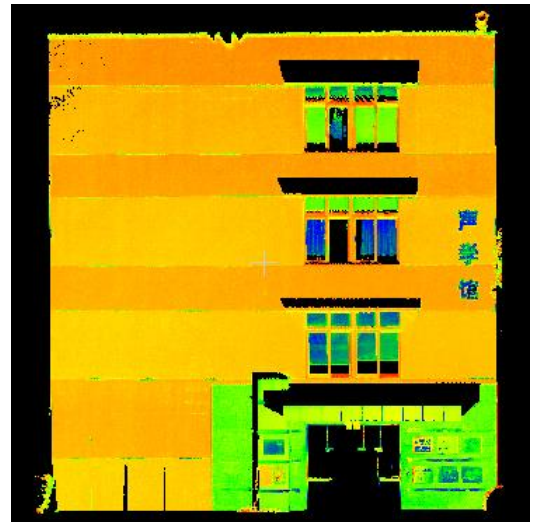
Method

Result

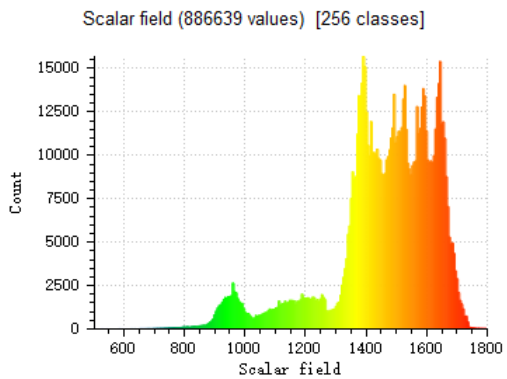
Original Intensity Image

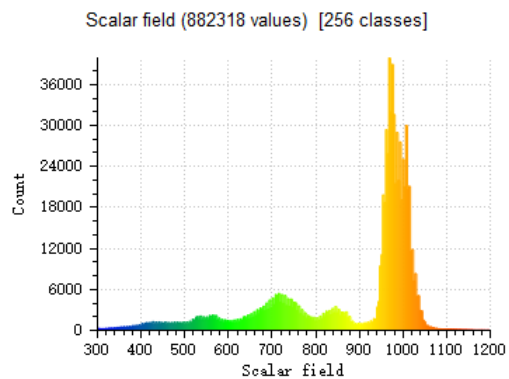




Corrected Intensity Image

Original Intensity Histogram





Corrected Intensity Histogram

Method

Color Correction

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} k_R & n_G & m_B \\ m_R & k_G & n_B \\ n_R & m_G & k_B \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

$$\Rightarrow \quad \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} k_1 & \omega_G & -\omega_G \\ -\omega_B & k_2 & \omega_R \\ \omega_G & -\omega_R & k_3 \end{bmatrix} \begin{bmatrix} R'' \\ G'' \\ B'' \end{bmatrix}$$

$$\Rightarrow \quad \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} k & \omega_G & -\omega_G \\ -\omega_B & k & \omega_R \\ \omega_G & -\omega_R & k \end{bmatrix} \begin{bmatrix} R'' \\ G'' \\ B'' \end{bmatrix} + \begin{bmatrix} \Delta R \\ \Delta G \\ \Delta B \end{bmatrix}$$

Method

Result

Scanning A RGB

Scanning B RGB

Corrected Scanning B RGB

Method

The I_i (intensity), and I_c (color) were used as vectors in coordinate system of classification

$$E = 10^{\sqrt[2]{(\log_{10} I_i)^2 + (\log_{10} I_c)^2}} + C$$

C is a variable based on distance $C = \frac{R}{R_s} * (I_s - I)$

R is distance of per point,R_s is standard distance,I is corrected intensity of per point and I_s is standard intensity

Experiment

Used the instrument **Faro Focus3D 120.**A façade of building was scanned three times at different distances and incidence angles.

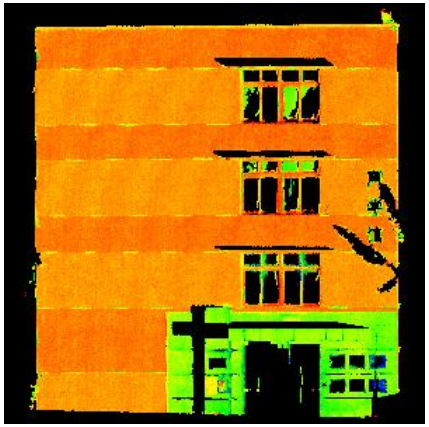
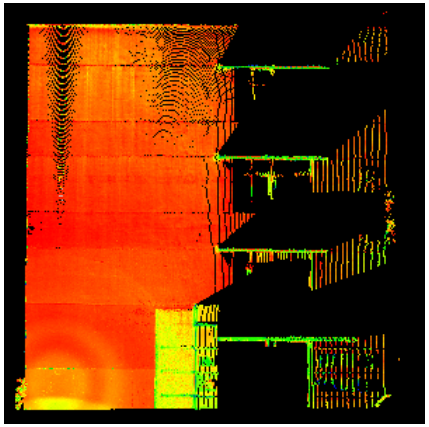
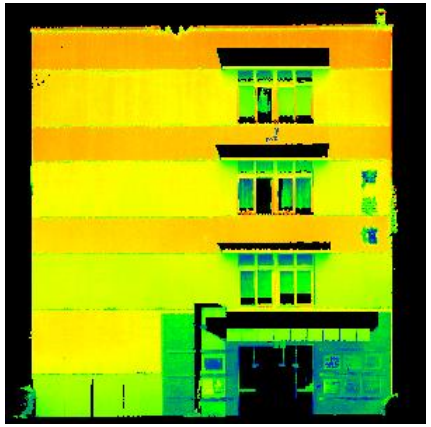
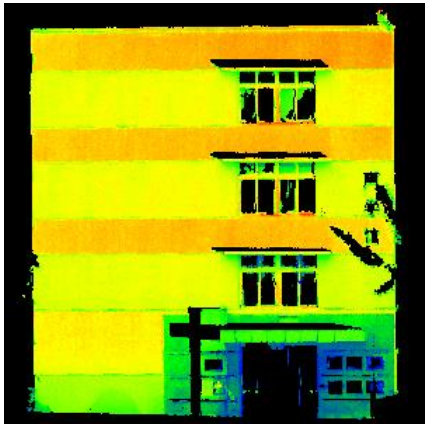
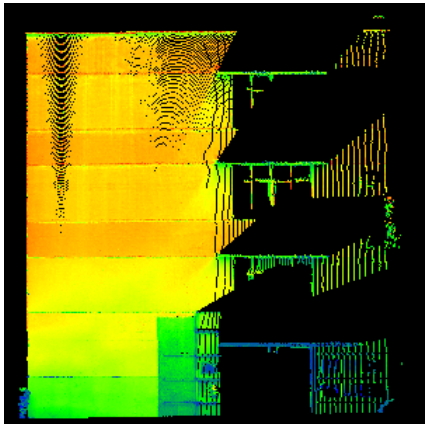
	Distance Range	Incidence Angle Range
Scanning A	6-19 m	0-89 degree
Scanning B	19-34 m	0-89 degree
Scanning C	1.5-19 m	0-89 degree

Experiment

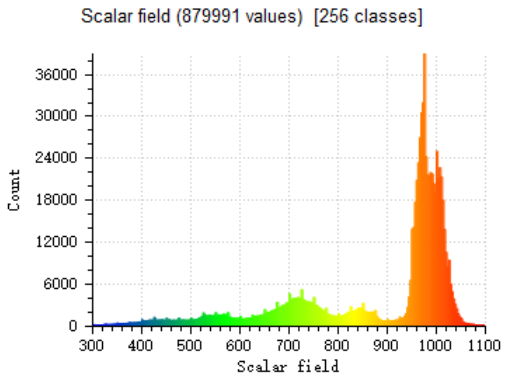
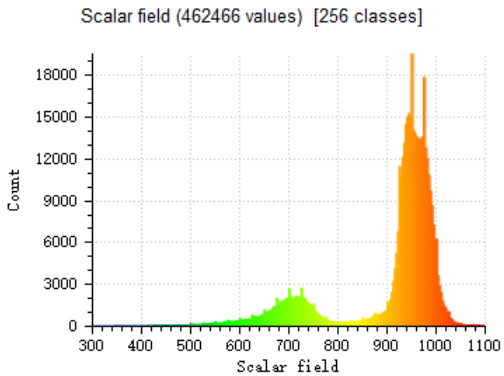
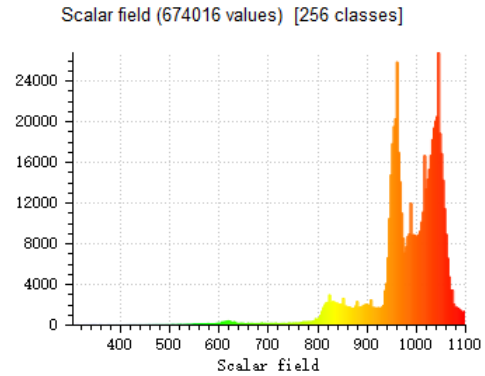
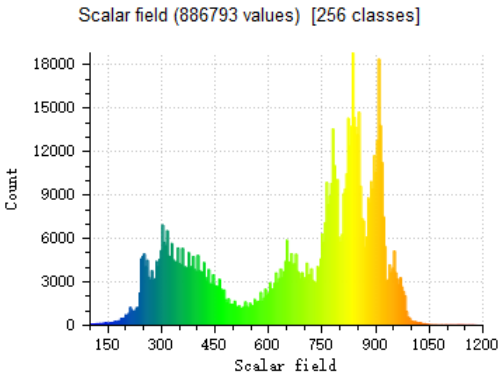
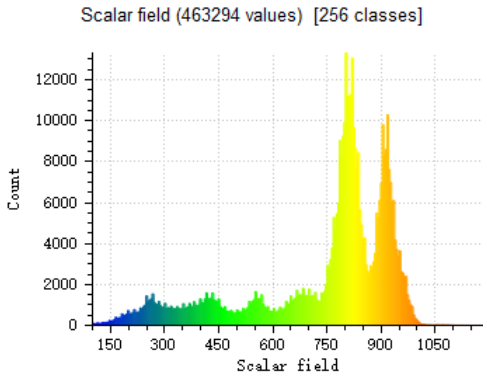
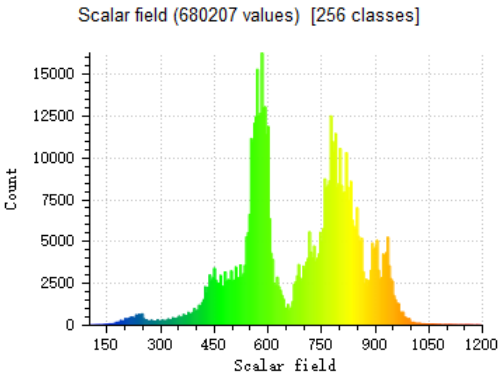
	Distance Range	Incidence Angle Range
Scanning A	6-19	0-89
Scanning B		
Scanning C		

Experiment

Classification Image

	Scanning A	Scanning B	Scanning C
Intensity Only			
Intensity & Color			

Experiment

	Scanning A	Scanning B	Scanning C
Intensity Only			
Intensity & Color			

Summary

This method has higher accuracy and universality

TLS of the Faro focus series has its specific characteristics

If the intensity of other TLS parameters are known, this method can be extended to other TLS intensity data correction as well.

Thank You