

Very short-term prediction model for photovoltaic power based on improving the total sky cloud image recognition

Shuang Sha

June 14,2018

1. Solar facula repair

1.1. Solar facula location

To remove the solar facula, researchers first need to locate the solar image on the nephogram. On the ground-based nephogram $I(x, y)$, the imaging circle radius is R , the imaging centre is $O(x_0, y_0)$, the location of solar facula image g is (x_g, y_g) . As shown in Figure 1, the solar altitude angle α_s can be calculated by latitude φ , time angle ω and declination angle δ . The latitude φ can be obtained from the basic information of the whole sky imager, and the time angle ω is equal to the time (hour) from the noon multiplied by 15° . The declination angle δ can be approximated according to the Cooper equation, and the method is as follows:

$$\delta = 23.45 \times \sin[360 \times \frac{284 + n}{265}] \quad (1)$$

Where n is the date serial number in a year, and the solar altitude angle α_s can be calculated as

$$\alpha_s = \arcsin(\sin \varphi \sin \delta + \cos \varphi \cos \delta \cos \omega) \quad (2)$$

The solar azimuth γ_s can be calculated by δ, ω, α_s

$$\gamma_s = \arcsin[\frac{\cos \delta \times \sin \omega}{\cos \alpha_s}] \quad (3)$$

Finally, calculate the location of solar facula on the ground-based nephogram

$$\begin{cases} x_g = x_0 + 12 \sin \gamma_s \\ y_g = y_0 + 12 \cos \gamma_s \end{cases} \quad (4)$$

Obviously, if $(x_g - x_0)^2 + (y_g - y_0)^2 > R^2$, the rule will end.

1.2. Solar facula removal

Based on the analysis above, if there is a solar facula on the nephogram, then it must be located at position g . Due to

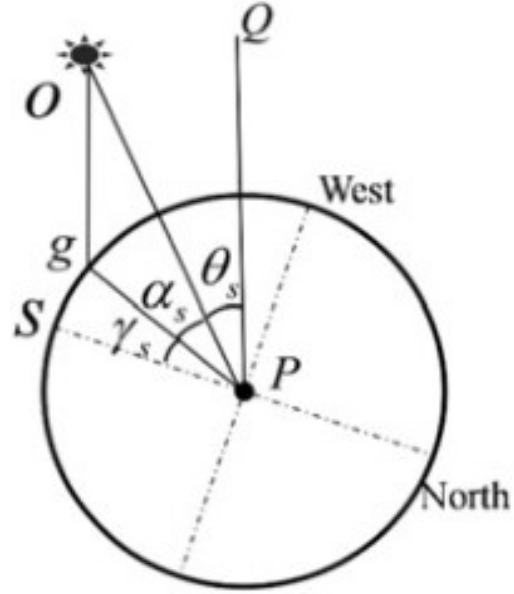


Figure 1. Horizon coordinate system.

light scattering, solar facula imaging will cover point g . Because of the sun light intensity and particle interaction, the spot size will be different. According to the statistical empirical results, the imaging radius of the general solar facula in the nephogram will not exceed one-third of the effective imaging diameter of the nephogram [2]. If the radius of the circle surface that covers the solar facula is r_g , then the detection area of the facula is $S_g \leq 2\pi r_g^2$. Therefore, in the nephogram $I(x, y)$,

$$(x - x_g)^2 + (y - y_g)^2 \leq r_g^2 \quad (5)$$

Gray scale histogram statistics are applied only to the circular area covering the solar facula, the result is shown in Figure 2. The gray level of the pixel in the circle surface is very high [1]. At this point, researchers can use the gray histogram feature of the facula area to filter the high gray area of the facula circle, so they can select the appropriate

threshold to remove the solar facula. The result is shown in Figure 3.

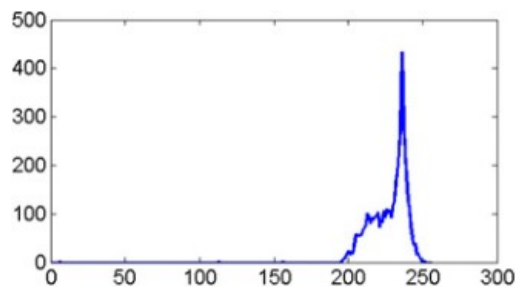


Figure 2. Gray statistical histogram of facula detection region.

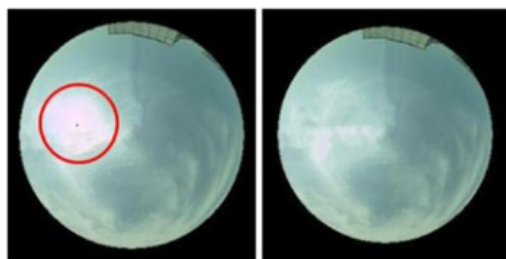


Figure 3. Facula removal.

References

- [1] B. Singh and A. P. Singh. Edge detection in gray level images based on the shannon entropy. *Journal of Computer Science*, 4(3):186–191, 2008. 1
- [2] X. Zhu, J. Wu, H. Zhou, J. Ding, F. Cui, and X. Zhao. Very short-term prediction model for photovoltaic power based on improving the total sky cloud image recognition. *The Journal of Engineering*, 2017(13):1947–1952, 2017. 1