Image restoration for blurred fringes of rail profile 3D online measurement based on PMP

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Abstract: In rail transportation, rail plays an important role in supporting and guiding the vehicle running. However, in the process of vehicle running, the friction and the pressure on the rail easily lead to wear and deformation. When rail wear and deformation reach a certain degree, it will bring potential dangers to the vehicle running. The measurement of rail shape and surface defects has become a focus in the railway industry. In recent years, 3D measurement techniques based on fringe projection have been introduced into online measurement of rail profile and surface defects. Phase measurement profilometry (PMP) is a widely-used method, which is suitable for 3D online measurement of rail with high precision and easy to measure online. In online PMP, when the velocity of the object is quite high, the collected reformed fringes often appear to be motion-blurred, which increases the measurement error, or even leads to the 3D reconstruction failure. In the 3D measurement of rail shape and surface flaw with online PMP, in order to clarify the blurred reformed fringes of the rail, several restoration methods, such as Wiener Filtering, Point Spread Function algorithm, Blind Deconvolution algorithm, and Richardson-Lucy algorithm were compared and analyzed. And the peak signal to noise ratio (PSNR) is used for evaluating the restoration effect. The PSNR is higher, the image quality is better. Meanwhile, the relationship between the vehicle speed and the restoration effect was studied, the error was analyzed and the 3D rail shape was reconstructed based on online PMP. Theoretical and experimental results show that in the online 3D measurement of rail shape and surface flaw, the Richardson-Lucy algorithm is best for image restoration of motion blur, and the relationship between the effect of image restoration and the vehicle speed is a polynomial. When online PMP method is used for reconstructing 3D motion blurred image, the 3D shape quality of the rail will be poor, and the 3D restoration of the reconstructed fringe images can get good 3D shape of the rail. In actual measurement, the obtained motion blurred fringe images are processed with Richardson-Lucy algorithm, and online PMP is used to reconstruct the 3D shape of the rail. In comparison with the 3D shape of the standard rail, the abrasion of the rail is obtained. If the rail surface is defective, the accurate position and size of the defect can be determined by the reconstruction of the 3D shape of the rail.

Keywords: deformed fringe; blurred image restoration; Richardson-Lucy algorithm; PSNR