# §19. Locus Analysis of Dust in Fusion Device by 3D Stereo Image Measurement

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For observation and analysis of trajectories of the dust particles, the experiment was conducted with spherical carbon dusts and the high speed stereo camera. The dust particle is inserted into the LHD through the dust holder set on the plasma orbit. If the trajectory of the dust particles is precisely obtained, the relationship between dust and plasma may be analyzed. In this research, a measurement method of dust trajectories from the sequential stereo images is proposed. This includes the calibration of the stereo camera on the basis of the stereo images and the CAD data of the reactor. In the explanation of the measurement method, an investigation of particle tracking methods is conducted to obtain a multitude of dust trajectory automatically. Moreover, a new stereo matching method is also proposed to enable better performance of stereo matching of high density dust.

In order to obtain the coordinates of the dust particles, a dust extraction process must be executed to the target stereo images. The dust particles in the images are consist of about 10 pixels. Therefore, they look like powder. We focused on such an intensity pattern, and Difference of Gaussian (DoG) is applied to the stereo images. DoG acts like a band pass filter in a frequency region. It can remove the row frequency content, such as the background structure, and the high frequency content, such as noise components, and the only dust pixels remain. After the process, thresholding is applied to the images to eliminate noise components. The window sizes of DoG are three by three and eleven by eleven. The parameter $\sigma$ of the small window of the DoG is 0.8, and the other one is 2.0. The threshold value is 10. The result of this procedure is displayed in Fig. 1. In this figure, the top image is the input image and the bottom image is the extracted dust image.

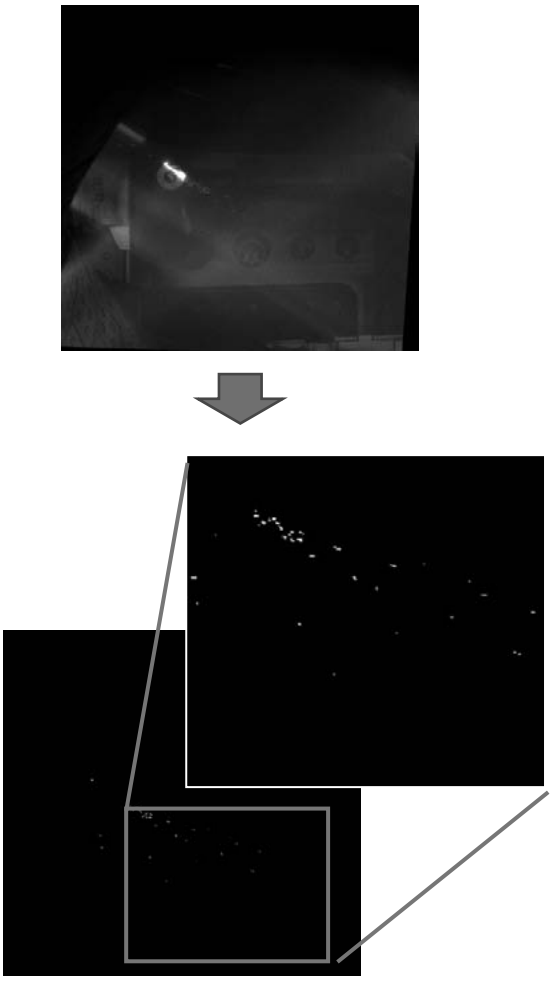

Figure 1 Result of dust extraction

We propose a new auto stereo matching method for high density dust. The main concept of the method is to make use of the dust trajectory data so far to predict the next coordinates of the dust. In order to link a dust particle in one image of the current frame to a previous particle in the trajectory data, the relaxation method is used. Once a dust in the focused frame is linked to a past trajectory data, the multi-evaluation criteria are applied for each matching candidate in the second of the stereo camera. First, the distance between two-dimensional coordinates of a dust particle and the coordinates predicted by the corresponding trajectory data is calculated. Second, three-dimensional distance between the coordinates is calculated by the corresponding points and the predicted coordinates. Third criteria is the distance from the epipolar line of the focused dust particle. The sum of all distance is treated as the evaluation score. The dust particle which has the minimum score is the result of the matching of the focused dust particle.

We conducted an experiment to estimate the dust trajectory. The experimental result is shown in Fig. 2. Total 60 trajectories were extracted from the 600 stereo image sequence. The dust holder which is the initial position of the dust particles is located on the LHD coordinate (x, y, z)=(2970, -1713, -1354). As can be seen, dust particles move above from the dust folder.

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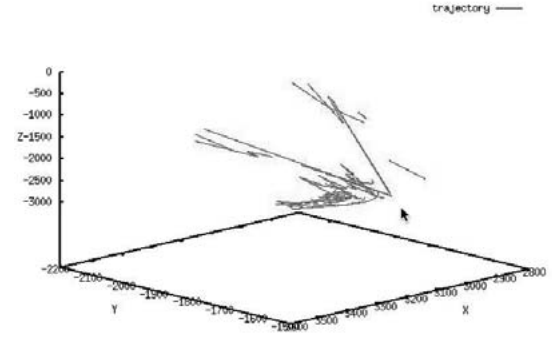


Figure 2 Result of dust tracking