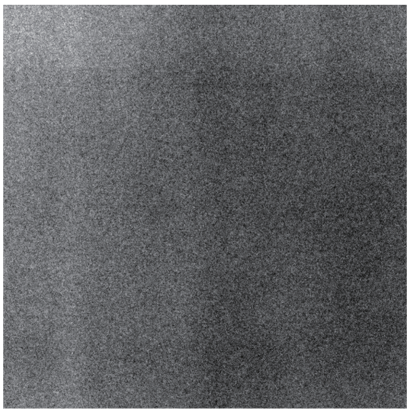

Fig. 1. X-ray images with 2 mAs (these images share the same window widths to integrate the noise hue).

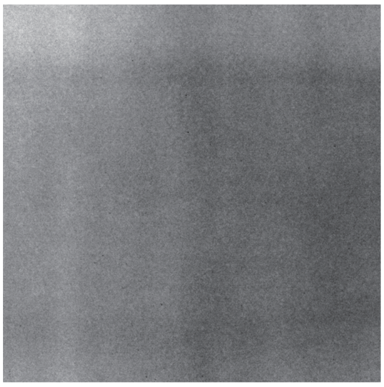

Fig. 2. X-ray images with 20 mAs (these images share the same window widths to integrate the noise hue).

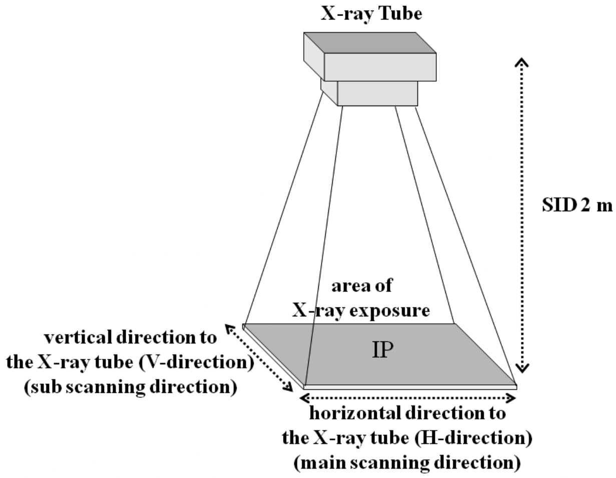

Fig. 3. Geometric arrangement of the X-ray exposure.

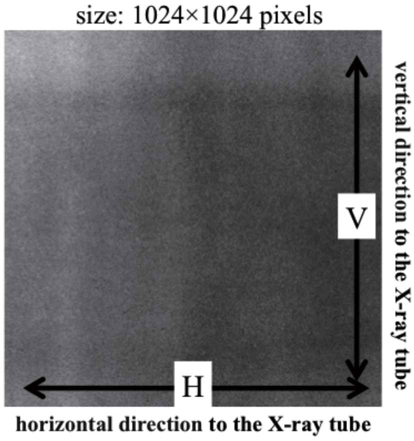

Fig. 4. Direction of each line profile in the X-ray images.

tification of non-stochastic low-frequency noise (stationary noise) superimposed onto X-ray images from a CR system. We then aim to develop a noise rejection method using a mathematical model that realizes an accurate digital X-ray imaging system.

2. Stationary Noise

Stationary noise is a noise component that appears independent of the radiographic factors in the X-ray images. Figures 1 and 2 show digital X-ray images without a subject that were taken from the same CR system with different radiographic factors. The radiographic factors in Fig. 1 are 70 kV and 2 mAs (a low-dose setting), while those in Fig. 2 are 70 kV and 20 mAs (a high-dose setting). Compared with Fig. 1, Fig. 2 shows a decrease in spike-like noise caused by fluctuations in the radiated photons. However, we can find a comprehensive variation of density (pixel value) at the same position in each image. This fluctuation component is stationary noise. In stationary noise, there is a nonuniform distribution of X-ray emissions attributed to the architecture of the X-ray target, structural nonuniformity of the X-ray acceptance surface (structural nonuniformity of the imaging plate (IP)), nonuniformity in the sensitivity of the IP readout systems, and so on.

A frequency analysis is generally used for the evaluation of noise in X-ray images. Dobbins *et al.* (2006) stated that when performing a frequency analysis, an evaluation of the noise characteristics should be based on X-ray images that have been cleared of stationary noise. On the other hand, because stationary noise interferes considerably with diagnostic imaging, Kunitomo *et al.* (2010) stated that an evaluation of noise characteristics should be based on X-ray images that include this type of noise component; however, the direct current component should be removed to prevent leakage-based errors. We also believe that this type of noise component prevents accurate diagnostic imaging. Therefore, stationary noise should be removed completely using our suggested method.

2.1 Examination of stationary noise extraction method

In the mathematical identification of stationary noise, the problem is how to extract stationary noise X-ray images that include various noise components. Therefore, to solve this problem, we consider the characteristics of stationary noise and accordingly suppose that each image obtained from the same X-ray imaging system with different radiographic factors and processed by a low-pass filter (LPF) of a specific frequency shares the same distribution profile. Based on this supposition, we verified whether this presumption was correct by using the X-ray images obtained from the same