MOTION-BLUR-COMPENSATED MICROSCOPIC IMAGING SYSTEM BY CONTROLLING THE OPTICAL AXIS USING A ROTATING ACRYLIC CUBE

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Motion blur exists when imaging moving objects. Conventionally, short exposure-time imaging with intense illumination is necessary to obtain high-resolution images. However, if the moving object is fast or the image resolution is high, the available illumination will have limitations. On the other hand, Galvano mirror was used to compensate high-speed target motion using back-and-forth motion with a longer exposure time possible [1, 2]. However, in conditions where image capture targets are continuous, such as in the inspection of walls, etc., after each image capture the optical axis must return to original angle to update the area of focus to capture the next image with a decrease in the imaging efficiency and exposure time. Therefore, in this research, we propose motion-blur-less shape monitoring method to compensate motion for longer exposure time and less intensity of illumination in microscopic environment. As shown in Fig. 1, the system is constructed with rotating acrylic cube and camera to capture moving prepared biological specimens such as fungus, spores, etc. (See Fig.2 (a)) at the speed of 300 mm/s on the linear actuator. As the acrylic cube rotates in synchronization with the motion of the linear actuator, the motion-blur is compensated by offsetting the relative velocity. It is based on the phenomenon that the optical axis is moved in parallel according to the incident angle to the acrylic cube by Snell's law. Originally 4.97 mm sized motion blur is occurred on the image (See Fig.2 (b)), however, our proposed method significantly improved image as shown in Fig.2 (c). The spatial resolution was improved around 165 times. Therefore, our proposed method enables to reduce intensity of illumination one thirtieth and to apply linearly moving biological specimen which is weak for heat by intensive illumination.

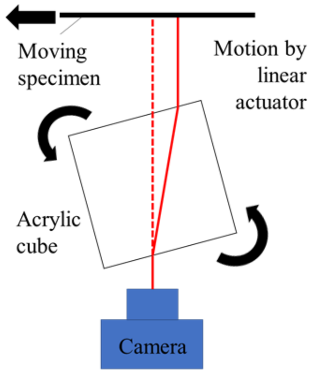

Figure 1: Schematic diagram of motion-blur compensation

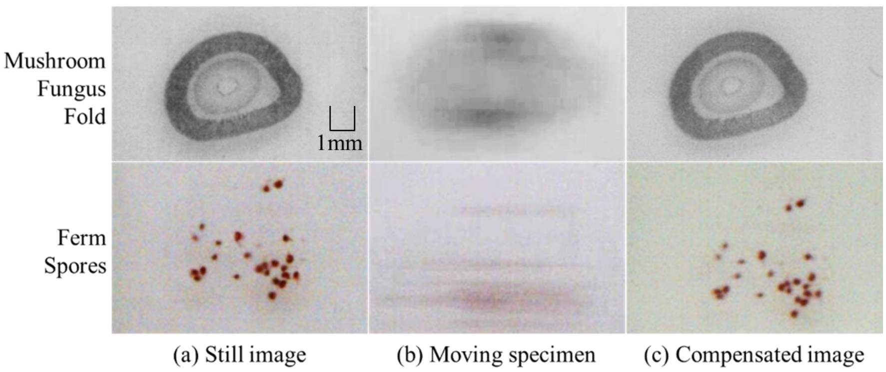

Figure 2: Comparation of result between still, moving, compensated images (after trimming and color correction)

[1] Inoue, M. et al., "Motion-blur-free video shooting system based on frame-by-frame intermittent tracking," *ROBOMECH Journal* **4**, No. 1, 28- (2007).

[2] T. Hayakawa et al., "Real-time high-speed motion blur compensation system based on back-and-forth motion control of galvanometer mirror," *Opt. Express* **23**, 31648-31661(2015).