Reduction of reconstructed particle elongation using iterative min-max filtering in holographic particle image velocimetry

Y. Tanaka¹, S. Murata¹

¹: Department of Mechanical System Engineering, Kyoto Institute of Technology, Kyoto, Japan
* Correspondent author: tyohsuke@kit.ac.jp

Keywords: DOF problem, Particle elongation in depth, Holographic PIV, min-max filter

Iterative min-max filtering in subvolume

This paper proposes a method that reduces reconstructed particle elongation (so called DOF problem Katz et al., 2010) using iterative min-max filtering in holographic particle image velocimetry. We applied the method to 100 elongated particles distributed at random. The proposed method is applied to the reconstructed intensity volume of tracer particles to reduce the particle elongation at each iterative step as shown in Fig. 1. The method consists of several steps that are as follows:

1. Apply min-max filtering (Westerweel, 1993) to a full reconstructed intensity volume which has greater intensity than a threshold value \( I_\text{th} \). The volume is normalized by minimum and maximum value of intensity:

\[
I_i(x,y,z) = \frac{I(x,y,z)-I_{\text{min}}}{I_{\text{max}}-I_{\text{min}}} \tag{1}
\]

2. Multiply the filtered intensity volume \( I(x,y,z) \) by the following equation to reduce the particle elongation.

\[
I(x,y,z) = \prod_{i=1}^{m} I_i(x,y,z) \tag{2}
\]

3. Divide the intensity volume into eight equal subvolumes.

4. Repeat these steps until minimum sub-volume (i.e.: minimum sub-volume: \( 1 \times 1 \times 1 \) voxel, full volume: \( 256 \times 256 \times 256 \) voxel) at each subvolume.

![Fig. 1 Iterative steps in proposed method with min-max filtering and subvolume](image)

Result

Figure 2 shows reconstructed intensity distributions of 100 particles with 10 \( \mu \text{m} \) diameters with iterative min-max filtering at each step in a reconstructed volume (x-y-z volume: \( 256 \times 256 \times 256 \) voxel and spatial resolutions \( \Delta x, \Delta y \) and \( \Delta z \): 10 \( \mu \text{m} \)). As can be seen from the steps, particle elongations decrease with an increasing number of divisions of a sub-volume. Step 1 of Fig 2 shows that it is hard to find particles due to elongations. On the other hand, the elongation is almost converged as shown in Step 7.

![Fig. 3 Reconstructed intensity distributions of 100 particles with iterative min-max filtering at each step (m=4)](image)

Conclusion

We applied the method to 100 elongated particles distributed at random. It is found that this method is capable of reducing the elongation of particles using iterative min-max filtering. The proposed method enables an iterative filtered light intensity to be completely divided into background and particle intensity.

References
