Real-time image processing for particle tracking velocimetry

Off-the-shelf three-dimensional particle tracking velocimetry (3D-PTV) experimental systems are complex, expensive and bulky. They consist of several digital cameras, multiple storage units (hard drives) and data streaming controllers. Their physical size is derived by the high amount of data and the extremely high data rate that need to be recorded and stored in real-time. The 3D-PTV systems are not data efficient; the data consists of images that include mostly redundant or irrelevant information. Efficient data management would lead to significant data reduction which could be expressed in reduced system dimensions or complexity, and increased mobility.

We present a novel high-speed 3D-PTV experimental system. Its novelty is due to the field-programmable gate based (FPGA) integrated into the camera electronics and a real-time image processing algorithm. It enables extracting positions of tracked objects, such as tracers or large particles, in real-time. The output data from the camera is reduced by more than 90%. In addition, we have designed a customized optical array of mirrors that provides four views of the observation volume from different angles. The present cost-effective solution is complemented with open source particle tracking software that receives raw data acquired by the real-time image processing system and returns trajectories of the identified particles. The combination of these components simplifies the 3D-PTV technique by reducing the size and increasing recording speed and storage capabilities. The system is capable to track multitude of particles at high speed and stream the data over the computer network. The system can provide a solution for the remotely controlled tracking experiments, such as in microgravity, underwater or in applications with the harsh experimental conditions.