Fundamentals and Practices of Advanced Aerodynamic Measurement Technology

Operation Manual for Lab #1

2023-11

1. PIV Measurement of Jet Flow in Water Tunnel

The whole system includes CMOS camera, light source, host computer, and experiment rig, which are connected as shown in Figure 1.

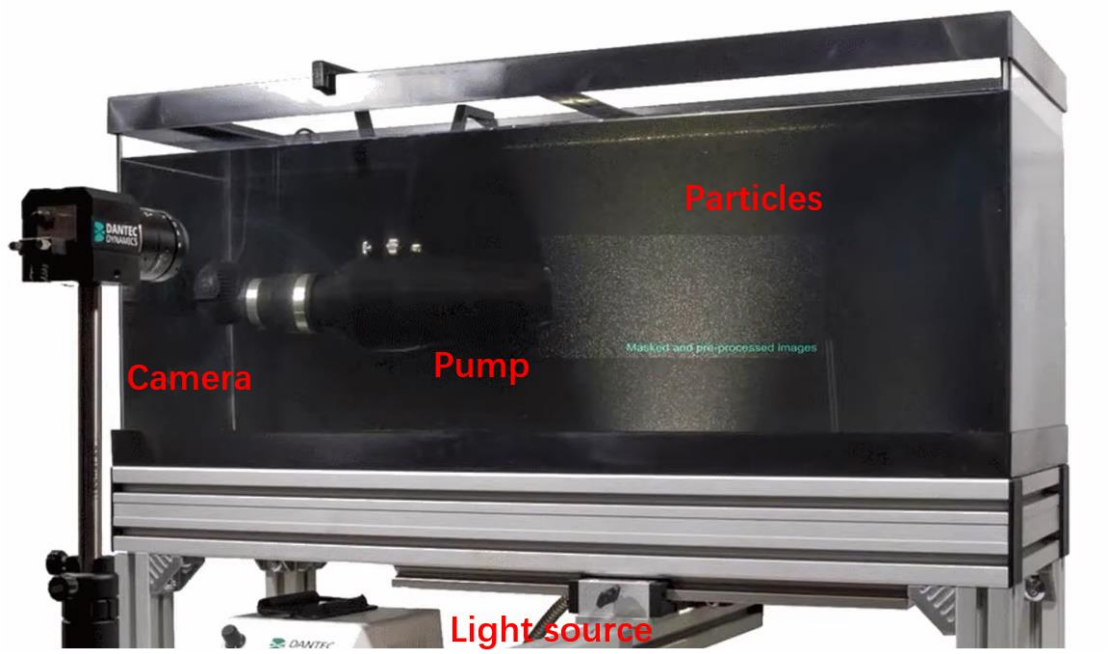


Figure 1 Experiment setup of the PIV system

- **CMOS Camera**

This camera is able to capture more than 100 frames per second with a resolution of 1960*1200 pixels. Make sure to turn off all light sources except the laser when recording the images. The camera control software is integrated into the data processing software.

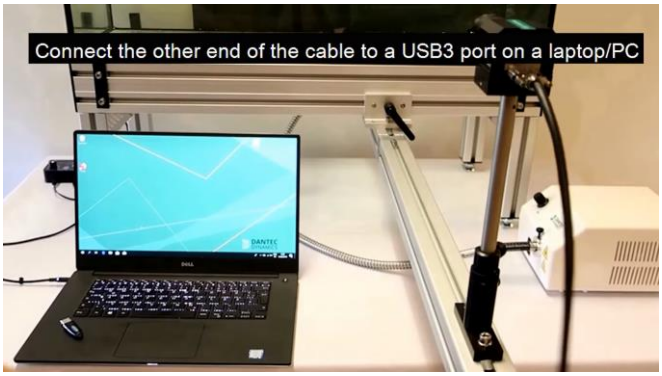


Figure 2 The CMOS camera

All the images are acquired by the software-DynamicStudio. First, build a new database. Then, enter the acquisition mode and adjust the acquisition parameter in order to get images that have bright and clear tracing particles, as well as proper particle displacement.

More details can be seen in the videos part 2 (https://jbox.sjtu.edu.cn/l/f1xd6M) and manuals in the lab.

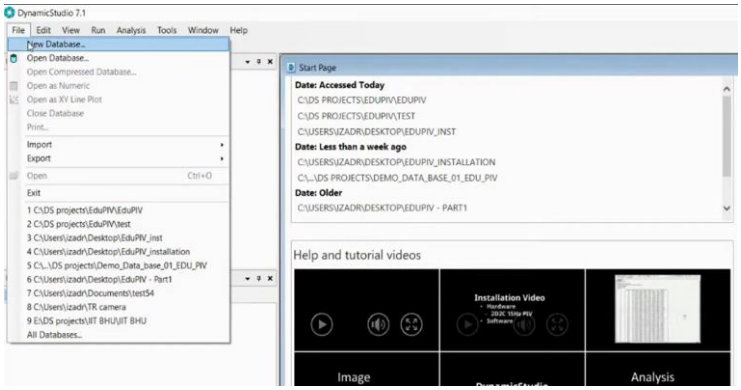


Figure 3 Build database

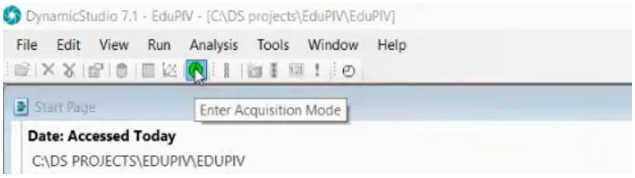


Figure 4 Enter acquisition mode

Figure 5 Adjust the parameters

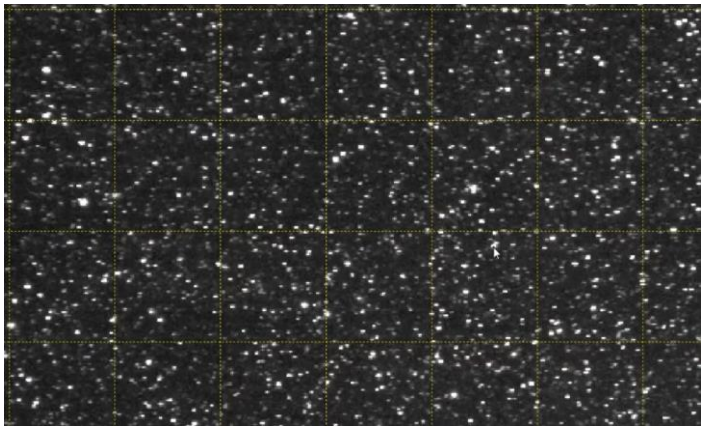


Figure 6 Clear particle images

- **Light source**

The light source system consists of a laser, controller, and optical fiber. It emits white light. Turn on the light sheet and adjust it to the maximum energy when the experiment begins.

Figure 7 The light source

- **Experiment rig**

The experiment rig contains a water channel, a nozzle, and a bump. The focus of the experiment is the flow structure in the nozzle outlet.

Figure 8 The experiment rig

2. Experimental Principle

The main purpose of the PIV measurement is to obtain the flow structures by capturing the particle displacement between two adjacent images. There are two pieces of advice to get valid raw image records:

a. Set the proper frame rate to make the particles have a displacement of about 4~`6 pixels during two images.

b. Set proper exposure time. Too short or too long exposure time will make the particles invisible or have a long trail.

The particle displacement is calculated using a cross-correlation algorithm, which is normally performed automatically in PIV software. The local flow velocity is determined based on displacement and time delay.

3. Experimental Procedure

(1) Turn on the pump inside the water channel.

(2) Make the light sheet horizontal so that the illuminated measurement plane is 2D, and adjust its position at the outlet of the nozzle. The camera should be vertical to the measurement plane.

(3) Turn on the light source and the camera. Set proper frame rate and exposure time.

(4) Record and save raw images of the flow field.

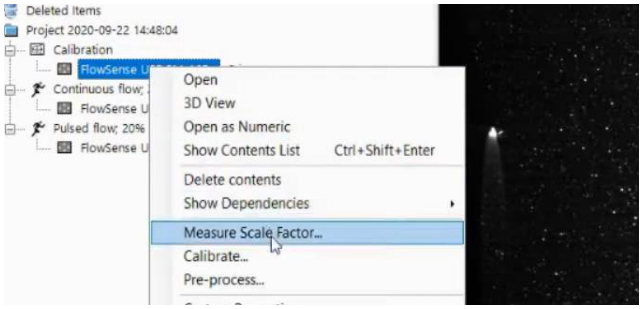
(5) Turn off all equipment after finishing the experiment.

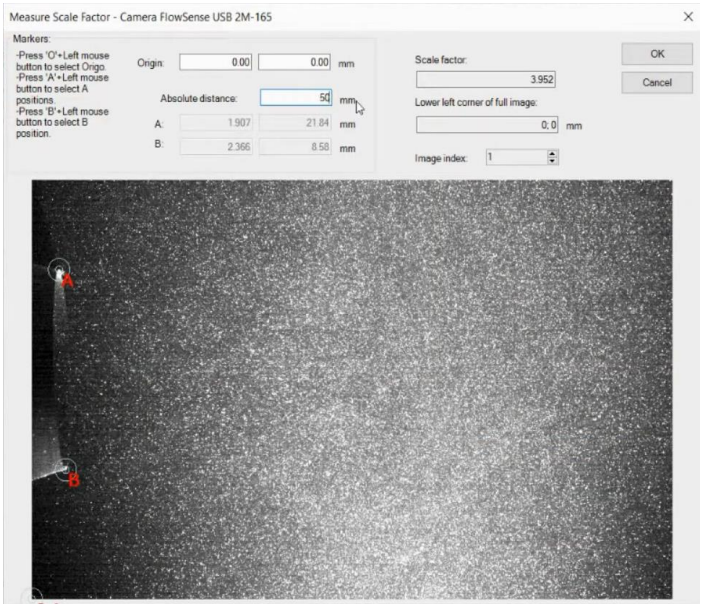
The details can be seen in the videos part 1 (https://jbox.sjtu.edu.cn/l/f1xd6M) and manuals in the lab.

4. Data Processing

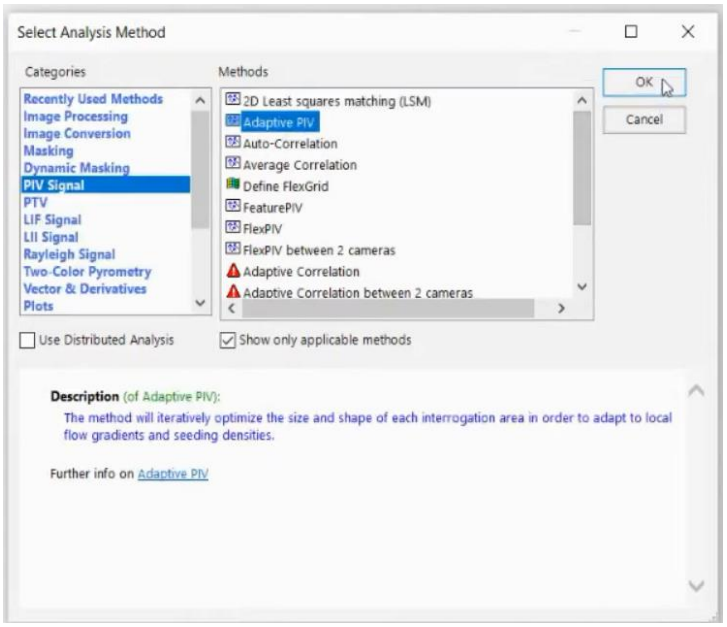
All PIV data are processed in software-DynamicStudio, which can be found on the desktop of the host computer. The whole processing can be roughly divided into three steps: (1) resolution calibration, (2) computing area selection, and (3) setting the parameters and computing.

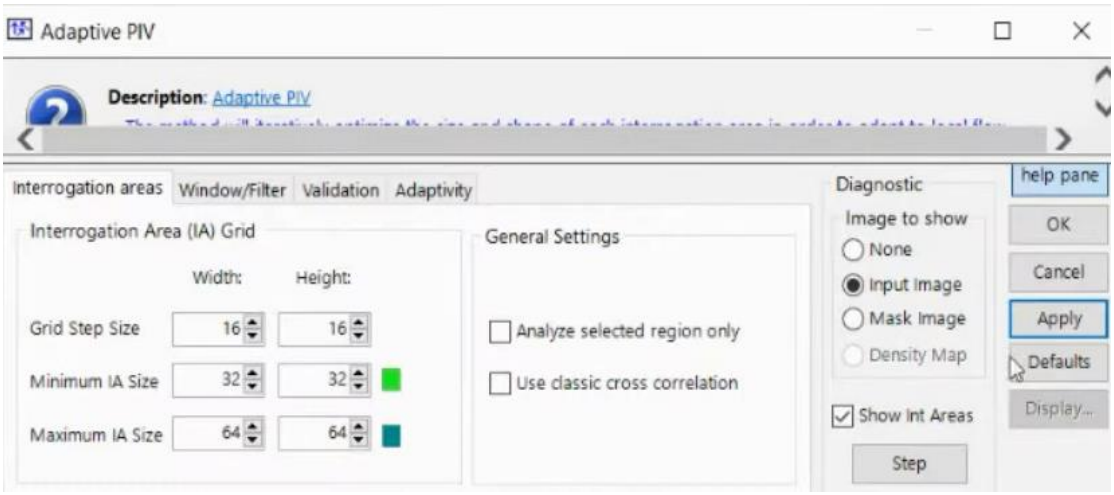
(1) resolution calibration





(2) computing area selection & (3) setting the parameters and computing





The details can be seen in the video part 3 (https://jbox.sjtu.edu.cn/l/f1xd6M).

5. Key issues to be addressed in the report

1. Take one sample velocity field from the PIV measurement and generate its vorticity field. Identify the location of all vortices within the flow field and determine the separation distance L between two adjacent vortices. Discuss the observed flow structure.

2. Take two velocity fields with a proper time delay so the same vortex has moved

for about 2/L, and calculate the traveling velocity of the vortex (Uv). Calculate the uncertainty and discuss possible reasons for errors.