MCG5138 Final Project

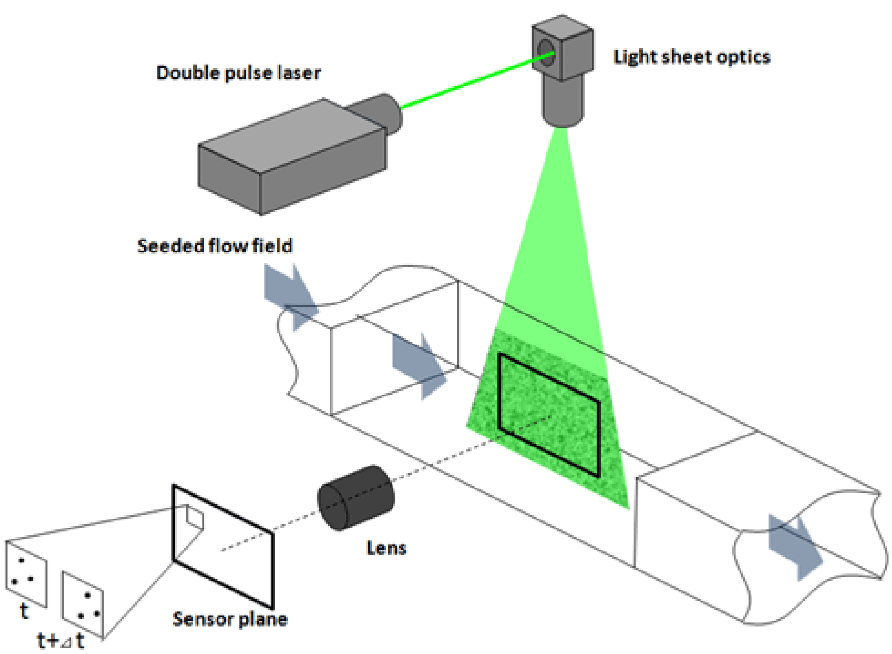
Particle Image Velocimetry (PIV) Data Processing

Each student is expected to submit a report on the final project. A complete submission should include the following elements:

- A written summary that reports the determined 2D velocity distribution of the target flow field. The write-up should also answer all the questions posed by the project description.
- A well commented source code with all subroutines attached
  Students are encouraged to program in Matlab, Python, or C/C++. Other languages are also acceptable. However, students who choose to program in other languages are expected to schedule a one-on-one appointment with the instructor to demonstrate the successful compilation of the source code and successful computation of the velocity field using the complied executable to process the raw images and to determine the velocity field.
- Executable file for Windows 32bit system if the language of your choice requires compilation of the source code and a short description so that the program can be tested.

<u>How PIV works:</u>

The basic principle of the PIV is that a laser light sheet is used to illuminate the flow field which is seeded with small particles to visualize a flow to be measured. A double pulse YAG laser and a double shutter camera are synchronized to record two particle images with very short time separation, typically less than 100 us.



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A laser is chosen as the illuminating light source in PIV because laser can deliver high light intensity for very short pulses, which freeze the motion of seeding particle in effect. The particles that are seeded to flow are typically fine TiO2 powers. It is can be assumed that the seeding particles follow the motion of fluid parcels that the seeding particles reside in exactly due to the very small size of the seeding particles.

Displacement and velocity evaluation

Once the images are successfully recorded, the next step is the PIV analysis. The images are divided into small search areas. These small search areas are called interrogation windows. The cross correlation is applied to these interrogation windows for both two images to obtain the correlation plane for each interrogation window. The location of the interrogation windows in both images are same in the standard cross correlation algorithm (the interrogation windows are shifted in the advanced algorithms).

Then the peak detection and displacement evaluation are applied to obtain the dominant displacement in each interrogation window. As the size of a pixel in flow and the time separation between two images are known, the velocity can be calculated. The size of a pixel in flow is determined by the simple velocity calibration.

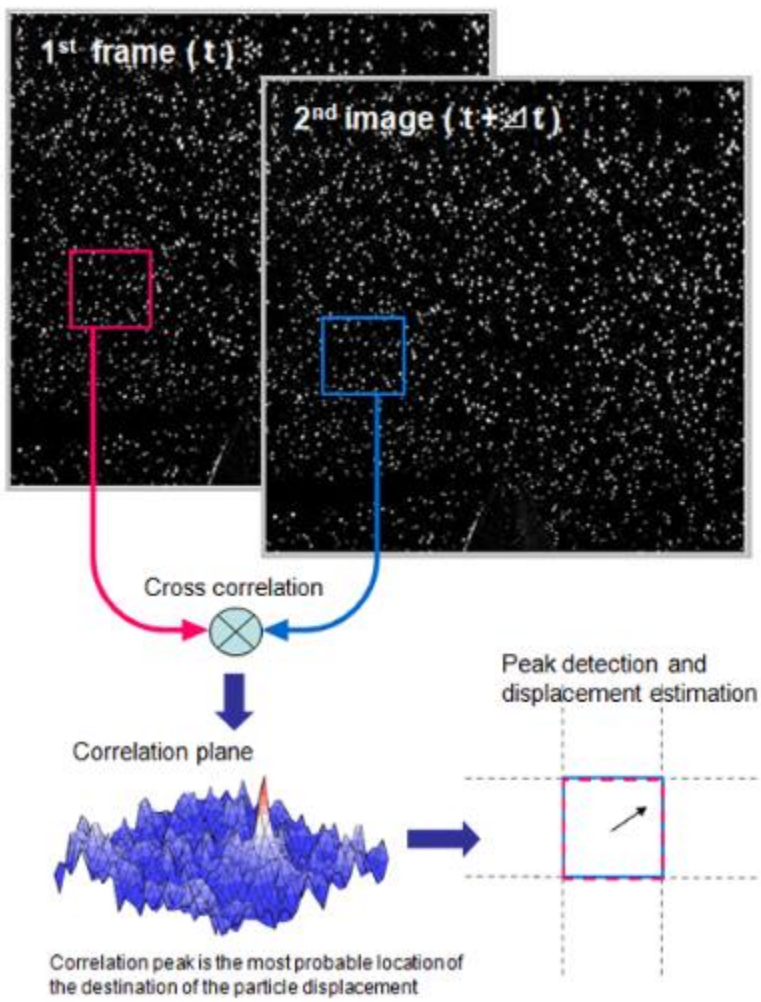
Your mission:

Develop a computer code that completes the following tasks and report your findings in the written report:

1. Confirm the code can read a frame of PIV image and properly display it. Please find and report the highest light intensity scattering off from a seeding particle. Also try to find the mean particle size (in terms of number of pixels per particle) by assuming a light intensity threshold for identifying seeding particles.
2. Determine the size of a square interrogation window. An optimal interrogation window should contain approximately 10 particles. The trade-off here is spatial resolution and the accuracy of each velocity determination. Specifically, big interrogation windows result in sparse velocity data points. At the same time, too small an interrogation window doesn’t contain sufficient number of seeding particles and results in large uncertainty in velocity.
   (a) Report the optimal interrogation window size returned by your code. An interrogation window size that’s often used is 32 pixel x 32 pixel. How does the optimal window size that you found compare to the convention?
   (b) For the interrogation window size of your choice, report the range of particle numbers contained in each and every window.

(c) If the original PIV frame is too big for your computer or you have difficulties in processing pixels near the edge of the image, you may choose to analyze only a subset of the original image pixels. Please specifically report the size and the coordinates of the four corners of your subset and display the subset w.r.t. the original frame. When you choose the subset for image processing, be mindful of the size of the interrogation window that you chose in step 2.

3. Choose any two consecutive PIV frames and calculate cross-correlations of all interrogation window pairs between the two frames. You will get a correlation plane as shown below. Report the correlation plane for the center interrogation window of the original frame or of the subset of your choice. For students choose Matlab as the language for programming, the 2D correlation can be calculated using a Matlab function `xcorr2`.



4. Find the maximum in the correlation plane for each interrogation window pair. Depending on how the correlation plane is defined, find the displacement of the particles appear in the interrogation windows of both frames. Display the displacement vector at the center of each interrogation window for the area you chose.
5. (Optional) advanced algorithm: iteration with decreasing size multi pass as described in LaVision FlowMaster Product Manual page 59 – 62.