PIV image analysis

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Sommario

Analisi di coppie di immagini PIV relative al campo di moto intorno ad un profilo alare di tipo NACA 23012.

1 Introduzione

La *Particle Image Velocimetry* (PIV) è un metodo per la visualizzazione qualitativa e quantitativa del campo di moto di un fluido mediante l'uso di particelle traccianti illuminate da una lama di luce e fotografate in due istanti successivi. I dati rilevanti per l'esperimento sono i seguenti:

- profilo alare *NACA 23012* di corda $30cm$,
- dimensione delle immagini: 1024×1280 pixel *grayscale* (cfr. Figura 4)
- dimensione della finestra di analisi: $103 \times 82mm$
- intervallo tra i fotogrammi: $\Delta t = 10\mu s$

L'analisi si compone di tre fasi: *preprocessing*, *correlazione* ed *analisi* dei risultati.

2 Preprocessing

Prima di procedere alla determinazione del campo di velocità è opportuno analizzare le caratteristiche delle immagini ed eventualmente migliorarne la qualità. Le tecniche di miglioramento possono riguardare:

- *Background subtraction*: tecnica utile ad eliminare lo sfondo comune alle immagini ed evidenziare solo il moto delle particelle. In genere serve una serie di immagini (almeno una decina) per poter eliminare lo sfondo in modo affidabile, pertanto non è stata impiegata qui.
- *Filtraggio*: varie tecniche utili a migliorare la distinzione tra particelle e sfondo e a ridurre il rumore di fondo.

Un utile passo preliminare consiste nell'analizzare la distribuzione dell'intensità di grigio dei pixel, come illustrato in Figura 1. Si evidenzia come sia presente una netta separazione, in entrambe le immagini, tra lo sfondo (maggioranza dei pixel scuri) e le particelle ad intensità massima.

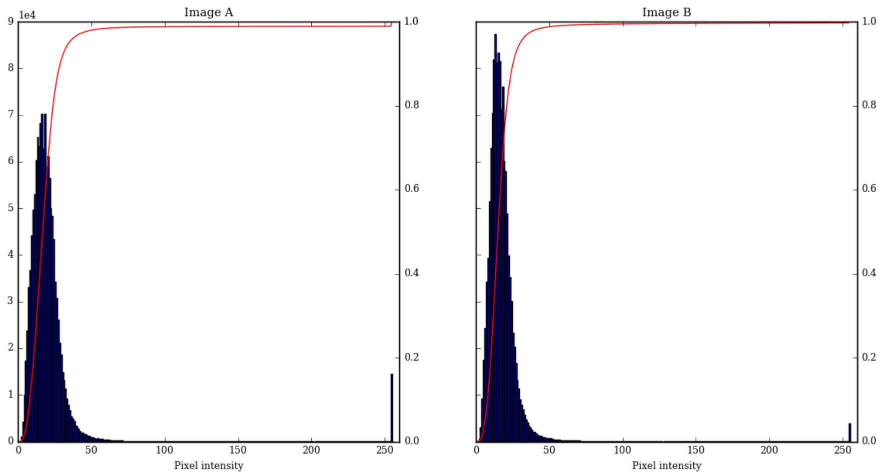


Figura 1: Istogrammi della distribuzione delle intensità di grigio

Per questo motivo si è deciso di utilizzare le immagini originali senza l'applicazione di filtri. Inoltre, alcune analisi preliminari hanno mostrato[1] come l'utilizzo di immagini filtrate possa in questo caso produrre un maggior numero di correlazioni spurie rispetto alle immagini originali, a parità di condizioni di test (cfr. ad es. Figura 5).

3 Correlazione

3.1 Two-dimensional Electron Gas

Here, explain the concept of a 2-DEG in GaAs/AlGaAs. What is a 2-DEG and why does it arise?

3.2 Hall Effect

Explain the classical Hall effect in your own words. What do I measure at $B = 0$? And what happens if $B > 0$? Which effect gives rise to the voltage drop in the vertical direction?

3.3 Quantum Hall Effect

Explain the IQHE in your own words. What does the density of states look like in a 2-DEG when $B = 0$? What are Landau levels and how do they arise? What are edge states? What does the electron transport look like when you change the magnetic field? What do you expect to measure?

[1]Test effettuati utilizzando semplici filtri a soglia o di tipo *min/max*[1]

Figura 2: Raw (unprocessed) data. Replace this figure with the one you've made, that shows the resistivity.

4 Experiment 1-2 pages

4.1 Fabrication

Explain a step-by-step recipe for fabrication here. How long did you etch and why? What is an Ohmic contact?

4.2 Experimental set-up

Explain the experimental set-up here. Use a schematic picture (make it yourself in photoshop, paint, ...) to show how the components are connected. Briefly explain how a lock-in amplifier works.

5 Results and interpretation 2-3 pages

Show a graph of the longitudinal resistivity (ρ_{xx}) and Hall resistivity (ρ_{xy}) versus magnetic field, extracted from the raw data shown in figure 2. You will have the link to the data in your absalon messages, if not e-mail Guen (guen@nbi.dk). Explain how you calculated these values, and refer to the theory.

5.1 Classical regime

Calculate the sheet electron density n_s and electron mobility μ from the data in the low-field regime, and refer to the theory in section **??**. Explain how you retrieved the values from the data (did you use a linear fit?). Round values off to 1 or 2 significant digits: 8.1643 = 8.2. Also, 5e-6 is easier to read than 0.000005.

!OBS: This part is optional (only if you have time left). Calculate the uncertainty as follows:
$u(f(x,y,z)) = \sqrt{(\frac{\delta f}{\delta x}u(x))^2 + (\frac{\delta f}{\delta y}u(y))^2 + (\frac{\delta f}{\delta z}u(z))^2}$, where f is the calculated value (n_s or μ), x, y, z are the variables taken from the measurement and $u(x)$ is the uncertainty in x (and so on).

5.2 Quantum regime

Calculate n_s for the high-field regime. Show a graph of the longitudinal conductivity (ρ_{xx}) and Hall conductivity(ρ_{xy}) **in units of the resistance quantum** ($\frac{h}{e^2}$), depicting the integer filling factors for each plateau. Show a graph of the plateau number versus its corresponding value of $1/B$. From this you can determine the slope, which you use to calculate the electron density. Again, calculate the uncertainty for your obtained values.

6 Discussion 1/2-1 page

Discuss your results. Compare the two values of n_s that you've found in the previous section. Compare your results with literature and comment on the difference. If you didn't know the value of the resistance quantum, would you be able to deduce it from your measurements? If yes/no, why?

Figura 3: This frog was uploaded to writeLaTeX via the project menu.

Item	Quantity
Widgets	42
Gadgets	13

Tabella 1: An example table.

7 Some LaTeX tips

7.1 How to Include Figures

First you have to upload the image file (JPEG, PNG or PDF) from your computer to writeLaTeX using the upload link the project menu. Then use the includegraphics command to include it in your document. Use the figure environment and the caption command to add a number and a caption to your figure. See the code for Figure 3 in this section for an example.

7.2 How to Make Tables

Use the table and tabular commands for basic tables — see Table 1, for example.

7.3 How to Write Mathematics

LaTeX is great at typesetting mathematics. Let $X_1, X_2, \ldots, X_n$ be a sequence of independent and identically distributed random variables with $\mathrm{E}[X_i] = \mu$ and $\mathrm{Var}[X_i] = \sigma^2 < \infty$, and let

$$S_n = \frac{X_1 + X_2 + \cdots + X_n}{n} = \frac{1}{n}\sum_{i}^{n} X_i \tag{1}$$

denote their mean. Then as n approaches infinity, the random variables $\sqrt{n}(S_n - \mu)$ converge in distribution to a normal $\mathcal{N}(0, \sigma^2)$.

The equation 1 is very nice.

7.4 How to Make Sections and Subsections

Use section and subsection commands to organize your document. LaTeX handles all the formatting and numbering automatically. Use ref and label commands for cross-references.

7.5 How to Make Lists

You can make lists with automatic numbering ...

1. Like this,
2. and like this.

... or bullet points ...

- Like this,
- and like this.

. . . or with words and descriptions . . .

Word Definition

Concept Explanation

Idea Text

We hope you find writeLaTeX useful, and please let us know if you have any feedback using the help menu above.

8 Figure Aggiuntive

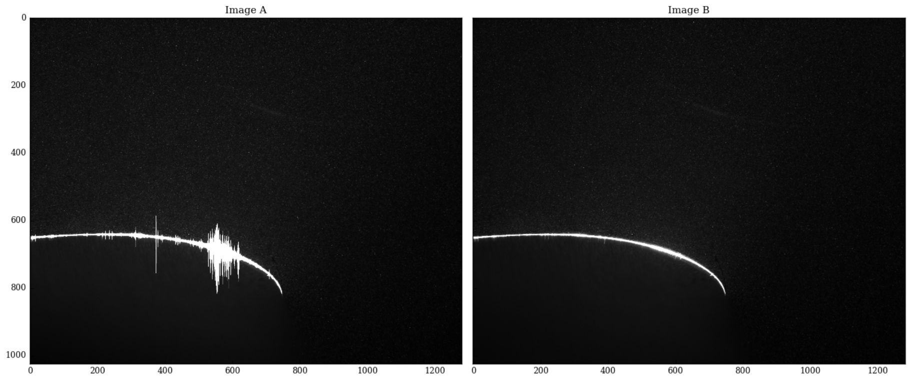
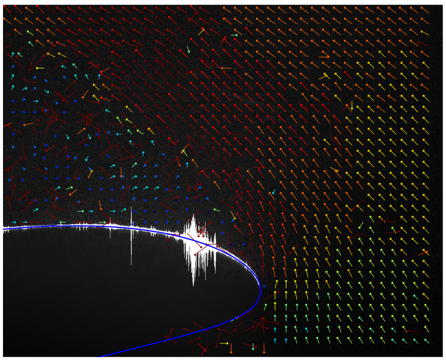
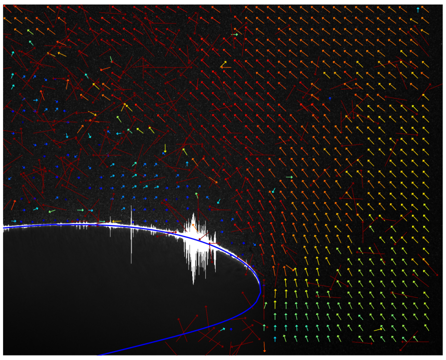


Figura 4: Immagini originali



(a) PIV con Correlazione - finestra 32px



(b) PIV con DFT - finestra 32px

Figura 5: PIV su immagini filtrate

Riferimenti bibliografici

[1] Deen, Niels G., et al. "On image pre-processing for PIV of single-and two-phase flows over reflecting objects." Experiments in fluids 49.2 (2010): 525-530.