Pre-processing for multidimensional spatial filtering technique

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On using Particle Image Velocimetry (PIV) a high amount of data has to be handled. The succeed images have to be downloaded from high speed camera for offline analysis. This takes a long time. To overcome this bottleneck of data transfer we propose to use pre-processing in connection with spatial filtering velocimetry.

One step in calculation of the spatial filtering signal is the summation of the pixels grey values of each row and column. This reduces the amount of data of an $N \times N$ array down to $2N$.

Spatial filtering velocimetry by means of structured detectors

In spatial filtering technique the image of the observed scene is weighted by a grating and summed up to a spatial filtering signal $s(t)$ as:

$$s(t) = \sum \int_i(t) g_i.$$  (1)

By using structured detector the weighting function of the grating is adjustable in certain ranges. Figure 1 shows the main principle.

The frequency of $s(t)$ is proportional to the velocity of the moving scene:

$$v = \frac{f_0 G}{M}.$$  (2)

Here $f_0$ is the main frequency of the signal, $G$ represents the size of grating period and $M$ is the magnification of imaging optics.

The procedure shown in figure 1 can be applied to each interrogation area compared to PIV and for $x$ and $y$ direction respectively.

Concepts for pre-processing

In the first concept for data pre-processing the internal summation of each pixels row and column of a smart pixel sensor is used. The sensor reaches frame rates up to 3200 fps. Arranged in an array of sensors each sensor represents an interrogation area compared to PIV. Figure 2 shows a schematically assembly of the array.

![Fig. 2 Schematically setup of sensor array](image)

The sensor array consists of 16 smart pixel sensors. The timing control and read out of data is handled by a Field Programable Gate Array (FPGA). The weighting of the sensors data and summing up to spatial filtering signal can be done by the FPGA. So only the signals have to be transmitted to the PC. This means a data reduction of 25MB/s down to 800kB/s. This pre-processing makes real time measurements possible.

The second concept utilizes an electrically controllable micro mirror device. The displayed image of the observed scene is reflected in two different directions (depending on the mirror state). Figure 3 shows the concept using a mirror array implementing a differential grating.

![Fig. 3 Principle for using a micro mirror array for spatial filtering velocimetry](image)

So the weighting if the image and the summation are already done in the receiver path.