

ARE MORE PIXELS BETTER?

APPLICATION NOTE PIV-023 (US)

Introduction

Are more pixels better? What is the optimal number of pixels for PIV measurements? How many pixels do you need to capture the flow features you are interested in? Is the trade-off in capture rate worth the increased spatial resolution afforded by an increase in pixels? How does pixel size factor in to spatial resolution?

All good questions. This technical note makes the comparison between a typical 4-mega-pixel (4MP) high-speed CMOS camera and a 29-mega-pixel low-speed 29MP CCD camera.

Experimental Setup

The 4MP camera was a Phantom VEO340 camera with 2560×1600 pixel resolution and 10-micron pixels and sensor size of $25.6 \text{ mm} \times 16.0 \text{ mm}$. The camera operates at a maximum frame rate of 800 frames per second (fps) with full pixel resolution (higher capture rates can be used at lower pixel resolutions). The tests performed here were at full pixel resolution.

The 29MP camera was the TSI model# 630094 CCD camera with pixel resolution of 6600×4400 pixels, pixel size of 5.5 microns, and sensor size of $36.3 \text{ mm} \times 24.2 \text{ mm}$. The maximum frame rate of this camera is 3.6 fps.

Both cameras imaged the free stream flow in a wind tunnel with soap bubble seed particle tracers generated by a TSI BG-1000 bubble generator with bubbles with a mean diameter of 15 microns. The seed particles were illuminated by a 200 mJ/pulse dual-head Evergreen Nd:YAG laser. Light sheet optics formed a laser sheet by which the seed particles were illuminated.

The magnification between the two camera setups is different at 0.1 for the 29MP and 0.04 for the 4MP camera. The reason for this is that the stand-off distance was changed in order to more closely match the approximate field of view.

Table 1 shows several of the relevant camera parameters.

Table 1. Camera Parameters

		29MP	4MP
Pixel Size	microns	5.5	10
Pixel Resolution		6600×4400	2560×1600
Field of View	mm	350×235	590×350
Sensor Size	mm	36.3×24.2	25.6×16.0
Lens Focal Length	mm	50	50
# of Vector		205×136	79×49
Magnification		0.104	0.043
Microns/Pixel		53.55	240.03
Vector Pitch	(50% overlap)	1.7	7.8
Stand-off Distance	mm	480	1150



Figure 1 shows a zoomed-in example of the interrogation windows—showing a 64×64 pixel region of the image. The image on the left is from the 4MP camera, and the image on the right is from the 29MP camera. Notice that the particle images from the 4MP camera encompass approximately 2 to 3 pixels, while the particle images from the 29MP camera encompass 8 to 16 pixels.

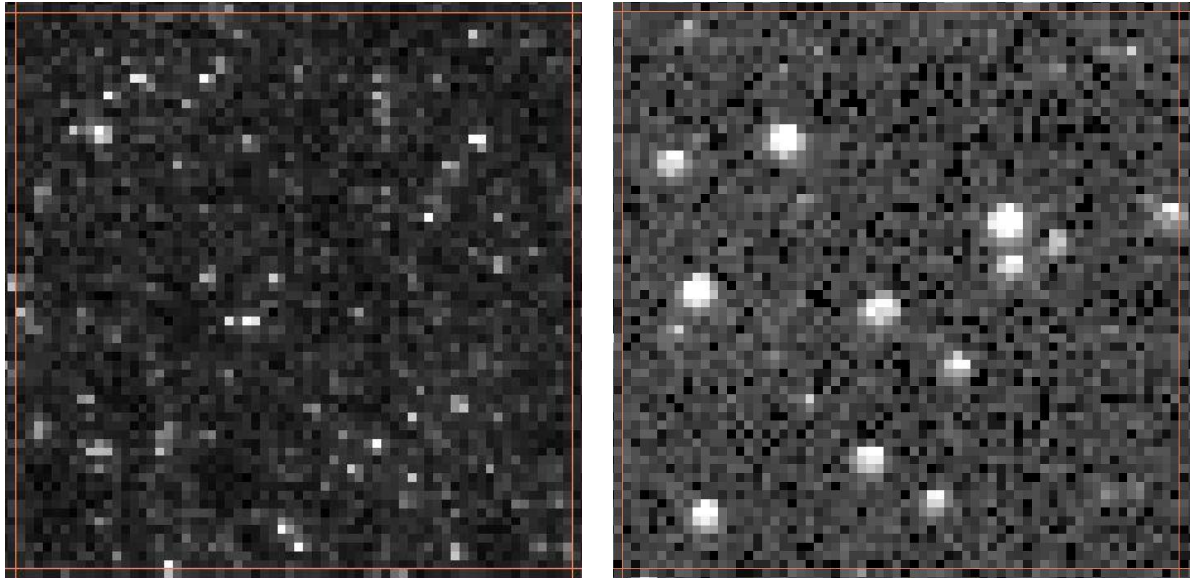


Fig. 1. A 64×64 pixel interrogation window from the 4MP camera (left), and the 29MP camera (right)

Results

Images were acquired and then processed using INSIGHT 4G™ software. The same processing scheme was used for both sets of images, which consisted of a recursive Nyquist cross-correlation, with a starting spot size of 128×128 pixels, and a final spot size of 64×64 pixels.

The following figures show several sample vector fields. Figure 2 shows an instantaneous vector field from the 4MP camera. A zoomed in portion of the vector field, representing an area $7 \text{ cm} \times 4 \text{ cm}$, is also shown to highlight the details. The vectors represent the velocity magnitude with the mean free stream velocity subtracted. Notice there is not much detail in the 4MP zoomed-in vector field.

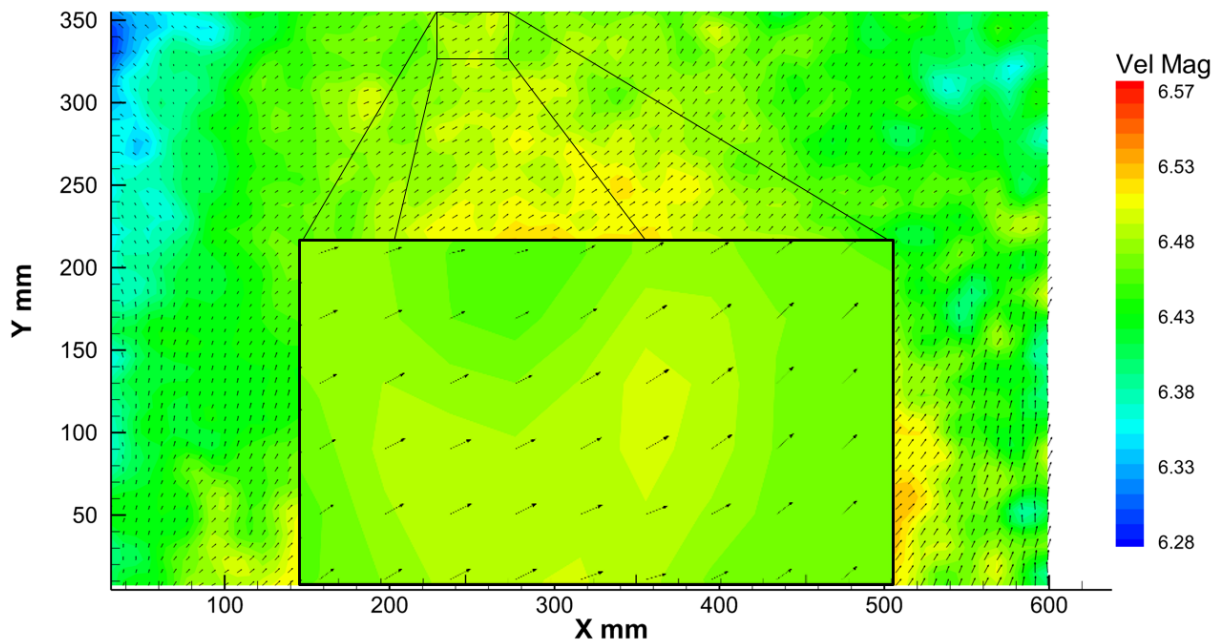


Fig. 2. An instantaneous vector field from the 4MP camera. The mean free stream velocity has been subtracted from the vectors. The inset shows a $7 \text{ cm} \times 4 \text{ cm}$ zoomed in portion of the vector field.

Figure 3 shows a vector field from the 29MP camera, with a similar 7 cm × 4 cm zoomed-in portion. Notice the increased level of detail even at the small scales that are visible in the higher resolution camera. The increased number of pixels allows for even small-scale spatial structures to be seen.

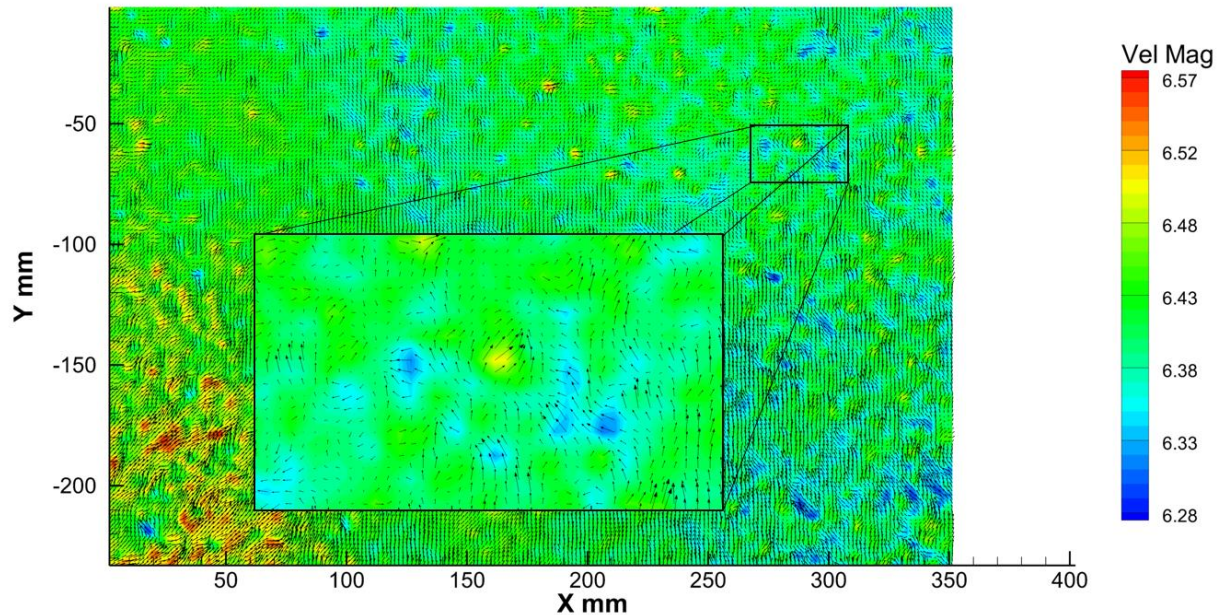


Fig. 3. An instantaneous vector field from the 29MP camera. The mean free stream velocity has been subtracted from the vectors. The inset shows a 7 cm × 4 cm zoomed in portion of the vector field.

Conclusion

The trade-off between a high-speed camera and a low-speed high-resolution camera is that the high-speed camera can capture at a high rate of speed. The advantage of a low-speed camera is that the higher pixel resolution allows for smaller spatial structures to be identified, within the context of the larger structures.

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