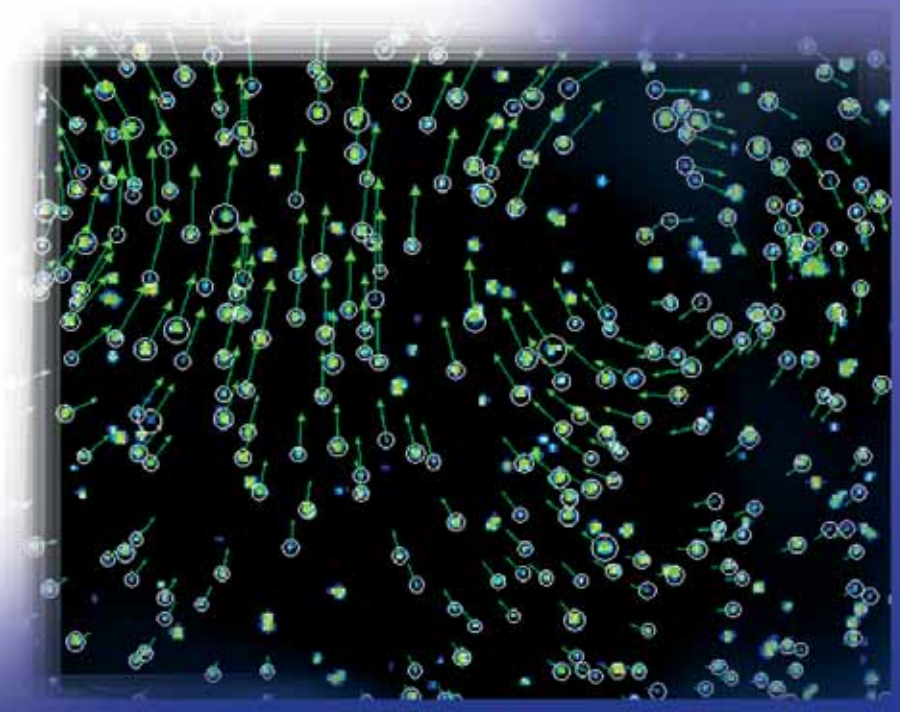
Super Resolution Particle Velocimetry

With Super Resolution Particle Velocimetry

- Obtain the highest possible vector resolution spatially, through the determination of individual particle velocity
- Extract the most accurate velocity vector field utilizing unique particle identification, tracking, and matching algorithms
- Obtain velocity values with the highest spatial resolution at uniformly spaced grid locations for further data analysis and interpretation
- Get particle image size and associated statistical properties using a robust and unique processing scheme
- Examine multiphase flows



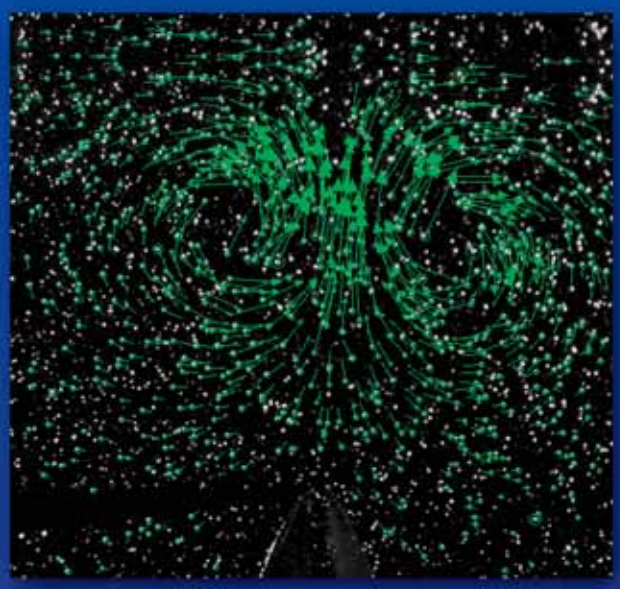
Super Resolution Particle Velocimetry

The revolutionary new *Super Resolution Particle Velocimetry* approach is included in the latest INSIGHT 3G™ Global Imaging Software package. This analysis approach provides the velocity field information with the highest possible spatial resolution and superior accuracy.

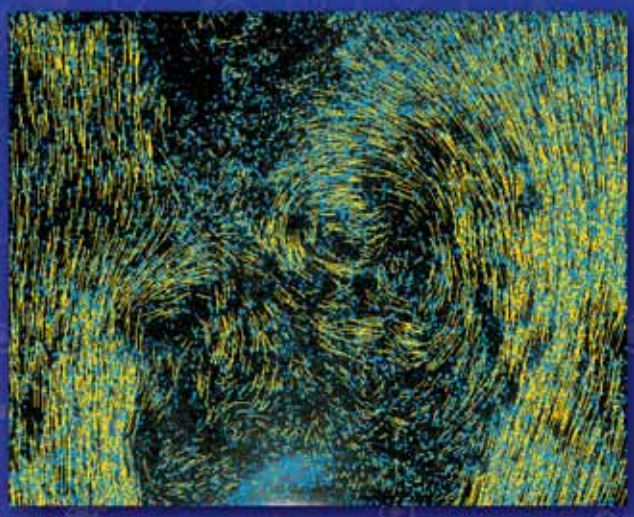
How does it work?

The unique processing approach employs a multi-step processing scheme to extract the velocity field with the highest possible resolution. From a pair of image fields, the analysis scheme:

- Identifies each particle using unique image processing tools
- Tracks each particle motion using the powerful ICP Scheme
- Solves the particle correspondence using a robust iterative convergent process
- Accounts for flow motion in translation, rotation, and deformation using a process incorporating correlation
- Provides an accurate data set using embedded match validation



Individual particle velocity field - vortex flow



Individual particle velocity field - circulating flow

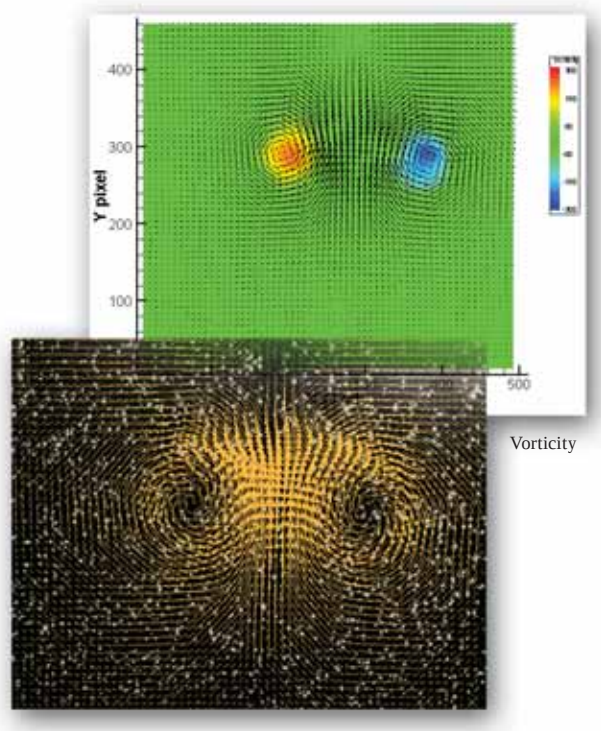
What are the Results?

In Particle Image Velocimetry (PIV), velocity values obtained at each interrogation region represent the velocity of the group of particles within each region. The ability to go from the velocity for the group of particles to the velocity of each individual particle within the interrogation region, separately, represents the highest possible spatial resolution. The results from the Super Resolution Particle Velocimetry offer the best possible matching of the particle images to get this highest spatial resolution velocity measurements.

Statistics, Data Analysis, and Interpretation from the velocity field

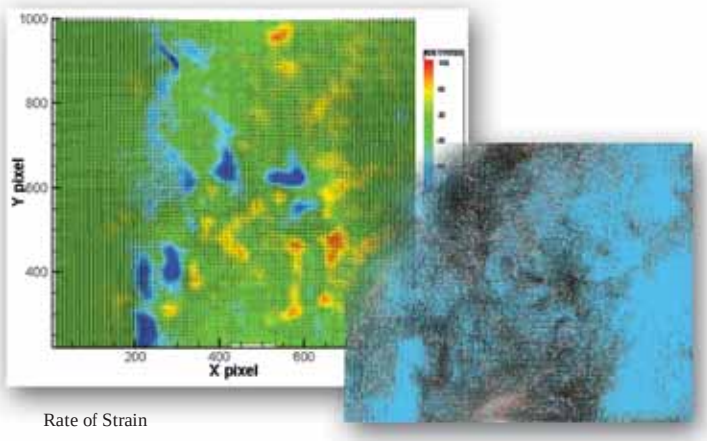
Detailed statistical properties of the flow are computed, generally using velocity values available in a regular or equally spaced grid arrangement. Special interpolation schemes have been developed to arrive at the super resolution velocity field in a regular grid format from the individual particle image velocity field. This ability to get the velocity field in a regular grid format is selectable in the *INSIGHT 3G* software package.

In Super Resolution Particle Velocimetry, the interpolation on a regular grid is performed adapting the Delaunay Triangulation method combined with a powerful bi-cubic scheme, providing a robust scheme to go from the individual particle velocity field to the velocity field values at evenly spaced grid locations.



Vorticity

Interpolated velocity field - vortex flow



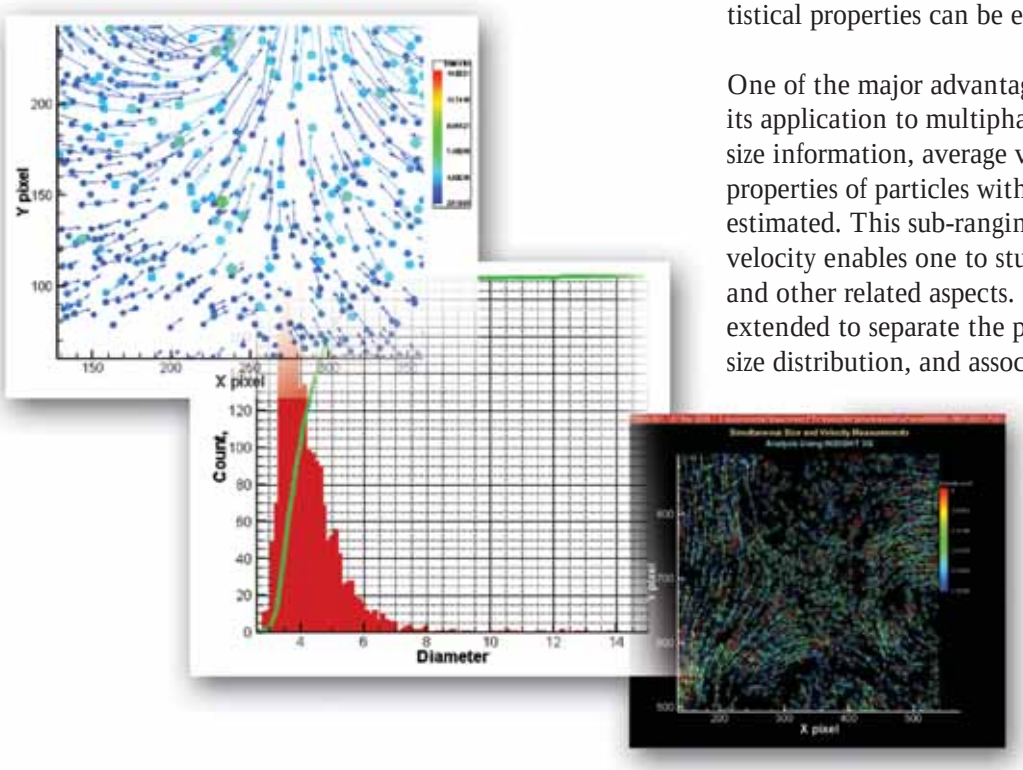
Rate of Strain

Interpolated velocity field - circulating flow

Velocity field with particle image size

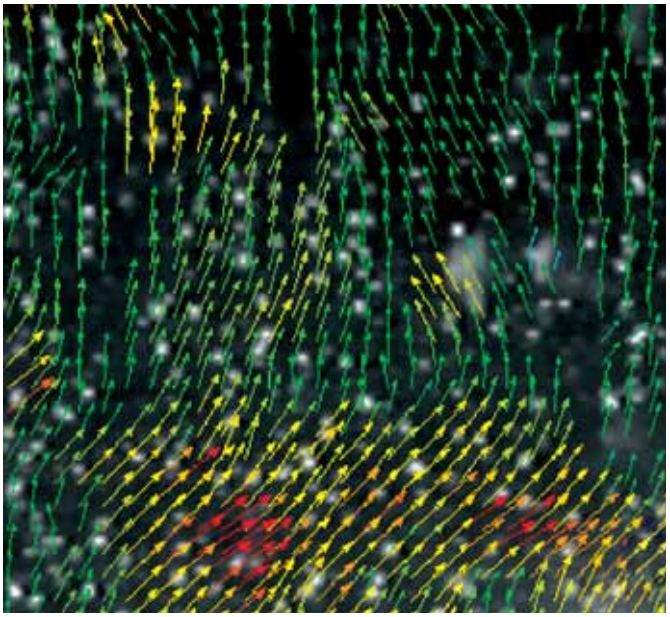
In many practical flow situations, the size of the particle in addition to the velocity field is of interest. During the process of determining the velocity field with super resolution, individual particles are identified along with their velocity. Thus, in Super Resolution Particle Velocimetry, the size of each particle image is also obtained along with the particle velocity. From these, size histograms, correlation of size and velocity, estimation of flux, and other statistical properties can be estimated.

One of the major advantages of having size information is its application to multiphase flow analysis. Based on the size information, average velocity and other statistical properties of particles within a selected size range can be estimated. This sub-ranging of data based on size and velocity enables one to study transport, particle dynamics, and other related aspects. This approach can be further extended to separate the phases and obtain their velocity, size distribution, and associated properties.



Multiphase flow Analysis

Another unique feature of the Super Resolution Particle Velocimetry included in the INSIGHT 3G package is the analysis of multiphase flows. Solid particles in liquid flows, spray droplets in gases, andgas bubbles in liquids represent some common examples of multiphase flows that are of interest. With Super Resolution Particle Velocimetry, sub-ranging based on image size can be advantageously used to separate the phases. Further, separating or removing the sub-ranged images enables one to examine the image field for each phase separately. The result is the ability to study the flow dynamics, transport, and interactions in great detail for each phase. These are only some of the abilities of the innovative new Super Resolution Particle Velocimetry approach.



Flow velocity - large bubbles removed

INSIGHT 3G Global Imaging, Analysis, and Display Software Platform

The INSIGHT 3G package features all of the tools needed for even the most advanced global imaging measurements, from our patented processing algorithms to the most elaborate data analysis features available. And now, equipped with the *HyperStreaming* Module, the power of the INSIGHT 3G Platform can be unleashed on enormous amounts of data, using features such as the POD Analysis Toolbox and distributed processing capability over a network of computers to quantify the flow properties of interest with the desired detail.

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