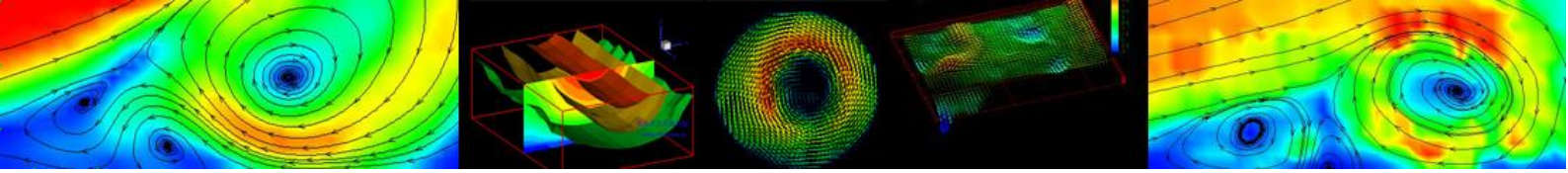
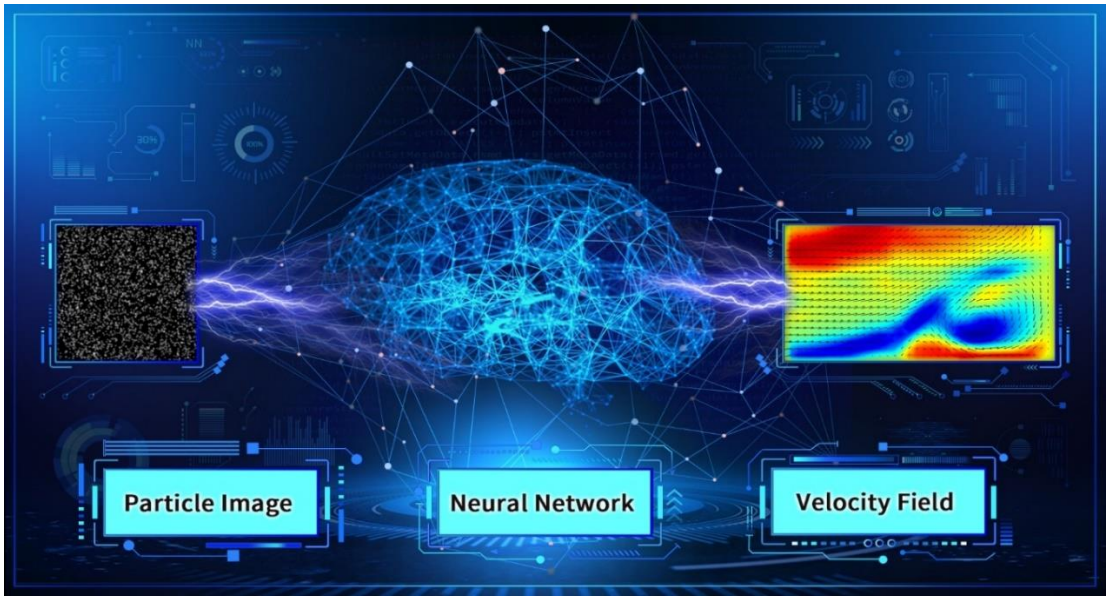
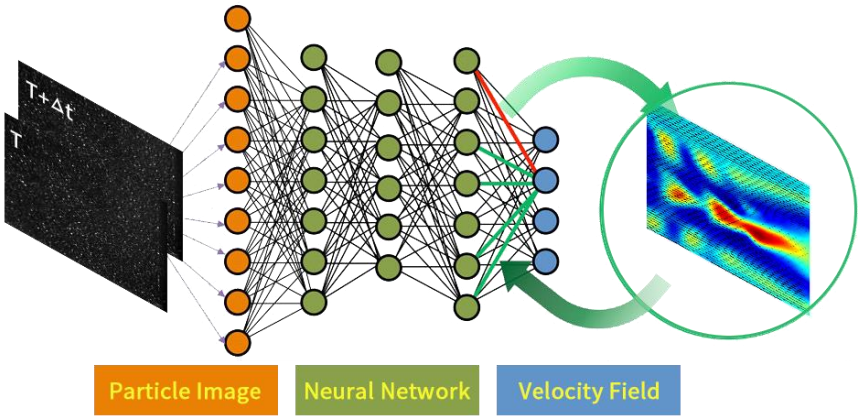


Microvec AI PIV

Microvec has been developing proprietary PIV technology and has been constantly improving and implementing new techniques and algorithms based on the latest research in the field since 2002. It has a history of constantly introducing new and innovative techniques and algorithms such as Pressure PIV in 2014 or Light Field PIV in 2017. The newest unique innovation is world's first introduction of Artificial Intelligence (AI) PIV.

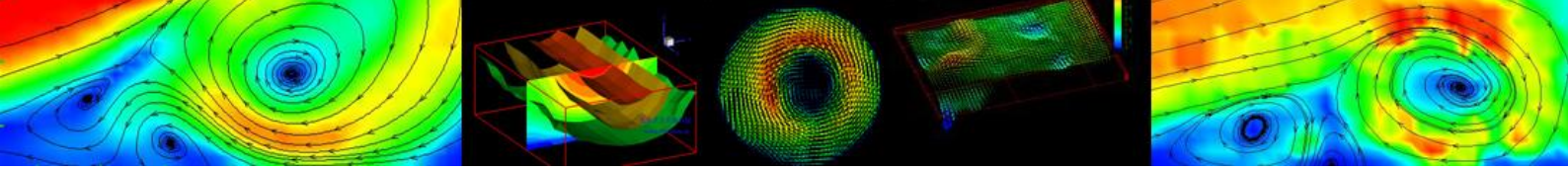


With the advances of artificial intelligence and ever wider adoption of deep learning techniques based on Convolutional Neural Network (CNN), common in the computer and machine vision worlds in recent years, PIV methodology based on deep learning has turned out to be very accurate. Microvec' AI PIV is based on the optical flow neural network which has already proven itself in the computer vision community. It has been successfully applied to fluid mechanics and particle image velocimetry, where global and quantitative velocity field from images can be extracted with improved computational efficiency without reduction of accuracy.



The first step is to generate a training data set including particle images and the ground truth fluid motions to train the parameters of the networks. Over 13,000 training data items have been generated with CFD, based in artificial images of 256 x 256 pixels with dense motion fields. Such a learning model gives satisfactory results on not only the training data but also the testing set. Even in much more complicated cases with DNS turbulence, containing a number of small-scale flow structures the proposed network model is superior to the other methods and has the ability to extract the flow motion from particle images.

At the end this deep neural network for PIV can provide dense motion estimation (up to max. one vector for one pixel) efficiently. There is no longer a limitation of velocity vector field based on interrogation window size. The feature matching of particle image extracted by the neural network is found to improve the accuracy



of estimation. The experimental results indicate that compared with the traditional cross correlation and optical flow methods, the proposed deep neural network has huge advantages in accuracy.

Microvec AI PIV software has several advantages:
- Calculation time is faster than traditional PIV calculation time when using GPU. The calculations speed is near real time.
- The accuracy extends to maximum single-pixel calculations, where it is one order of magnitude higher than in case of cross correlation calculations.
- Dense velocity field is obtained much faster
- "What You Get Is What You Use". Some of the post-processing techniques like outlier detection, velocity filtering etc. are no longer necessary to get correct and accurate results
- It is easy to use without the need of Interrogation Window sizes, iteration number and sub-pixel fitting
- Automatic and accurate restoration of the flow field.
- Can be applied to jet field, boundary layer flow, shock in hypersonic flows, micro flow channel, etc.
- Especially effective for stagnant flows where single pixel calculations increase accuracy of the results

Case study: Estimated velocity magnitudes of the jet flow

The experiment has been performed on a jet flow to obtain velocity field. This experiment can form typical flow structures such as jet, velocity gradient, vortex and separation flow, all of which are common flow types in experimental fluid mechanics. Microvec traditional 2D PIV software based on cross-correlation algorithm has been used to calculate the results shown in Figure 1 on the left and AI PIV software has been used to calculate the results shown in Figure 2 on the right. There is no significant difference in the results between the two measurements. However, since the dense velocity field obtained in AI PIV contains more detailed information, down to single pixel level, it can be seen from the amplitude map, that the results of the deep neural network are smoother than those of the correlation analysis method and a new vortex can be seen, previously invisible because of the spacial limitations.

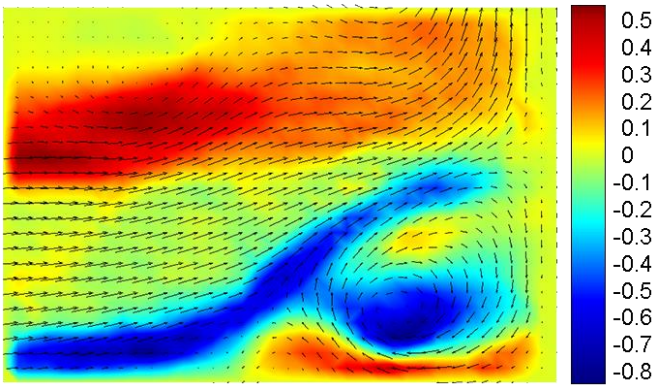


Figure 1. Cross correlation PIV result

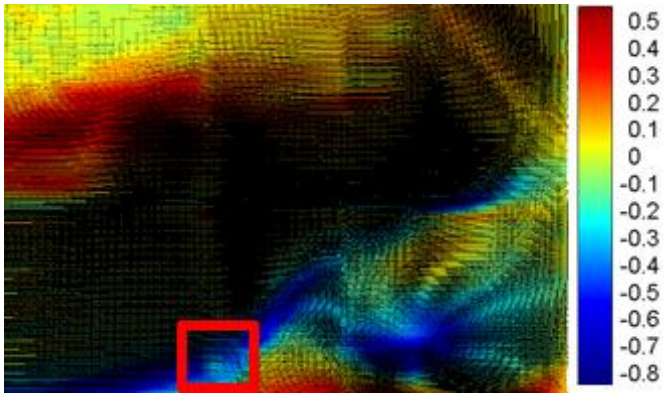


Figure 2. AI PIV result

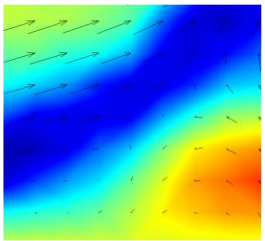


Figure 3. Detailed Cross correlation PIV result

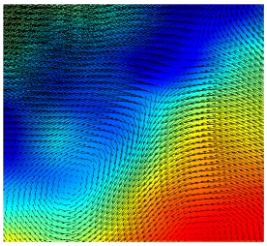
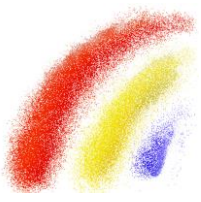


Figure 4. Detailed AI PIV result



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