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A large scale synchronous velocity measuring system based on the PTV technology

Hydrolink

A LARGE SCALE SYNCHRONOUS VELOCITY MEASURING SYSTEM BASED ON THE PTV TECHNOLOGY

BY JUN ZHENG, MINGXUAN REN, XIHUA WANG AND ZHAOSONG QU

The technology of Particle Image Velocimetry (PIV) can be used to measure simultaneously and instantaneously velocities over an entire field. Fujita (1998) used the PIV technique to measure velocity distributions in a wide range of conditions. Since the PIV algorithm is complicated, the time required to calculate the measured velocity distribution is large, which makes real-time measurements of broad velocity distribution fields hard.

A branch of the PIV technology is Particle Tracking Velocimetry (PTV). Because of its simple algorithm and fast computation, it is more practical to use PTV to measure the velocity distribution over large fields in hydraulic model experiments. A velocity distribution measuring system developed based on PTV, has been used in physical model experiments (Xingkui Wang, 1996). The images recorded and stored on video tape, are processed after they have been collected, and then the required calculations and analysis are performed by the system. This makes it hard to use this approach for real-time measurements. The development of monitoring cameras has made it possible today to obtain real-time measurements of the velocity distribution over large areas (Mingzhong Yu, 2002). However, the data transmission of the cameras is limited by bandwidth, and it is not possible to synchronize the collection and transmission of data from multiple cameras. Consequently, the method of collecting images introduces cumulative errors leading to incorrect results when velocity measurements over large areas are combined. Beijing Sinfotek Technology Co., Ltd (Sinfotek) has developed a large-scale synchronous velocity measuring system based on the PTV technology. The system can obtain quickly and accurately the flow field in a model test, as well as the flow velocity distribution on cross sections, and the velocity history at single or multiple points. The system has solved the problem of multi-camera collecting images simultaneously, and has improved the synchronization of collecting images greatly. (Sinfotek Open Patent No.: CN100487372C). In order to measure the velocity distribution over large areas the system was further improved by using Local Area Network (LAN) technology. The system has been used widely in hydraulic model experiments in many scientific research institutes and universities.

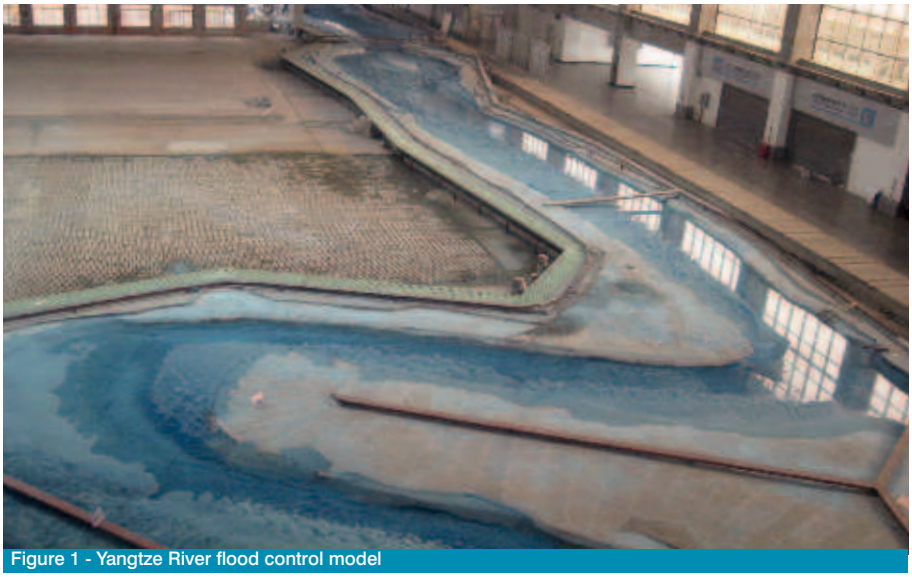

Figure 1 - Yangtze River flood control model

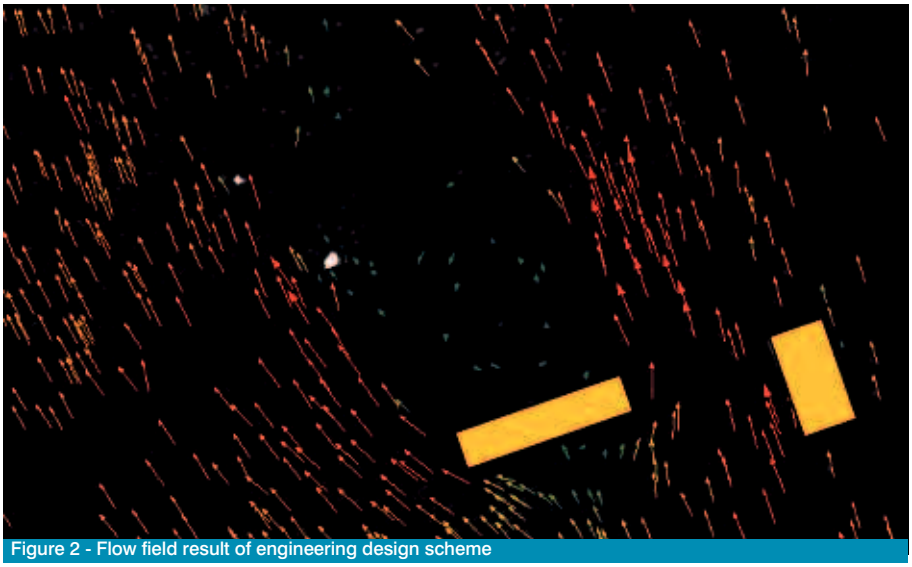

Figure 2 - Flow field result of engineering design scheme

Key Technology

Acquisition Terminal

The system uses high-resolution Charge Coupled Device (CCD) cameras for image acquisition. Cameras are installed above the hydraulic model. The vertical distance of each camera from the model is determined by the range of measurements. When the camera is installed at a fixed height above the model, the number of cameras can be calculated based on the size of model and the vertical distance from the camera to the model.

The system uses optical fiber and cable to sample images, and then transfers the images to a computer for processing.

Figure 3 - The real scene of bend model test

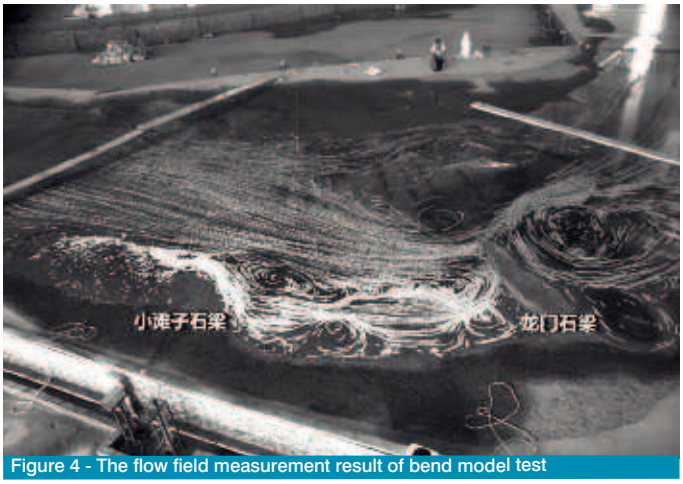

Figure 4 - The flow field measurement result of bend model test

Software Algorithm

The software system uses image processing to recognize individual particles and extract their coordinates. Then, the system processes sequences of images matching individual particles. The coordinates of matched particles are used to calculate their velocity.

The system uses the method of adaptive threshold to achieve image segmentation, the purpose of which is to recognize individual particles. The pixels belonging to different particles are divided into groups, one group per particle. Each group contains a few pixels.

The center coordinate of a particle is calculated based on the coordinates of all the pixels in a group.

Local Area Network (LAN) Extension

It is very difficult for a standard system (16 cameras) to meet the needs of large models. In this regard, the system is expanded using a LAN.

With this expansion, the system can measure the velocity distribution over large areas. The expanded system consists of a number of standard systems. The standard systems communicate with each other via 1 or 10 Gigabit LAN. All the standard systems aggregate into one network edition system. Any of the standard systems can play the role of “server” or “client”. The "server" sends instructions to the "client", receives the velocity data from the "client", and then merges and saves the velocity data. The "server" also has other functions, such as, real-time monitoring of each channel of the "client" adjusting the threshold of each channel setting parameters and so on.

In order to make the system more integrated, the “client” and the “server” are packaged in a cabinet. To perform simultaneous velocity measurements the operator only needs to control a “server”, which controls the entire system.

Application

The system has been widely used in hydraulic model experiments for rivers and harbors, as well in various flume experiments. Many universities and research institutes in China, such as Tsinghua University, Yangtze River Scientific Research Institute, Nanjing Hydraulic Research Institute and Wuhan University, have used the system.

Conclusion

The technology of Particle Image Velocimetry, a non-contact and high-precision velocity measurement technique, is widely used in hydromechanics. A system developed based on the technology of PTV has been applied to real-time measurements of the velocity distribution over large areas. The system has solved the problems of synchronization and expansion, which has improved greatly the accuracy of velocity measurements, and expanded the scope of its applications. ■

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