Supplemental Material

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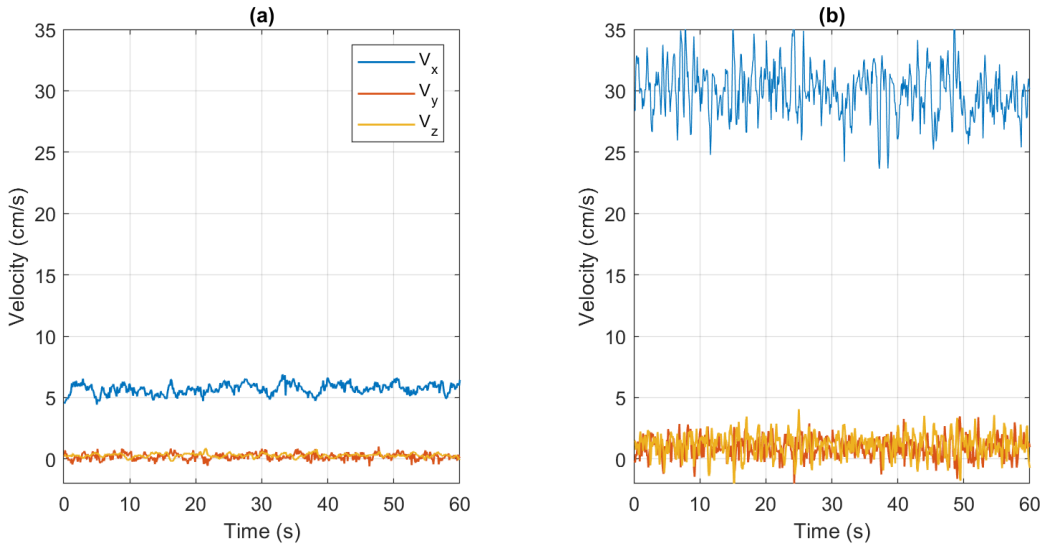

Figure S1 The behaviors of flow in the experimental flume as measured by an ADV. (a) The flow at lowest velocity setting where the main flow velocity is 5.7±0.4 cm/s. (b) The flow at highest velocity setting where the main flow velocity is 29.9±2.0 cm/s.

S1. Real-time Processing Detailed Method

To explore the ability of the VIV to perform real-time velocity measurement, data from the field deployment was used to benchmark the processing speed of several candidate internal computers. For this study, three models of Raspberry Pi: model Zero W, 3A+ and 4B (2GB RAM) were evaluated. All three boards ran on 32GB Class 10 microSD Card (SanDisk, California) flashed with Rasbperry Pi Operating System. Each unit was powered by a benchtop power supply (Eventek) that supplied 5V. The current draw of the computers was measured by connecting a multimeter (Extech Instruments, Massachusetts) from the positive end of the power supply to the positive input of the computer board.

The video from the deployment shown in Fig. 5 was read by each computer, which was programmed to obtain two consecutive frames from the video ports and then run the full processing algorithm to estimate the velocity components before obtaining the next pair of frames. All programming was done in Python 3.7. The video decoding and image processing were handled by OpenCV package, and the image cross correlation and peak detection were handled by OpenPIV package. The analysis time for each pair of images as measured in the Python code was recorded for 1000 velocity estimations. The data presented in Table 2 represent the mean and the standard deviation from the set of 100 measurements.

Additionally, a Jetson Nano developer kit (Nvidia) with 4GB RAM, another low-cost single board computer, was also tested. It represents a family of single board computer with a more powerful graphical processing unit that enables accelerated image processing. The developer kit was chosen for this test because it worked natively with Raspberry Pi Camera V2, which was used in the VIV, without any need for additional software installation. The experimental setup for the Nano developer kit was the same as for the Raspberry Pi boards, but the SD card was instead flashed with Ubuntu 18.04 operating system.