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Towards handheld UVP

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Through its hardware size, the installation and handling of UVPs was not convenient. Also the setup complexity limited the UVP technology to trained users or ultrasonic technology experts. In this extended abstract, we present the world's first handheld UVP, which simplifies its use on large setups and moving systems. The UB-Lab P has, through the presented results, proven its efficiency in hydraulics engineering studies on physical models, especially with a moving carriage. The high sensitivity of the UB-Lab P enables measurement even in low scatterers suspension conditions, such as low flow rates. The cloud.ubertone.eu processing and visualization tool allows fast visualisation of raw measured data. It also provides processing scripts to prepare the data for non-acoustics-experts, synchronising carriage positioning systems with velocity measurements, processing the raw Doppler velocity measurements in multi-components vectors and filtering data.

Keywords: UVP, compact, autonomous, hydraulics, flow scanning

1. Introduction

As Ubertone's first goal is to bring the UVP technology to more users and applications, we follow several RTD (research and technology development) axes. One axis concerns the multiplication of measured velocity components along a profile, while keeping a high space-time resolution, which led to the UB-Lab 2C, launched in 2018, a commercial ADVP (Acoustic Doppler Velocity Profilers). Another axis is mobility and easy installation with miniaturisation and autonomy. While UVPs are usually of the size of PC towers, Ubertone released its first compact laboratory UVP in 2011. Continuing in this direction, we launched last september 2020 the UB-Lab P, the world's first handheld UVP, a ready-to-use battery-powered instrument, with an embedded web-interface accessed by wifi.

Apart from the convenience of having instruments of small size and wireless that can be controlled with a smartphone, these characteristics may be a strong advantage when working on large setups, industrial plants or on moving systems. This is the case in many physical models used in hydraulic engineering [1] or on small rivers [2] in which high resolution velocity measurements are needed.

This presentation will focus on the UB-Lab P, with an application example on a physical model of a river section.

2. Material and Method

2.1 The UB-Lab P

The UB-Lab P is a handheld profiler equipped with a Wifi connexion and an internal battery in a compact enclosure. Some specifications are given in Table 1.

Table 1: Specifications of the UB-Lab P

Emitting frequency	0.025 to 3.6MHz
Spatial resolution	Down to 0.73 mm
Cells number	200
Transducers channels	2
Velocity accuracy	0.2 to 1 %
Sampling rate	up to 15 Hz
Trigger	IN/OUT
Communication	Wifi
Weight	0.2 kg
Consumption	2.5 W, on battery

A trigger 'in' or 'out' is available on the device. The input mode has been used in this measurement campaign. When a recording is started through the graphical user interface, the input signal enables the storage of data. Only blocks where the "trigger" signal is at high level (at the beginning and the end of the block) are effectively stored in the record file.

2.2 UVP Measurements

The UVP (Ultrasonic Velocity Profiler) technique has been introduced to Fluid Mechanics by Takeda [3]. This technique based on coherent Doppler provides velocity profiles measurements with a high spatial and temporal resolution. An ultrasonic pulse is emitted in a narrow beam and the particles, suspended in the flow, scatter the pulse. The echoes of the particles are received by the same transducer (monostatic mode) which allows the observation of a profile composed of many measurement cells distributed along the beam axis. The signal is processed providing information of the velocity component projected on the transducer's axis.

Combining cells in two diverging beams allows getting average two-components velocity profiles.

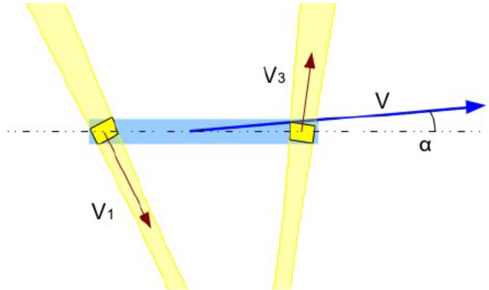

Figure 1: Combining two velocity projections on two transducers to get the velocity vector orientation and module

The backscattered echo amplitude is recorded simultaneously with the velocity measurement. The water level (or of any other interface) can be evaluated by observing a strong variation of the backscattered echo amplitude gradient.

2.3 Setup

The flume is a physical model of a river with a hydraulic structure and is situated in the hydraulics lab hall of the CNR - Compagnie Nationale du Rhône, in Lyon, France.

The maximal depth in the flume is around 50 cm and flow velocities vary from -10 to 50 cm/s.

The CNR was interested in the flow mapping over the whole physical model. They defined a few specific transects of interest.

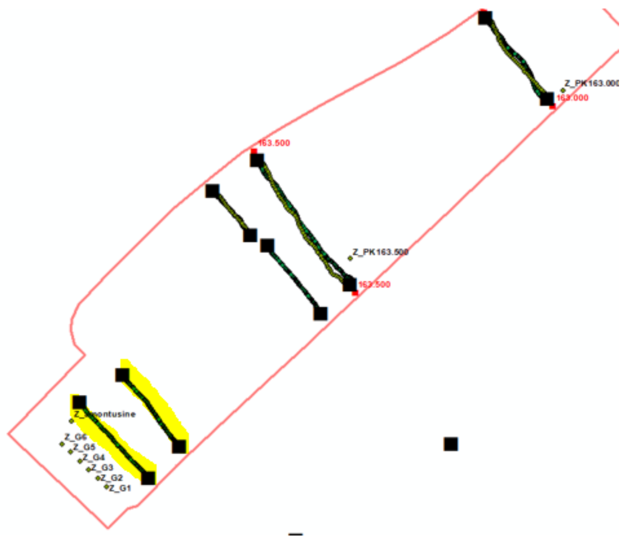

Figure 2: Flume sketch. Hydraulic structure situated downstream in the bottom left corner. Transects of interest indicated with lines.

The flume was equipped with a programmable carriage, recording xyz positions and able to manage a few sensors.

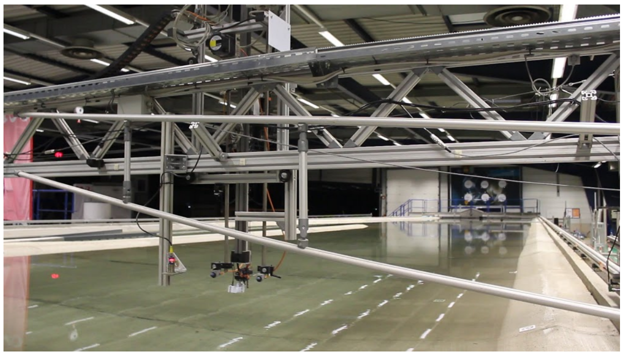

Figure 3: Carriage above the flume

2.4 Installation

The instrument's small size, weight and wireless communication make the installation easy.

As the access to the graphical user interface goes through a common web browser and is compatible with a smartphone, the use of this device is plug-and-play simple.

The internal battery of the UB-Lab P has a 4 hours autonomy. The use of an external power bank can enhance the autonomy up to a few days.

The trigger input of the UB-Lab P was connected to the carriage control unit.

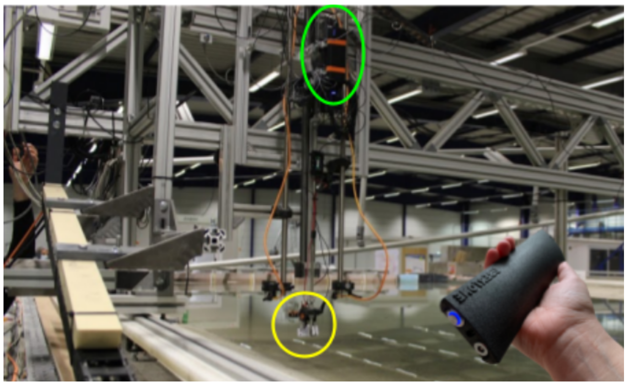

Figure 4: UB-Lab P (within the green circle) installed on the carriage

Two diverging transducers are used to get average two-component velocity profiles along the vertical axis, and a motor orients the transducer holder between U/W or V/W plane.

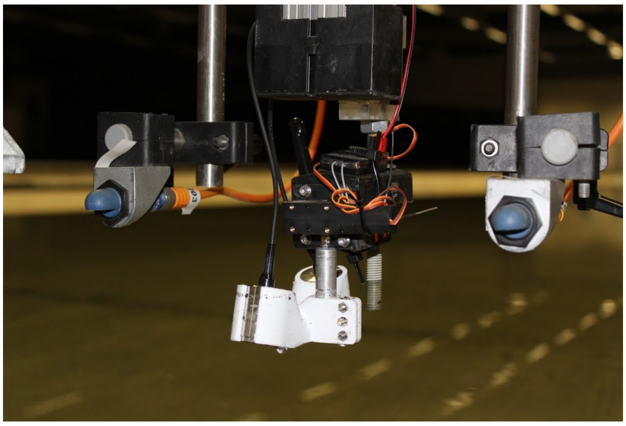

Figure 5: Transducers holder beneath the carriage (within the yellow circle in fig 4)

2.5 Procedure

The recording is started on the UB-Lab P, then the carriage routine is started. Profiles indeed recorded by the UB-Lab P are downloaded, after stopping the recording, in a binary data file (.udt). Human readable .csv files can be extracted from it when uploading it to the cloud.ubertone.eu processing and visualization tool.

The carriage xyz positions are recorded simultaneously and custom scripts on Ubertone's cloud allow synchronizing data from the carriage file with the UB-Lab P data. We also adapted our interface detection to obtain a robust and accurate measurement of the riverbed position, using echo amplitude profiles.

In those scripts, the velocity data beyond the detected interface are kept out and the data are filtered with the Doppler signal-to-noise ratio (SNR) measured by the UB-Lab P. U and W components are processed from the monostatic projected velocities and the Doppler angles given by the user. Other input parameters allow taking into account environment aspects such as model scale, for lab vs field measurement comparisons.

For the measurements presented here, two 3MHz transducers were used, with a spatial resolution of 5mm. The UB-Lab P switched periodically between both transducers to alternate the measurements of both monostatic components. Each cycle lasted about 1s.

3. Results and Discussion

3.1 Dynamic measurements

The first routine was to scan several transects and record continuously during the displacement, the trigger was set to low when transiting between transects to avoid recording.

In the following figures, in each group of three graphs, the first above represents the U component profiles, the central the W component profiles and the one below the distance between the transducer and the flume bed. The y-axis is the depth and the x-axis is the resulting profile number obtained along the transect.

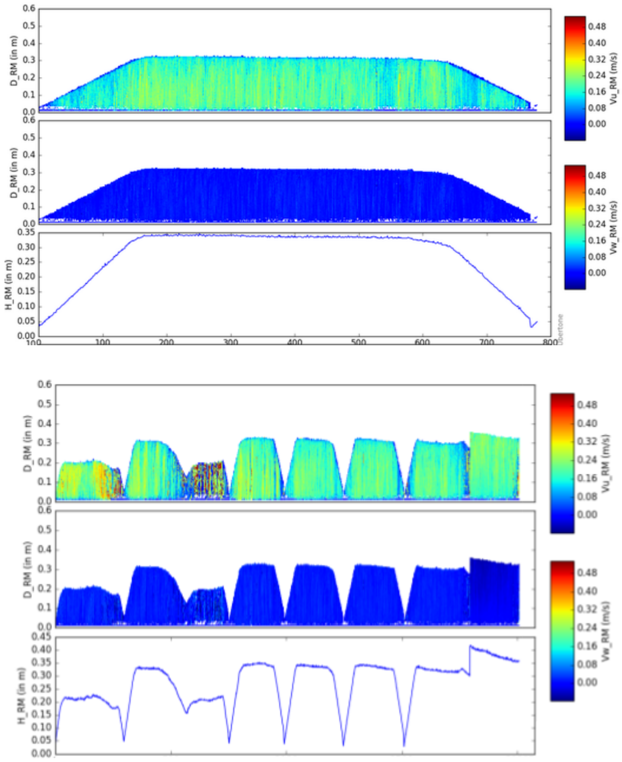

Figure 6: Processed dynamic transects acquisition

3.2 Static measurements

As for some discharge conditions, the signal was weaker, scatterers settling faster, another routine was to measure in fixed positions of the transect for a few seconds. Another script developed by Ubertone on the cloud application then averages the data collected in each fixed position for a better spatial cover.

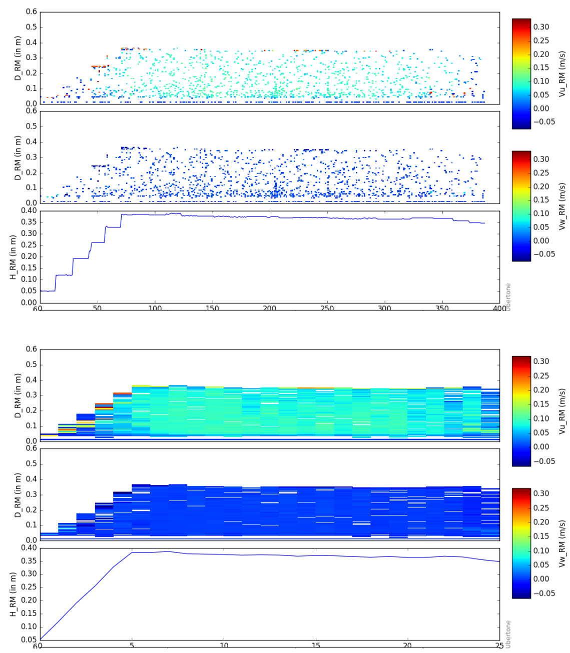

Figure 7: Processed static-positions-wise transect acquisition

In Fig. 7, the first display shows the measurements processed by the dynamic script. The second shows the result after averaging per fixed position.

6. Summary

Using a handheld UVP device can be helpful in mechanical design of setups, especially where the weight of the moving carriage is critical. The wireless communication and plug-and-play simplicity enables easy on-the-spot UVP measurements.

The next step in handyness improvement will be a wireless trigger management.

As shown in this abstract, the UB-Lab P's high sensitivity results in good quality velocity profile measurements even when few scatterers are in suspension. The Doppler SNR filtering improves the quality of the average velocity.

The echo signal is used to detect the bed and prepare the data for post-processing analysis.

The cloud.ubertone.eu processing and visualization web tool easens the work for non-acoustics-experts, providing processing scripts. The data is prepared for further analysis: synchronisation of carriage positions with velocity measurements, processing of raw Doppler velocity measurements in multi-components vectors and data filtering.

Now for hydraulics studies, the following development will be to measure 3 components by adding transducer channels.

References

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