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A pioneering measurement station for the estimation of surface flow velocities from digital video acquisitions

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Abstract

In this poster, we present the first implementation of a permanent measurement station for the estimation of surface flow velocities from digital video acquisitions. The station is located on the Tiber River at Ponte del Foro Italico, in the center of Rome, and has been designed and realized in collaboration with CAE S.p.A. based on Mhas (multi hazard system) technology.
Based on preliminary experimental tests described in [Tauro et al., Water Resources Research 2014], the measurement station comprises a Mobotix FlexMount S15 video system and two laser modules for remote image calibration. The digital video system hosts a weatherproof internet protocol camera with two miniature sensor modules connected to the camera housing. Two separate rooms allow for a hemispherical dual lens system to simultaneously capture different fields of view of the stream. Specifically, two lenses (a Mobotix L25 lens with an 82° angle of view and a Mobotix L76 lens with a 27° angle of view) are located with their axis perpendicular to the water surface to capture the central portion of the river.
The higher angle of view (L25) lens allows for acquiring a larger area of the river surface, whereas the lower angle of view (L76) lens synchronously captures finer details in the center of the L25 field of view. The digital video system is set to capture 1 minute-long videos of the river every 10 minutes. The frame acquisition frequency is set to 12 Hz and image resolution to 1024x768 pixels. The laser-based image calibration system features two 20 mW green lasers mounted with their beam axes perpendicular to the water surface. The laser modules are installed 1 m apart on the right and left sides of the camera. The measurement station is suspended through an aluminum bar underneath the bridge and is located at approximately 15 m from the water surface. The digital video and laser systems can be configured in real time through the internet via the integrated SIM card. Videos and settings are stored in a 1 Tb hard disk that is periodically removed and substituted for image backup.
Activated since January 2015, the measurement station will allow for noninvasively monitoring the discharge of the Tiber River in real time. In particular, captured videos will be analyzed through large scale particle image velocimetry (LSPIV) to develop surface velocity maps. Such maps will then be combined with information on the bathymetry of the river section to provide discharge data. Notably, the pilot measurement station is located next to an existing ultrasonic meter and a radar flow meter that are currently operated by the Agenzia Regionale di Protezione Civile, Centro Funzionale Regionale at Regione Lazio, Italy. We look forward to comparing estimates from the pilot station to such more established measurement equipment.

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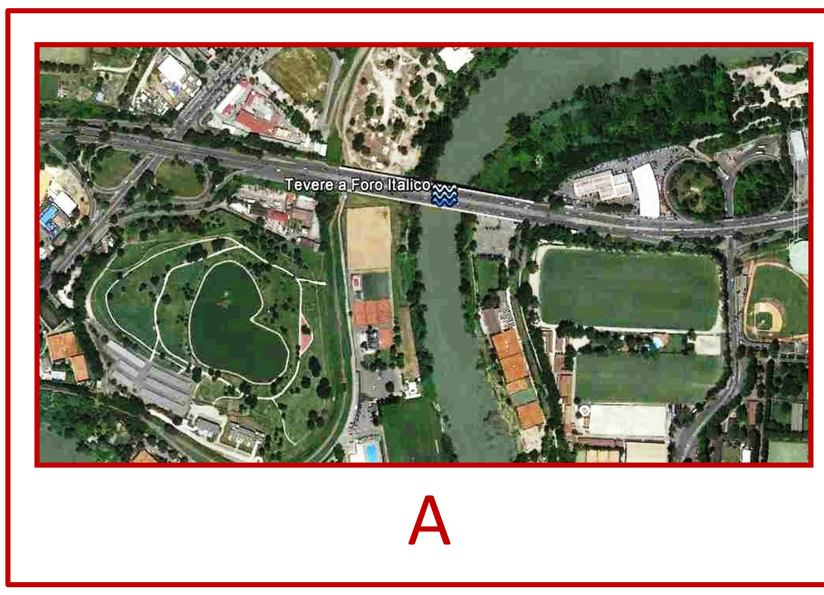

The experimental station

The measurement station is shown in (A) and illustrated in detail in (B). It comprises a Mobotix FlexMount S15 video system (B2) and two laser modules for remote image calibration (B3).
The digital video system hosts a weatherproof internet protocol camera with two miniature sensor modules connected to the camera housing. Two separate rooms allow for a hemispherical dual lens system to simultaneously capture different fields of view of the stream. Specifically, two lenses (a Mobotix L25 lens with an 82° angle of view and a Mobotix L76 lens with a 27° angle of view) are located with their axis perpendicular to the water surface to capture the central portion of the river.
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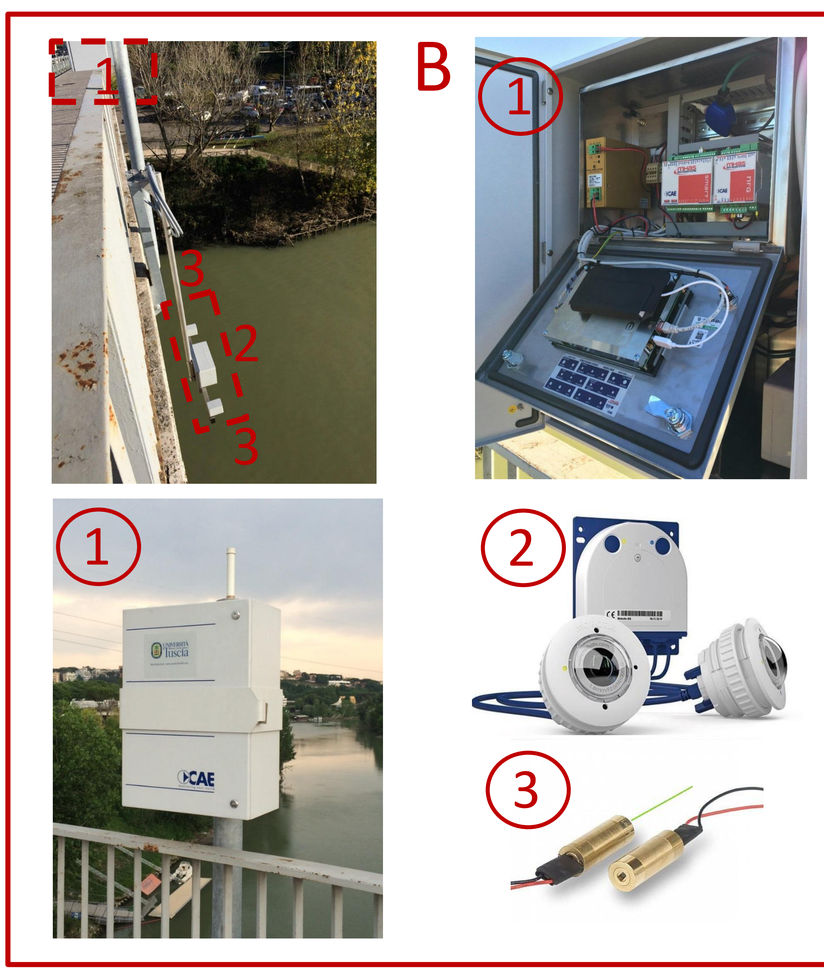
The laser-based image calibration system features two 20 mW green lasers mounted with their beam axes perpendicular to the water surface. The laser modules are installed 1 m apart on the right and left sides of the camera. The measurement station is suspended through an aluminum bar underneath the bridge and is located at approximately 15 m from the water surface. The digital video and laser systems can be configured in real time through the internet via the integrated SIM card. Videos and settings are stored in a 1 Tb hard disk (B1) that is periodically removed and substituted for image backup.



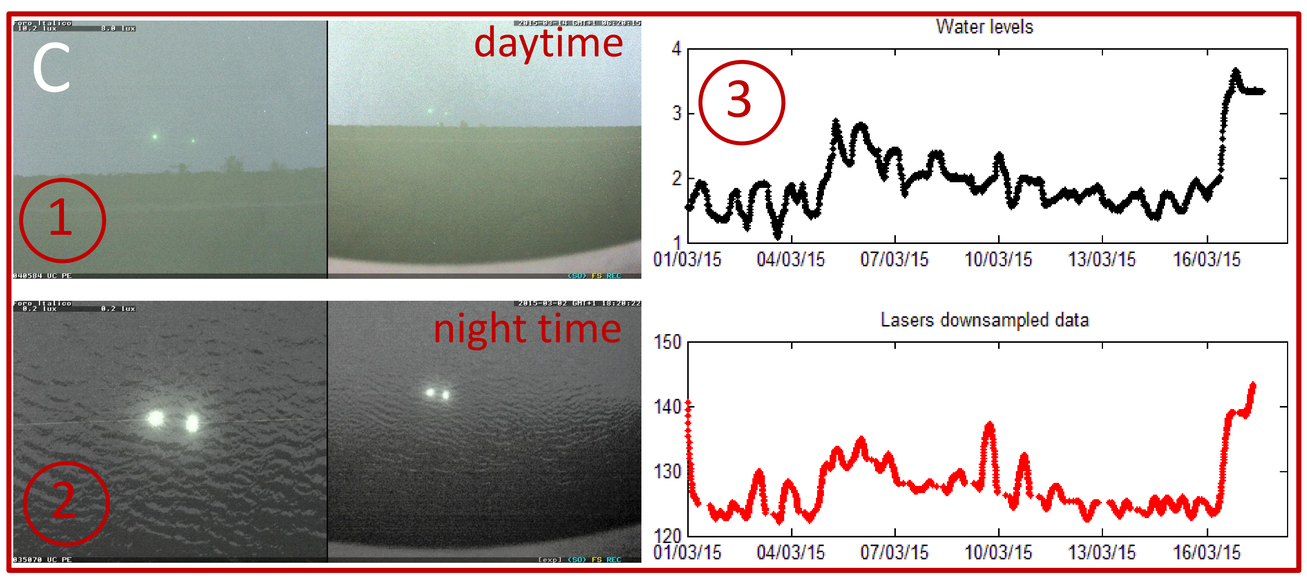
Observations

Large Scale Particle Image Velocimetry (LSPIV)

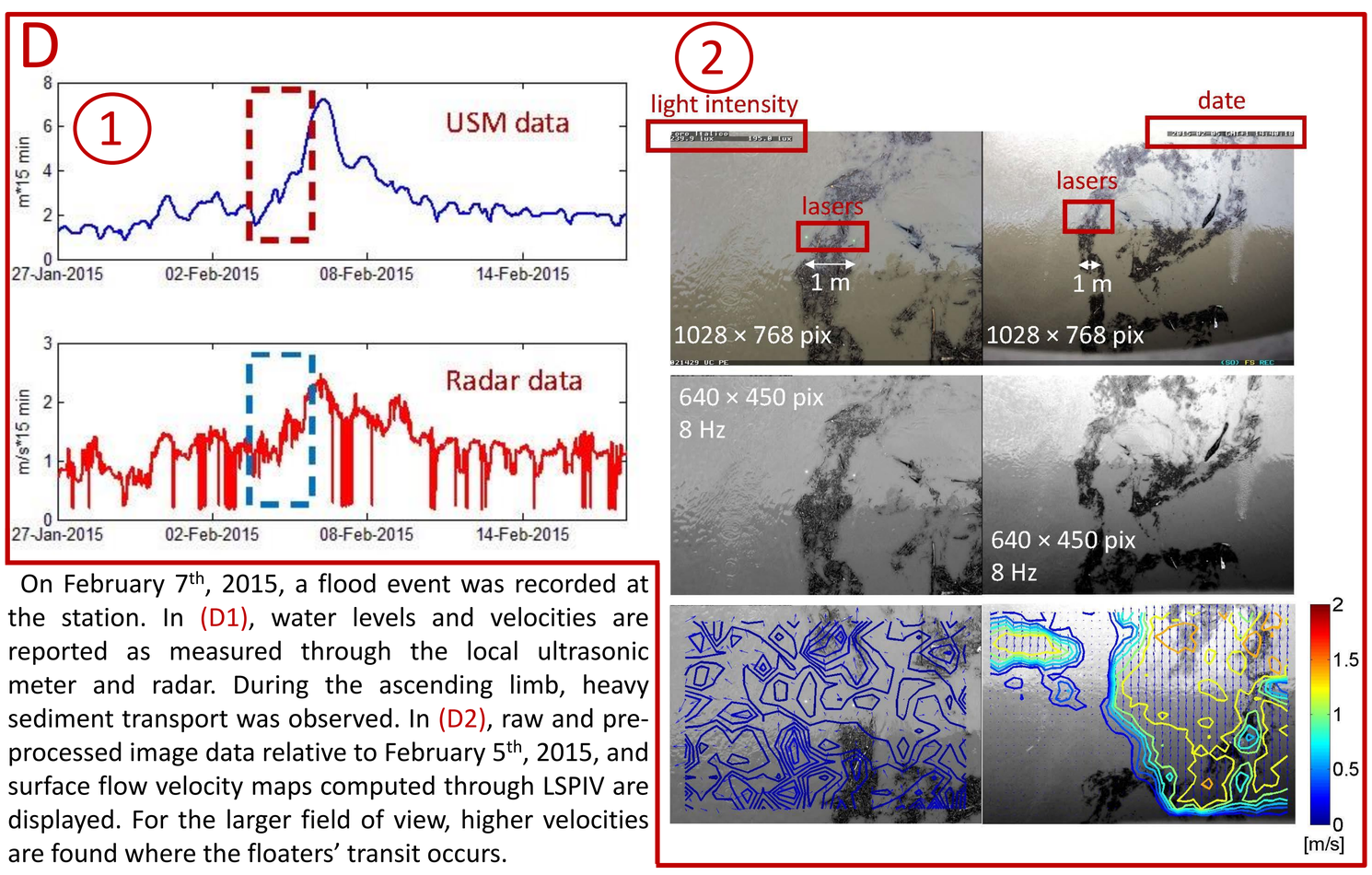
LSPIV implementations include: i) a digital image acquisition system; ii) surface flow tracers; and iii) a processing unit to extract flow velocity from images. After acquisition, digital images are orthorectified, calibrated, and applied a high-speed cross-correlation algorithm to extract the surface velocity field.

Traditional Measurements

The cross-section is monitored by the Centro Funzionale at Regione Lazio. Water levels and surface velocity are recorded every 15 minutes through an ultrasonic water meter and a radar.



Proof of concept analysis: February 2015



On February 7th, 2015, a flood event was recorded at the station. In (D1), water levels and velocities are reported as measured through the local ultrasonic meter and radar. During the ascending limb, heavy sediment transport was observed. In (D2), raw and pre-processed image data relative to February 5th, 2015, and surface flow velocity maps computed through LSPIV are displayed. For the larger field of view, higher velocities are found where the floaters' transit occurs.

Lasers and water levels

Lasers are utilized to create reference points on the water surface and, therefore, to calibrate images (C). They are activated for 20 seconds at the beginning of each 1-minute long recording. The appearance of the lasers' trace on the water (C1 & 2) is highly dependent on the illumination conditions (recorded and displayed in the top left of each image).
The pixel distance between the lasers' trace is a proxy of the water level in the river. In (C3), water levels measured through the ultrasonic flow meter are plotted above the pixel distance between lasers for the first half of March 2015.

References

Tauro F., Porfiri M., Grimaldi S.: "Orienting the camera and firing lasers to enhance large scale particle image velocimetry for stream flow monitoring", Water Resources Research, 50 (9), 7470–7483, 2014.

Tauro F., Petroselli A., Porfiri M., Giandomenico L., Bernardi G., Mele F., Spina D., Grimaldi S.: "A novel permanent gauge-cam station for surface flow observations on the Tiber river", under review.

Tauro F., Olivieri G., Petroselli A., Porfiri M., Grimaldi E.: "Flow monitoring with a camera: a case study on a flood event in the Tiber River", under review.