On the characterisation of open-flow seeding conditions for image velocimetry techniques using UASs

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Nowadays the implementation of optical methods in hydrological monitoring suffers the influence of seeding characteristics and environmental conditions.

- Priori quantification of seeding characteristics in terms of seeding density, spatial distribution of tracers and coefficient of variation of area in the ROI
- Statistical evaluation of the influence of seeding characteristics on PTV and LSPIV technique accuracy based on field experiments

Assess the uncertainty of computed surface velocities and remote river flow estimates
Field experiments

- Artificial tracers deployments
- FHD videos captured at 24 frames DJI Phantom 3 Pro Quadcopter
- Benchmarking velocities estimated using current meters Seba F1
A) Seeding density (particles per pixel)

B) Index of dispersion: 
\[ D = \frac{\sigma^2}{\mu} \]

C) Mean area of tracers (cm²)

D) Coefficient of variation of tracers’ area
Methodology

• For each case study, PTV and LSPIV techniques were applied considering five different sets of images (FWs).

<table>
<thead>
<tr>
<th>Frame windows</th>
<th>FW1</th>
<th>FW2</th>
<th>FW3</th>
<th>FW4</th>
<th>FW5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frames</td>
<td>1-100</td>
<td>26-125</td>
<td>51-150</td>
<td>76-175</td>
<td>101-200</td>
</tr>
</tbody>
</table>

• For each FW, the average of absolute errors calculated for the different measurement locations was computed and correlated.

\[ \varepsilon = \left( \frac{(U_c - U_m)}{U_m} \right) \times 100 \]

• Multiple linear regression analysis was performed to statistically evaluate the significance of the investigated seeding parameters.
Results and discussion

\[ e = c_1(\rho/\text{max}(\rho)) + c_2(\nu/\text{max}(\nu)) + c_3(\text{CV}_{\text{area}}/\text{max}(\text{CV}_{\text{area}})) \]

<table>
<thead>
<tr>
<th></th>
<th>( c_1 )</th>
<th>( c_2 )</th>
<th>( c_3 )</th>
<th>( R^2 )</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV</td>
<td>-14.6932</td>
<td>2.9118</td>
<td>35.7002</td>
<td>0.8001</td>
<td>0.0001</td>
</tr>
<tr>
<td>LSPIV</td>
<td>-18.5738</td>
<td>21.0869</td>
<td>26.0480</td>
<td>0.8083</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

- The three metrics have a similar statistical significance (Table). It can be observed the negative correlation between the absolute error and the seeding density and the positive correlation with the index of dispersion and coefficient of variation of tracers' area.

- The Figure shows the error predicted by the multiple regression analysis vs error observed with the PTV and LSPIV techniques.
In this work three metrics based on seeding density, index of dispersion, and spatial variance of tracers’ were adopted for the characterization of seeding in the field.

Statistical analysis of field results show that these metrics have a significant contribution to the velocity estimation accuracy.

A priori evaluation of flow seeding conditions can allow to choose the best frame footage for the image velocimetry analysis.

Further investigation are necessary along with the application of these ideas to case studies with very different field conditions.

