Automatic classification of bridges and continental water bodies from 3D point clouds (aerial LiDAR)

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Head of LiDAR service
1. PNOA-LiDAR project

2. Classification PNOA-LiDAR

3. Classification bridges

4. Classification continental water bodies

5. Conclusions
1. PNOA-LiDAR project
1. PNOA-LiDAR project

First Coverage: 2009 – 2015

AÑOS DE VUELO

<table>
<thead>
<tr>
<th>Leyenda</th>
<th>Años</th>
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<tbody>
<tr>
<td></td>
<td>2008</td>
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<td>2014</td>
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</table>

Surface: 505,000 km²
Years: 2009-2015
Density: 0.5 p/m²
RMSE: Z: 20 cm
DTM: 5m
1. PNOA-LiDAR project

Second coverage: 2015 – 2020

AÑOS DE INICIO DE VUELO

<table>
<thead>
<tr>
<th>Leyenda</th>
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<tbody>
<tr>
<td></td>
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<td>2018</td>
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<tr>
<td></td>
<td>2019</td>
</tr>
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<td></td>
<td>2020</td>
</tr>
</tbody>
</table>

Surface: 505,000 km²
Years: 2015-2020
Density: 0.5 to 4 points/m²
RMSE: Z: 15cm
DTM: 2m
1. PNOA-LiDAR project

Second Coverage: density

**DENSIDAD DE PUNTOS**

<table>
<thead>
<tr>
<th>Leyenda</th>
<th>Puntos / m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0,5</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

Map showing the distribution of point density across regions in Spain.
1. PNOA-LiDAR project

Third coverage: ¿2021?-¿?

- Planning to continue with a 3rd coverage after 2021
1. PNOA-LiDAR project

Integration of photogrammetric camera

Since 2015 we are acquiring imagery simultaneously with LiDAR, since 2017 is mandatory

Medium format camera are used, acquiring RGB and infrared information.
1. PNOA-LiDAR project

Download Center

http://centrodedescargas.cnig.es/CentroDescargas/index.jsp
2. Classification PNOA-LiDAR
2. Classification PNOA-LiDAR

1. Colorization

RGB

Infrarred
2. Classification PNOA-LiDAR

2. Automatic classification (Terrasolid)

- Ground
- Buildings
- Vegetation (low, medium, high)
2. Classification PNOA-LiDAR

3. Buildings improvement
2. Classification PNOA-LiDAR

3. Buildings improvement

Radiometry + Cartographic information

- NDVI
- Cadaster information
2. Classification PNOA-LiDAR

4. Sea water classification
2. Classification PNOA-LiDAR

4. Sea water classification
2. Classification PNOA-LiDAR

4. Sea water classification

Radiometry + cartographic information + geometry

- HUE from the RGB information
- Density
- Height
- Other external information
5. Powerline classification

Geometry + intensity

- **Density**: points per $m^3$ around the point evaluated
- **Roughness**: distance between the point evaluated to and adjusted plane
- **Intensity**
3. Classification bridges
3. Classification bridges
3. Classification bridges
3. Classification bridges

1. Introduction

- Automatically misclassified as ground or buildings
- Need of a good classification for DTM (removal of bridges).

- Geospatial Reference Information on Transport Network (GRI-TN) in IGN
3. Classification bridges

2. GRI Transport Network

1. Road TN
   - Roads + KPs: Motorway, freeway, roadway, E-Roads
   - Street roads + Building Numbers
   - Bicycle road, Paths

2. Rail TN
   - Railway lines +KPs, Railway stations, Railway links

3. Waterway TN
   - Ferry Crossing Ports

4. Air TN
   - Aerodroms, Heliports

5. Cable TN
   - Chairlift, cabin, cable car, ski tow
3. Classification bridges

3. Methodology

- Cartographic information + geometry
3. Classification bridges

3. Methodology
3. Classification bridges

3. Methodology

1\textsuperscript{st} TN filtering (main roads bridges) (axis)
\( \text{SHP}_{L1} \)

2\textsuperscript{nd} Point cloud intersection

- Classified point cloud \((PC_1)\) intersects \(\text{SHP}_{L1}\).
- **Result**: \(PC_2\) where all the points inside \(\text{SHP}_{L1}\) are considered bridge.

3\textsuperscript{rd} DEM generation

- Generation of a \(\text{DEM}_1\) 2x2m with \(PC_2\) using average height.
3. Classification bridges

3. Methodology

4th
- $SHP_{T1}$ intersects $DEM_1$
- **Result:** a $SHP_{T2}$ with an average height assigned per section.

5th **End of first loop**

- $PC_1$ intersects $SHP_{T2}$ → points with a difference lower than 1m are considered bridge.
- **Result:** $PC_3$ with the first iteration of points classified as bridge.

6th **Beginning of second loop**

- Back to 3rd step and generation of $DEM_2$ 2x2m with $PC_3$
- Repeat steps 4th and 5th
- 3 Loops are implemented
3. Classification bridges

4. Results

- Test Area of 1.000 km²

- Visual review: ortophoto acquired simultaneously with LiDAR used as ground truth.

<table>
<thead>
<tr>
<th>Type of detection</th>
<th>Number of bridges</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omissions</td>
<td>9</td>
<td>21%</td>
</tr>
<tr>
<td>Commissions</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>Partial detections</td>
<td>4</td>
<td>10%</td>
</tr>
<tr>
<td>Full detections</td>
<td>29</td>
<td>69%</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>100%</td>
</tr>
</tbody>
</table>

- 18,838 points classified as bridges
- 80% accuracy between full and partial detection.
3. Classification bridges

4. Results: Full detection
3. Classification bridges

4. Results: Partial detection
3. Classification bridges

4. Results: Omission
3. Classification bridges

4. Results: Error
3. Classification bridges

5. Conclusions

- Highly dependent on TN

- Feedback with TN needed (already in motion) → detect errors in the TN and report → loop where every project help each other.

- Satisfactory results (as a first approximation) → it improves previous classification, although more improvement is needed.
  - Already part of the workflow
  - Not main bridges.
  - Manual edition still needed
4. Classification
continental water bodies
4. Classification continental water bodies
4. Classification continental water bodies
4. Classification continental water bodies

1. Introduction

- Automatically not classified (or misclassified as ground or vegetation.
- Need of a good classification for DTM (hydro flattening)

- Geospatial Reference Information on Hydrography (GRI-H) in IGN
4. Classification continental water bodies

2. GRI Hydrography

- Accurate (XYZ) and Update automatic river extraction from LiDAR data
3. Methodology: indexes

- Radiometry + geometry + cartographic information

\[ NDVI = \frac{(NIR - R)}{(NIR + R)} \quad NDWI = \frac{(G - NIR)}{(G + NIR)} \]

Normalized False Colour = \( \frac{(NIR \times R \times G)}{2^{bits}} \)

<table>
<thead>
<tr>
<th>Probability</th>
<th>NDVI</th>
<th>NDWI</th>
<th>NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>&lt; -0.10</td>
<td>&gt; 0.20</td>
<td>&gt;0.03</td>
</tr>
<tr>
<td>High</td>
<td>&lt; -0.20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Medium</td>
<td>&lt; 0.15</td>
<td>(-0.15, 0.40)</td>
<td>&lt;0.03</td>
</tr>
</tbody>
</table>
4. Classification continental water bodies

3. Methodology: filtering

- **Point cloud classified**: all ground or low vegetation are considered, discarding the rest.

- **Slope**
  - Value in points selected as water must no differ on 0.5m of Z mean value in an area of 2x2m
  - In this way we eliminate shadows.
4. Classification continental water bodies

3. Methodology: filtering

- **Hydrographic Network**
  - If the convex hull polygon to near points radiometrically selected as water intersects in a percentage of surface greater than 50% with a polygon of the hydrographic model, those points are considered to have more probabilities to belong to a water body.

> 50%
4. Classification continental water bodies

3. Methodology:

- Indexes and filtering
- Slope and intersection with hydro model

Filtering of hydro model
4. Classification continental water bodies

3. Methodology: water bodies
3. Methodology: water bodies

- Removal of points classified as water.
- Vectorization of empty areas where there was water
- Fusion of different areas
4. Classification continental water bodies

4. Results:

- Test Area of 1.000 km2
- Visual review: ortophoto acquired simultaneously with LiDAR used as ground truth.
- Rivers have been considered as a unique element, with some exceptions.
4. Classification continental water bodies

4. Results:

<table>
<thead>
<tr>
<th>Type of detection</th>
<th>Number of water bodies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omissions</td>
<td>5</td>
<td>16%</td>
</tr>
<tr>
<td>Commissions</td>
<td>2</td>
<td>6%</td>
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<tr>
<td>Partial detections</td>
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<td>16%</td>
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<tr>
<td>Full detections</td>
<td>20</td>
<td>63%</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>100%</td>
</tr>
</tbody>
</table>

- 356,168 points have been classified as water
- 79% accuracy between full and partial detection
4. Classification continental water bodies

4. Results: Full detection
4. Results: Full detection

- 4. Classification continental water bodies
4. Classification continental water bodies

4. Results: Partial detection
4. Classification continental water bodies

4. Results: Omission
5. Conclusions:

- Low dependent on GRI-Hydro

- Automatic DTM hydro flattening from the water bodies generated.

- GRI-Hydro will use the water bodies generated for their model.

- Not able to classify water not seeing in the imagery (below trees) (obviously!!).

- Not working well in complicated rivers, as shown in the partial detection example.

- **Satisfactory results**, it is already part of the standard workflow → improves previous classification, small improvements are needed.
5. Conclusions
5. Conclusions

- Improvement of LiDAR classification.

- Error reporter for the products used → future results will be more accurate.

Future ideas


- Data collected for the whole country in different years, conditions etc etc makes difficult the automatization → The algorithms would need some parameter of machine learning.
Thank you for your attention

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Earth Observation

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