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POTENTIAL OF LINEAR FEATURES DETECTION IN A MEDITERRANEAN LANDSCAPE FROM 3D VHR OPTICAL DATA: APPLICATION TO TERRACE WALLS

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1. INTRODUCTION

Mediterranean cultivated landscapes are prone to floods, erosion and water pollution. They are also considered as hotspots for biodiversity. As hydraulic and linear artificial settlements, terrace fronts or terrace walls consisting in historic man-made levees on agricultural plot margins, can alter hydrological fluxes, limit erosion, favour soil water storage and biodiversity (habitat and corridor effects) [1]. More and more spatially explicit models and indicators need the map of these landscape linear features to diagnose the hydrological risk or biodiversity at catchment or region scale [2].

However, terraces walls are almost never mapped in any map agency databases. Therefore, the potential of very high spatial resolution remote sensing data, in 2D or 3D scenes, to map these linear elements, need to be addressed. Some recent studies showed that terraces from 2D VHR scenes, i.e images, can be poorly detected, due to both vegetation cover altering objects visibility having poor spectral signature or due to anisotropic shadowing effects. The use of 3D scenes, i.e. digital terrain models (DTM) and digital surface models (DSM), appears therefore as more reliable.

A lot of literature exist in landscapes linear elements detection from remote sensing 3D scenes, e.g. for hedges corresponding to surface convexities or hydrographic networks corresponding in terrain concavities [3, 4]. However, very few remote sensing or geomorphometry literature exists for terrace walls linear detection, corresponding to terrain stairs or discontinuities.

2. MATERIAL AND METHODS

2.1. Study site and data

2.1.1. Study site

The studied landscape is the 28 km² Mediterranean Peyne catchment. It is located in south of France, 50 km west of Montpellier. The land-cover is mainly vineyards, with a small amount of cereal fields and shrubs. The climate is Mediterranean with 600 mm to 800 mm of precipitation per year and two short but intense rainy seasons in the autumn and spring. This climate combined with the intensive vine cultivation, causes the area to be sensitive to flooding, erosion and pesticide contamination. Consequently, settlements have been build intensively from roman times to limit floods and erosion: ditches, terrace walls, embankments.

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2.1.2. Data

VHR optical Pleiades-like 3D scenes over the Peyne catchment have been simulated from both LiDAR and stereophotogrametric airborne survey providing digital terrain models (DTM) or digital surface models (DSM) with resolution from 1 to 5 meters. At the same time, field surveys of terrace fields were conducted at an average speed of 1.5 to 3 km² per day and per person according to the difficulty of the terrain. The height and width of these elements vary from approximately 30 cm to 10 meters. These man-made drainage linear landscape elements were then digitalized and georeferenced using the Quantum GIS (QGIS) software.

2.2. Methods

2.2.1. Linear detection methods

Three detection methods from DTM or DSM scenes or images were used within the Orfeo Tool Box (OTB).

The first method (TO) rely on the thresholding of the openness index [5], recently used to classify geomorphic features in landscapes [6]. Openness index a derivative DTM index traducing terrain discontinuities and local morphology at a given resolution. This method is considered as the first basic reference method. The second tested method (RE) is a linear extractor based on a spectral angle on a multispectral image initially developped by [7]. Here multispectral image is artificioially build from multiresolution openness index layers. The third tested method (LSD) uses the fast-LSD algorithm [8] on a local enhanced topography image obtained by substracting to the initial DTM image the filtered DTM image through a simple Gaussian filter.

2.2.2. Linear detection performances assessment

To assess linear detection performances when reference data and test data do not perfectly collapse in planimetry is a problem. We chose here to use the buffer method developped initially by [?]. This method relies on the successive and cross computations of the reference length falling within a distance of one DTM pixel of the detected elements and conversely. As a result, this method gives the usual True Positive and False Positive statistics corresponding to detection and comission rates respectively and expressed as a percentage of the reference cumulated length of linear elements.

3. RESULTS

Figure 1 shows an example of initial VHR 3D optical data and the obtained detected terrace walls using the LSD method. With this method 86 % of the terrace walls are detected (and 97 % of the one with height higher than 2.5 m) but comissions are still not neglectable, especially on vegetated areas.

The performances of the proposed methods have been assessed on the 3D available scenes. The results are resummed in table 1. Definitely the LSD method is the more reliable.

Method	3D scene	resolution	TP	FP
TO	DTM	1	87 %	65 %
LSD	DSM	1	53 %	38 %
LSD	DTM	1	86 %	18 %
RE	DTM	1	80 %	26 %
LSD	DSM	5	43 %	49 %

Table 1. Detection (TP) and Comission (FP) of terrace walls from 3D scenes

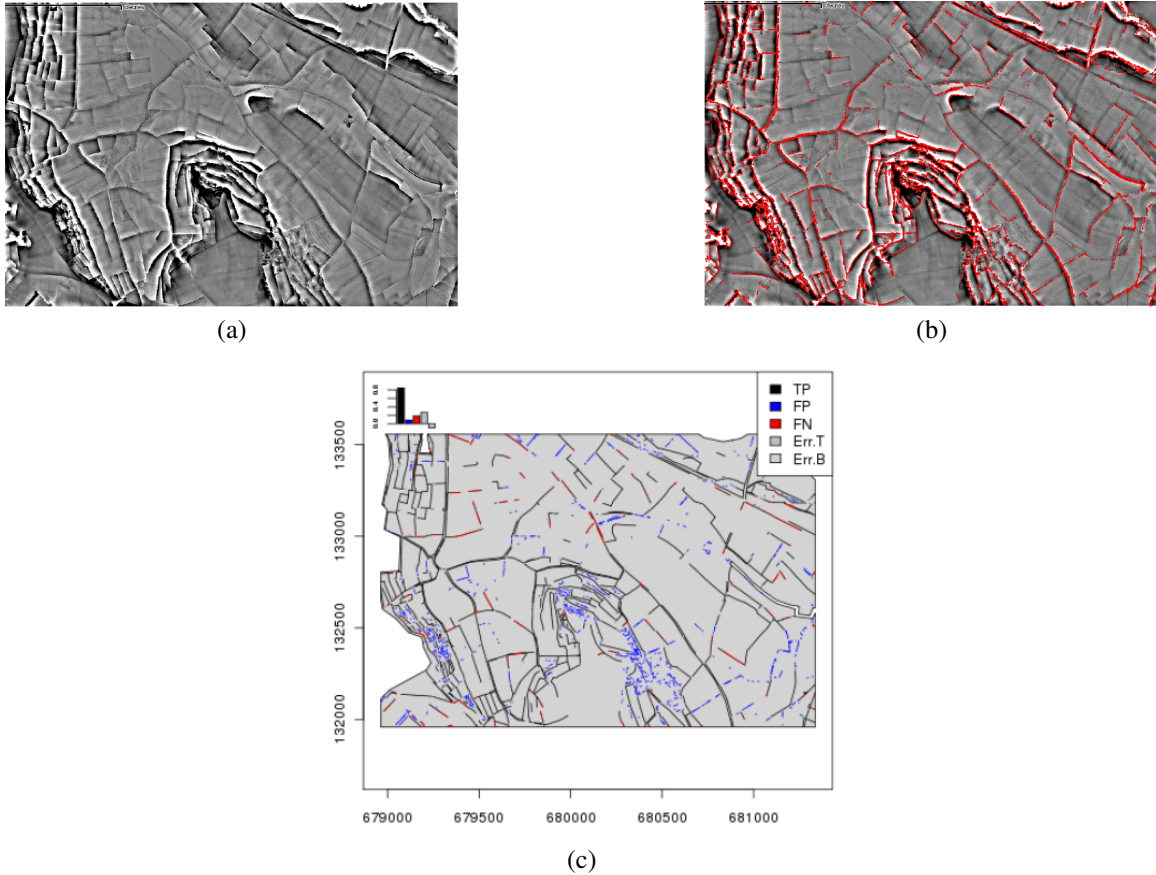


Fig. 1. Example of an initial shaded 1 m DTM (a) and detected linear terrace walls with LSD method (red segments) (b) and according detection performances (c) with True Positive (TP), False Positive (FP) and False Negative (FN).

4. CONCLUSION

Despite having a high commission rate, the potential of an automated terrace walls detection from VHR optical 3D scene (DTM) is high using a line segment detection method on a simple DTM transform. Of course, the initial accuracy (in altimetry), the resolution of the DTM (or DSM) data are highly conditioning the results. Detection is obviously more performant on DTM than DSM. In further works, the actual performances of terraces walls detection from 3D pleiades scenes will be assessed as well as the added value in detection when combining it to VHR radar data.

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