

## Original article

## Comparative cluster analysis to localize emergencies in archaeology

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**Abstract**

In the Northwestern Peru, near the city of Trujillo, an Italian Archaeological Mission (MIPE), in close collaboration with the National Institute of Culture (INC) of Peru, is working on the site of Chan Chan, the widest archaeological complex in the world for the constructions in raw earth. The mission is carrying out a multidisciplinary survey with the purpose to study a methodology for the site maintenance and the creation of a local center of documentation. Inside this project we want to explain a step of the research by means of a remote sensing analysis based on a Quickbird high-resolution image. By applying some image classification techniques, it has been possible to investigate the whole archaeological site, with the aim of a better definition of its general features and of a contribution to the exploitation of the surroundings. This analysis was carried out in open source environment implementing and performing two different classification algorithms and comparing the final results. As we had at our disposal no set of reliable ground truth of the study area it was necessary to follow an unsupervised classification approach. The off-line clustering techniques have been: K-means and Fuzzy K-means. Both approaches rely on minimizing a cost function of dissimilarity (distance) measure. We have overcome the problem of data group overlapping in a hard classification testing a fuzzy approach where each observation belongs to a cluster with a fuzzy membership degree. The resulted classification clearly separates the central archaeological site from the areas intensively cultivated and besides puts in evidence the coastal band, characterized by a reduced parceling and by the presence of damp zones. Another purpose of this research has been also to individualize the principal features of the Chan Chan site, possibly, by putting in evidence some archaeological emergencies and discovering new mark and signs. We performed every phase by the software Integrated Land and Water Information System (ILWIS) 3.4 developed by the ITC of Enschede and open source from July 2007. All collected information are useful to organize a master plan in a GIS, dedicated to the conservation of the archaeological complex.

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*Keywords:* Remote sensing; Quickbird; K-means; Fuzzy classification; Open source; Archaeology

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**1. Introduction**

In the Northwestern Peru, in proximity of the coasts of the Pacific Ocean, 600 km North of Lima (Peru), near the city of Trujillo, the archaeological complex of the city of Chan Chan, capital of the Kingdom Chimù, covers an area of about 14 km<sup>2</sup> (Fig. 1). This site is the widest archaeological complex of the world for the constructions in raw earth. The complex includes ten vast enclosures called “palacios”, which were the regal residences of the Chimù sovereigns (Fig. 2). Its exceptional historical-cultural value inserted it in the list of the monuments at risk of the UNESCO World Patrimony. In fact, it is in continuous dangerous, due to the atmospheric agents, the uncontrolled agricultural activities, the expansion of the area of Trujillo city

and finally due to the disfigurements of the so-called “tomberos”. Since the year 2000, an Italian Archaeological Mission (MIPE), in close collaboration with Italian CNR, Università Politecnica delle Marche (DARDUS) and the Institut National de Culture (INC) Peruvian, has carried out a multidisciplinary survey with the aim to study a methodology for the site maintenance and for the creation of a local center of documentation, that can autonomously continue the activities of research and the training for local technicians. In the past the different steps of the research, already presented in literature [1,2], were:

- the GPS surveying;
- the line plotting coming from aerial images;
- the DTM generation by automatic matching procedures;
- the orthoimages draped on the 3D digital terrain model;
- last but not least, the thematic classifications derived from the multi-spectral satellite imagery performed by Envi software.

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Fig. 1. Localization of the survey area in Peru.

Every step was made with the principal aim to collect and to organize such information in a dedicated GIS.

On this occasion, we are presenting more and various unsupervised classification techniques properly implemented by ourselves, in an open source environment (ILWIS 3.4) [7]. This necessity is born not only to investigate these new methods but also to prove their potentiality in respect of the argument of the research: the discovery of new emergencies in archaeology.

We worked on a subset of the original Quickbird multi-spectral image acquired on 10 May 2003 as Standard level with

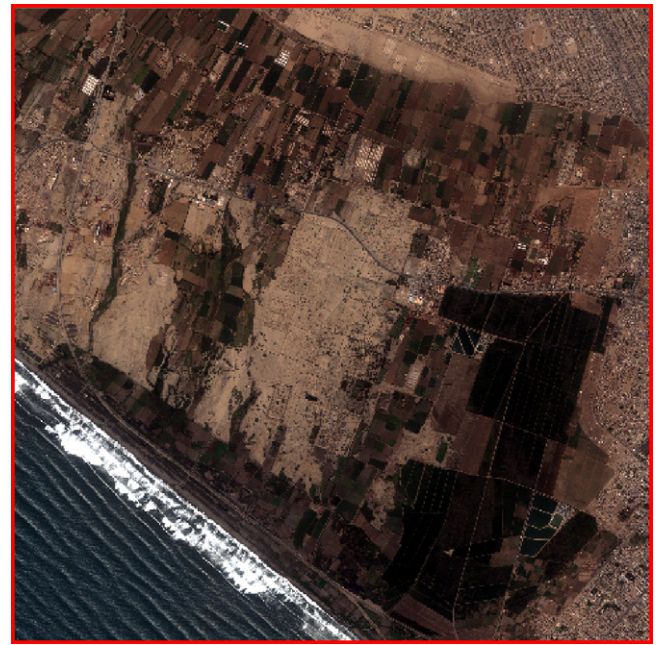


Fig. 3. Quickbird multi-spectral high-resolution image.

a ground resolution of 2.51 m and furnished by Eurimage<sup>TM</sup> (corrections of the system, radiometric corrections, geometric corrections, organization in a specific cartographic system of reference: Datum WGS84, UTM projection, 17 Fuse, South Hemisphere was given) (Fig. 3).

## 2. Remote sensing preliminary image analysis

The available satellite image dataset has a so high quality that it has been an extremely useful tool for our research. The work has been improved, respect to the previous image analysis, using some filters and statistic relations and implementing successively new unsupervised algorithms.

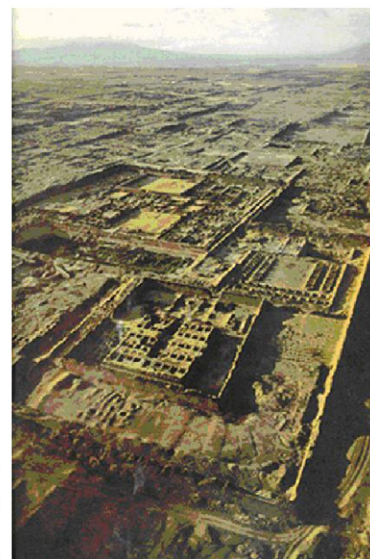
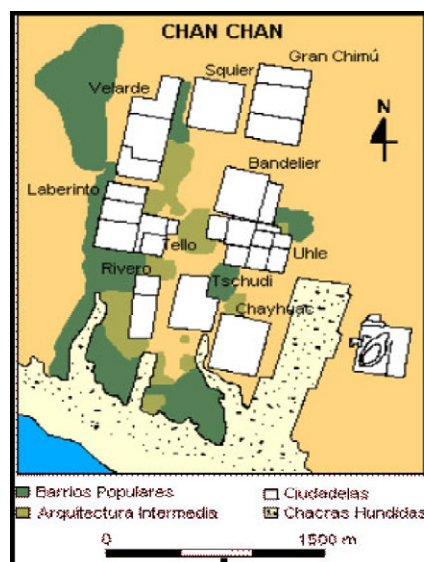


Fig. 2. The Chan Chan summary draft and the aerial view of the archaeological site.

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