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Application of pattern recognition in detection of buried archaeological sites based on analysing environmental variables, Khorramabad Plain, West Iran

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ABSTRACT

Archaeologists continue to search for techniques that enable them to analyze archaeological data efficiently with artificial intelligence approaches increasingly employed to create new knowledge from archaeological data. The purpose of this paper is to investigate the application of Pattern Recognition methods in detection of buried archaeological sites of the semi-arid Khorramabad Plain located in west Iran. This environment has provided suitable conditions for human habitation for over 40,000 years. However, environmental changes in the late Pleistocene and Holocene have caused erosion and sedimentation resulting in burial of some archaeological sites making archaeological landscape reconstructions more challenging. In this paper, the environmental variables that have influenced formation of archaeological sites of the Khorramabad Plain are identified through the application of Arc GIS. These variables are utilized to create an accurate predictive model based on the application of One-Class classification Pattern Recognition techniques. These techniques can be built using data from one class only, when the data from other classes are difficult to obtain, and are highly suitable in this context. The experimental results of this paper confirm one-class classifiers, including Auto-encoder Neural Network, k-means, principal component analysis data descriptor, minimum spanning tree data descriptor, k-nearest neighbour and Gaussian distribution as promising applications in creating an effective model for detecting buried archaeological sites. Among the investigated classifiers, minimum spanning tree data descriptor achieved the best performance on the Khorramabad Plain data set.

1. Introduction

The detection and spatial characterization of archaeological sites based on geomorphological parameters is now an essential aspect of landscape archaeology research (Ayala and French, 2005; Barton et al., 2002, 2010; Butzer, 1982; Schiffer, 1983; Tartaron et al., 2006; Wells, 2001). Increasingly this work is being integrated through the application of GIS based analyses that allows efficient spatial and locational analyses of site – environment relationships. (Myrsini et al., 2011; Kuiper and Wescott, 1999; Balla et al., 2014). Within the suite of quantitative GIS based techniques applied to landscape archaeology, predictive models are enabling researchers to estimate the possibility of presence or absence of archaeological evidence across extensive areas of search (Ebert, 2004; Kamermans and Rensink, 1999). Inductive based approaches used in both Archaeological Heritage Management (AHM) and scientific research, creates a model based on correlations between previously identified archaeological sites and variables that are obtained from the current physical landscape. Deductive approach, which are relatively rare, constructs the predictive model based on prior anthropological and archaeological knowledge, and uses previously identified sites to evaluate the model (Kamermans, 2006). Numerous predictive models have been developed using different methods including Bayesian statistics and Dempster-Shafer modeling to detect archaeological sites (Verhagen et al., 2010; Kvamme, 1990; Lang, 2000; Gibbon, 2000; Konnie et al., 2000; Fernandes et al., 2011) and in developing these approaches Verhagen et al. (2009) has identified a range of problems concerned with quality and quantity of archaeological input data including relevance of the environmental input data, lack of temporal and/or spatial resolution, use of spatial statistics, testing of predictive models, and need to incorporate social and cultural input data. A number of recommendations to address these problems have been developed as archaeological experience with quantitative GIS has emerged (Verhagen et al., 2009).

Artificial intelligence (AI) is the intelligence exhibited by machines or software. In recent years there has been growing interest in applying

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AI in many fields including data mining (Perumal et al., 2015). In archaeology its application has been through Artificial neural networks (ANNs) and expert systems (Vitali, 1991; Voorrips, 1990; Richards, 1998). Deravignone and Jánica (2006) studied the basic concepts required to bring artificial intelligence, in particular ANNs into archaeological research investigating the application of ANNs in a raster GIS environment with the aim of creating archaeological predictive models. Barceló (2010) reviewed the implication of using Computational Intelligence in archaeology. He explained that artificial intelligence models are feasible in archaeological recognition systems just like other sciences. Puyol-Gruiart et al. (1999) has considered the possibility of using more recent subfields including Knowledge Discovery in Databases (KDD), Visual Information Management (VIM) and Multi-agent Systems (MAS) in archaeological research.

This paper is a first comparative analysis of the spatially predictive capabilities of different AI methods in a semi-arid regional context. Environmental variables that have influenced formation of archaeological sites located in the Khorramabad Plain, Iran, are derived through application of Arc GIS. These variables are then utilized to create a predictive model based on Pattern Recognition, one of the most important subfields of AI. The term pattern recognition has evolved substantially from its roots in artificial intelligence, engineering and statistics. Patten recognition is the study of how machines perceive the environment, learn to recognize pattern of desired class from their background, and from these machine based observations make reasonable decisions about the categories of the different patterns (Jain et al., 2000). One-class classification as a pattern recognition method was developed by Moya and Hush (1996); Pimentel et al., 2014). One-class classification endeavours to identify objects of a specific class among all samples, by learning from a training set containing only the samples of that class. In one-class classification, it is assumed that only information of one of the classes, the target class, is available (Tax, 2001). So, the most valuable feature of one-class classifiers that makes it important to the objectives of this paper is that these types of classifiers can be built using only data from archaeological sites when the data from n*on*-archaeological site class is difficult to obtain (which they usually are).

In this paper applications of GIS spatial analysis and one-class classification methods are employed to detect buried archaeological sites of the Khorramabad Plain, a geomorphic unit located in the southern part of the Khorramabad Valley with antiquity more than 40,000 years of human settlement. Section 2 of the paper examines the details of defined variables and generated data set together with a brief overview of pattern recognition models considered. Experimental results and discussion are drawn in Section 3; in this section the efficacy of using one-class classification in detecting buried archaeological sites is clearly shown and discussed. Section 4 gives a summary of this work and propose some ideas for future research in the field of Pattern Recognition applied to archaeology.

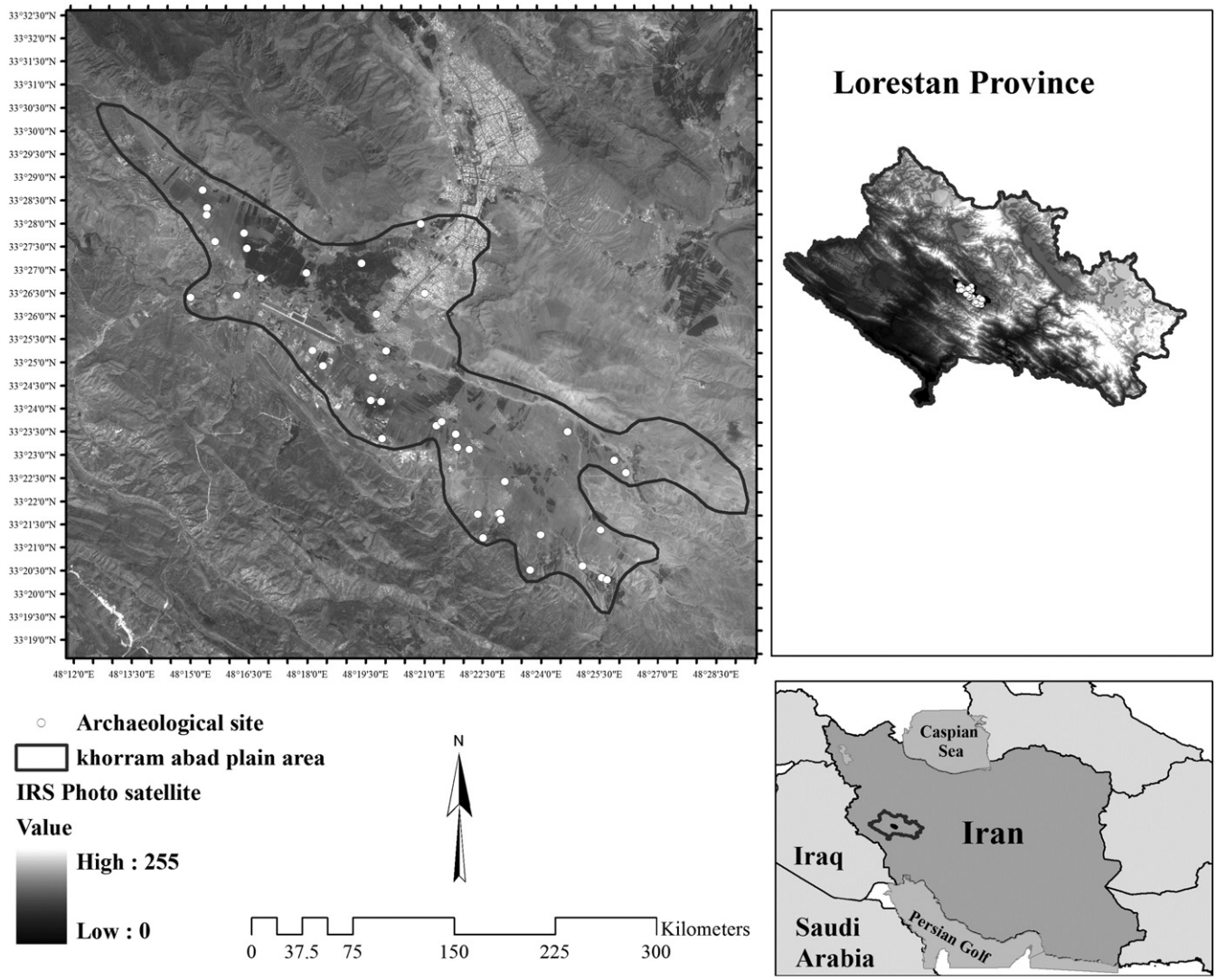

Fig. 1. Location of Khorramabad Plain in Iran together with the location of 43 previously known sites in the study area.