Precision Archaeology: a computational approach to archeological risk assessment

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Motivation

Our cultural heritage (CH) is increasingly exposed to the risk of the massive expansion of urban settlements. In the last decades, the constant growth of modern agglomerations has threatened earlier settlement areas, resulting also in permanent destruction of any unearthed archaeological remains (Hafner 2013). In order to lower such risk and to address the modern requirement of urban expansion, in Italy it is mandatory to perform risk and potential estimation of eventual presence of archaeological remains or sites of interest. Such activity can be highly demanding in terms of coordination of multiple expertise, time and costs. It requires gathering of bibliographical elements, accurate establishment of their locations and relations (often with inaccurate or generic descriptions), subjective interpretation and historical contextual estimation (Yaworsky et al. 2020). This requires to explore new solutions and develop new quantitative tools that can help in the detection, identification of archaeological sites. One promising solution is computational archaeological risk assessment. While modeling and prediction are a long standing subject of research (Nebbia et al. 2016, Arnoldus-Huyzendveld et al. 2015), the recent statistical, machine learning (ML), and, artificial intelligence (AI) developments provide new ways to improve the quality of assessment, reduce costs and provide objectivity to the estimation.

Related Works

There exists a plethora of technical chapters, journal papers, and conference proceedings, describing decision-making approach for the automatic evaluation of archaeological risk. However, there are very few examples reported in the literature of AI-based system for tackling this issue. The state of art methodological approaches proposed are based on multivariate statistical techniques such as Logistic Regression (Wachtel et al. 2018). Recently, researchers have started to explore more complex models, based on innovative applications of statistical and spatial computing, as well as on machine learning (ML) algorithms like random forests (Castiello 2022). However, applications of ML in the domain of archaeological risk assessment are very limited in literature.

Research Gap

Archaeological applications of predictive models encounter different underlying problems. Some issues are theoretical (e.g., limited a priori consideration of the decision variability on land use, a-theoretical selection of environmental variables), others are empirical (e.g., predictor data collinearity, insufficient spatial resolution of environmental data, failure to report dissimilarities in meaningful temporal and functional sites subsets), and some are analytical (e.g., improper or incomplete statistical models).

Proposed Approach

Considering the above, we coined a new concept: “Precision Archaeology” (PA). PA is an archaeological management concept based on observing, measuring and responding to inter and intra-field variability in land. The goal of precision Archaeology research is to define a decision support system (DSS) for whole archaeology management chain with the goal of optimizing returns on inputs while preserving resources.

DSS provides digital tools that enable the addition, the definition, and analytics of archeological sites, including artefacts. At its core, by using ML to perform statistical analysis, recommendation to understand similarity, and AI to model uncertainty, it enables an objective risk estimation that lowers the dependency on subjective expert sensibility. This is enabled by exploiting approaches based on neural networks in presence of few, noisy or unbalanced datasets (Li et al. 2019).

Significance of our Approach

By coining this new concept and clarifying its scope, we are paving the way for future research to have a clearer focus and a common ground to improve potential and risk forecasting as well as establish a new method for obtaining archaeological prescription maps. In fact, our study differs from the above-mentioned ones not only in that it results in both the assessment of the environmental factors and the elaboration of a predictive map for archaeological site location, but also in the implementation of an accurate procedure for the model evaluation and validation.

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