Estimation of archaeological potential with Page Rank based predictive model: the MAPPA project results

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## Data Model

### Secondary Data
- Obtained data

### Primary Data
- Historical cartography data
- Archaeological data
- Urban data
- Geographical/geomorphological data

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ARCHAEOLOGICAL POTENTIAL

- represents the possibilities that a more or less significant archaeological stratification is preserved
- is calculated by analyzing and studying a series of historical, archaeological and paleo-environmental data retrieved from various sources, with a degree of approximation that may vary according to the quantity and quality of the data provided and their spatial and contextual relationships
- is a factor independent on any other following intervention that is carried out, which must be regarded as a contingent risk factor
- the map of archaeological potential is a predictive model

PARAMETERS

- type of settlement
- density of settlement
- multi-layering of deposits
- removable or non-removable nature of archaeological deposit
- degree of preservation of the deposit

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Archaeological findings: Categorisation of archaeological data

Assigning the potential value of archaeological information

Shaping the urban elements i.e. roman domus, medieval tower-house etc

Relations between archaeological category in the same historical period

Creation of functional areas:
- Urban area
- Suburban area
- Rural area

Creation of geomorphological maps

They operate on the expansion of archaeological potential

Relations between archaeological category through different periods

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Assigning the potential value of archaeological information

Every category of archaeological findings can give information about:

- production
- building techniques
- trade
- food
- agriculture/breeding
- worship
- waste management
- political/institutional aspects
- social and gender aspects
- physical anthropology
- fauna/flora
- geomorphology
- viability/transport
- health and hygiene
- warfare
- land management
- leisure
- tradition
- water system

For each of them we assign a binary value. The sum of values gives the archaeological potential of each category.
We express the relations between archaeological categories in the same chronological period.
1. Real-world problem

2. Make assumptions
   Basic rules governing the system
   Probability distributions

3. Formulate the abstract problem

4. Solve the abstract problem

5. Interpret the solution

6. Verify the model: TESTING

7. Report, explain, predict

MATHEMATICAL MODELS

STATISTICAL MODELS

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1. Real-world problem

2. Make assumptions
   BASIC RULES governing the system
   PROBABILITY DISTRIBUTIONS

3. Formulate the abstract problem

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Estimation of archaeological potential with a page rank based predictive model: the MAPPA project results
1. Real-world problem

2. Make assumptions
   e.g. PROPORTIONALITY
   e.g. CORRELATION

3. Formulate the abstract problem

4. Solve the abstract problem

5. Interpret the solution

6. Verify the model
   TESTING

7. Report, explain, predict

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A key issue in detecting archaeological potential is the identification of relations, both in spatial and in functional terms, influencing the probability of higher level structures presence \( \rightarrow \) influence the potential of an area.

A 3-d grid models the subsurface. A cell can:
- attribute potential to surrounding cells
- receive importance by surrounding cells

Analogy with criteria for assigning importance to web pages by search engines cell = web pages

In PageRank a web page:
- attributes importance to pages it links to
- receives importance from pages linking to it

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A page pointing to other pages distributes its importance to those pages

\[
P_{\text{initial}} \text{ provides the initial potential values, given by the available data}
\]

The matrix \( W \) assigns values of links between cells

\[
W = \begin{bmatrix}
0 & 1 & 0 \\
2/3 & 0 & 1 \\
1/3 & 0 & 0 \\
\end{bmatrix}
\]

\[
\begin{cases}
P_1 = P_2 \\
P_2 = 2/3P_1 + P_3 \\
P_3 = 1/3P_1
\end{cases}
\]

\[
P_{\text{initial}} = [1 \ 2 \ 3]
\]
The area of influence is proportional to the value of the functional area the cell belongs to.
PageRank for archaeological potential

The relative values of links are obtained weighting by the geomorphological datum

High-valued functional area
Low-valued functional area

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✓ The total “weight” of links distributed by a cell with finds will vary on the basis of the estimated probability of the presence of certain finds near particular finds → DONE!

✓ The functional areas will be computed automatically on the basis of the rules already implemented “manually” by the archaeological team → DONE!
Using the archaeological findings we draw up the functional areas, i.e. levels of spatial and functional organization (e.g. urban, suburban, rural areas) in which the urban space is organized.
Creation of functional areas

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THE ESTIMATED GROWTH OF ARCHAEOLOGICAL DEPOSIT

Today

Etruscan period

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The map of archaeological potential is given by the composition of the 7 layers, one for each archaeological period under consideration: Protohistory, Etruscan period, Roman period, Early Medieval period, Late Medieval period, Modern Age, Contemporary Age.
Contemporary Age.

Modern Age

Late Medieval period

Early Medieval period

Roman period

Etruscan period

Protohistory
The final result has obtained after a validation of the results provided by a preliminary version, through 14 new core-drillings, with which the algorithm was tested, in order to obtain a better fitting model.
THE MAP OF ARCHAEOLOGICAL POTENTIAL OF THE URBAN AREA OF PISA

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A 3D VISION OF ARCHAEOLOGICAL POTENTIAL

Estimation of archaeological potential with a page rank based predictive model: the MAPPA project results
Estimation of archaeological potential with a page rank based predictive model: the MAPPA project results
THANK YOU!