Preface

Antiquity and human history in general is a topic that always attracts human interest and arouses curiosity. For this reason, a considerable deal of science research is devoted to the evolution of History and Archaeology. The information acquired via these scientific disciplines is very valuable not only in association with important history facts (great battles, regime changes, important political ideas, art and technological achievements, etc.) but also in relation with details of everyday life of the past. The latter information is, in most occasions, more difficult to acquire but it is equally significant and important, since it contributes to a better understanding of the way society was structured and functioned in the past ages and the social models developed throughout centuries.

Over the years, the acquisition of this information is getting more and more difficult. This may lead to gaps in history knowledge and thus, to the alteration/distortion of historical facts. To avoid such dangerous phenomena and in order to better exploit the historical elements brought to light by the scholars, it became more than clear that an interdisciplinary cooperation is needed. To be more specific, Computer Engineering proves to be one of the most valuable disciplines to utilize towards this direction.

Computer is a very strong tool that in a very short period of time, it can process complicated algorithms that humans would need very many years to accomplish. In addition to that, computer's ability to save huge amount of data information to a very small space, gives one the possibility to easily relate and exploit information coming from different sources. This is why Computer Engineering combined with Mathematics and especially when applied to the fields of Pattern Recognition, Image Processing, Signal Processing, Statistics and Differential Geometry, can be of great assistance to disciplines such as Archaeometry, Archaeology, History and Classical Studies. This interdisciplinary approach can help scholars better understand and easier and more accurately interpret information related with archaeological finds. In addition, the reconstruction of archaeological finds that are unearthed (highly) fragmented may become easier, faster and more objective. Recently, more and more applications related with these fields are being developed offering novel results both technical & methodological and in the way Archaeological finds are studied.

Concerning the purely technical and methodological aspects of such applications, they incorporate techniques (existing and new) mainly from the fields of Pattern Recognition, Signal Processing, Statistics and Differential Geometry, in order to formulate and resolve the Archaeological finds study in terms of a computer system.

Pattern Recognition tackles one of the most important and difficult problems in Computer Engineering. Its main target is the identification and extraction of "hidden" patterns existing in digital images and multimedia content stream such as sound and video streams. Specifically, Pattern Recognition can offer valuable information to many scientific areas, such as History, Archaeology, Archaeometry and Anthropology. In this way, one can state quantifiable criteria associated with numerous archaeological findings. In most cases, image processing of digital images of these findings must first take place in order for the pattern recognition algorithms to work in a more robust way.

Image processing is important not only because of the nature of the treated objects but due to the wear that archaeological findings have usually suffered. Thus, noise suppression is more than necessary before the implementation of Pattern Recognition algorithms and Mathematical Analysis take place.

After the extraction of possible patterns from the considered archaeological artifacts, statistical processing of the related results is, as a rule, required. This processing offers a lot of pros, especially in the validation of the results, since using statistical models can help scholars better understand the underlying content and take into consideration possible loss of related information. This loss may be due to the wear that archaeological finds are suffering or other artifacts that can exist on the actual images and processed data. A very important advantage of this methodology is that it can offer quantifiable results. Particularly, in Archaeology and Archaeometry, the combination of the statistical results together with the experienced archaeologists' approach may offer very impressive results. In this way, objectivity in the obtained results is reinforced.

In many cases, some findings are excavated in very many fragments and a reconstruction is needed in order that the find regains its meaning. In this way, the entire information associated with the find is available to the scholars. Differential Geometry implemented by means of Computer Engineering methods is a strong tool towards the reassembly of the unearthed object.

The novel methodological results and the new approaches to the study of Archaeological finds that Computer Engineering applications offer, has been attracted the interest from different disciplines scholars, who tend to realize the importance of the application of Computer Engineering and Mathematics in the processing of archaeological finds.

In particular, the topics presented in this book may help computer engineers better understand the applicability of their science to other disciplines such as History, Archaeology and Sciences dealing with Cultural Inheritance in general.

Similarly, mathematicians may both realize the applicability of their science to these humanitarian disciplines, as well as they can better understand the roots of Mathematics and the association of their Science with Art and human needs and functions in general.

Archaeologists and historians may find out that they can look for objectivity and general assistance in their cooperation with computer engineers and/or mathematicians. Concerning the chapters of the present book, archaeologists and historians can extract and use valuable information associated with their research field, while computer engineers and mathematicians may familiarize with new approaches and algorithms in Pattern Recognition, Image Processing and Analysis, Curve and Surface Fitting and Statistical Analysis of digitized archaeological data.

Moreover, conservators of archaeological finds may understand how the disciplines of Computer Engineering and Mathematics can assist them in speeding up their work, making it easier with more objective results.

Concerning the works in this book, they can be grouped mainly in 3 categories: a) writer identification applications, b) pattern identification and classification in decorative themes and c) automatic restoration and reconstruction of archaeological finds.

Writer identification/classification treated in this book is a very important issue, since it constitutes the kernel of the graphological analysis.

The first chapter deals with automatically identifying the writer of some Ancient Greek inscriptions by employing Methods of Computer Engineering and Mathematics. The need of such a system is important, because it helps scholars to date the carved inscriptions and deduce proper historical conclusions, a fact that otherwise cannot be achieved. The proposed system consists of two different approaches. The first approach is based on Pattern Recognition methods in order to compute an ideal representative of each alphabet symbol in each inscription separately. Next, by means of introduced, new statistical criteria, the classification of the inscriptions to the corresponding hands is achieved. The second approach also uses statistical criteria in order to accept or reject statistical hypotheses if two distinct inscriptions belong to the same writer or not. In this methodology, geometric characteristics of all letters realizations are used to make the decision for the writer identification. Both methods have been applied to 29 ancient Athenian inscriptions of the classical era and offered correct, accurate classification into 8 different hands. The combination of the application of both approaches and the fact that their results are consistent in themselves and agree with prominent epigraphists' opinion, show that the system may substantially contribute to ancient inscriptions' dating, in a robust and reliable manner.

The next chapter refers to writer identification concerning graphic documents. The main objective of the work presented in this chapter is the identification of the writer in old music scores. The proposed methodology combines three different writer identification approaches. The first one is based on the use of two symbol recognition methods, robust as far as hand-drawn distortion is concerned. The second one generates music lines and extracts information about the slant, width of the writing, connected components, contours and fractals. The third approach generates music texture images and computes textural features. The obtained high identification rates demonstrate the suitability of the proposed approach to the problem in hand.

In the third chapter, an index of lexical richness is derived based on elasticity considerations. More specifically, the indexes of lexical richness are derived by introducing a new methodology, which is based on the elasticity of vocabulary with respect to text size. After determining the related equations, regression analysis may be used to estimate the indexes of lexical richness or to test hypotheses of interest, e.g. assumptions concerning the author/writer of one or more documents. In addition, for the first time, to the best of our knowledge, a rigorous proof is published concerning the derivation of the mathematical formulas of indexes of lexical richness, on the basis of the specification of elasticity. These theoretical derivations are supported by a consistent analysis of empirical data.

Pattern Recognition applied to archaeological artifacts has a significant impact on the scientific society in recent years. In the subsequent chapters (four and five) of the present book, two related applications are presented.

The first one (chapter four) deals with the determination of the method used to draw several celebrated and beautiful wall-paintings belonging to the Late Bronze Age (c. 1630 B.C.), that were excavated at Akrotiri, Thera island, Hellas (Greece). In the first stage of the presented work, processing of the wall paintings' digital images takes place in order to extract the contour of the main drawn figures appearing on the walls paintings. Subsequently, a number of fundamental definitions are given and the main hypothesis is stated, namely that geometrical stencils were used for the drawing of the considered wall paintings. A first estimation of the probable one-stroke parts of the contour is undertaken, based on curvature considerations and minimization of corresponding error functions. Next, families of geometrical curves as potential prototypes of the employed stencils are selected. This selection is based on archaeological and historical criteria. In the next step, a novel exhaustive curve fitting method is introduced that offers unambiguously optimal matching of two digital curves. In this way, the exact values of the stencils' parameters are determined. Finally, the hypothesis that stencils were used for the drawing of the considered wall paintings is supported substantially by a visual representation of the one-stroke parts together with the corresponding stencil segments that generated them.

The fifth chapter refers to the automatic classification of decorative patterns in the Minoan pottery. More specifically, this work attempts to identify and classify decorative elements in pottery of Kamares style. This artistic style constitutes a significant manifestation of the Cretan cultural production between the first half of the II millennium BC. This high level painted production characterized by the combination of several diverse motifs, presents an enormous decorative repertoire. The extraordinary variety of combinations between elementary motifs according to a complex visual syntax makes interesting the automatic identification of the motifs, particularly upon potsherds. The accomplishment of this task is still a challenge to Computer Vision and Pattern Recognition. Starting from a digital image Regions-of-Interest (ROI) identification, motif extraction, robust contour detection should be performed to obtain a bulk of digital shapes. In a second phase, each of the extracted shapes has to be classified according to a number of prototypes stored in a database. The co-occurrence of the different shapes in a specimen will, in turn, be used to help the archaeologists in the cultural and even chronological setting.

In chapter six, a systematic analysis of corrosion damage on cultural heritage objects is undertaken. This analysis is an aspect of multidisciplinary interest. The application of computer-aided approaches in corrosion control has recently become a challenging issue. However, the majority of researches attain to estimate the decay presence by evaluating colour and texture alterations. This work is geared towards investigating non-destructive detection and quantification of stone degradation by using machine vision schemes. The work presented in this chapter consists of 4 procedures: (1) several detection schemes have been developed, each handling in a different way the background in-homogeneity. (2) Numerous statistical metrics have been introduced to quantify corrosion damage. These metrics mainly consider the decay areas size, spatial distribution, shape and darkness. (3) The potential of several monitoring modalities in determining corrosion attributes is studied, and (4) the corroded areas' shape features are considered in association with the cleaning and structural state that they represent.

In chapter seven, statistical methodologies are presented applicable to archaeological problems. In fact, this is an approach belonging to Quantitative Archaeology, which had a rapid development in the past few decades due to the parallel development of methodologies in Physics, Chemistry and Geology. These disciplines can be implemented in archaeological findings and produce measurements on a number of variables. Those measurements form the basis for a statistical analysis, which in turn, may furnish objective results and answers, within the prediction or estimation framework about the archaeological findings. Exploratory statistical analysis was almost exclusively used initially for analyzing such data mainly because of their simplicity. This simplicity originates from the fact that exploratory techniques do not rely on any distribution assumption and conduct a non-parametric statistical

analysis. However the recent development of the statistical methodology and the computing software allows for making use of more sophisticated statistical techniques and obtain more informative results. The work presented in this chapter, explores and furnishes the results of three such techniques; a)the finite mixture approach for model based clustering, b)the latent class model and c) the Bayesian mixture of normal distributions with unknown number of components. All three methods can be used for identifying sub-groups in the sample and classify the items.

Next, it is a well-known fact that archaeological finds are, as a rule, unearthed highly fragmented. The necessary reassembly process is usually a very pain-stacking and time-consuming process. Additionally, there are cases where humans, even expert ones, have intrinsically difficulty in properly matching the fragments. Thus, computer-based systems that automatically look for proper matching between fragments may be of great assistance to the dedicated scholars and experts. In chapter 8 of the present book, an overview of existing methods that tend to perform/contribute to the automatic reassembly of fragmented archaeological objects is presented.

Modern technology and Culture are two of the most important scientific areas that attract interest worldwide. All the chapters of this book refer to the core of these areas and more specifically to Computer Engineering and Mathematics and how these disciplines can be implemented on problems that concern the scholars of Archaeology, Archaeometry and History. The context of the presented chapters is of great interest not only for experts of these disciplines but also for a wider audience. The articles presented are of high quality as their authors are well known for their expertise on the related areas. In addition to that, the methodologies that they present are highly novel and the obtained results are very impressive. This book, hopefully, could prove of great assistance to experts of Humanitarian Sciences and help them solve problems that already exist or may come up in the years to come. It may also show how computer scientists and mathematicians can use their research work in favor of other Sciences with great interest such as Medical Science, Physics, etc. Conclusively, Research is always evolving and, hopefully, this book can contribute to this direction by implementing the produced methodologies or by giving ideas based on the work presented in the chapters of this book.

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