Virtual Reading of a Large Ancient Handwritten Science Book

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Abstract

We present a fundamental development step of a new technique to read and digitize ancient handwritten documents. Chemical analysis by x-ray fluorescence and x-ray tomography enabled us to decipher words and drawings from inside a closed, 200-pages 18^{th} century handwritten book. The ink chemistry is essential: tomographic reading is feasible thanks to the iron present in ancient inks (iron gall) over one millennium – whereas carbon or organic inks do not provide sufficient x-ray contrast. The results presented are a key progress towards the ultimate goal of the technique: non-invasive reading of fragile and/or unopenable documents.

Keywords:
X-ray fluorescence, iron-gall inks, ancient manuscripts, x-ray tomography, digitization

1. Introduction

We applied the new x-ray tomography "virtual reading" technique to read inside a large ancient handwritten book without opening it. Positive results were obtained using a compact, laboratory-based radiology system.

This work is based on preliminary investigations that included extensive chemical analysis of ancient manuscripts over six centuries [see Fig.2[b] and (Albertin et al., 2015a)]. The objective was to verify the iron content of black inks in ordinary specimens, e.g., private and administrative records. This element and its quantity are crucial for the technique: its the x-ray absorption of the ink that provide the necessary x-ray contrast not only for radiology but also for tomographic reconstruction of the writings.

Previous tests in the similar direction also included text recognition by tomography on small fragments of ancient and modern manuscripts using synchrotron radiation (Albertin et al., 2015a) and laboratory based (Albertin et al., 2015b) x-ray sources. The investigations provided the capability of the technique to detect characters and words on small samples and also assessed the use of contrast mechanisms based on phase effects rather than on attenuation.

All these pioneering efforts aimed to address the key issue: can the technique work for real, large-size books with hundreds of pages - still using a laboratory based equipment suitable for future applications in the manuscript collections sites? This was the objective of the present investigation, and the results are positive.

The development of the virtual reading technique is primarily inspired by the Venice Time Machine (VTM) project (EPFL, 2015). This is an ongoing collaboration between the Ecole Polytechnique Fédérale de Lausanne (EPFL) and two institutions in Venice: the University Ca' Foscari and the "Archivio di Stato". The Archivio is an historical collection containing almost 100 kilometers of handwritten documents covering ten centuries of the administrative and legal life of Venice. But, as for all ancient collections, their exploitation by scholars is problematic for conservation and logistic reasons: without massive digitization, deciphering, indexing and storage, they are almost unusable. Such are the tasks targeted by the VTM project.

The project also includes the development of novel digitization techniques, since the present ones would

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