

# Quantitative hyperspectral imaging as a conservation tool in archives and libraries

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The study of aging processes of historical materials found in library collections and archives is essential for developing and assessing risk models for their preservation. This is done by keeping records of two main factors: the changes occurring on the preserved artefacts and the environmental conditions in which they are kept, which provoke or influence these changes. The environmental conditions (mainly temperature, humidity, light intensity and air pollutants) are generally controlled as tightly as possible and monitored to verify that the pre-set conditions are kept stable. Non-invasive monitoring is performed to detect and quantify any changes of the physical and chemical conditions of historical objects. This is required to determine whether the pre-set environmental conditions are in fact suitable for the preservation of a specific object or material [1].

The *Nationaal Archief* (National Archives of The Netherlands) is constantly investing in the improvement of established monitoring techniques and in the development and implementation of new ones. The goal is to improve the amount and the accuracy of the condition documentation for historical documents so that conservators can evaluate preventive conservation procedures in a more objective way [2].

Quantitative Hyperspectral Imaging (QHSI) is a non-destructive optical measurement technique that has a great potential for condition monitoring and other document analysis applications in archives and libraries. A few years ago, the *Nationaal Archief* together with commercial and academic partners has started a multidisciplinary project to develop dedicated instrumentation and explore the uses of the QHSI technique in the field of archival documents [3].

Spectral imaging techniques record high-resolution digital images of an object surface at a number of bands in the ultra-violet, visible and near-infrared regions of the electromagnetic spectrum. Spectral imaging can reveal localized chemical and physical differences that influence the light reflection characteristics of the object without direct contact. As compared to conventional multi-spectral imaging, the quantitative hyperspectral imaging technique developed in the project provides a much greater number of spectral bands (70 instead of typical 5 to 10), which allows a much better discrimination between different types of degradation processes that

induce different changes of the spectral characteristics of the object. For monitoring of historical documents over long periods of time, it is of utmost importance that the hyperspectral images are highly repeatable so that any spectral changes of the historical documents can be detected with high sensitivity and accurately quantified. Therefore, an important task of the hyperspectral project is to develop measurement procedures and processing algorithms for calibrating the hyperspectral measurements with maximum accuracy [4].

The potential of the QHSI technique, especially for monitoring purposes, is studied by carrying out repeated measurements on original documents before and after they have been on display or in storage for longer periods of time. The second approach is to use QHSI for measuring spectral changes induced by accelerated aging of laboratory samples that were manufactured with specific materials and techniques. Such artificial aging experiments help to establish correlations between the hyperspectral data and typical degradation processes in the substrates and inks. These experiments are also very useful for further developing of advanced software algorithms for extracting the maximum amount of information from the huge numeric data sets (several gigabytes per object) provided by quantitative hyperspectral measurements.

Recent and current experiments address specific research questions concerning the use of quantitative hyperspectral imaging for non-destructive characterization of ink and pigment degradations, paper yellowing, foxing and also the influence of restoration treatments. In this presentation representative results of these experiments will be presented and the future development and application of QHSI as a standard monitoring technique will be discussed.

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