

# Quantitative Hyperspectral Imaging for the Standardization of Documents Monitoring at the Nationaal Archief (The Netherlands)

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Since 2004 the *Nationaal Archief* (National Archives of The Netherlands) has been investigating the use of Quantitative Hyperspectral Imaging (QHSI) for the non-destructive analysis and monitoring of the surface of historical documents. This research is conducted in a close collaboration between conservators, curators, engineers and software developers, who combine the skills of their disciplines to address the numerous technical challenges found along the investigation path.

Especially for long-term monitoring of the condition of historical documents, the necessity to standardize the measurement method have posed different requirements on the optical instrumentation, as well as on the sample preparation, data acquisition and processing protocols [1].

For a measurement with the QHSI instrument “SEPIA”, which was developed in a cooperation between the *Nationaal Archief* and Art Innovation, the object is placed in a light proof cabinet to eliminate any influence of external light. With a fixed arrangement of wavelength tunable light sources and camera the instrument records spectral reflectance images with 4 megapixel resolution at 70 discrete, contiguous wavelength bands (365-1100 nm) [1]. These raw spectral images are recorded according to a fixed protocol that includes repeated recordings of a standard spectral reflectance target (Spectralon®). From the raw data, the calibrated spectral images are calculated, resulting in the so-called “hyperspectral data cube” that contains a complete reflectance curve for each spot on the document surface [2].

By eliminating in this calibration step the variations of the camera response and light intensity distribution between different recordings, the spectral curves contained in the different hyperspectral data cubes are comparable even when the recording times lie several months or even years apart. The construction of the instrument and the measurement protocol ensure a minimal impact of the measurements on the natural degradation process, so that documents can be measured multiple times to monitor their changes both in the short and long term.

Using the developed standardized data recording and calibration procedure, in recent years quantitative hyperspectral reflectance data has been collected from a considerable number of original documents that are frequently exhibited by the *Nationaal Archief* due to their great historical importance. The available calibrated hyperspectral data cubes enable a comparison of the surface spectral characteristics of a particular document recorded at different times and also of different documents. The resulting information about the degradation process is then linked to the monitoring data of the exhibition and storage conditions of these artifacts to study ageing trends. Parallel to the measurements on original documents, experiments are conducted with laboratory made samples which are subjected to accelerated ageing with different parameters, in order to study links between the spectrally measured deterioration effects and their causes. The goal is to achieve a better understanding of the deterioration processes and of how changes in the documents condition can be quantified to enable an extrapolation of the observed changes into the future.

[1] Padoan et al. 2009. Monitoring Aging Processes of Archival Documents by Means of Quantitative Hyperspectral Imaging: A Part of the Hyperspectral Project at the *Nationaal Archief* (National Archives of the Netherlands), The Book and Paper Group Annual, (AIC), Volume 28, 2009, pp. 63-72;

[2] Klein, M.E., et al. 2007. Quantitative Hyperspectral Reflectance Imaging. *MDPI Sensors*, 8(9), pp. 5576-5618.

**Biographical information of presenting author**

Roberto Padoan is a paper conservator with a ten years experience in the field of conservation of historical documents, having worked as external collaborator at the Secret Vatican Archives and than at the *Nationaal Archief* (National Archives of The Netherlands). He received a BA in “Methods and Technologies for the Conservation of Books and Documents” at the University of Rome “Tor Vergata” and at the moment he is attending a master of research (Mres) in Heritage Science at the University College London (UK). Together with his work as paper conservator, Roberto has been involved in the non destructive testing of documents focusing his last years of research in the application of Quantitative Hyperspectral Imaging (QHSI) as investigation and documentation tool in archives. Within the COST Action (D42) he presented results regarding the possible application of QHSI for the monitoring of the Dead Sea Scrolls.