SURFACE APPEARANCE ASSESSMENT AS A TOOL FOR CHARACTERIZING SILVER TARNISHING

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Abstract

The aim of this study is to create a methodological approach based on imaging techniques and computer vision that can be used as a tool for the characterization of silver tarnish and the presence of fingerprints on silver museum objects. To this extend, material properties of artificially tarnished silver coupons were examined, with the aim to classify the degree of tarnish and to detect fingerprints. Surface alterations were assessed using visual inspection, colorimetry, gloss measurements and monochromatic Reflectance Transformation Imaging (RTI). For the chemical characterization Scanning Electron Microscopy equipped with Energy Dispersive X-rays Spectroscopy (SEM-EDS) and Linear Scanning Voltammetry (LSV) was implemented.

Background Information

In museum collections silver artefacts, when exposed to uncontrolled environment, develop tarnish. Even though tarnishing creates a passive film, it also generates alterations to the surface appearance, which are characterized by loss of shininess and colour changes. Additionally, the improper handling of silver objects with bare hands can cause the appearance of fingerprints on the surface as a result of localized corrosion phenomena.

Goal of the Project

To create a methodological approach using contactless, non invasive techniques, such as imaging, for assessing the material properties of historical metal objects, with the aim to identify descriptors of change that will be able, through statistical analysis, to identify indicators for the detection, characterization, monitoring and if possible prediction of changes on the surface of silver museum objects. To validate the results analytical techniques are complimentary used.

Material Selection & Preparation

Pure silver coupons with two different finishes (mirror and mat) were selected. To mimic the tarnish observed on objects exposed to uncontrolled museum environment, and to ensure a gradual change of the metals surface appearance, a protocol using egg white proteins was used.

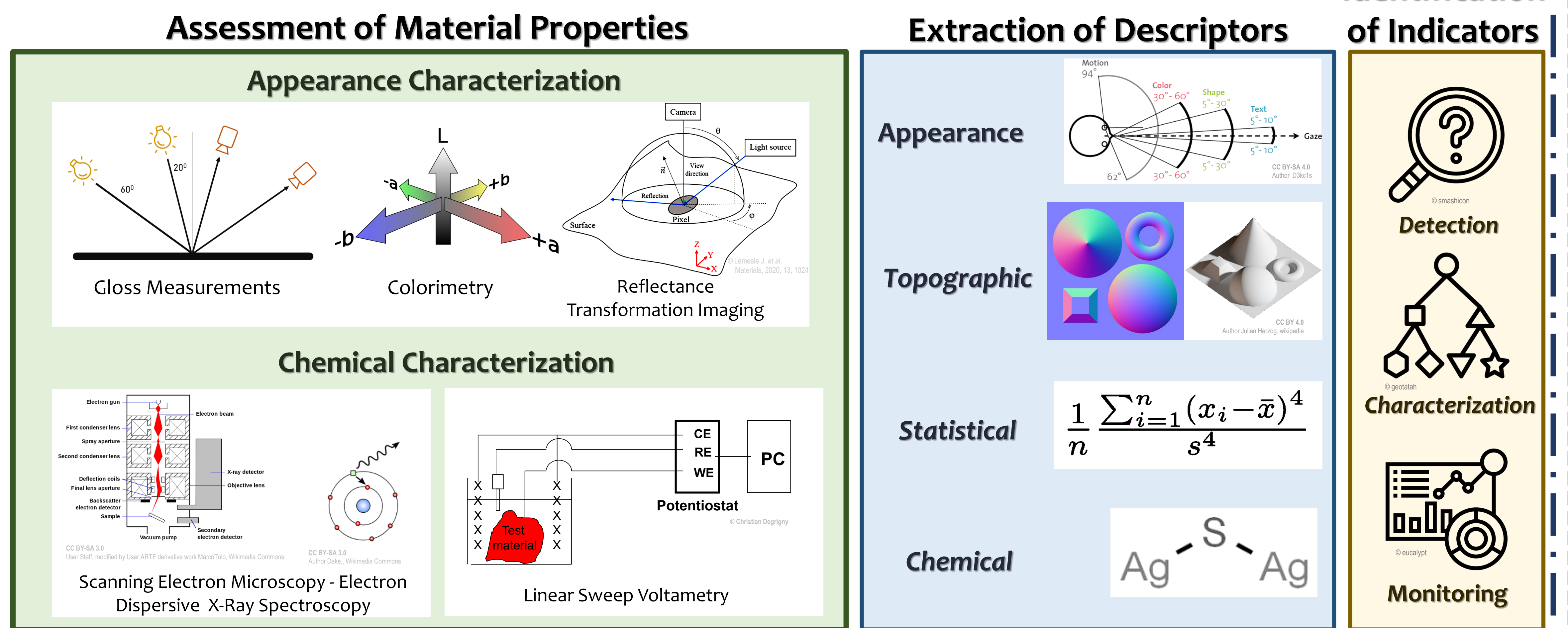*Different degrees of tarnish on historical silver objects*
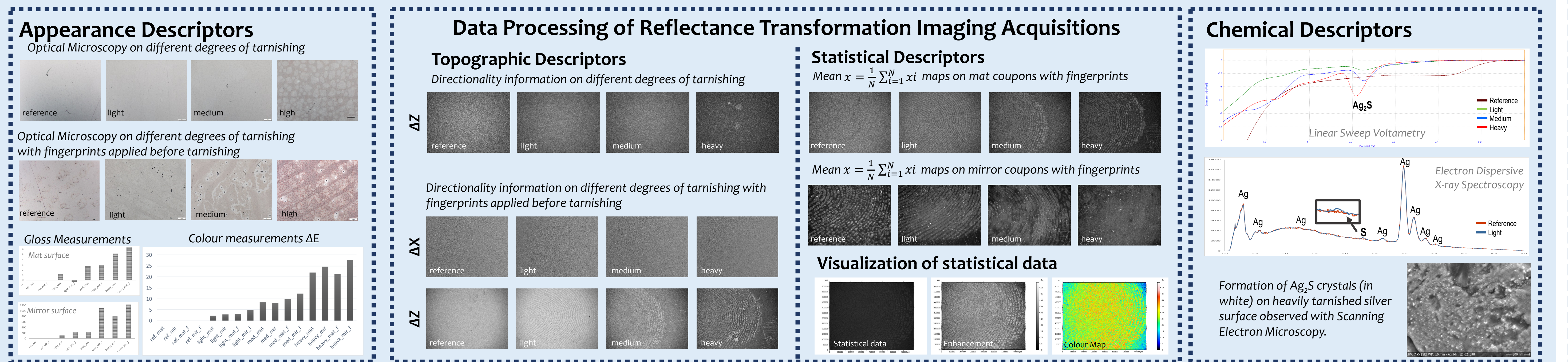
CASE STUDY

Pure Silver coupons with different degrees of tarnish (left) and placement of fingerprints (right)

METHODOLOGICAL APPROACH

Assessment of Material Properties

Appearance Characterization

Gloss Measurements · Colorimetry · Reflectance Transformation Imaging

Chemical Characterization

Scanning Electron Microscopy - Electron Dispersive X-Ray Spectroscopy · Linear Sweep Voltammetry

Extraction of Descriptors

- Appearance
- Topographic
- Statistical

$$\frac{1}{n}\frac{\sum_{i=1}^{n}(x_i - \bar{x})^4}{s^4}$$

- Chemical

$$Ag - S - Ag$$

Identification of Indicators

- Detection
- Characterization
- Monitoring

PRELIMINARY RESULTS

Appearance Descriptors

Optical Microscopy on different degrees of tarnishing

reference · light · medium · high

Optical Microscopy on different degrees of tarnishing with fingerprints applied before tarnishing

reference · light · medium · high

Gloss Measurements · Colour measurements ΔE

Mat surface · Mirror surface

Data Processing of Reflectance Transformation Imaging Acquisitions

Topographic Descriptors

Directionality information on different degrees of tarnishing

ΔZ — reference · light · medium · heavy

Directionality information on different degrees of tarnishing with fingerprints applied before tarnishing

ΔX — reference · light · medium · heavy

ΔZ — reference · light · medium · heavy

Statistical Descriptors

Mean $x = \frac{1}{N}\sum_{i=1}^{N} xi$ maps on mat coupons with fingerprints

reference · light · medium · heavy

Mean $x = \frac{1}{N}\sum_{i=1}^{N} xi$ maps on mirror coupons with fingerprints

reference · light · medium · heavy

Visualization of statistical data

Statistical data · Enhancement · Colour Map

Chemical Descriptors

Ag_2S

Linear Sweep Voltammetry — Reference, Light, Medium, Heavy

Electron Dispersive X-ray Spectroscopy — Reference, Light
Ag · Ag · Ag · S · Ag · Ag · Ag

Formation of Ag_2S crystals (in white) on heavily tarnished silver surface observed with Scanning Electron Microscopy.

Conclusion and Perspectives

- Early tarnish is not easily detected visually but is more detectable in the case of fingerprints.
- Colour changes, due to tarnish, can be detected by a spectrophotometer. These changes are more profound in the case where fingerprints are present.
- Gloss changes can be recorded but without presenting identifiable descriptors.
- Visualization of raw RTI data, using a monochromatic sensor, doesn't allow the distinction of different degrees of tarnish, however it allows the observation & assessment of the fingerprints.
- The detection and characterization of fingerprints is enhanced through statistical and geometrical analysis of RTI data.

- Characterization of Ag_2S and assessment of the degree of tarnish were possible with LSV and SEM-EDS.
- The correlation study of different descriptors (appearance, topography, statistical, chemical) was performed to assess surface alteration caused by changes in material properties, that through statistical analysis, will allow observation and classification of changes during silver tarnishing or placement of fingerprints.
- Future perspectives include the use of RGB – RTI, acquisitions and statistical analysis, to identify descriptors related to the reflection response of the metal surface to different colour bands.

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