Determining the elastic modulus of historic oil paintings

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View of Delft by J. Vermeer (1660-1661)
Obtained from [1].

Introduction

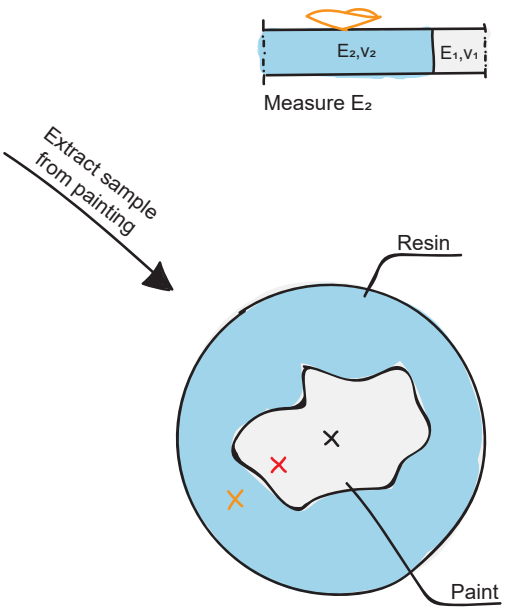
Nano-indentation is a technique that can be used to retrieve mechanical properties, such as the elastic modulus, at small scales. This technique is particularly advantageous when, for conservation purposes, material properties of historical oil paintings are required. In this way, measurements can be performed on small samples of actual historical paintings, allowing for more realistic values than if the properties were retrieved from artificially aged mock-ups. However, to perform the indentation tests, these samples need to be embedded in a resin. This influences the calculated stiffness [2].

Goal of the research

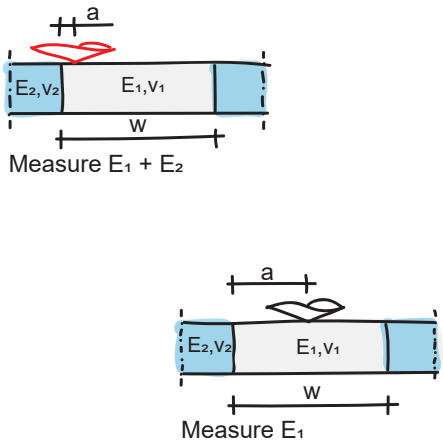
This research aims at understanding the effect of the embedding material on the material properties obtained from an indentation test, irregardless of the position at which the indentation is performed.

Methodology

The work is based on a set of numerical simulations to be compared with experimental data from real paint samples.

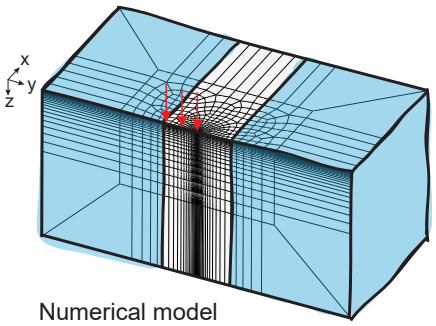


Schematic drawing of a paint sample embedded in resin.



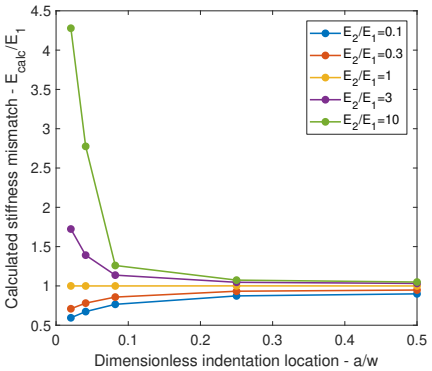
Model

- The model is three dimensional;
- Symmetry boundary conditions apply on y-z plane;
- Infinite elements ($u \rightarrow 0$ for $d \rightarrow \infty$ [3]) are assumed along the other planes;
- Linear elastic constitutive behavior is assumed.



Numerical model

Results



Calculated stiffness normalized by the stiffness of the paint as a function of the indentation location, for a relative indentation depth of 2.5%.

Future work

- Include visco-plastic constitutive behavior;
- Validation with experiments performed by The Getty conservation Institute.

References

[1] https://www.mauritshuis.nl/

[2] A. Freeman et al. Mechanical characterization of a cross-sectional TiO_2 acrylic-based paint by nano-indentation, Unpublished.

[3] O.C. Zienkiewicz et al. A novel boundary infinite element, 1982.

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PhD progress

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The Getty Conservation Institute