Visualising surface texture through the combination of 2D and 3D data

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INTRODUCTION

The National Gallery in London has recently been testing the potential of 3D scanning technology to record and measure the surface of paintings, using a Lucida laser scanner designed by Manuel Franquelo and custom built by Factum Arte. The Lucida scanner outputs 3D information as 2D grayscale depth-map files which can then be used to generate both 2D shaded renders of the textured surface in addition to the traditional 3D triangular meshes.

There are, however, issues with these two outputs when it comes to visualisation. On one hand, greyscale rendered images can only display surface texture illuminated from a range of defined positions, they are individual static images that cannot convey texture information as a full interactive 3D model. On the other hand, generated triangular 3D meshes of detailed surface texture require a vast amount of computing power to visualise and interact with the final processed 3D model.

A new workflow is being developed that combines 2D images and 3D data captured at the National Gallery with RTI images to facilitate the efficient visualisation of the surface texture of paintings. A portrait by Goya from the NG Collection, Doña Isabel de Porcel, is used as an example.

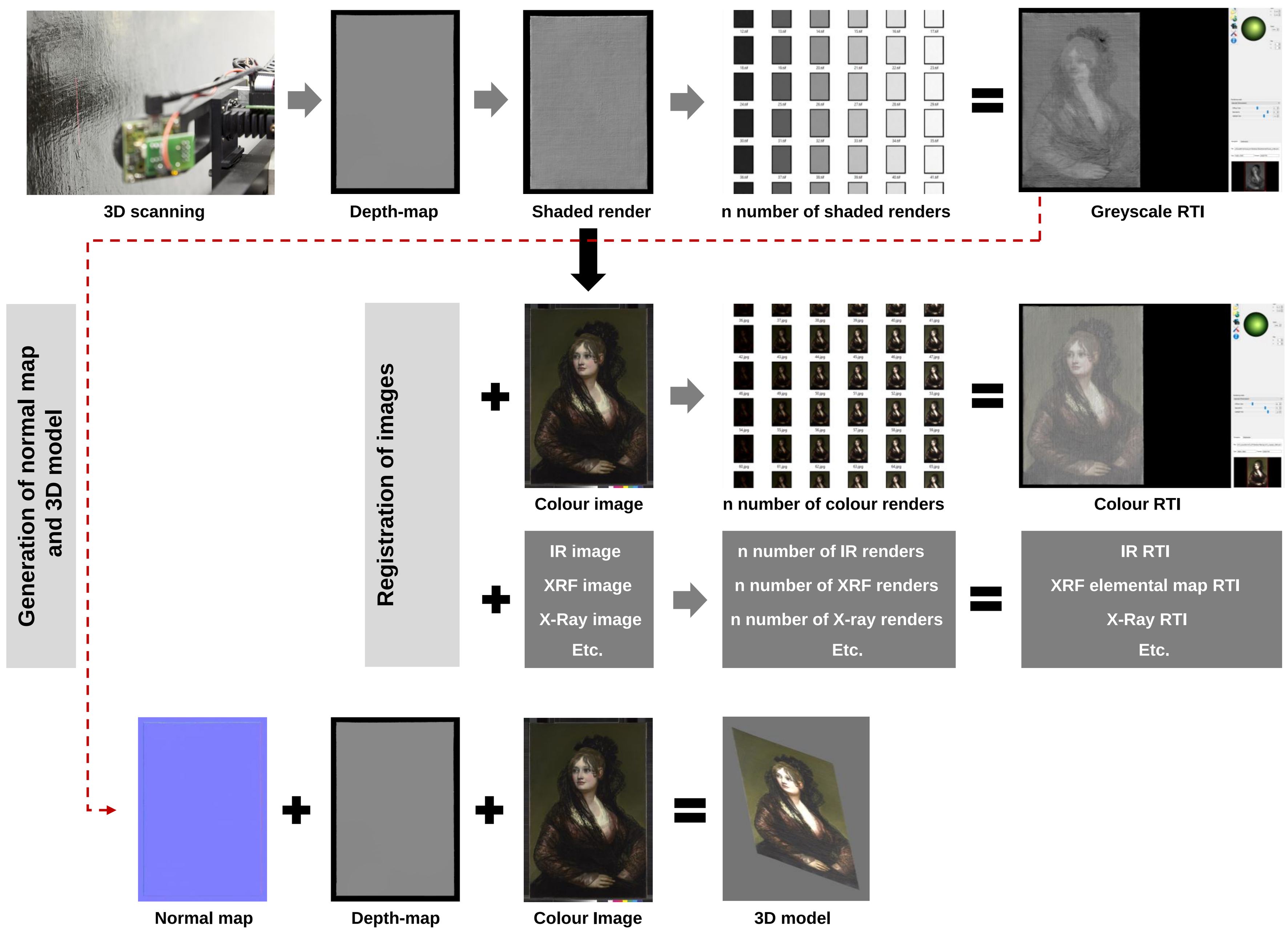
WORKFLOW

3D scanning and processing

The 3D scanner projects a beam of red light onto the surface. The deformation of the beam is recorded by two cameras as it moves across the surface at a resolution of 100 microns. All files are saved as raw black and white video data and processed as a tone depth-map. The scanner records individual tiles (480mm x 468mm) which are then edited, stitched and merged to create a whole record of the surface. After scanning and processing the 3D data, a final 32 bit grayscale depth-map file is obtained. The different grayscale tones in the file define the depth of each pixel recorded of the surface of the painting.

Generation of colour RTI images

The Lucida software uses the depth-map file to generate a controlled number of shaded rendered images lighted from different directions and a light position file which indicates the normalised position in space of each light source used in each image. The images and the LP file can then be processed with the RTI builder or the PTM software to generate a final RTI interactive image.

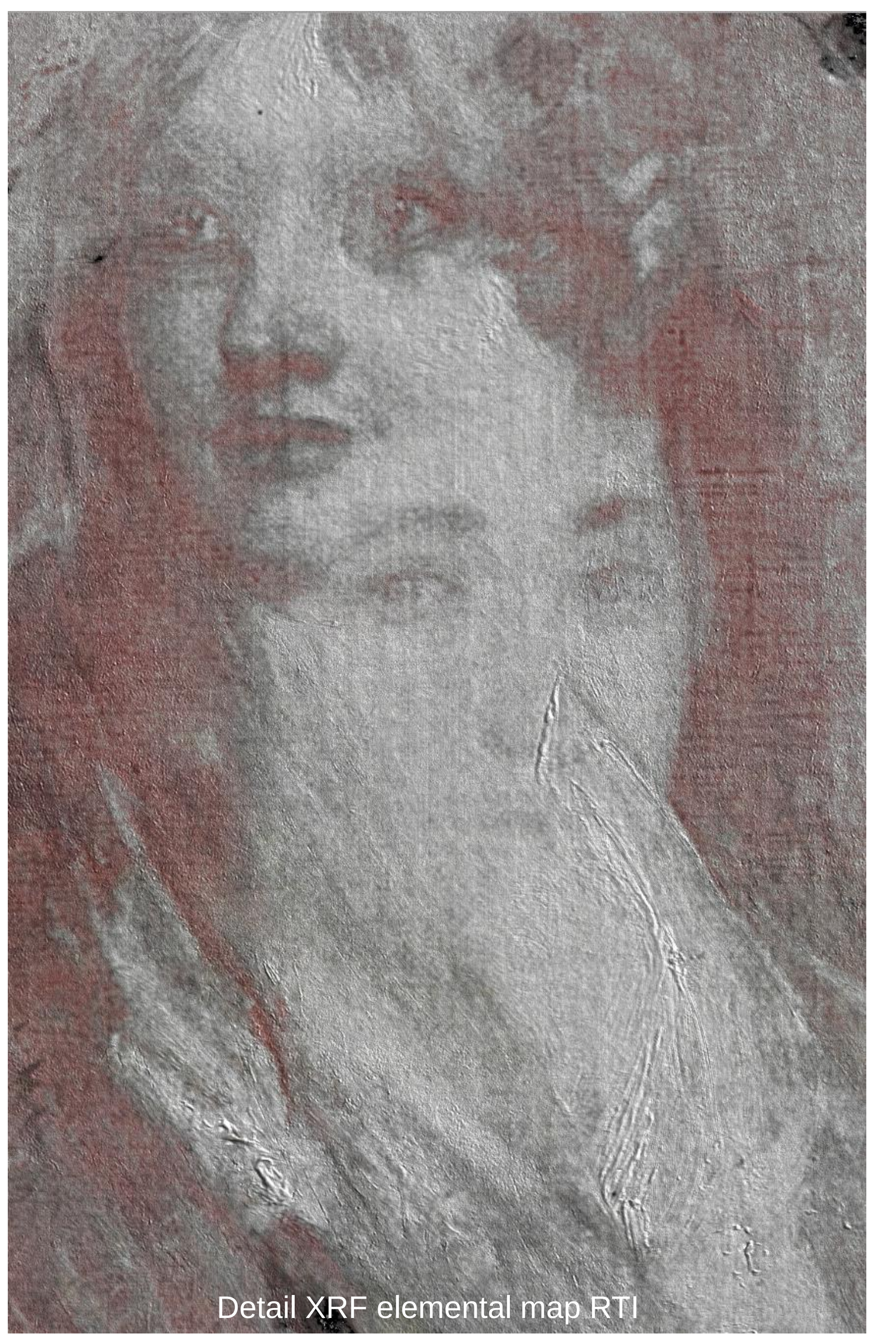


Workflow overview. Generation of 3D data, RTI images and 3D models.

To generate the 3D model the same grayscale depth-map used to produce the shaded renders is imported into the 3D software Blender as a 2D image plane. Once imported, a number ‘modifiers’ are applied to the plane to extract the 3D information in the form of a triangular mesh. In order to keep the model manageable the plane is only subdivided around half a million polygons. This provides the model with an overall shape sufficient to show the possible deformations of the canvas or wooden support and enough detail to display the thickest impasto on the surface of the painting as the finer surface details will be later provided by the normal map.

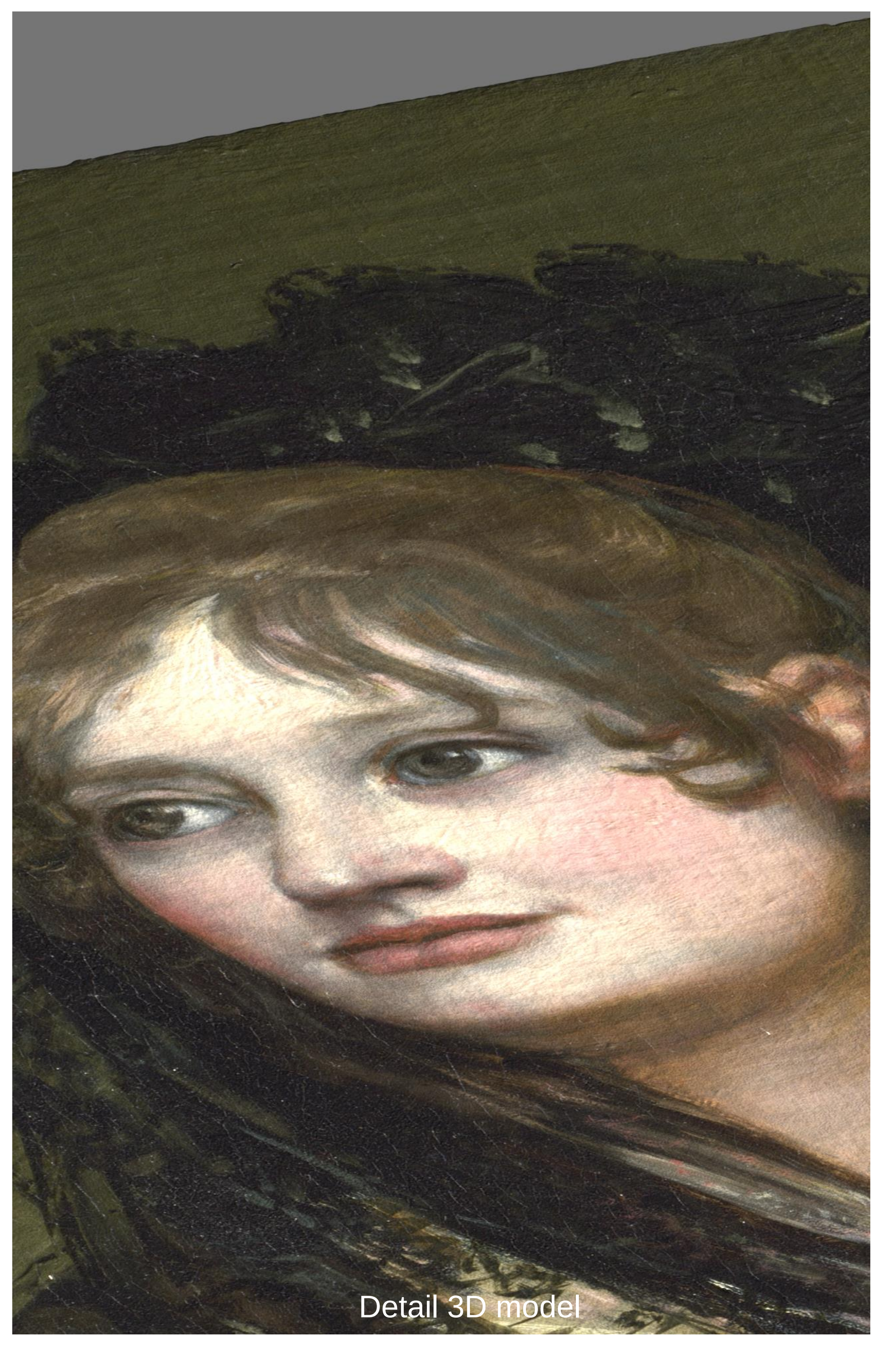
Once the modifiers are applied, the normal map and the colour image are mapped to the mesh. As the colour image has been previously registered to generate the coloured RTI, and the normal map has been extracted from that same RTI, there is no need for further adjustments when mapping the images.

The final stage involves adding the correct type of lights and camera parameters, and modifying the diffuse and specular properties of the various surfaces to achieve the appropriate appearance of the surface of the painting. When the model is ready it can be


Detail XRF elemental map RTI


Detail Colour RTI


Detail Infrared Reflectography RTI


Detail 3D model

Because the shaded renders are only in grayscale, the RTIs can be further explored by registering existing colour, Infrared Reflectography, elemental XRF maps and X-ray images of the painting to the shaded renders to visually compare the relationship between the textured data and the other image based examination techniques.

Registration is a two-step process; first, a perspective match transformation in order to correct size, translation, rotation and perspective distortion differences between the two images; second, converting all images to Lab colour space and substituting the ‘ab’ colour channels into the greyscale shaded renders. This results in the same series of images with surface data information, but with the added benefit of having colour, infrared or X-ray information. These operations are efficiently done with Nip2 open source software.

Generation of colour 3D models

Visualisation of highly detailed meshes of painted surfaces requires the use of professional workstations with powerful GPU cards that can process the model in real time. This ideal scenario is highly unlikely even within important heritage institutions. In order to overcome this issue the proposed workflow borrows some of the techniques used in the gaming industry to produce highly detailed 3D models of the surface of paintings. We take advantage of the normal maps generated with the RTI or PTM software and incorporate them into the 3D models. The normal maps allow us to create the illusion of a highly detailed surface texture without the strain of a multimillion polygonal mesh.

both interacted with instantly using current physically based rendering standards within the 3D software or it can be rendered to produce 2D images or videos of the painting.

CONCLUSIONS

The generation of 3D information as 2D greyscale depth-map files facilitates the production of shaded renders that can be used to create interactive RTI images. By registering these with existing 2D images to generate further RTI images provides a way of visualising possible relations across paint layers and whether hidden layers actually show on the surface of a particular painting.

By combining existing 3D data, colour images and normal maps to generate realistic 3D models of the surface of paintings we overcome the problem of relying on extremely powerful computers to interact and visualise the models.

REFERENCES

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