An investigation into the micro surface of artworks using alternative lighting techniques

Flavia Tisato 1, Carinna Parraman 2
1University of Ferrara, Scientific-tecnologic pole - via G. Saragat, 1 - 44121 Ferrara, Italy.
Centre for Fine Print Research, University of the West of England, Bower Ashton Campus, Kennel Lodge Road, Bristol, BS3 2JT, UK

ABSTRACT
The objective is to create a micro-environment - an illuminated dome with a constant geometry of illumination - to undertake non invasive observation of the surface topography of artworks. The dome is attached to a stereo-microscope, which is able to gain - at the same time - both colour and texture features of the sample. By using a stereo-microscope, a more detailed observation is possible. Important elements including colour, texture, the morphology of the sample surface, in terms of specular and diffused components of reflected light, can be summarized/condensed in the measure of Bidirectional Texture Function.

Keywords: 2.5D printing, lighting dome, artworks, microscope, raking light

1. INTRODUCTION
The technique of raking light consists of illuminating objects at an oblique angle from a light source that is very close to the surface. [1] By using raking light, the details of brushstrokes and the surface texture of a painting is accentuated, both by the increased illumination of surfaces facing the light source, and the exaggerated shadows of non-illuminated surfaces. This sort of method provides useful information about the surface topography and relief of the artefact, and that is why it is widely used in the examination of works of art. Furthermore, raking light can help to emphasize various painting techniques, and can for example, assist conservators through non-invasive examination of artworks. It also may be useful in order to monitor the effects of conservation interventions.

In the context of recent developments in additive layer manufacturing and projects investigating the application of contemporary texture to surfaces or construction of surface topology, paintings can be considered as a three-dimensional landscape, although composition and colour are key components of an artwork, texture is also vital, as it provides a unique ‘fingerprint’ of an artwork’s surface [2].

In this paper, an alternative approach is presented, starting with an illuminated dome that is attached to a stereo-microscope, which is able to gain visual information on the colour, texture and gloss of a sample. By using a stereo-microscope, a more detailed observation is possible. Important elements including colour, texture, the morphology of the sample surface, in terms of specular and diffused components of reflected light, can be summarized and condensed in the measure of Bidirectional Texture Function [3].

The whole apparatus consists of an enclosed rotating dome in which is placed the sample. On the external shell of the dome a hole is present, through which a light source is inserted, a small Lambertian bright 0.5W LED lamp (6000k) illuminates the sample surface at a fixed angle. The dome is rotated around the sample so that the sample is illuminated from different directions. By rotating the dome, it is possible to obtain both single pictures and a 360° rotating view.

This method would be useful in order to better characterize the sample with its colorimetric and texture features, then it would allow an easier digital reconstruction of the sample and, thus, a more simple reproducibility by printing. Furthermore, for restorers involved in a conservative intervention, it could be a useful way to monitor their work and to provide a feedback, that is, on a scientific basis for the subsequent steps. [4, 5]
2. THE DEVELOPMENT OF VECTOR BASED METHODS FOR 2.5D PRINTING

This paper presents ongoing research into the application of 2.5D printing at the Centre for Fine Print Research [6,7] and methods of capturing and visualising brush marks. The project has developed as recent trends in digital printing and manufacture has moved from 2D inkjet printing to 3D additive layer deposition. It has explored ideas around 2.5D deposition printing, and the fluid dynamics of paint on paper by adjusting the topological surface of the substrate by layering inks or pigments to achieve modifications in tone, viscosity, gloss and texture. A current enquiry is concerned with firstly historical and contemporary approaches [8] to analogue style Textons (drawing, printmaking painting, sculpture) and how these could be transcribed into vector-based methods for image generation.

This research is influenced by technologies for the scanning and printing of two-dimensional and three-dimensional artefacts. For example Polynomial Texture Mapping (PTM) techniques to create a Reflectance Transformation Image (RTI) [9-11] are being used for the inspection, conservation and heritage of fragile artefacts and artworks. The object, painting or texture is photographed at different angles using a single light source and stacked together. These methods of image capture are non-invasive and non-destructive and provide highly detailed image-based simulations of, for example, texture, relief, cracks, brushstrokes and faults.

As shown in figure 2, a series of brush strokes are mechanically applied at regular intervals, at a relative even pressure and consistency of paint. Although the brush strokes are applied mechanically, there are still modulations in the stroke. The strokes appear uniform, and where more paint is applied, the brush strokes appear darker. In the magnified section...
of figure 3, there is a significant difference in appearance between the area of the stroke that is heavily charged with paint, which appears darker and is more concentrated, compared to the area where less paint is applied, which appears lighter and more translucent.

![Figure 3. Showing 1 x magnification of brushstroke (file VJ27) using a cork nib held at a 45° angle. Flow rate: 2 x 10; Paint head force:100](image)

### 3. SET UP OF THE APPARATUS

Our objective is to investigate the 2.5D surface qualities under magnification of artworks such as brush strokes, Woodburytypes, printing plates and relief surfaces.

Our approach was informed by the work undertaken at the National Gallery London. The NG dome was a wooden frame octagonal polynomial structure comprising 24 small low voltage spot lights, which were attached to the inside of the frame and directed towards the central base. [12]

For this project, we decided that the dome should be enclosed, so that the illumination across the surfaces could be controlled and a LED could provide a sharp field of light. In order to guarantee a “micro-environment” with a constant geometry of illumination and observation of the sample, a closed hemispherical covering, approximately 20 cm high, is placed above the sample. The whole apparatus consists of an enclosed rotating dome, which is fixed into a rigid bevelled ring, and is placed onto a solid wooden base. The sample is centrally positioned on the solid wooden base and the rigid ring allows the dome to be rotated around the sample. The size of the sample that can be micro photographed is 2.16 x 1.7cm².

#### 3.1 Building the dome and base

The 20cm high lightweight dome is fabricated in paper maché and painted a matte black on the inside. A 20cm aperture is cut in the top to accommodate the microscope objective and to allow the microscope to focus on the sample. The rigid 285mm diameter ring (15.5mm high) into which the paper maché dome is fixed, is generated in Solid Works 3D CAD, exported as an .stl file to a Stratasys 3D printer, and fabricated using a rigid opaque polypropylene.

The side elevation, (fig. 4) of the bevelled ring (base) shows a channel at the top in which the dome is fitted, and a ridge along the bottom which slots into a solid wooden base. A routed channel in the solid wooden base allows the dome and the ring to be freely rotated and without allowing light to enter.

In order to rotate the ring accurately, the outer bevelled edge of the ring is divided into 360 1° increments around the circumference. There are small tabs that are equally spaced at 45° increments. The paper dome is slotted into a 1.5mm channel of the ring. This holds the dome in place and ensures stability and accuracy when rotating the dome.
3.2 Capturing the samples

In order to provide a better understanding of the relationship between ink or paint on the different substrates, the samples are examined under a stereo-microscope. The samples are captured using a Nikon SMZ800 stereo zoom microscope with a P-ED Plan 0.5x objective, attached to a G-US2 universal table stand so that a range of samples can be examined. Nikon Elements software can be used as both a visualisation and measuring tool. Images obtained emphasize the three-dimensionality of every smallest detail, of a single brushstroke, making it possible to digitally reconstruct the surface. In the following figure 6, raking light is used at different angles, highlighting the shadows created by the ridges of paint, the texture of the paint and paper.
Figure 6. Illustrates the appearance of a painted sample, captured using raking light at 0, 90, 180 and 270 degree (file VP19, flow 1 x10, force 100, brush: cork nib)

Figure 7 shows the use of raking light in combination with magnification of the sample. Peter McCallion [7] is investigating the use of CNC machining and casting using silicones to create texture in continuous tone digital images. The following images show McCallion’s cast silicone prints under increasing magnification. The magnification using raking light (from the same position) highlights the different depths of the silicone, the gloss and texture, but also dust and air bubbles.

Figure 7. Silicone cast print by P. McCallion (2013). The magnification increases from 1x (top left) to 6.3x (bottom right). Measurement bars (shown in white) are equivalent to 1mm. The raking light is positioned equivalent to 180° as shown in figure 6.
4. CONCLUSION

This paper has described a method for building an illuminated dome that is designed to be attached to a stereo-
microscope. The objective of the project was to be able to provide a tool that can be used to visualise, capture and
compare fine surface textures and microscopic detail. A range of surfaces that include 2.5D characteristics have been
observed, and include etchings, relief prints, continuous tone prints. The raking light enables better visualisation of the
details that could assist in methods of analysis for the field of conservation and heritage. The aim is also to be able to use this
information for further digital and texture applications.

Acknowledgements

Thank you Chris Bytheway for the CAD rendered drawings of the bevelled ring.

REFERENCES

[4] Artal-Ishbrand, P., Klausmeyer, P., Murray, W., “An Evaluation of Decorative Techniques on a Red-Figure Attic Vase from the
Worcester Art Museum using Reflectance Transformation Imaging (RTI) and Confocal Microscopy with a Special Focus on the
Measuring, Modelling, and Reproducing Material Appearance (2014).
[8] Parraman, C “The visual appearance and surface texture of materials according to the old masters,” SPIE Proceedings Vol. 9018,
Measuring, Modelling, and Reproducing Material Appearance (2014).
analysis and presentation of archaeological materials,” In, ISPRS Commission V Midterm Symposium, Newcastle, UK, p.218-223
(2010).
the Arts, London, 6 - 8 July (2011).