Re-illuminating the past
Introduction to Reflectance Transformation Imaging

Click on the image to watch the video

III. 1. How to use Reflectance Transformation Imaging to visualize the daguerreotype's surface, by Archaeovision
ABSTRACT

Reflectance Transformation Imaging (RTI) has been used for cultural heritage documentation after its first publication by Tom Malzbender in 2001. The technique allows us to record 3D surface reflectance properties and visualise them as 2D interactive images. It can be used to investigate the object in various lighting conditions to enhance very small surface changes, to bring out cracks, tool marks, scratches, pencil impressions etc. that are not visible to the naked eye. It is a perfect tool when looking at coins, writing tablets and also daguerreotypes. For example, in the case of daguerreotype plates, it brings out its fine polishing lines, retouching and deteriorations. It makes the condition report more accurate and it helps conservators to make decisions about the conservation needed.

In this paper we will give a brief introduction about the RTI technique to daguerreotype researchers with some practical tips illustrated through a case study that took place at the Estonian Literary museum in Tartu, where five daguerreotypes are kept.

KEY WORDS: Computational photography, Reflectance transformation imaging

CURRENT RESEARCH

For decades raking light has been used for inspecting paintings and objects to gather information about their relief and surface topography. Very low angle light illumination, almost parallel to the object surface, creates strong shadows to enhance the visibility of small topographical changes. The same effect is now digitally manipulated and is no longer limited to only one angle and one direction but it covers all the angles and all the directions of the hemispherical space. Reflectance Transformation Imaging (RTI) introduces us to the possibility to relight the object digitally and enhance the output via filters based on several mathematical algorithms.

RTI was invented by Tom Malzbender from Hewlett Packard Laboratories and published in 2001 (Malzbender 2001). Originally the method was known as Polynomial Texture Mapping (PTM) based on the algorithm created, and it is how it is still known by some who use the technique. In this first paper the method was used on archaeological artefacts such as writing tablets and funerary statuettes. Since then it has been used for a variety of applications, for example in forensics, as seen in Hamiel & Yoshida (2007), classical text research as seen in Earl et al (2011), Egyptology by Piquette (2014), numismatics by Mudge et al (2005), community driven churchyard documentation projects, investigating rock art engravings as seen in Diaz Guardamino & Wheatley (2013) and statues through the work of Pitts et al (2014) and many more.

WHAT IS RTI?

RTI is a technique that is based on a set of photographs taken of the same object from the same location and with the same camera settings. The only thing that changes in each photograph is the position of the light source (external flash or continuous light which is stronger than ambient light). Distance is of extreme importance when capturing this data with the light source having to be kept at the same distance from the object. This light source is moved around the object of interest, to cover a “dome like” area.

In total, between 40 and 70 images should be captured, each with a different light position. These are then processed and fitted as one interactive image which can then be digitally manipulated. Importantly this image is not a composite image, where the original photographs are stored and displayed, but the result of mathematical calculation, where the light illuminates the object based on the topographical information extracted from the images, the lighting function created for each pixel and also the colour information for each pixel. (see video by clicking on the III.1)

The topographical information expressed is in a form of surface normals which the RTI processing software is able to calculate. Surface normals are vectors (III. 2), perpendicular to the surface at any given position. This then gives us three dimensional shape information visualised in a two dimensional space. This type of visualisation is sometimes referred to as “two and a half dimensional”. Within the RTI viewing software, users have the ability to move the virtual light source in any direction, the software then uses the shape information to visualise the light behaviour and reflections on the surface. In order for the software to work correctly, each image captured needs to be processed to create these surface normals. This is completed in the processing phase within the creation of the RTI file, whereby each light position is calculated for each image. The location and generation of the light source varies depending on the method used and will either be given to processing software via known light position or automatically calculated when unknown positions are used.

TOOLS FOR RTI CAPTURE AND PROCESSING

One of the benefits of the RTI method is its accessibility there is no need for advanced or expensive equipment (assuming that most
Researchers and institutions already own an SLR camera) or for expensive software. Images for RTI can be acquired using for example the following two methods. One is to use a fixed set of lights, known as a “dome setup” (Ill. 3). With this method the lights are in fixed positions and do not change, therefore the calculation of their locations for each capture session is not needed as the same set of location information is used for RTI processing. This method speeds up the capture and processing time but requires the “dome” or other kind of fixed setup.

The second method of capture is called high light RTI (HRTI). In this method the light positions are unknown. In order to generate surface normals, a spherical shiny ball is used within the capturing process. Using a shiny spherical ball allows a highlight to be captured on the sphere’s surface. The highlight is then extracted in the processing software, which then generates the light source location. As a result, only a single light is needed within this method and it provides flexibility in terms of the sizes of objects that can be recorded.

As the method works via a camera, and with the light source needing to be at a distance of three times the longest length of the object captured, it means that areas as large as rock art panels can be captured as can those under a microscope, with the main difference being the power of the light source used.

The main tools for RTI capture are (Ill. 4):

- SLR camera,
- reflective spheres (snooker ball, ball bearings),
- light source (flash or continuous)
- piece of string (for keeping the distance

The processing of the images is completed within the free software called RTI Builder and the results are viewed in the RTI Viewer. All of the software, user and capture guides are available from Cultural Heritage Imaging website.

**RTI FOR DAGUERREOTYPES**

RTI images provide information about daguerreotype production, as well as their current research.

*Ill. 3, RTI dome. Dome produced during ACRG funded RTISAD project set up at National Archives, London. Photo by Hembo Pagi*

*Ill. 4, RTI capture in action. External flash is used as light source. Photo by Yahir Puik*

*Ill. 5, Raking light from the top to bring out polishing lines*

*Ill. 6, Close up view in “Specular enhancement” mode in RTI Viewer*
condition. For example, polishing lines which run parallel across the surface of the plate are visible often only in raking light (Ill. 5). With the help of RTI visualisation, the 3D nature of the object is exaggerated (Ill. 6) and for that reason, a conservator is able to inspect more closely the surface of the plate. It allows for zoomed in detailed views of tool marks, hand colouring, tarnish, scratches, biological growth, surface dust, accretions etc. It also enables detailed reference images to be saved and therefore makes the condition recording more accurate, and helps prevent damage caused by handling the original object.

There are several problems when photographing daguerreotypes, not only do they contain a reflective surface which picks up ambient light reflections, but the introduction of the protective glass covering, which may bear scratches and dust, make the process much harder. As the surface detail is reflective, one has to take extra care that no external light source, other than the one intended, is captured within the data. Examples of external light sources that often affect a data capture are ceiling lights and windows. Great care must be taken when setting up the camera as the majority of the ambient light can be removed by changing the aperture of the camera. This is important as the processing software might otherwise include ambient light within the final RTI file and thus may produce erroneous data.

In Webb & Wachowiak (2011) a home-made snoot was added to the lighting source when photographing a daguerreotype to decrease the amount of flare (Ill. 2) captured within the photographs. However, this would lead to the covering of surface detail required within the RTI dataset. In order to move away from using added material with an already difficult to capture object, a series of low angled light position photographs were taken. The strongest shadows, which bring out the most detail, are created when the light is at a low angle. Flare and reflection from the reflective surface is only evident when photographs with higher angled lights are taken. As such the capturing process focused on creating the least amount of flare and reflection as possible with only the best angled photographs used for the generation of the RTI dataset.

**Conclusion**

RTI is a way to interactively visualise the surface of the daguerreotype to bring out even the smallest details such as scratches and polishing lines, which run parallel across the surface. It is very accessible as no special equipment is needed and software for processing the images and viewing the end result is free.

**SELECTED BIBLIOGRAPHY**

Cultural Heritage Imaging. (n.d.). Retrieved February 04, 2015, from culturalheritageimaging.org


