COST Action TD1201 – Colour and Space in Cultural Heritage (COSCH)

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Visualising an Archaeological Object by 3D Colour Imaging

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The P3DIM Research Centre at UCL has developed a method of processing a digital image set captured in a hemispherical illumination dome to extract surface normals by the photometric stereo technique. When combined with the geometry from a 3D laser scanner this enables an accurate and highly detailed digital terrain model to be generated of an object's surface topography.

The dome photographic apparatus and method was developed for polynomial texture mapping (PTM) which combines the set of 64 pixel-registered digital images for visualisation of the object, allowing a virtual light source to be moved interactively to reveal the 3D features of the surface. We have developed an alternative means of processing the same image set, by using the photometric stereo technique to extract normals and the bidirectional reflectance distribution function (BRDF) of the surface. The method achieves a higher angular resolution than the normals derived from the PTM representation. We map the spatial detail obtained from photometric stereo onto the underlying geometry of the surface obtained from the point cloud representation produced by an Arius 3D colour laser scanner. From this combination the height of each point can be accurately reconstructed, producing a digital terrain model of the surface. Over the past decade the principle of PTM has been generalised into a family of image capture techniques, known as reflectance transformation imaging (RTI). This has become established as a powerful method for acquiring and representing the 3D surface reflectance properties of an object, enabling realistic rendering and 'relighting'. Colorimetric accuracy has been ensured by measuring the spectral power distribution of the flash lights in the dome and the spectral sensitivity of the three channels of the Nikon camera at 5nm wavelength intervals to establish a known relationship between the CIE *L*a*b** values of any object colour and the *R,G,B* signal values generated by the camera.

The method will be illustrated through a case study on the original and a plaster cast of the so-called Hunters Palette, an early Egyptian (*c*. 3100 BCE) stone slab in the British Museum, relief-carved with figures of humans, animals and other imagery. Using depth profiles derived from the terrain model to complement the PTM visualisation, there seems to be evidence for recarving which probably occurred during the original manufacture of the object.

Surface normals of the Hunter's Palette, derived by the photometric stereo method, shown in false colour with the X,Y,Z components represented by R,G,B channels.

Author's Biography

Lindsay MacDonald is a Research Fellow in the Photogrammetry, 3D Imaging and Metrology (P3DIM) Research Centre at University College London (UCL). The Centre carries out a wide variety of scientific and applied research directed towards the acquisition and understanding of precise and reliable measurements of a diverse range of natural and man-made objects and structures. Expertise encompasses the accurate spatial and colour recording of fine art and heritage artefacts, photogrammetric image networks and sequences, vision metrology, laser scanning, range imaging and 3D modelling techniques.

Lindsay is editor of eight books on colour image science and its applications in cultural heritage and author of over a hundred papers in conference proceedings and journals articles. He is a Fellow of five professional societies, including the Royal Photographic Society. He has served on several CIE Technical Committees, and is currently a member of the Executive Committee of the International Colour Association (AIC).