

The Visualisation and Expression of Virtual 3D Surfaces Explored through Custom Developed Interactive Software, Optically Mixed Coloured Surface Contouring and Fine Art Printmaking

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Abstract

This short presentation paper describes an exploration and the visualisation of virtual 3D compositions through custom developed software and fine art printmaking. The author, a trained and practising visual artist considers this innovative visualisation as an exploration into the newly emerging visual language of the computer in similar vein to some of the NPR artists. The comprehension of virtual 3D objects is achieved primarily through linear surface contouring. The colour of these 3D surfaces is created by components intrinsic to the contour structure culminating in optical colour mixtures. The custom software, developed by the author, facilitates the application of the surface contouring to imported pre-constructed 3D object's surfaces, computing the contouring component configurations and dimensions. Fine art screen-prints are created from DIBs generated within the software from the colour layers comprising the surface contouring. The printed DIBs form monochrome positives that are available for the artist to edit at will, before or following the transfer to screen-print screens and printing in CMYK screen-printing inks. The entire process can be reiterated editing the composition's coloured contouring using the software, the positives or even the screens themselves until a satisfactory aesthetic result is obtained.

J.5[Arts and Humanities]: Fine Arts

1. Introduction

The late twentieth century saw the emergence of new artistic mediums derived from the burgeoning electronic digital technologies. Many visual artists, excited by these technologies, have embraced and integrated these artistic mediums with those of tradition, while few have recognised the arrival of a unique visual language.

A growing minority of these visual artists became aware of the limitations imposed by mass produced commercial software with its trend to emulate the traditional mediums. Driven by these software limitations, these artists decided to take control of the medium and create their own software.

This research was motivated by the author's desire to extend his ideas, fundamental to his painting and printmaking practices, into the emerging medium of 3D computer imaging exploring its visual language. To accomplish this goal the author has developed and written an interactive software application program for the representation of 3D free form surfaces by contours and employing optically mixed colour by averaging [AGO87].

The use of lines of contour to depict 3D surfaces (not to be confused with the occluding contour or silhouette) has a centuries-old tradition, particularly in the printmaking method of the Renaissance line engravers [KEM94]. The surface contour, little understood until the

late twentieth century [Mar82], is one of our most important visual perception depth cues for 3D surface comprehension. Although employed less by painters, some artists have combined the surface contour with techniques of optical colour mixing that is achieved by juxtaposing narrow lines of colour modelling the surface of objects.

The software is part of the author's developed system for creating fine art screen-prints from virtual 3D compositions on whose objects' surfaces a novel coloured surface contouring is applied. From a selected view of the colour contoured 3D composition, a 2D image of each colour component layer is printed to form positives for the production of fine art screen-prints [MAR79]. The unique structure of these colour positives allows them to be manually edited by the artist printmaker prior to the printing process.

2. Background, Origins and motivation for the investigation

The origins of this research lie firmly within the author's particular fine art painting and printmaking methods. Explorations into colour processes in printmaking, Figure 3, were an extension of the author's earlier divisionistic painting techniques, Figures 1 and 2. The methods developed here became an intrinsic component and partly directed and exemplified the thematic nature of the particular compositions created (not discussed in this paper).

These compositions in both the painting and the printmaking were based upon perspectival representations of 3D scenes derived from drawings by the author. After witnessing a demonstration of CAD the author was enthusiastically compelled to consider the possibilities of extending his earlier preoccupations with 3D representation and colour perception, into the relatively new digital medium. While exploring several state-of-the-art 3D modelling and CAD application programs, a means of transposing these ideas started to evolve.



Figure 1: P.J.Lee, 1986, Painting, Egg Tempra on Gesso Panel, *Park*, 64x154cm



Figure 2: Detail of *Park* (centre right) showing optically mixed coloured lines forming surface contouring.

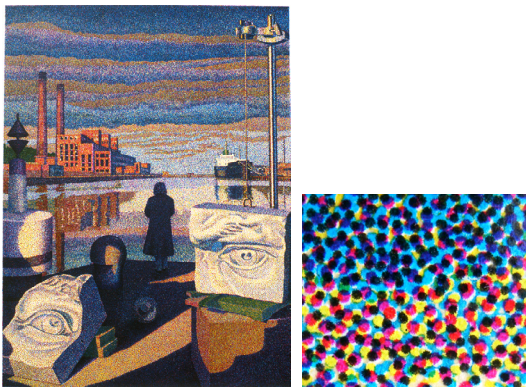


Figure 3: P. J. Lee, 1995, Screen-print on paper, 32x42 cm, with detail showing hand-drawn dot texture.

3. The Surface Contour

Although contemporary research into the surface contour involves computer imaging, the underlying principles can be visualised with the use of traditional graphic mediums. The historical use of this important visual phenomenon, the surface contour, lacked explanation until the late 1970s [MAR82]. The surface contour takes

many forms, the simplest being a single contour line while the most complex can be an intricately structured pattern or texture. Considerable work on surface shape comprehension via surface contouring textural elements has been carried out in many areas, one being medical computer imaging [IFP97]. The Non Photorealistic Rendering (NPR) artist Elber is among the few computer graphics researchers to have consciously explored the surface contour as a divisive artistic depth cue [ELB95] while others have employed it in the representation of traditional graphic mediums i.e. pen and ink drawing [WS96]. Ostromoukhov employed a quasi 3D surface contouring method with a four-colour reproduction technique for his portraits that simulated copper plate engraving [OST99].

Comparatively few artists since the Renaissance line engravers have explored the surface contour with fewer exploring optically mixed colour contouring. One of the finest examples is by the Futurist painter Umberto Boccioni's Figure 4.



Figure 4: Boccioni U, 1910, Oil, canvas, *The City Rises*.

4. Outline of the Optically Mixed Coloured Surface Contouring System

The author initially tested the tenability of the overall process by successfully creating an optically mixed colour contoured fine art screen-print from a freehand drawn composition and hand-drawn positives. An equivalent overall pipeline system using custom developed interactive software was then devised.

The system 'pipeline' starts with the construction and visualisation of a virtual 3D composition in perspective and aesthetically arranged with suitable illumination, using commercial software application programs. This visualisation forms an artistic reference for the later contouring process. The 3D composition is imported into the software, the core system element that facilitates the application of the coloured surface contouring to the 3D composition's objects. On completion of the composition contouring the cyan, magenta, yellow and black (CMYK) colour layers comprising the optical colour mixture are separated. For each colour layer a monochrome 2D image of the 3D viewing space is then created and printed. The four images printed on drafting film form monochrome

positives for the screen-print production. These images can be manually edited using pen, black ink and eraser.

5. The Software Application Program

The simplest approach for creating surface contouring of the 3D composition was to use the mesh quad faces upon which to construct the coloured 3D quads. The contouring is formed by contiguous 3D quads that the author has termed 'platelets', Figure 5. The direction of the contouring is therefore determined by the orientation of the model mesh quad faces.

5.1 The Software Functionality

The software written in C using OpenGL to run on a PC Win 32 platform was designed for ease of use with the following principle functionality: 1) Import 3D composition, 2) Transformation and lighting of 3D composition, 3) 3D composition surface selection, 4) selection of desired colour, 5) Application of coloured contouring, 6) Editing and saving contoured composition, 7) Creation of colour layer DIBs.

The importation of the meshed 3D composition is achieved via DXF format and the transformation & lighting model enables suitable viewing.

The selection of the mesh surface is facilitated by polygon boundary picking with the mouse cursor. The colour, based on a particular CIE Lch colour solid, is applied to the 3D-face selection set. Scroll-bars are adjusted to achieve the desired Lch colour that is displayed in a sample window. On the acceptance of the colour, contouring is created for the selected area and comprises a combination of CMYK coloured 'platelets' Figure 5. Their dimensions are computed and purely for visualisation purposes the selected area is rendered with approximate equivalent RGB value.

Facilities are available for ease of use by the artist/author to edit the applied contouring and saving for future contouring sessions. The image size is now set for the off-screen DIB generation of each CMYK layer.

6. The Optically Mixed Colour Surface Contouring

The novel construction of the surface contouring that describes the surface of the composition's object and the optical colour mixture, uses the notion of colour mixing exemplified by the Munsell colour solid [BUR02] developed primarily for art-school students [MUN05] in 1908. Artists to this day intuitively use this approach when mixing colour, as this model is near perceptually linear. For this reason the author chose the CIE Lch colour model, as it was the nearest intuitively linear model and computationally suitable for this investigation.

This intuitive colour control process results in a higher chroma mixture that lies between a subtractive

and an additive colour mix often referred to as an optical colour mixture by 'averaging' by virtue of the average tonal value of the component hues, [AGO87], [BUR63]. It is also known as pointillistic or 'partitive' colour mixing [WC83].

Four colour halftone reproduction methods for colour printing [BUR00] are the nearest equivalent to the colour mixing methods devised in this investigation. The means for predicting and displaying the resulting colour of a halftone-printed area based on the Neugebauer equations [KAN97] were considered as a possible solution to the problem of colour measurement but were rejected for the sheer complication and dependency of such a wide range of parameters. Therefore, the author was compelled to develop a novel computational model using device independent colour calculations giving tristimulus CIE XYZ values [WS00] with an additional RGB output to the calibrated CRT display.

To compute the coloured contouring 'platelet's' dimensions and configurations for the desired colour a colour solid based on the CIE Lch model was constructed from spectrophotometer values of screen-printed CMYK samples plus the particular printmaking paper as the maximum luminance value, Figure 5. For the expedience of simpler calculations and a marginally reduced colour gamut the colour solid cross-section was made trapezoid.

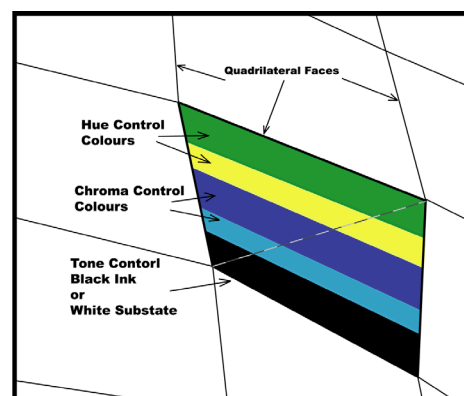


Figure 5: schematic of Hue, Chroma & Tone 'platelets'.

6.1 Computation of Contouring Colour

The 'platelet' dimension calculations fall into three main areas, the Hue, Chroma and Luminance that is referred to here as Tone, the term most artists use. The order in which the interdependent calculations are computed is Hue Chroma then Tone. The Hue is the combination of individual or over printed 'platelets' in CMY. The Chroma is controlled by the introduction of complimentary colour 'platelets' from a combination of CMY and the Tone is controlled by the introduction of either a black 'platelet' or 'white' space (the paper). The overall Tone and Chroma correction is then computed for the final combination of 'platelets'.

6.2 Measurement of the Optical Colour Mixtures Created by the Surface Contouring

Since no precedent could be found for the measurement of optical colour mixtures generated in this unusual configuration, the author was compelled to devise an innovative method. A range of Maxwell Disks [AGO87] were created within the contouring software, screen-printed and cut-out and their Lch values were obtained using an adapted spectrophotometer. The correlation between the software application Lch values and the measured Maxwell Disk Lch values proved conclusively the viability of the system.

7. The Fine Art Screen-print production

From the output stage of the 'fast track prototype' software the four coloured (CMYK) layers were rendered as off-screen DIBs with inserted registration marks. Once the positive images for the screen-prints were printed onto dimensionally stable polyester drafting film on a large format inkjet printer, the opportunity for manually editing these images could be undertaken. These images were next transferred to the meshed screen frames for the creation of the screen-print. Besides the very particular care required for the registration accuracy of the over printed colours, the screen-printing followed the conventional fine art 'hand-pulled' print process. From the production of the test screen-prints empirical tests were made to ascertain the optimal viewing distance for optical colour mixing to occur. Figure 6 shows an example of a finished artist's proof.

8. Conclusions

The final screen-print results exceeded all expectations and proved conclusively the viability of the overall system. The 'fast track' software was found to be very user friendly and robust but lacked sophistication. Ideally, the direction and configuration of the surface contouring would be set within the software instead of being dictated by the imported mesh model. Perhaps major curvature axis contouring would improve shape comprehension such as Interrante et al [IFP97]. The ratio of the width of the contouring to the screen-printed 2D selected view dimensions and the diminution due to perspective were based upon empirical measurement and both require resolving computationally. Achieving the full colour gamut i.e. the complete colour space model envelope, is also very desirable. Quantitative evaluation, using a novel experimental paradigm for objectively measuring the accuracy with observers making integrated judgements about shapes and depth is not within the scope of this investigation.

The other outcome from this investigation, besides the author now having the facility to create and experiment with these innovative and very particular large format screen-prints, is that it demonstrates that practising artists can exert a degree of control over the new medium of 3D computer graphics by extending ideas from one artistic medium to another.

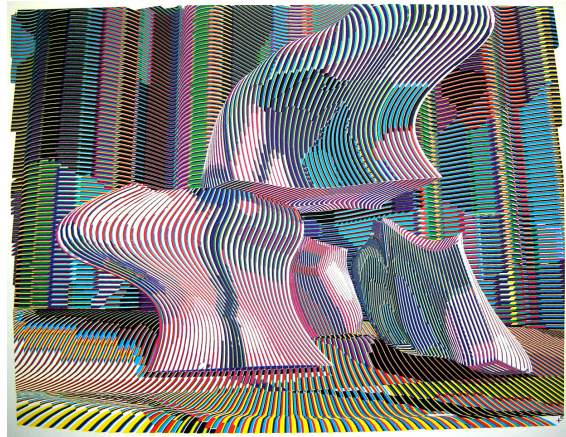


Figure 6: P. J. Lee, 2003, *Untitled*, screen-print on paper, image 92x72cm.

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