The diversity of digital print technologies used in the creation of high quality Fine Art

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Abstract

The Centre for Fine Print Research in Bristol UK undertakes research into print technologies from the traditional 19th Century to the latest digital capture and print. Outcomes of this research are often realised in collaborative projects with well-known artists. The breadth of technologies used in the creation of printed digital art is huge, and often mixes analogue and digital techniques. At the CFPR we print artwork using digital photographic technologies that range from, fired enamel on metal for large-scale public art projects, continuous tone photo-ceramic relief panels, digital moulds for glass artists. On-glaze ceramic print, Digital photogravure, flexographic print both intaglio and relief, Helio-relief, collotype and Woodburytype, as well as large-scale digital inkjet for Blue chip artists such as Richard Hamilton. In order to understand and quantify colour and surface print quality differences between each process, colourmetric measurement is available alongside microphotography to support and back up the subjective analytical data that is collected during a project. Examples from this data will be used to illustrate the differences between digital print techniques and explain why the artist has chosen a particular print technique.

In order to fully explain the breadth of technologies available this paper will also demonstrate the work other studios from Europe and the USA that develop projects using digital technologies to print artists work.

Introduction

It is first necessary to establish a definition of the terms; the common assumption of Digital Fine Art is an ink jet digital reproduction print of an existing painting or photograph sometimes referred to as 'Giclee'. The literal translation from the French meaning to spurt! This is a somewhat confusing definition. In real terms there are actually two or more separate markets, which use the term digital fine art. For the purposes of this article we will define those markets as digital reproduction and original artists' prints. The former tends to cover everything from posters through to signed prints used for interior decoration. The latter is used where the artists' original print is a print in any medium that has been conceived solely as the final printed work and does not exist in any other previous form. This market tends to cover original works made through traditional printing processes up to the highest quality museum collected artworks. These definitions are somewhat crude and there will always be examples that cross the borders. In this case we are concentrating on original artists' prints of the highest museum quality.

Artists who make original prints have always chosen the medium that best suits the conception of the idea. In crude terms if one wanted to produce large flat areas of colour such as that used by the pop artist Andy Warhol one would choose screen-printing. If you wanted delicate watercolour like wash tones one would choose lithography and for a very dark black line or tone one would choose etching. It is the surface topography of the image on the paper combined with the density and/or translucency of the ink on the paper surface that creates the different visual appearance of these processes and this topography is separate from the range of colour gamut that is obtainable. For these reasons artists choose to combine digital reprographic processes with traditional forms of print rather than directly print the image using inkjet. The problem with inkjet for the artist is not its ability to faithfully reproduce an image in full photographic clarity but the fact that inkjet creates such a minute surface topographic film that the image will always look very flat and two dimensional, regardless of the photo-realistic qualities.

Artist's traditional processes

The traditional forms of print used by artists fall into four categories, which will need basic definitions, these are:

Relief printing is printing from a raised surface, where ink is rolled onto the raised parts and the background is lower to avoid taking ink. A piece of paper is laid on top and pressure is applied; when the paper is peeled away the raised areas have transferred their ink to the paper's surface. The defining characteristics of a relief print are its overlapping thick film ink deposits and the direct contact of ink and paper in the press.

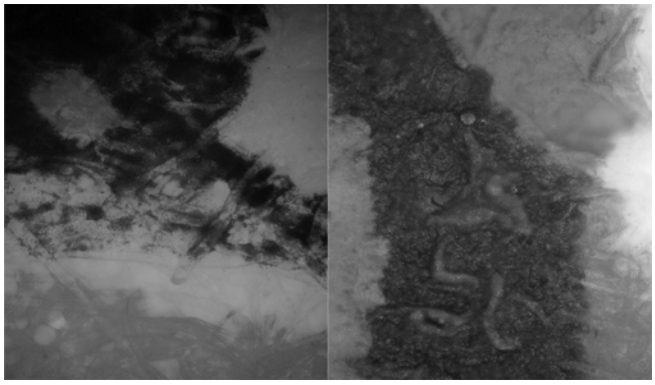

***Figure 1**: Microphotographs. Left, relief print. Right screenprint, both on artist's mould made paper*

Screen-printing is a monofilament polyester mesh stretched over a frame to a specified tension in order to act as a support for a stencil. The stencil is usually a light sensitive diazo polymer emulsion coating that can create a photographic half tone or any other form of image, including large areas of flat tone. The characteristics of screen-printing are a thick film deposit of flat even tone with a semi-matt finish. Screen-printing also has the ability to use a colour set mixed from either a transparent or

opaque white base medium. Thus giving screenprint the ability to print with a greater covering power on a substrate than any other process.

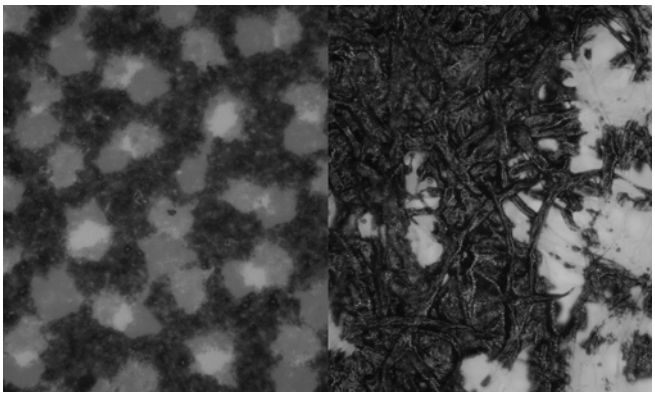

***Figure 2**: Microphotographs. Left, commercial 4 colour separation litho. Right traditional hand drawn stone litho on artist's mould made paper.*

Lithography is a planographic process, meaning that everything happens on the surface of the plate. The basic principal is that grease attracts the oily ink and the non-greasy areas of the plate are encouraged to reject ink by being kept damp with water. The defining characteristics of lithography are a thinner film deposit compared to the other processes. This tends to create translucent colour and the process retains good colour clarity from overlapping colour. Commercial offset litho has the ability to print a very precise thin film layer, hence it adoption as the mass market printing medium of choice.

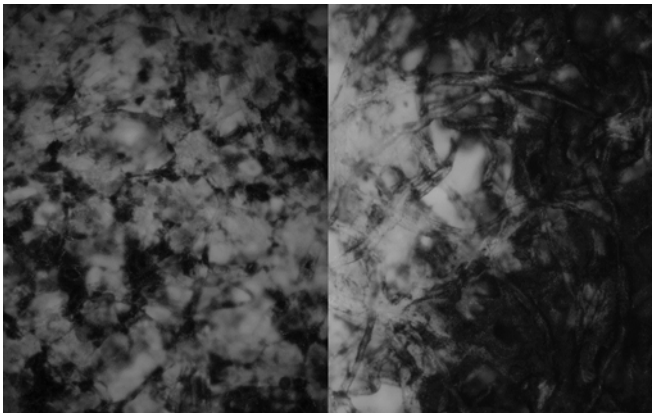

***Figure 3**: Microphotographs. Left, collotype. Right photogravure on, both artist's mould made paper.*

The intaglio processes are etching, engraving, mezzotint, aquatint and photogravure. Intaglio means from below the surface, the opposite of the relief process, for engraving a copper or steel plate is cut with a v shaped tool to form an incised line. The ink is then forced into the lines and the surface of the plate wiped clean. A sheet of damp paper is placed on the plate and both are run through an etching press like a sophisticated mangle. The characteristics of an intaglio print are also a strong ink deposit but the depth of the deposit depends on the depth of the plate and varies between a very strong and thin but strong coloured line. Light tone thin deposit, dark tone thicker physical deposit. It therefore has a greater surface topography.

Colour

With regard to colour each of these processes demonstrates a separate gamut. Whilst it is possible to measure the range of gamut for a typical set of inks used by artists, these ink sets are not like using a CMYK four-colour set. They are individually tailored to the subjective choices of the manufacturer and user. Therefore plotting gamut is only an indicator of the colour and tone available. The gamut graphs shown below also do not demonstrate the integration of surface topography and colour rendition or give an indication of the additional qualities represented by combining the two. When compared to current pigmented ink jet these processes demonstrate a wider gamut. This at first appears surprising, most data, indicates that ink jet has a very wide gamut. This is because it is normally compared to commercial litho. where the primary restriction is to just CMYK and the secondary restriction is a thin film deposit. So that printing a really intense colour relies on a very good quality ink and a very fine pigment grind. In the case of these artists printing processes the deposition is heavy, as most of these processes are printed by hand. Screenprinting, as can be seen from the diagram, demonstrates the potential of a very wide colour gamut. In this example the screenprint colour set was restricted to 9 representative colours from a total set of 28 (TW 1000 series), the etching (Intaglio Printmaker) and relief (TN Lawrence) sets were 7 inks from sets of 20. However as can be seen from the graphs each has colour characteristics, which define the individual processes. Difficulties in presenting a true picture also occur partly due to the type of analysis made with colourmetric spectral analysis. Colourmetric analysis assumes a base white substrate or media and colour reflectance from transparent ink applied to that substrate. It does not allow for the use of white ink as an integral part of the mixing process, which may be printed in the middle of the process, with further transparent colour on top. This is a common occurrence in processes such as screen-printing.

In order to demonstrate the diversity and mix of digital and analogue techniques a series of examples are demonstrated below.

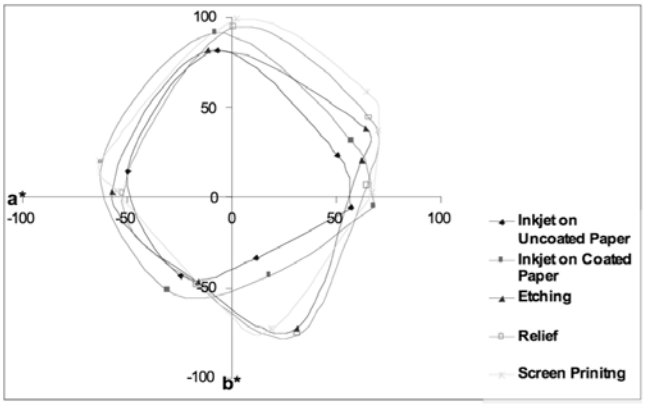

***Figure 4**: L*A*B* Values for inkjet, coated and uncoated artists digital paper, Relief, screenprint and etching on uncoated mould made paper*

Digital photogravure

Traditional dust grain photogravure is a 19th century process that dates back to the birth of photography. Fox Talbot first created

gravure like plates in the 1850's and filed a patent on October 29th 1852 (British patent no. 565). [1] Although the process has its origin in Talbot's process, Karl Klic a Viennese printer devised the technique we now know as photogravure in 1879. Photogravure is created by coating a copper plate with a thin coating of bichromated gelatine. This is sensitive to light and the gelatine will harden in direct relation to the amount of light it has received. The plate is exposed through a continuous tone film negative. The gelatine is then developed in water to wash away the unexposed gelatine and create varying degrees of hardness of gelatine, which will absorb water in relation to its exposure. A random half toning structure is applied with rosin known as aquatint. The plate is etched in a series of baths with varying strengths of ferric chloride and water from strong to weak. The gelatine coating absorbs water and ferric chloride from the baths and creates hydrochloric acid on the face of the copper, thus etching the plate. The process is capable of creating incredibly dense blacks (densitometer readings in the region of 2.4) and extremely subtle mid tones.

The peak of photogravure was from 1890 to the 1920's. In the early Victoria period companies such as Goupil et Cie in France produced gravure portraits and in the early 20th century photo-secessionists photographers such as Stieglitz produced delicate mid tone gravures for publications such as Camerawork. In the latter part of the 20th century gravure was revived along with platinum printing as a high quality medium for art photography. Where photographers were looking for new surface qualities other than the traditional silver gelatine.

An example of contemporary photogravure is the film director's John Walters print, "Drunk". A 6 colour, 4 plate gravure print. This is particularly interesting because at first glance is appears to be a standard four colour separation print. [2] I am grateful to Deli Sacilotto, head of research at GraphicStudio USF Tampa Florida for the break down of how the four plates were printed. The size of this image is only, 5 inches by 14 inches, and is created with very fine stochastic positives that replace the need for an aquatint on the gravure plate.

***Figure 5**: John Waters 'Drunk". Copyright courtesy GrpahicStudio, University of Southern Florida*

To create the stochastic positives used the original colour negatives were first scanned by a commercial reprographic house and then processed as a four-colour separation set using a very fine digital stochastic separation. For gravure this replaces the rosin and creates the random half tone needed to make pockets of ink on the surface of the copper plate. To create the tonal range with in the print, a specific tone curve is needed. Also, the density of the commercial film is geared to litho and will not cope with the long exposures needed for gravure gelatine. The screens were then contact printed onto Kodalith film, first as a negative and then as a positive to increase the contrast and density of the films. From the final positives four photogravure plates were made. The plates were printed in the following manner. Plate one was printed with a violet ultra marine and carmine inks, plate two was printed with processed blue ultra marine carmine and primrose yellow, the third plate used processed blue and a primrose yellow and white mixture and the fourth plate was printed in black.

This print aptly demonstrates the integration of digital technologies through the use of digital positives with traditional printing processes. It is a good example of how a skilled printer can enrich the printing process by using a different gamut colour set and overlaying a series of colours to build subtle tonal changes.

Laser technologies and digital print

The combination of new technology, digital capabilities and traditional process can lead to exciting new means of obtaining a finished result, that has all the appearance of the traditional, but is created in a very different way. This is exemplified by a recent request to the Centre for Fine Print Research for the creation of a large-scale photogravure print. The logistics of creating a large-scale print, 2 metres by 1 metre, using traditional photogravure are almost impossible. You would need etching baths that covered an area 2 metres by 8 metres just to bite the plate. The original image however was created in the vector programme 'Illustrator', the file was to have been generated as a film positive by commercial reprographic techniques and then transferred to a copper plate as described above. The solution was to transfer the file as a vector line image to a 30 watt CO2 laser, which is used for cutting textiles, paper and board. In order to create the rich and varying tones of black the file had to be adjusted to make the laser take multiple passes in several directions over one area to replicate the nature of the bitten gravure plate and to create in essence a stochastic appearance. The image was then burnt into an acrylic sheet in order to create the gravure plate. The plate is then inked in the traditional manner and printed onto a very large sheet of artists cotton mould made paper for a traditional etching press. The final print is indistinguishable from an original photogravure to the untrained eye for the absolute perfectionist it has perhaps a slightly greater surface topography in the blacks and a slightly more regimented stochastic appearance.

Collotype

Collotype was a natural progression from photogravure invented in 1855 by Poitivan and further developed by Albert three years later.[3]

Comprises of a glass plate, which is first coated with a substratum layer of gelatine and sodium silicate. This forms a receptive base for a layer of bi-chromated gelatine from which the printing is done. As in gravure when the gelatine is exposed to light through a continuous tone film negative the gelatine will harden in relation to the light received. After processing with water the soft parts wash away and the remaining parts swell and absorb water in relation to the light received. When the gelatine is dried at 50 degrees centigrade, it will reticulate and from a random halftone structure similar to a stochastic algorithm used for inkjet. When the gelatine layer is rolled up with greasy ink, the ink is attracted to the hard exposed parts of gelatine and progressively rejected as the gelatine has received less light. Unlike lithography where the ink is either accepted or rejected and therefore deposited in a uniform layer which is either on or off. With collotype the ink can be accepted in

graduated layers of differing densities. Collotype is often sited as the peak of printing perfection it is possible to print many colours with out and interference pattern and the process is capable of rendering mid tones of immense subtlety. The process died out due to commercial expediency, as it required a highly skilled work force.

The process has been undergoing a slow revival with in the artistic and photographic community because of its subtle qualities. CPFR has undertaken a five-year research project to reassess collotype in the light of digital technology and has pioneered the use of digital multiple colour film separations with the collotype process. The Benrido collotype atelier in Japan founded in 1905 with a long tradition of high quality facsimile printing has also been experimenting with the use of digital imagery for collotype. The company uses digitally created stochastic negatives with traditional collotype masking techniques. Exemplified by a recent print, "Vermeer study (a great story out of the corner of a small room)" by Yasuma Morimura, printed in 2004. This print is a 12-colour collotype print onto silk that is then backed onto a sheet of paper.

Enamel on metal

The Centre for Fine Print Research has one of the largest kilns in the country for firing enamel glass glaze onto flat metal sheets. This kiln is used primarily for large-scale public art projects such as the signage for Bristol Children's Hospital. This consisted of 2,000 hand decorated and printed 30 cm square steel panels. The bulk of which were made by school children directly painting the enamel glaze onto individual tiles and then firing them. The centre section of each of these signs contained lettering naming the ward and the sponsor of the panel. The CFPR holds a patent on a screen-printed decal process for ceramics on enamel for metal. This process is capable of producing decals up to 40 by 50 centimetres The positives for the screen-printed sections were first created in 'InDesign' and then printed on an Epson 9600 wide format printer in black onto Agfa Selectjet film. From these positives the screens were made either as spot colour relating to company logos or as 75 line halftone separations and the decals were screen-printed with a water based medium and enamel colour. The decals were then applied to the panels and fired. Further explanation of this process is available in the companion paper given by the author at this conference.

Woodburytype and Continuous tone photo-ceramic relief panels

In 1864 Walter Woodbury patented his process of continuous tone relief printing known as Woodburytype. It consisted of a thick layer of bi-chromated gelatine, which was exposed to a continuous tone negative. When developed and washed out in water a dried, the result is a relief image in tough insoluble gelatine. The relief is in direct relation to the tone of the image, thick in the shadows, about 0.13 millimetres, and progressively thinner in the mid tones and high lights. To make a printing matrix, Woodbury placed the gelatine mould and a sheet of lead in a hydraulic press with a pressure of 5 tonnes per square inch. The resultant matrix was used for printing where it was placed on the bed of the press and filled with a translucent pigmented liquid gelatine. A sheet of paper was laid on top and pressure was applied in the press. Once the gelatine had cooled, the paper was removed from the press and dried. This process was the only truly continuous tone printing process that has ever been invented. Its limitations are the small size of the image, the fact that the print has to be trimmed to remove the gelatine that squirts out whilst printing and therefore has to be pasted into a book and the slow number of copies that can be printed at once. We have been exploring the potential of creating digital Woodburytypes and this has been published at previous IST conferences. [4]

For the past five years the CFPR has been using CNC technologies to create low relief continuous tone photographic images in ceramics. These images are created by converting a photographic black and white file into two hundred and fifty-six tones of grey and then assigning the grey tones a virtual height in relation to their density in an XYZ axis. This enables the creation of a DXF file that can then be translated to a machine code in order to CNC mill a ceramic tile. The CNC milling machine then cuts the three dimensional photographic image into the tile. A CNC machine is used because the nature of the drill bit cutting tool path removes any stepping that would normally occur when transcribing a bitmap grey tone file into three dimensions. Interestingly this means that a high definition image can be created from a relatively low-resolution bitmap file. In actuality the three-dimensional file is plotting points on a tone curve rather than individually using eight bit data to define a spot.

This process has been used to replicate the original photo- ceramic tiles and by a series of artists invited by CFPR to explore the potential offered by the process, resulting in an exhibition at stoke-on-Trent city museum and art gallery. Artists, such as Ivor Abrahams, explored the subjective qualities reminiscent of the early 19th century offered by the process. In a playful reworking of a 19th century embossed postcard he has transformed a saucy lady into a mermaid. The medium has proved perfect for retaining both the tone and feel of the postcard while the nature of the relief surface has retained the novel quality of the original embossed postcard.

***Figure 6**: Left, Martin Constable viewing, 'Exhausted Space man. Right: Ivor Abrahams Photo-ceramic tile.*

Digital moulds for glass artists

An extension of the above process is to use the CNC milling machinery to cut plaster moulds from which glass can be slumped. The process by which this is undertaken is first to transcribe as above a photographic black and white file into 256 tones of grey and the assign the grey tones to a virtual height in an XYZ axis.

For this process the heights are somewhat greater, where as previously the maximum depth is only 3 millimetres in this case it is up to 10 times that depth. The CNC machine cuts the mould in a plaster that is capable of being fired to 550 degrees Celsius. A flat sheet of glass is placed on top of the mould with in the kiln and the temperature taken up to 550 degrees centigrade. At this temperature the glass begins to become fluid and slumps into the mould, accurately taking the milled structure from the mould.

Ink jet printing

Having stated that the common assumption of digital fine art is an ink jet digital reproduction print of an existing painting or photograph examples need to be given of how the artist approaches the problem of creating an original print, starting with the well known artist Richard Hamilton. This print is based on a copy of a Marcel Duchamp sculptural work that Richard Hamilton first recreated in the nineteen sixties and is a map of Duchamp's original notes to the sculpture. This print was conceived in the vector programme 'Illustrator' and is one half of a final print that is one point seven meters wide by approximately four metres high. The image took six months to construct and is made up of a hundred and two primary layers. With each of those layers having up to ten further layers behind them. Potentially there are up to a thousand layers. The careful choices and slow build up of layers to create the right sort of image is to say the least very deliberate and the selection of colour is a thoughtful building process. Therefore to have only four colours and lighter versions of the same colour plus an extra black in which to print this image and do it justice seems very restrictive.

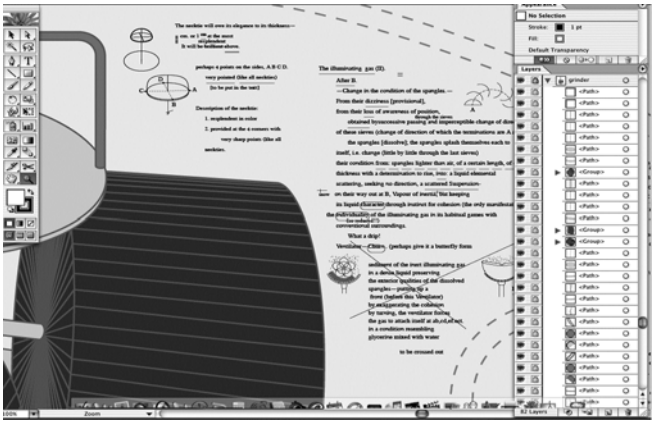

***Figure 7**: Detail of vector file for Richard Hamilton Print 'Typo/Typography*

The second example is the artist Martin Constable's print (AKA Jack Youngblood) the exhausted space man. This print is a life size representation of the artist himself wearing an original NASA space suit borrowed, for the purpose of creating the print, from the science museum in London. The main considerations for the printing of the file were; file resolution, quality and colour. Due to the concept of the work, it was important that the scale would be determined by its source, Jack Youngblood- a human. [5] This conjecture for the output of the image dictated the capture methods and file sizes required to retain high image resolutions at life size proportions. Youngblood had imported different components of the image using a range of image capture devices, such as a flat bed scanner and both digital and analogue cameras. These were then imported into 'Photoshop' where they were composed and altered so that each collaged element was unified within the file. The file size for the image was 400 megabytes and contained around 155 adjustment layers to create the aged image of the figure. The first proof was printed onto a HP productivity photo-gloss paper using both media and paper settings for this particular substrate. Proofing literally creates a new prospective for evaluating the image and often amplifies any imperfections. From close inspection of the printed proof a rough diagram of the image was made indicating the locations of each adjustment area. Alterations though minor in appearance often lead to adjusting sub-layers within layers because the image is composed with combinations of layer masks and filter effects, minor cleaning tasks become more involved. Youngblood's notes in no way offer the amount of description needed to resolve these corrections but as visual notes they refer to print qualities and add a personal dimension to the working process. (Youngblood's Photoshop adjustment notes; frothy edge, too sharp, extra tone and clumsy). I am grateful to Paul Laidler for the detailed description of this process.

Conclusions

With new digital technology, such as ink jet, the co-relation between the conception and software output has been designed to be seamless. The relation between traditional technologies and digital creation has not been resolved and it is clear that the problems lie in the area of reprographics. In fact for the artist, this allows for greater flexibility. Traditional reprographics relied on an analogue camera capture onto small scale negative film. Then an analogue enlargement onto either continuous tone positive film or a halftone intervention onto line film. Currently the analogue negative is replaced with the digital file and the large film positive then has to be created, it is no longer possible to create a continuous tone positive using digital means. A representation has to be created using a stochastic algorithm to randomly create a very fine tone structure.

For the artist who is used to the range of surface topography and choice of differing colour gamut offered by traditional technologies. The interplay between digital generation and traditional technology offers a much wider range of options. The hybrid print offers the best of both worlds; good photographic rendition and capture with a wide selection of gamut and surface topography.

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