The Petra Sancta Script: Connoisseurship in digital engraving

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Abstract

Engraving is one of the oldest arts. For thousands of years, people have embellished the surfaces of caves, tools, buildings and armour, using hard materials to make marks in softer ones. Whilst crudely incised love hearts on a tree bark or names on bus windows can be carved with little practice, to cut precise lines requires the skill of an experienced practitioner. Engraving has, therefore, long been practiced as a specialist trade across cultures. More recently, powered rotary cutters, machines that can trace a predetermined path with a greater degree of accuracy, have supplemented the tools and techniques of hand cut engraving. Today, data from digital files guides rotating bits or laser beams across flat materials, cutting or burning designs into a wide variety of woods, metals and plastics.

In this paper, we describe a piece of software developed to support the use of traditionally derived engraving patterns in digital design work. Placing this software in the context of a constantly developing skilled trade, we see no need to lament the loss of skill often associated with advances in mechanisation. We argue that as the transition between a design and its material realisation becomes increasingly digitised, sensitivity to the existing best practices and guiding principles of a trade must be carefully supported in our tools and the software that drives them. In the case of engraving, these practices and principles are the result of thousands of years of work, presenting a rich history of knowledge that might easily be lost in the gaps between the cobbled together hardware and software of digital fabrication labs.

Keywords: *Engraving; software development; craftsmanship.*

The Engraver's Bench

As with all skilled trades, engravers have long since made use of available tools and techniques developed to reduce the demands on their dexterity. Compasses, ink and paper are used to mark out a job. Sandbags and clamps conveniently secure work. An engraver's traditional cutting tools, their gravers, have sharp tips that are variously shaped, inclining them to travel in a favourable direction for different types of cut. For centuries, even before the advent of powered mechanisation, the engraver's bench has been home to an assortment of tools, both specialist and common, which have been employed to improve the precision and efficiency of the trade.

The adoption of each new tool brings a reconfiguration of the engraving trade as it adapts to the potentials of new techniques. No doubt the introduction of electric task lights, allowing practitioners to work at any hour, sharply illuminating any imprecision in their work, had a dramatic impact on an engraver's practice. With the advent of digitally controlled engraving, we argue that the newest techniques are simply a continuation of this history, another step in the development of the craft, and there is no need to lament any loss of skill. In fact, the development of digital tools has forced engravers to develop new skills, similar to those of digital typographers and machinists.

Of course, these skills are different in nature to the manually dexterous action required for hand engraving. And some might argue that trades, such as engraving, are weakened through this technological deskilling or, perhaps more accurately, re-skilling. This is not, however, our line of argument. Our concern is not for the skill of hand engraving, but the knowledge of best practice that is learned alongside dexterous action.

Our position is founded on three observations:

1. That any theoretical distinctions between 'handwork' and 'machine work' are difficult to sustain.
2. That there exists a body of communicable knowledge about a craft's best practice, which helps to both create and define notions of quality in that craft.
3. That this knowledge of best practice can and should be better supported through more considered software development.

In this paper, we explore these themes, before describing a piece of software developed to support the use of traditional hatching patterns in digital engraving.

Hand & Machine Work

In the context of a skilled trade, to discuss the relative virtues of engraving by *hand* or *machine*, as if they are somehow opposed, is to begin on a path fraught with what design and craft theorist David Pye would call 'thought preventers' (1972, p.52). In his attempt to bring a logical clarity to matters of craftsmanship, Pye explored what is meant by the phrase 'hand made', observing that, except perhaps in a few examples, such as the making of coil pots or basketry, all manufacturing techniques require the use of tools (ibid, pp.25-29). And these tools, owing to their design, and in the context of skilled use, invariably aid the hand, enabling more consistent results.

One of the first tasks a novice engraver learns is how to sharpen a graver, so that it may cut a smooth, clean line with control. As soon as this newly sharpened tip cuts into a surface, its path is guided not just by the hand, but by the whole system of hand, graver and material. The tendency for a tool like a graver to move through material in a particular way, led Pye to dismiss the idea of 'hand work' and the 'handmade' object as 'all but meaningless' (ibid, p.25). Considering the similar propensity of a woodworker's chisels to 'cut their own jig' (ibid, p.28) as they enter a piece of wood, Pye showed that even seemingly unaided tool use is, in fact, nearly always guided in some sense by a determining system.

To discuss hand engraving and machine engraving then, whilst a useful shorthand, we must accept that wherever our work with materials is mediated through tools, those tools also guide the work. Using Pye's terminology, the variously risky or certain (ibid, p.20) techniques of making cannot be placed into discrete categories based upon the degree of manual dexterity they require. To base an argument for the relative virtues of a particular technique, or entire trade, on the grounds that it relies on more skilled handwork is flawed.

In an era of mechanized cutting then, our concern should not be for the skill of engraving. Powered rotary engraving machines have supplemented traditional bench work, offering a means of accurately transferring designs to surfaces with a degree of certainty impossible in hand engraving. The first of these machines were based on the pantograph system, wherein a powered cutter is connected by a series of linkages to a hand-controlled stylus, which the operator uses to trace a master pattern.

Today, computer-controlled laser cutters and rotary heads zip across surfaces, cutting and etching, guided by the data from digital files. Although there remains a subtlety and diversity in hand work that is impossible to achieve using a rotary cutting bit or laser beam, digital control has become, in a great many instances, the preferred technique.

These new techniques have demanded that new skills be assimilated into the engraving trade. In contrast to the popular notion of technology as a deskilling force, engravers have been forced to develop new talents, manipulating hardware and software, working simultaneously as digital typographers and machinists.

For anthropologist of technology François Sigaut, the engraving trade would certainly conform to his 'law of the irreducibility of skills', under which the 'the entire history of technics might be interpreted as a constantly renewed attempt to build skills into machines by means of algorithms, an attempt [that] constantly failed because other skills always tend to develop around the new machines.' (1994, p.446)

Sigaut's law assures us that there is no call to lament the loss of skill often associated with new techniques – skilled practice will always remain vital for human work. As the engraver's hand retreats from holding the graver, to tracing the master pattern on a pantograph, to clicking a mouse and pressing go, the demands on manual dexterity certainly decrease, but, at the same time, novel tools and techniques require new skills that must be assimilated into the trade.

Best Practice

We have, thus far, considered the mechanical skill of engraving, the dexterity with which a hand or computer-controlled tool can be manoeuvred during a job. We now go on to discuss how the rules and principles of best practice support this action. To understand engraving just in terms of mechanical skill that can, and has been, codified into machines by means of algorithms would be to ignore the body of associated communicable knowledge that is developed and shared in practicing a trade. It is this knowledge, not the dexterity of engraving, that we argue is most at risk in the typical processes of digital engraving.

Within a craft, 'best practice' is guided by a set of foundational principles and rules. An insightful discussion of the nature of best practice can be found in Janet and Charles Keller's anthropological study of expert artist-blacksmiths (Keller & Keller, 1996). Keller & Keller identify three guiding principles used during a blacksmiths' practice: 'transformation'; 'think hot'; and 'work freehand' (ibid, pp.52-58). These three principles are relied upon to influence and guide the blacksmith's work.

The principle of 'transformation' dictates the nature of the processes used when blacksmithing: rather than add or remove material, by welding or filing the iron, blacksmiths are inclined to change the shape of their material without addition or subtraction. Transformative processes, such as folding and twisting are therefore the basis for much work. By 'thinking hot', blacksmiths are encouraged to exploit the plasticity of iron at high temperature. Cold forming processes, such as drilling a hole rather than punching it whilst the iron is hot, are avoided. The final principle, 'work freehand', encourages blacksmiths to rely on only a very limited range of jigs and templates: the preference is for forms worked freely over the anvil, rather than pressed using dies.

Throughout practice, guiding principles provide a set of criteria with which to discriminate between different approaches to a blacksmithing job, underpinning every design drawing, material selection and hammer blow. It is their adherence to such principles that helps artist blacksmiths give 'life to the ironwork' (ibid, p,53), completely transforming the surface texture and form of stock material.

This idea, that principles continuously guide an expert's practice, is at odds with the popular notion of skilled expertise as somehow unconscious. Although prompts, such as 'mirror, signal, manoeuvre', are well known to help novices learning new skills, the idea that mental rehearsal no longer plays a role in expert performance is often taken to indicate that skills become automatic with practice (Dreyfus, 1990).

Anthropologist Tim Ingold, however, criticizes the assumption that, during expert practice 'awareness intervenes only to interrupt the otherwise automatic and involuntary flow of habitual action' (2011, p.61), instead observing that the critical aspect of any skill is its continual attendance to ever changing environmental conditions (see also Bernstein, 1996).

This awareness and attendance, Ingold claims, only deepens with fluency and experience. The expert blacksmith's hammer blow, or the well-practiced engraver's cut, are not mechanically repeated, but respond to the variable plasticity and hardness of their materials, and to the emerging qualities of their work.

As in the example of artist-blacksmiths, these responses are continuously tuned with reference to their knowledge and understanding of best practice. Philosopher Andy Clark also insists that, whilst some linguistic prompts may no longer be required by experienced practitioners, 'high-level concerns or policies' (1997, p.203) are still relied upon in the pursuit of skilful work. Maxims like the blacksmith's 'transformation', 'think hot' and 'work freehand' are examples of how such high-level concerns constantly influence performance. These are not principles reserved for reference only when novel challenges interrupt habitual practice, but an underlying guide for all action.

It is here that we might find a more meaningful distinction than the opposition of hand and machine work dismissed above. Perhaps the critical difference between hand engraving, wherein the explicit, communicable principles of best practice and their dexterous execution are tightly bound, and mechanised digital engraving, is in the latter's division of designing from its material realisation. To design things on a screen and then execute them afterwards presents an interruption that does not exist in direct hand engraving. We acknowledge that such a significant theoretical and practical divide, between designing and making, cannot be bridged simply by means of different software. It's a divide that rests at the foundation of modern Western understandings of production (Deleuze & Guattari, 2004, pp. 409-412; Ingold, 2013), and is strongly reinforced by the techniques and processes of digital production. The piece of software we introduce below, however, is an attempt to support at least some of the best practice of engraving; although not continuously throughout its material execution, the aim is to introduce these principles throughout the making of a digital design.

The question of why such an attempt, to take the traditional principles of best practice and apply them in the context of digital production, is valuable requires us to explore the nature of quality and connoisseurship in a craft. For those who, as Peter Dormer describes, have gone 'native' in a craft (1994, p.44), it is clear that the rules of best practice have not been developed and shared for their own sake, or, as might be assumed, out of a traditionalist adherence to the old ways, but because they help lead towards outcomes with certain favourable qualities.

As we have seen in the example of artist-blacksmiths, adherence to the three principles helps to give 'life to the ironwork'. And, whilst such metaphorical qualities might appear obscure to the uninitiated, Dormer observes that, within the practice of a craft, these are criteria of quality that are judgments not 'made on a whim', but with a basis in objectivity (ibid.).

Through his own experience of learning calligraphy, Dormer describes how, with time and practice, he came to distinguish between the 'rightness and wrongness' (ibid., p.47) of letter forms with a degree of objectivity. The objectivity with which such judgements of quality are made, and the appreciation of qualities that follow from the rules and principles of best practice, this is what Dormer calls the connoisseurship of a craft. It is this that we fear may be lost in the typical processes of digital engraving.

Whilst the notion of connoisseurship might often be associated with exclusivity, the basic rules and principles of practice are not as mysterious as an outsider might assume, and may be found in the vast literature of how-to guides supporting the continuation and development of skilled trades. Our work is inspired by this literature. In the case of engraving, whilst offering advice on the development of an engraver's hand skill, practical guide books such as *Engraving on Precious Metals* (Brittain, Wolpert, & Morton, 1958), also articulate a knowledge of best practice that sits alongside the dexterity developed through training.

In engraving, there is a right and wrong way to do things. There is, for example, a correct way to order the cuts, or strokes, of lettering (ibid., p.61); a correct way to contrast the *brightness* of a cut (which is increased by polishing the graver tip) with the surrounding material (ibid., pp. 83-84); and, particular to the engraving of heraldry, a correct way to use hatching patterns to represent specific colours (ibid., p.32). This is a subject to which we return when describing the Petra Sancta script. In the pursuit of good work, these ideas inform

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practice at every stage, step-by-step, helping to ensure that each job meets the required criteria of quality.

These criteria are, of course, open to question. And no doubt they have been debated through the practice of engraving throughout centuries of development. In a classic discussion on the nature of making in traditional societies, Christopher Alexander considers the development of traditional forms to be the result of sequences of decisions, made over generations (1964).

In such a system, ill fitting forms are easily identified and improved, as seen in Alexander's architectural examples, where the makers of buildings not only build them, but also live in them. Here, there is a direct, on-going relationship between failure and correction, such that traditional forms will always tend towards good fit: 'misfit provides an incentive to change; good fit provides none' (ibid., p.50), writes Alexander.

Key to this understanding is the idea that recognising *bad fit* is a relatively simple task that is within the capacity of most people. As the activity of building, making, or dwelling proceeds, flaws in the work are easily identified and rectified. The revisions made in response might eventually be incorporated into the broader practices of a tradition.

Alexander contrasts this process of gradual adaptation, influenced by the commonplace intuition that something is wrong, with what he terms the 'self-conscious' process of more recent design activity (ibid., pp. 55-72). Whereas the ability to spot *bad fit* might be widely distributed, the self-conscious process requires us 'to achieve in a few hours at the drawing board what once took centuries of adaptation and development, to invent a form suddenly which clearly fits its context.' A situation wherein, according to Alexander, 'the extent of invention necessary is beyond the average designer' (ibid., p.59). Alexander's observations should perhaps be tempered with reference to his broader condemnation of modern architectural practice and its 'limelight-bound architects' (ibid., p.57), but they offer a valuable insight into how and why the traditions, best practices and guiding principles of a craft come into being.

In the context of digital engraving then, we suggest that, wherever possible, better efforts should be made to support the shared, explicit knowledge of the trade in the software. If, as the title of this conference suggests, increasing access to digitally controlled manufacturing techniques, means we are all *makers* now, it follows that, more specifically, when incising acrylic, metal or wood, we are also all engravers. Our work is an effort to draw upon the wealth of knowledge that has been developed throughout the long history of engraving, and use it to support contemporary digital practice.

The Petra Sancta Script

The Petra Sancta script is a piece of software that we have developed. It allows practitioners to automatically hatch areas of an engraving design, converting the solid colours of vector graphics

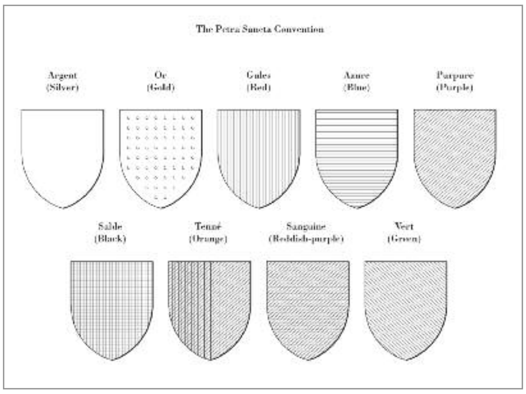

Image 1

software to the traditional patterns of engraving, with reference to the 'Petra Sancta' system.

Published in the 1630s by Silvester Petra Sancta, the Petra Sancta convention for heraldic engraving remains the recognised standard for translating colours into engraved patterns. The system defines hatching patterns for nine colours (Image 1), providing legibility and contrast with one another. Although still in widespread use, the Petra Sancta convention represents an instance where, as the mechanical skill of engraving has been codified into digital hardware, an associated body of knowledge has remained unsupported in the software: how many practitioners raster engraving with a laser cutter in the typical digital fabrication lab, for example, are even aware of such a convention?

The problem with using digital graphics software to design for engraving is that it is almost exclusively developed with print or on-screen outputs in mind. Whilst dedicated engraving software does exist, its adoption is limited by the broad availability of more versatile programs that, paired with drivers to link them to engraving machines, can offer all the features of engraving-specific applications. And, because of the cross-program compatibility of vector file types (e.g. .ai; .pdf; .eps, and those other formats which may be used to drive engraving hardware) practitioners designing for rotary or laser engravers may choose from a wide range of vector graphics software.

Typically then, those applications that are most widespread, popular and well supported by both their authors and networks of users online are used to generate engraving designs. One such program, which is widely recognised as the industry standard vector graphics software, and serves as the test bed for the Petra Sancta script, is Adobe Illustrator (Illustrator).

Illustrator is an application developed to produce printed or on-screen graphics. Indeed, like most graphics software, the very first action when setting up a document in Illustrator is to choose between *screen* or *print* as the intended output. It therefore offers little specific support for those practitioners designing engravings. Whereas in digital typography software, the lexicon and workflow of a typesetter's workshop has been recreated and then enhanced, and in photography editing applications the tools and techniques of the dark room are applied to pixels,

Image 1: The Petra Sancta Convention there is no such legacy in the software of digital engraving. Even in those programs that are specifically developed for creating engraving designs, we see more influence from the world of existing graphics software than from the engraver's bench; with 'vectorisation wizards', 'gradient fills' and 'distortions and special effects' notable features of one engraving program (see EngraveLab).

Perhaps the most telling result of using software developed for generating print or on-screen outputs is the wide availability of tools that convert photographic images into variable depth engravings. In the example of laser raster engraving, the power of the beam can be modulated with reference to the colour values of an image. As it passes back and forth over a surface, the laser beam etches with more intensity in the darker sections of an image, burning a result that looks as though it might have been printed. Whilst such techniques doubtless offer creative opportunities to the practitioner, it appears that there is more interest in recreating the fidelity of photography than exploring the opportunities for digital hardware to extend the expressive potential of engraving.

Despite their drawbacks, however, programs such as Adobe Illustrator, do offer the opportunity for users to develop and run scripts, to extend their usefulness. Scripts, like the Petra Sancta script, are pieces of code developed, either by Adobe or a third-party, to enhance the functionality of Illustrator. They can be installed by the user and then accessed from within the application. Scripts usually offer a novel feature to users, or can be used to automate repetitive command sequences.

Once installed, the Petra Sancta script may be used to recognise areas of artwork that are filled with any of the Petra Sancta colours (a group of specific colour swatches is bundled with the script), and then replace those colours with the associated hatching style (Image 2).

The script generates vector lines using a process that we have found to create robust files when exporting into other formats for various cutting hardware. Indeed, one of the motivations for creating the script was to avoid the frustration of using Illustrator's native 'pattern' feature to create vector lines that were unreliable when exported. The Petra Sancta script

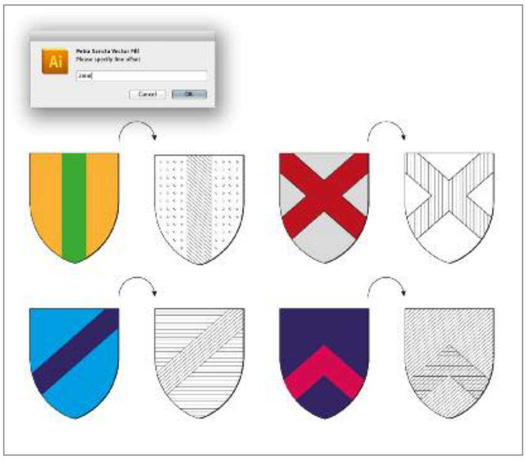

Image 2

Image 2: The Petra Sancta Script.

therefore offers an efficient means of specifying hatching patterns for both laser and rotary cutting tools, which we hope can support the use of the convention, and more nuanced engraving techniques generally. Although developed with the traditional patterns of heraldic engraving in mind, we see it having much broader application, as a more sophisticated alternative to the solid raster fills of laser engraving or the efficiency-focussed pocketing of rotary cutting software.

Summary

In addition to its usefulness in practice, the Petra Sancta script is intended to demonstrate how, as we build increasingly dexterous hardware, software can be developed to support and encourage a sensitivity to the principles or connoisseurship of a craft.

With ever increasing access to digital fabrication techniques, we believe that it is important for digital practitioners to recognise the existing knowledge in the more traditional variants of their fields and to consider how this knowledge might best be translated into digital hardware and software. Our goal was to take one of the principles of best practice in engraving and apply it in design software. This small effort has provided us with a useful tool and a better understanding of the potential for modifying software.

Learning more about traditional engraving, however, has also made clear the relatively unsophisticated processes and results of digital engraving – we have found many other aspects of best practice that remain unsupported in our machinery and software. Furthermore, despite their rapid advances and huge growth in availability, we believe such unsophistication might be true of all digital fabrication processes. There is still much to be improved, in both our software and hardware. And, if you are wondering where to start – we would urge you to buy an old how-to guide.

The Petra Sancta script is open source, and can be used and modified by other practitioners. Please visit www.jethomas.co.uk/petrasancta to download it.

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