Graphics and Visualization within Cross-Stitch

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Abstract

The leisure industry, in fields such as the games market, is immersed in computer graphics. However, non-traditional visualization techniques are slow to appear within many leisure pursuits especially cross-stitch.

Even more than a decade after the *Visualization* area was formally defined, visualization as a discipline mainly consists of 'scientific' techniques and examples. Here technical data is used to generate specialised realisations for a scientific audience. However, the level of interest and application of non-scientific visualization techniques, such as visualizations for the leisure industry, is increasing.

Within this paper, we evaluate the level of computer graphics and visualization within the area of 'Cross-stitch', and propose some new visualization techniques. We conclude that although the cross stitch field is very traditional, the use of computers in the process of generating a completed cross-stitch is very important: increasing the ease of use and the speed of production.

1 Introduction

Many years ago it was stated that only four computers would be needed for the whole world. - How ideas have changed! The current aim of 'a computer for everyone' is becoming a more realistic and achievable goal. Due to this, there has been a growing need to develop programs that allow users to express their ideas in a more natural or convenient way: to provide packages that are usable and available to the average non-scientific householder.

Cross-stitch could be seen as representative of the general leisure industry; an industry that is establishing its development and design cycle with the growth of the personal computer market. Cross-stitch is a hobby that is based on a traditional approach [Gui98]- a time-honoured activity with cross-cultural interest. It is widely used as an inexpensive method of therapeutic relaxation which has the added advantage of creating a visually appealing outcome that may be given as a gift to a friend or loved one!

In this paper we evaluate the level of graphics and visualization within this cross-stitch field and propose new methods of visualization. Thus, we split the paper into two parts.

1. we provide an evaluation of cross-stitching and visualization, investigating the variables used within cross-stitch (section 2), different components of visualization (section 3) and the level of visualization within current cross-stitch computer products (section 4).

2. Second, we present a discussion of the level of computer graphics in cross- stitching (section 5) and describe some new ways of visualizing this pattern-based information (section 6).

DMC	Anchor	Madeira	Symbol	Colour
498	020	0513	⊕⊕	Dark red
562	208	01213	⋄⋄	Dark green

Table 1: An example of a thread chart as frequently used in specialist magazines

We summize that, although much effort is invested to place 'computer graphics' into these leisure packages: with fancy animations and colourful pictures adorning the most simple of tools. The application of relevant non-scientific visualization has been surprisingly neglected.

2 The Craft of Cross-Stitch: A Component Analysis

Cross-stitch may be performed using a variety of stitches, methods, colours and threads, and carried out on different fabric. These represent the components of cross-stitch and will be considered in the order that a cross-stitcher would consider them as they stitch. The general quantifiable components of cross-stitch comprise the following:

The Fabric Type - The most complimentary material group for cross-stitch embroidery is called 'even weave', e.g. Aida. This is a 100% cotton fabric has the same count or gauge in both directions, that is, the same number of threads to every 1-inch of fabric. This count varies from fabric to fabric.

The Fabric Colour - Fabrics are available in large shade ranges, and textures.

Thread Type (including Number of Strands) - The most widely used of the embroidery threads is the six-strand mercerised cotton embroidery floss. It is made from loosely twisted strands allowing lengths to be split up into different weightings, from one to six strands for different weights of fabric. These cottons are generally sold in skeins that are approximately eight metres (nine yards) long. The recommended, manageable length for stitching is around the 18-inch mark.

The Thread Colours and Names of the Colours - Threads are available from different manufacturers who have their own colour ranges (for example [DMC98]). Some of these colour series coincide and so conversion charts are available to provide the closest possible matches between colours. Magazine patterns usually show a combination of range colours, see Table 1.

Thread ranges are expanding to accommodate the demand for a wider selection of hues and effects of colour. There is now the possibility of purchasing 'blended' or 'space-dyed' threads that combine usually two or more colours, or variations of the same colour along the length of the skein, creating a variegated appearance. Metallic threads are also becoming more common place [KH97].

Stitch Types - The choice of stitch for general cross-stitch is limited. The overall effect of cross-stitch is a general uniformity of weave, so that the eye is drawn to the colour co-ordination and impression of the pattern rather than to the effect of the textured rise and fall of the threads, as is the case with free-style embroidery. The variations of cross-stitch, which are mostly self-explanatory, include full cross-stitch, quarter stitch, three-quarter stitch and half stitch. Additionally, backstitch is used to create detail, definition, or text, and the French knot adds a raised texture [Eat91].

Position of the stitch - This is the consideration of where the stitch is to be located on the chart's grid or pattern and ultimately on the fabric itself. A pattern designer would consider the position in relation to the other stitches, the fabric (x, y) position, other colours and the area of the pattern.

3 Visualization Techniques: A Component Analysis

The components of computer graphics may be separated into many human perceivable variables. Jacques Bertin [Ber81, Ber83], for example, describes what he calls 'retinal variables'. Their use must be selected in such ways that correct, unequivocal, and efficient transmission of data be carried to the user. Based on Bertin's work, we describe nine variables, as follows.

- **(X,Y) Two Dimensions of the Plane** - allows objects to be positioned in space, using regular or irregular grids. Objects mapped onto this space may be of points, lines or areas.

- **(Z) Position** - The Z dimension adds the literal and conceptual third dimension to a visualization or image.

- **Size** - can be used as a qualitative portrayal of proportion between two magnitudes. The perception of order is an innate characteristic of this variable.

- **Value** - This is the 'continuous progression which the eye perceives in a series of greys ranging from black to white' [Ber83]. If colour is used rather than neutral black and white, then this is given an associated grey value. It is an innately ordered variable that can be easily quantified.

- **Texture** enables a realistic appearance of the subject, allowing neighbouring areas to be visually distinguished.

- **Hue** represents the 'colour' of the object. It is one of the most discussed and yet unresolved areas of visualization. But with appropriate use, it has the potential to enhance human interpretation of an image [TS90].

- **Orientation** can help to clearly distinguish points, lines or areas of visualization. It may be described as the variation in the angle between areas that is formed by "one or more symbols or signs" [Ber83].

- **Shape** - or symbol represents "a mark with a constant area that can assume an infinite number of different shapes. This variation has unlimited length, and it is tempting to abuse it" [Ber83]. This may require some explanation, as meaning need not be innate. This variable is not selective, ordered, nor quantitative.

- **Transparency** could be used either to simulate reality, or to reveal an object or an image's inner geometry or layout. These objectives require either reality simulation (or refractive transparency), or non-refractive transparency that allows the simultaneous display of multiple superimposed structures without distortion [Int98].

- **Glyphs** - are ideal for the representation of multivariate data due to their ability to make large data volumes quickly comprehensible and ready for analysis. They may be described as symbols that can communicate multiple values and proportions. For examples, see [RAEM94, CE98].

Visualization techniques	Paper-Based	Easy Cross de Luxe [Ful98]	X-Stitch Master Elite [Urs98]	X-StitchDesigner Supergold [Ils98]
(X, Y) Two Dimensions of the Plane	possible manually	Yes	Yes	Yes
(Z) Position	No	No	No	No
Size	manual re-scaling	Yes	Yes	Yes
Value	Yes	Yes	Yes	yes
Texture	in photo form	Yes	No	Yes
Colour	Yes	Yes	Yes	Yes
Orientation	manually	No	No	No
Shape	possible to do manually	Yes	Yes	Yes
Transparency	No	No	No	No
Glyphs	No	No	No	No
Realistic Rendering	in photo form (as texture)	No	No	Yes

Table 2: Overview of the current cross-stitch methods and the visualization techniques in use.

- **Rendering Techniques** - Rendering can involve familiar operations from computer graphics and image processing, but might also involve new algorithms, such as, light reflections, surface texture and realism.
- **Others Possible Variables** could take the form of *luminosity*, *reflectance*, or *animation*, which could almost be seen as distortions of what is already available.

4 Visualization Techniques in Cross-Stitch

Combining the previous two sections, we will now analyse the visualization techniques used in current paper-based and computer-based cross-stitch methodologies, and how they have evolved. Other analysis have been achieved, but these have been from a users viewpoint, such as that written by David Taylor [Tay98].

In the past there was a need to strengthen fabric by darning; this developed into embroidery and to the decorative craft practised today. Samplers for example, have been embroidered for centuries as a means of gathering together collections of stitches and designs, see [Per87]. These though, have been losing out to paper-based libraries of motifs, and these in turn have been superseded by the computer due to the ease of creating designs and saving them to disk. Although, samplers are still being created and designed [Mil91], the historical reasoning behind it has been more or less forgotten as technology advances and facilities improve and expand. Nowadays the art of the sampler has become no more than an art for art's sake.

Table 2 shows an overview of current cross-stitch methodologies (general paper-based, plus three examples of computer-based patterns) tabling which visualization methods they use.

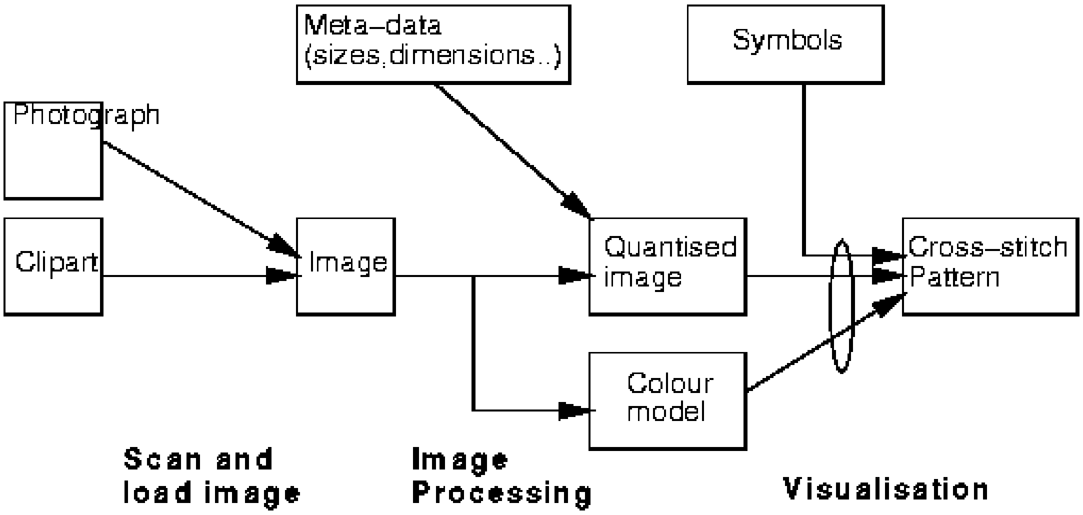

Figure 1: The graphics and visualization processes involved in generating a computer based cross-stitch pattern

4.1 Current Paper-based Visualizations

Current Paper-based Visualizations provide a pattern, and the fully-stitched end product in photograph form. The visualization uses a graph-paper pattern of colour and/or symbol representations which informs the user of the possible use of colours, the position of those colours and the type of stitch to use, for example full cross-stitch or quarter stitch.

The pattern does not specifically include concepts dealing with the fabric type or colour, thread type, number of strands of thread, amount of fabric, area of the pattern and design size. Little consideration is given to pattern information such as the amount of thread required, and the expense entailed. Time estimations must be made from personal experience, and thread use is given very limited space and is often ignored. Some written instructions are usually provided but, help on time estimations, miscellaneous implementations, or 'How to design your own' are dealt with as side issues. Moreover, no graphical representation is attempted of any of this 'meta-information'.

The photograph image of the final product gives a demonstration of how the stitched area will look on the fabric chosen by the designer but the pattern itself is generally kept free of any additional information.

The patterns allow the user to create an 'exact copy' of the designers artwork. However, creativity should be encouraged and the pattern need not be exactly copied. Thus, it may be useful to include information about how to read patterns and how to start stitching, and perhaps delve into such developments as how to rotate borders and patterns, create corners, transfer or scale designs, 'design original patterns' or freestyle stitch.

4.2 Computer-based Visualizations

Computer-based designing for cross-stitch has come about through the desire of a few particular stitchers to evolve their craft into a new age.

Figure 1 describes the main processes involved. In essence a photograph or art image is loaded into the program. Image processing technique are then applied to generate an appropriate cross-stitch model. The visualization stage maps the coloured symbols onto a grid to generate the cross stitch pattern, Figure 2 presents a typical symbol based image.

In general, packages rely on a basic grid representation that may be switched on or off,

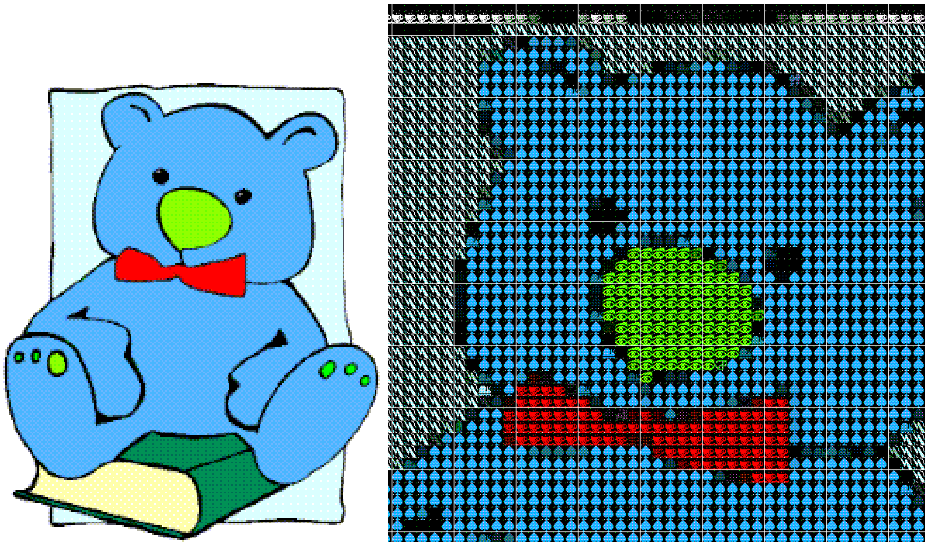

Figure 2: Typical clipart drawing and symbol based visualization

resized by specific percentages and the count adjusted to the level desired. Usually, as the cursor is moved around the screen, the grid co-ordinates are shown following it.

Attempts are now being made at realistic rendering of different types of fabric - canvas, linen, and Aida, in a limited range of colours. For example, XStitch Designer Gold [Ils98] generates a form of realistic rendering, albeit on a pseudo-coloured square grid

The packages only allow representations of a limited range of thread types. This does not reflect the extensive choice of these on the market. The user is told what to use in the legend to the pattern. Although, XStitch Studio [Urs98], one of the most recent packages to come on to the market has made the first attempt to represent the different thickness of thread for stitches other that backstitch.

The packages provide the user with extensive colour ranges. It could easily be assumed that the colours used were in some way scientifically measured, or at least provided by the manufacturers of the threads, but sadly, all that is necessary is good eyesight! Some of these packages include descriptive names for the colours but generally, only a code number and representative colour is provided in the user-selected palette.

Computer design for cross-stitch has proved to be a marvellous time saving device, allowing the fast editing and transforming of any pattern. Improved tutorials are provided for the user, with information on all aspects of the programs.

Specific pattern information such as design size in number of stitches, centimetres, and inches, and thread use in number of skeins needed, is provided by the computer packages. Estimations of cost, even through inputting your own regions prices, is avoided.

This analysis has shown the areas of cross-stitch still left to be tackled by the designers in terms of visualization methods. As far as the visualization techniques themselves are concerned, the approach has not evolved to any great extent.

5 A Summary

Cross-stitch patterns enable the user to generate a crossed-weave representation of an original design on a material canvas. Such patterns may be generated using a computer by image processing techniques, to split the image into regions and quantise the colour-space, and visualization techniques to map the segmented data into a displayable and form, see Figure 1.

Within the previous sections we have analysed and evaluated different components of the cross-stitch, described the visualization variables and discussed the level of graphics in current pattern creation products. In summarising these previous sections, especially from the comparison table (Table 2), we state:

a) The current pattern visualizations are very effective, a user may take a pattern and easily generate an appropriate fabric version.

b) The thread colour is often visualised using both a symbol and a colour mapping. This redundancy of information [Tuf83b] is useful as colour is visually ordered and the symbols are individually recognisable.

c) The patterns are generally intuitive, allowing a novice to easily generate a representation.

However,

1) The current computer-generated patterns are 'paper based' equivalents. They do not utilise the full potential of the computers interactivity.

2) The current patterns display the minimal amount of information, some include information about the length of cotton required, but it may be useful to visualise extra statistical information within the pattern.

3) Computers are capable of rendering complex scenes. Products are appearing that generate a realistic rendering of the cross-stitch, but other complex computer graphics could be used.

4) The information content on a pattern is quite high. This is because all the descriptions to generate one cross-stitch is placed on one pattern and each of the quantised segments on an image are represented as icons on the pattern.

These four points come under the headings of: Interactivity, Meta-information, Complex Graphics and Simplification, respectively.

6 Proposed Visualizations

Within cross-stitch visualization and many other leisure visualizations the realisation needs to be developed so the user may understand the encoded information and be able to generate finished cross-stitch. Thus, some visualizations may be possible, but in fact unrealistic, as they obfuscate the information to such an extent that it would be difficult to generate an effective cross-stitch.

Within this section we describe some new visualizations (based on the four headings from our Summary section), explain they were achieved and discuss their merits.

6.1 Interactivity and Meta-information

Computer based cross stitch patterns have the advantage over the paper based equivalents in that the computer based versions may be interrogated and dynamically manipulated. The

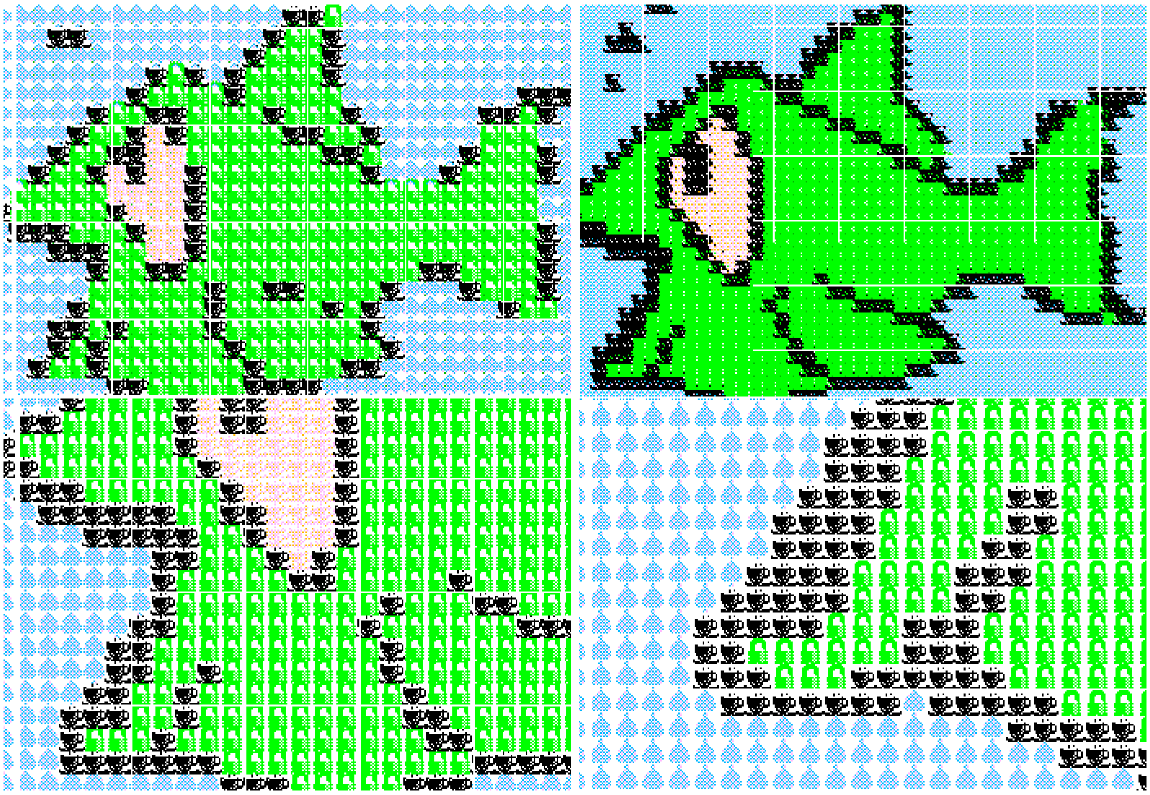

Figure 3: Computer based manipulation of the cross-stitch pattern, showing zoom and resolution changes

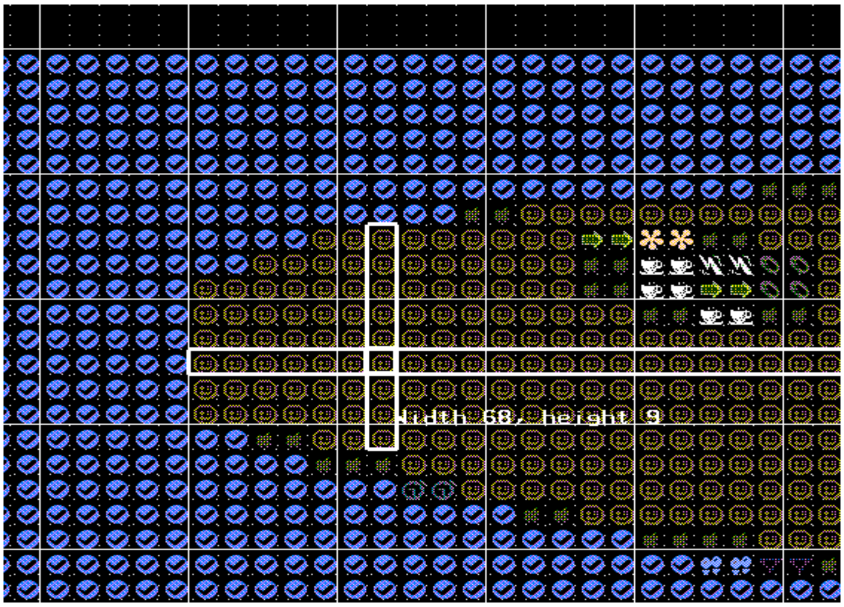

Figure 4: A cross-stitch pattern of the mouth of a fish, showing the extents of a row and a column. The user may select a square to display the meta-information.

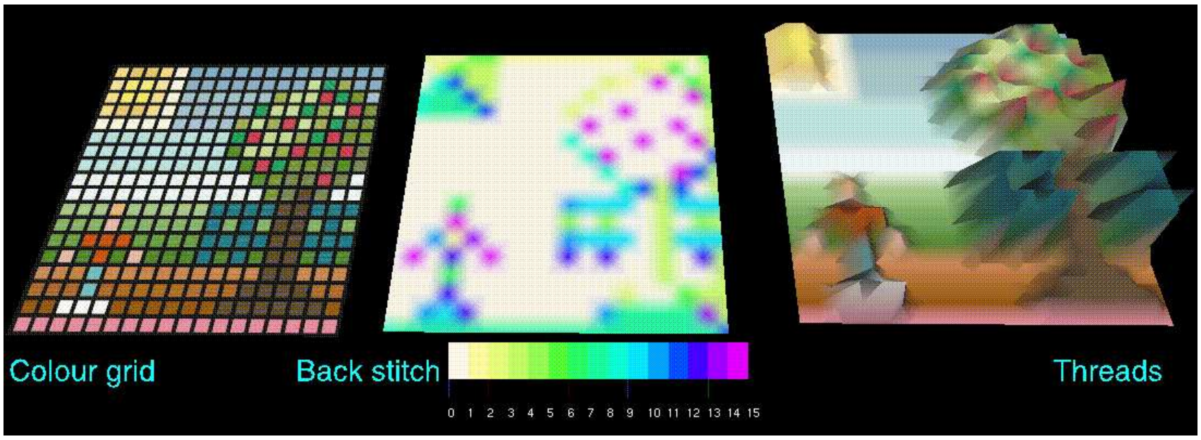

Figure 5: Left, depicts the colour of the stitch; Centre, encodes the shape of the backstitch; and the Right image represents the number of threads by height.

patterns may be enlarged (zoomed) to focus on a particular area or scaled to provide a more coarse pattern of the same image, see Figure 3.

Moreover, additional information may be included with the visualization. For example, the user achieving the cross-stitch continuously counts the number of symbols in a line, to generate the next row of stitches. This count information may be added to the visualization, to the position of the mouse click. Figure 4, depicts this width and height count information on a typical computer generated pattern. Here the computer is aiding the cross-stitcher in following the pattern.

These images are generated by our Cross-Stitch visualiser (VisXS). This software uses OpenGL and C and reads in SGI image files. The user may display the image as symbol representations or colour cubes, change the scale and detail of the displayed pattern, take a snapshot of the image or export VRML code.

Interactivity is very important within visualization, and allows additional information to be displayed to the user. However, such techniques require the user to be present at a computer something that the traditional cross-stitcher may not wish to do, and such interaction does not lend itself to being 'printed on paper'!

6.2 Complex Graphics

From our previous analysis, we see that the current patterns do not use the third dimension. It is possible to use the third dimension to represent, for example, the number of threads of the pattern; Figure 5 depicts such a visualization.

These visualizations were generated using IRIS Explorer [HYM92], they give an 'impression' of the overall image and give some information of where the emphasis and highlighting of the backstitch are to appear. They do not give exact information and are thus open to interpretation. This uncertainty information may be beneficial: as to encourage creativity of design.

6.3 Simplification

The information content of the patterns tends to be quite dense: a typical pattern is made from a lot of closely packed symbols. This tends to generate a low 'data ink ratio' [Tuf83b], with a lot of redundant ink that could be removed. We present two methods to improve the visualization of a typical pattern: separation and abstraction.

Separation (as named by Tufte [Tuf83a]) or Multiple Viewing [Rob98] enables the information to be separated into different views, rather than overlaying all the information in one view. Figure 6 depicts four views of the same 'pattern'. Here, separate images represent the amount of strands, colour of the cotton and the backstitch information; a fourth image merges each of the images together to generate a 'glyph' view of the entire information.

It is useful to separate the information out into multiple views, this may generate a 'more correct' understanding of the information [Rob98]. However, within this visualization it is difficult to view the amount of cotton strands and in practice, the cross-stitcher may find it hard to follow three 'views' of information.

Abstraction techniques generate visualizations that display generic or the most important information. Techniques may augment, adapt or simplify the information to display a clearer realisation [Rob95]. In this pattern based information, there is usually a lot of repeated runs of icons; it may be clearer to generate a visualization that displays a reduced number of the symbols together with a count on how many stitches in a particular row.

Figure 7 depicts such an abstract visualization. Here, the numbers represent the total quantity of stitches in the specified row, terminated by the change in icon.

This realization provides a simplified view on the data, the user does not need to continually count the number of stitches, as the information is presented in the visualization. This realisation may be used both interactively and printed to paper. However, when the visualization becomes large the font size would become small and may become unreadable, but, the online version would allow the image to be enlarged to view a particular area.

7 Conclusion

We have evaluated the level computer graphics and visualization within the cross-stitch leisure pursuit. We conclude, that the visualization content used within cross-stitch patterns is currently based on the paper based method. Some interactivity and realistic rendering is being introduced within the computer based products. But, there are many techniques that are currently available and would be useful to an end-user both following a pre-designed pattern (on a computer screen) and to generating their own designs.

It is true that the whole craft of cross-stitching is extremely traditional. But as the computer becomes 'part of the furniture' it will increasingly be more accepted and used to aid such traditional hobbies.

Additionally, a cross-stitcher may not be near a computer whilst relaxing and following a pattern. But, many 'hand held' devices are being developed that could be used to display the cross-stitch developer or stitch-aid program. Indeed, such stitch-aid programs, especially on the portable computers, could then dynamically aid the cross-stitcher by (say) automatically updating the pattern with information about 'how far through the design the cross-stitcher has proceeded' or to notifying the user of the 'best place to start stitching' and to estimate the 'amount of thread required' for a particular design.

Within this paper we have analysed the components of cross-stitch, the variables of the visualization space and looked at the visualization content within both the paper and computer based methods. The whole essence of our progression of this evaluation, itself, provides a structured way to evaluate the visualization content within a new area.

We have described and implemented some new computer based cross stitch visualizations. One of the methods uses a technique of abstraction; this is a very powerful process, and if appropriately used, it achieves an improved visual representation of the viewed information. Our abstract view removes the need for the user to 'count the number of stitches' in a row, and

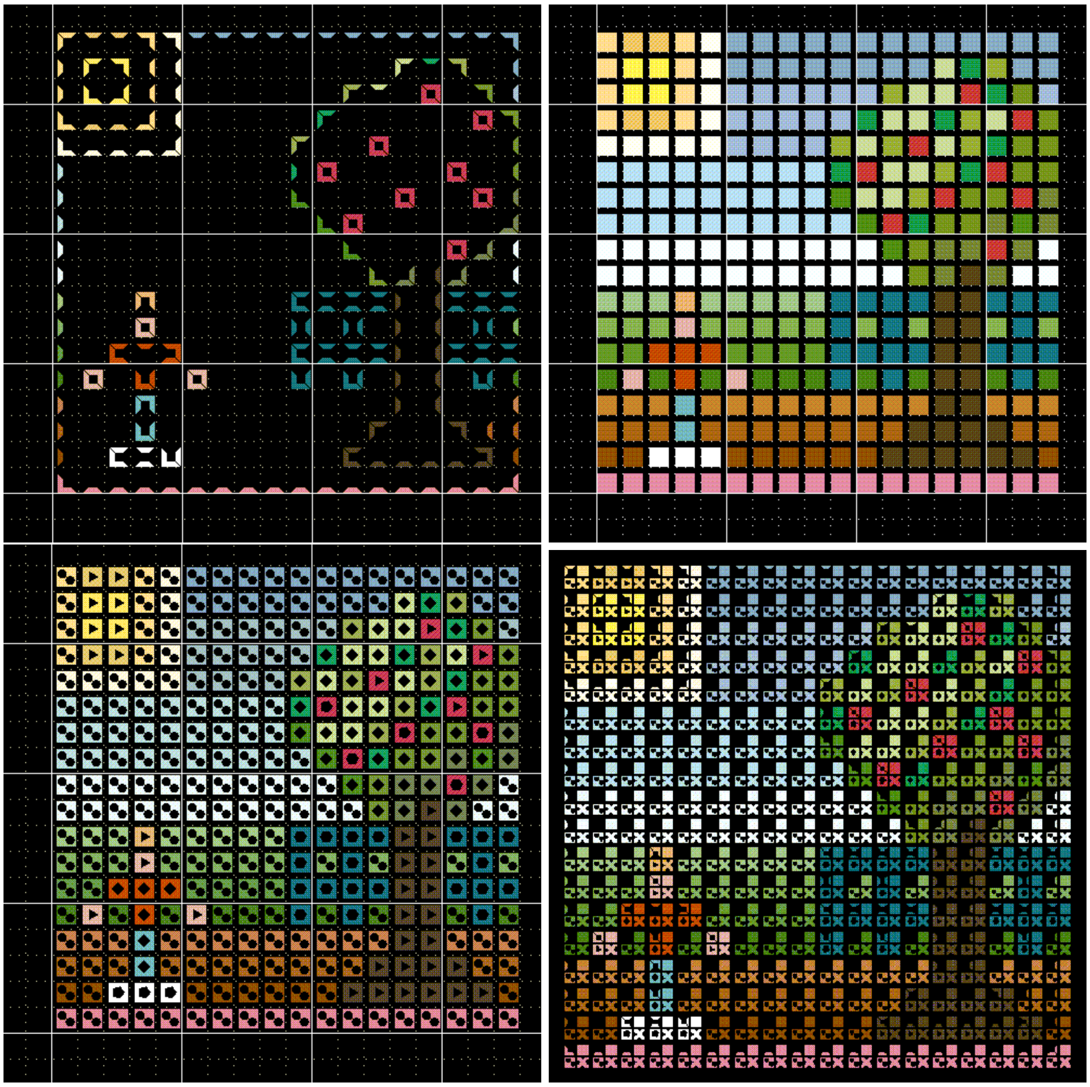

Figure 6: A Separation of the different cross-stitch variables into multiple views. Top left, represents the backstitch. Top right is the cross-stitch colour. Bottom left shows the number of threads (one circle is one thread, two circles two threads, triangle three threads, square four threads, etc). Bottom right depicts a combined glyph visualization of the same information.

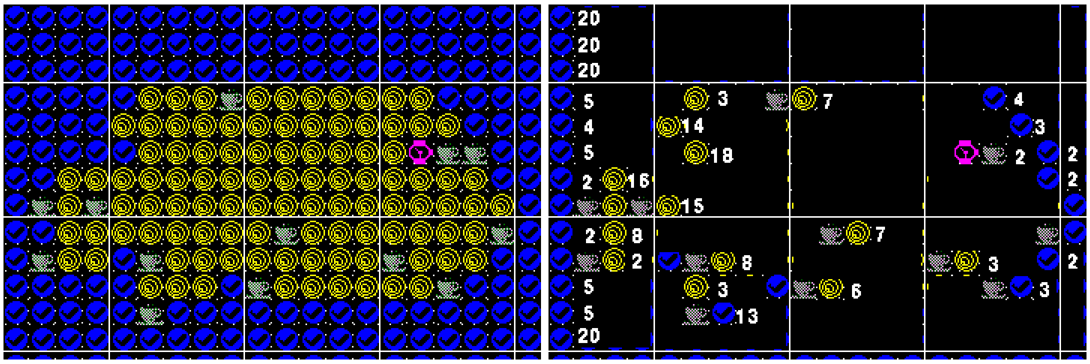

Figure 7: The right image shows an abstract visualization of the fish on the left, the numbers represent the extents of the particular cross-stitch.

thus reduces the mathematical calculations a typical user would achieve.

Through our evaluation procedure it is possible to see that there are additional visualization methods that may be easily applied to this non-scientific data. It is true that some visualization techniques, such as using the third dimension, may not be useful to the person following the cross-stitch pattern, but they are useful in allowing an 'interpretation' of the pattern and to generate an understanding of how the final canvas may appear.

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