Automatic Analysis of Coloured Images

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I. Introduction.

The design of woven fabrics involves an aesthetic, as well as a structural, consideration, and this challenge has traditionally been approached in a number of ways. One such approach is the design of a well-bound, structurally stable fabric whose interlacement arrangement is as unobtrusive as possible. The intersection pattern is constructed in such a manner as to be homogeneous and regular and so as not to compete with any surface treatment of the fabric. An excellent example of this is found in textiles which have surface designs printed or painted on a plain tabby or satin structure. Plain, regular weaves can also be used to advantage in conjunction with expensive or exotic yarns such as alpaca or metallics. Coloured stripes, checks, plaids and tartans are normally incorporated into fabrics with a fairly simple structure, with a 2/2 twill weave being extremely common, where the drape and stability of the interlacement are of greater importance than the surface pattern generated by the arrangement of intersections. [**1**]

A second approach to the visual design of woven fabrics is to develop surface interest through the use of structural patterning. Lace weaves, either in borders or along entire fabric lengths, are used to great advantage to create visually interesting textiles suitable for clothing and household furnishings. Small all-over motifs, often known as dobby weaves, also produce patterns which can be very subtle when the warp and weft are the same colour, or can be more obvious when a contrasting warp and weft are used. Block weaves such as the damask combination of satin and sateen can also result in complex fabrics with a very intricate arrangement of intersections reflected in the surface imagery (Photo 1) [**2**].

ARS TEXTRINA **5** (1986), pp. 151-166

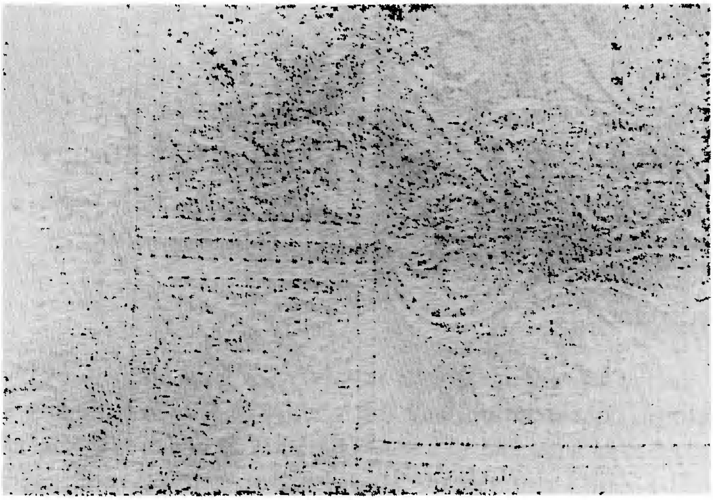

Photo 1A. Detail of damask pattern.
Photo: J. L. Allston

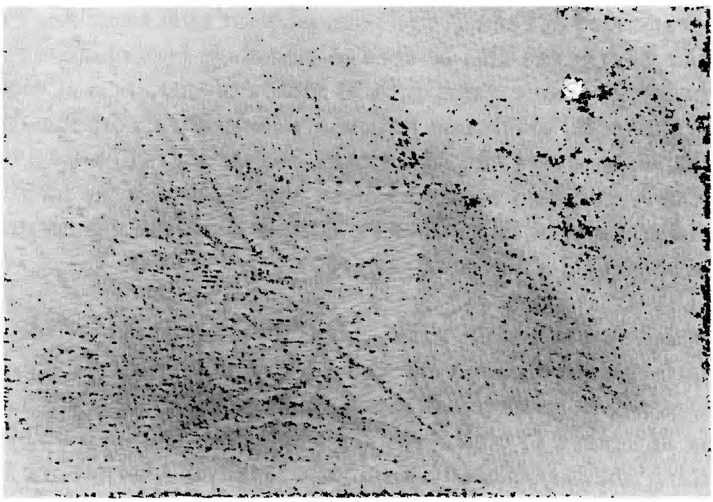

Photo 1B. Detail of damask pattern.
Photo: J. L. Allston

A third approach is to utilize both the weave structure and a constrasting or co-ordinating warp and weft colouring to produce surface patterns which are, at once, a function of the interlacement array while obscuring some aspects of this arrangement of inter - sections [3]. This type of patterning, known as "colour and weave effects" (Photo 2) [4], will be the focus of the the ensuing discussion.

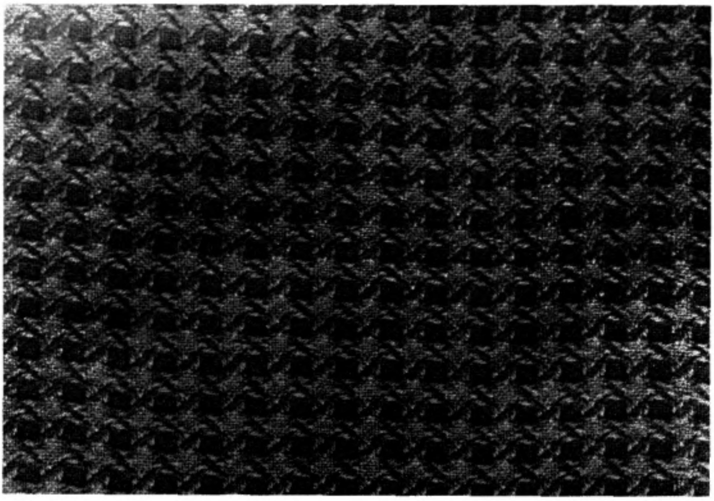

Photo 2A. Rug pattern.
Photo: J. L. Allston

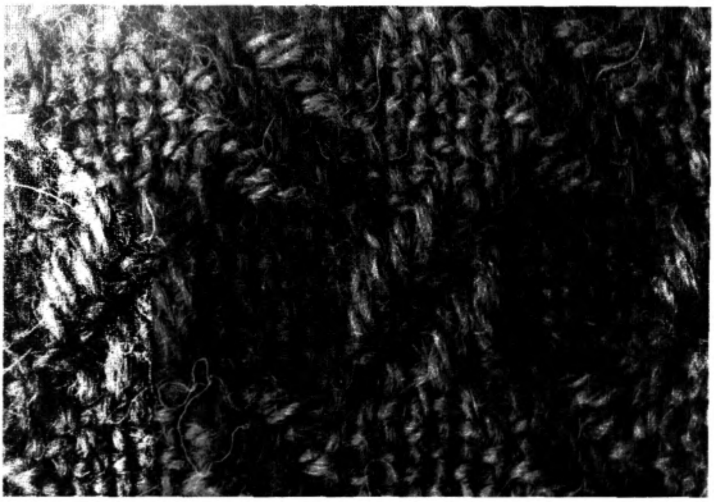

Photo 2B. Detail of rug weave.
Photo: J. L. Allston

2. Design Criteria.

In designing a colour and weave fabric, two observations can be made, as follows:

1. The visible surface colour will be a function of which yarn (warp or weft) is uppermost at a given inter-section.
2. If two strands of the same colour intersect, then the visible surface colour will be the same, regardless of whether the warp or the weft is uppermost. The type of intersection can be freely chosen according to structural considerations, in these situations.

These two points may appear complete obvious, however, they are the key factors in the development of colour and weave patterns.

3. Colour and Weave Motif Development.

The process of developing a colour and weave pattern involves a simple mapping of the interlacement array through two vectors of warp and weft colours. When a warp over weft intersection occurs, the black square which traditionally denotes this in the interlacement array is replaced in the *coloured interlacement array* by a square coloured to correspond to that particular warp colour. Similarly, weft over warp intersections have the white square designation in the interlacement array replaced by a square corresponding to the weft colouring. Figure 1 shows a simple 36 by 36 pattern formed from nine 12 by 12 repeats. In Figure 2, the *coloured interlacement array* which results when a striped warp and weft are used, is shown. It should be noted that the structure of both of these fabrics is identical, even though the visible surface appearances are very different.

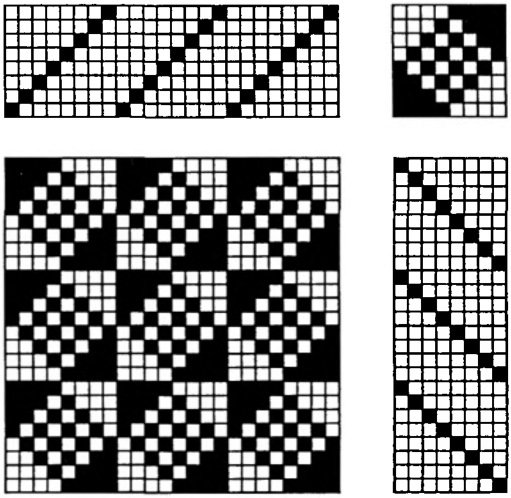

FIGURE 1

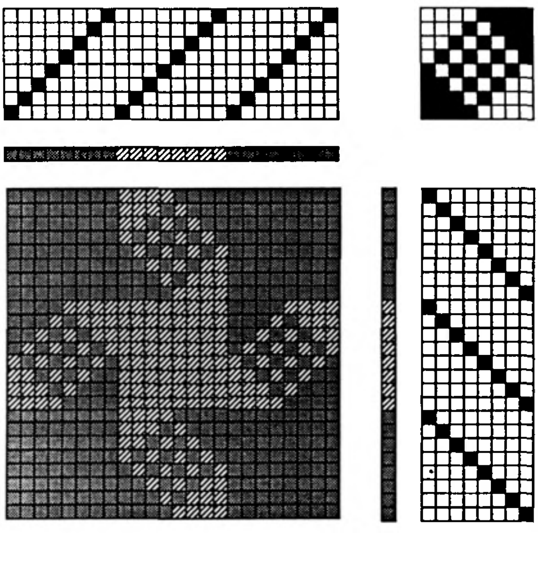

FIGURE 2

Computationally, it is convenient to represent the interlacements numerically as ones and zeros, where one corresponds to a warp over weft intersection, and zero corresponds to a weft over warp inter - section. Similarly, the *coloured interlacement array* can be repre - sented by an integer matrix, with each distinct colour being repre - sented by some integer. Figures 3 and 4 give the numeric representa - tions for the interlacement and *coloured interlacement* arrays of figures 1 and 2, respectively.

1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0
1	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1
0	0	0	1	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0	1	0	1	1	1
0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0
1	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1
0	0	0	1	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0	1	0	1	1	1
0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0
1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0
1	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	0	1	0	0
1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1
0	0	0	1	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0	1	0	1	1	1
0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1

FIGURE 3

2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	3	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	3	3	2	3	2	3	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	3	2	3	2	3	3	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	3	2	3	3	3	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2
2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2	3	3	3	3
2	2	2	3	2	3	3	3	3	3	3	3	3	3	3	3	2	2	2	3	2	3	3	3
2	2	3	2	3	2	3	3	3	3	3	3	3	3	3	3	2	2	3	2	3	2	3	3
2	3	2	3	2	3	2	3	3	3	3	3	3	3	3	3	2	3	2	3	2	3	2	3
3	2	3	2	3	2	3	2	3	3	3	3	3	3	3	3	3	2	3	2	3	2	3	2
3	3	2	3	2	3	2	2	3	3	3	3	3	3	3	3	3	3	2	3	2	3	2	2
3	3	3	2	3	2	2	2	3	3	3	3	3	3	3	3	3	3	3	2	3	2	2	2
3	3	3	3	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	2	2	2	2
2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	3	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	3	3	2	3	2	3	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	3	2	3	2	3	2	3	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	3	2	3	2	3	3	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	3	2	3	3	3	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2

FIGURE 4

4. Colour Analysis Algorithm.

Normally the analysis of a woven textile fragment begins with the development of the corresponding binary interlacement array, with some notation being made as to the colours of the various warp and weft yarns. At this point, any of the preceding factorization algorithms can be applied to the interlacement array to determine the appropriate threading, tie-up and shed sequence matrices. It should be noted that this factorization is "essentially unique" [5,6].

Sometimes, however, a given coloured design is to be analyzed to determine how, or in fact if, it can be produced on a loom. This design then must correspond to a multi-valued array which is a *coloured interlacement array* if and only if it can be decomposed into a vector of warp colours, a vector of weft colours and a binary inter - lacement array, all of which are self-consistent. In other words, we require that the resulting factors reproduce the original coloured design when the *coloured interlacement array* computation process previously described is applied to them.

The first step in this analysis is therefore to determine a vector of warp colours (WARP), a vector of weft colours (WEFT) and an interlacement array ($D = \{d_{i,j}\}$), which correspond to the given *coloured interlacement array* ($K = \{k_{i,j}\}$). An additional part of this stage is the determination that the given coloured image is, in fact, a valid *coloured interlacement array* .

The algorithm is given by the following steps:

1. Set $WARP_j = K_{1,j}$ for all columns where $K_{1,j} = K_{i,j}$, for all i.
2. Set $WEFT_i = K_{i,1}$ for all rows where $K_{i,1} = K_{i,j}$, for all i.

****** It is assumed that this is, in fact, a *coloured interlacement array* and, therefore, that the warp contributes at least one element in every row and the weft contributes at least one element in every column. Steps 1 and 2, above, search for columns and rows where are all of the elements in the column or row are the same colour as each other. The warp or weft vector can then be set to that colour in its corresponding position. An example of this type of array is given by the "trivial" cloth, which is a single colour.

3. Terminate the process if the WARP and WEFT vectors are complete.
4. Choose a value for j (j = 1,2,..., rows) such that there exists some $K_{i,j} \neq K_{1,j}$ (i = 1,2,..., columns).
5. Let $K_{1,j}$ be a warp over weft intersection and set $WARP_j = K_{1,j}$.
6. All $K_{i,j} \neq WARP_j$ are weft over warp intersections. Set $WEFT_i = K_{i,j}$ for all of these values of i.
7. For all $WEFT_i$ determined in step 6, locate all $K_{i,j} \neq WEFT_i$ and set $WARP_j$ equal to these $K_{i,j}$.

****** Steps 6 and 7 are involved in a search for *colour circuits,* sets of strands whose colours are mutually determined. Each such set of strands defines a *colour plane.* This concept is related to the work of Newton and Sarkar[7] on the reducibility of fabrics, in which they examined the levels of the constituent intersections in a woven fabric.

8. Repeat steps 6 and 7 until all values for WARP and WEFT in the current *colour plane* have been defined.

9. If the *coloured interlacement array* consists of one *colour plane* then terminate the algorithm.
10. Otherwise, choose the array element whose corresponding WARP and WEFT values have not been determined which has the smallest column index and then the smallest row index. Set the corres - ponding WARP value equal to this element and repeat steps 6 through 8.

****** If, at any point in this process, an inconsistency develops, the array K is not a *coloured interlacement array.*

All that remains to be done now is to replace each element in the array which corresponds to a warp colour and does not correspond to a weft colour by a one, and to replace each element which corres - ponds to a weft colour and does not correspond to a warp colour by zero. Clearly, any element in the *coloured interlacement array* which corresponds to the crossing of a warp and weft of the same colour can be set either to a one or to a zero. This could be done automatically, with reference to some set of pre-defined rules, however, this is likely better left to be determined interactively, at the discretion of the designer.

5. Examples.

The application of this algorithm to the *coloured interlacement array* of Figure 2 (4), results in the following warp and weft colourings and interlacement array.

```
2 2 2 2 2 2 2 2                                      2 2 2 2 2 2 2 2

2 2 2 2 2 2 2 2     3 3 3 3 2 2 2 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     3 3 3 2 3 2 2 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     3 3 2 3 2 3 2 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     3 2 3 2 3 2 3 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 3 2 3 2 3 2 3     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 2 3 2 3 2 3 3     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 2 2 3 2 3 3 3     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 2 2 2 3 3 3 3     2 2 2 2 2 2 2 2

2 2 2 2 3 3 3 3     3 3 3 3 3 3 3 3     2 2 2 2 3 3 3 3    3
2 2 2 3 2 3 3 3     3 3 3 3 3 3 3 3     2 2 2 3 2 3 3 3    3
2 2 3 2 3 2 3 3     3 3 3 3 3 3 3 3     2 2 3 2 3 2 3 3    3
2 3 2 3 2 3 2 3     3 3 3 3 3 3 3 3     2 3 2 3 2 3 2 3    3
3 2 3 2 3 2 3 2     3 3 3 3 3 3 3 3     3 2 3 2 3 2 3 2    3
3 3 2 3 2 3 2 2     3 3 3 3 3 3 3 3     3 3 2 3 2 3 2 2    3
3 3 3 2 3 2 2 2     3 3 3 3 3 3 3 3     3 3 3 2 3 2 2 2    3
3 3 3 3 2 2 2 2     3 3 3 3 3 3 3 3     3 3 3 3 2 2 2 2    3

2 2 2 2 2 2 2 2     3 3 3 3 2 2 2 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     3 3 3 2 3 2 2 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     3 3 2 3 2 3 2 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     3 2 3 2 3 2 3 2     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 3 2 3 2 3 2 3     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 2 3 2 3 2 3 3     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 2 2 3 2 3 3 3     2 2 2 2 2 2 2 2
2 2 2 2 2 2 2 2     2 2 2 2 3 3 3 3     2 2 2 2 2 2 2 2
```

FIRST *COLOUR PLANE*

FIGURE 5

```
                  3 3 3 3 3 3 3 3

2 2 2 2 2 2 2 2   3 3 3 3 2 2 2 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   3 3 3 2 3 2 2 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   3 3 2 3 2 3 2 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   3 2 3 2 3 2 3 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 3 2 3 2 3 2 3   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 2 3 2 3 2 3 3   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 2 2 3 2 3 3 3   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 2 2 2 3 3 3 3   2 2 2 2 2 2 2 2   2

2 2 2 2 3 3 3 3   3 3 3 3 3 3 3 3   2 2 2 2 3 3 3 3
2 2 2 3 2 3 3 3   3 3 3 3 3 3 3 3   2 2 2 3 2 3 3 3
2 2 3 2 3 2 3 3   3 3 3 3 3 3 3 3   2 2 3 2 3 2 3 3
2 3 2 3 2 3 2 3   3 3 3 3 3 3 3 3   2 3 2 3 2 3 2 3
3 2 3 2 3 2 3 2   3 3 3 3 3 3 3 3   3 2 3 2 3 2 3 2
3 3 2 3 2 3 2 2   3 3 3 3 3 3 3 3   3 3 2 3 2 3 2 2
3 3 3 2 3 2 2 2   3 3 3 3 3 3 3 3   3 3 3 2 3 2 2 2
3 3 3 3 2 2 2 2   3 3 3 3 3 3 3 3   3 3 3 3 2 2 2 2

2 2 2 2 2 2 2 2   3 3 3 3 2 2 2 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   3 3 3 2 3 2 2 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   3 3 2 3 2 3 2 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   3 2 3 2 3 2 3 2   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 3 2 3 2 3 2 3   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 2 3 2 3 2 3 3   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 2 2 3 2 3 3 3   2 2 2 2 2 2 2 2   2
2 2 2 2 2 2 2 2   2 2 2 2 3 3 3 3   2 2 2 2 2 2 2 2   2
```

SECOND *COLOUR PLANE*

FIGURE 6

```
2 2 2 2 2 2 2 2   3 3 3 3 3 3 3 3   2 2 2 2 2 2 2 2

1 ? ? ? ? ? ? ?   1 1 1 1 0 0 0 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   1 1 1 0 1 0 0 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   1 1 0 1 0 1 0 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   1 0 1 0 1 0 1 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 1 0 1 0 1 0 1   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 0 1 0 1 0 1 1   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 0 0 1 0 1 1 1   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 0 0 0 1 1 1 1   ? ? ? ? ? ? ? ?   2

1 1 1 1 0 0 0 0   ? ? ? ? ? ? ? ?   1 1 1 1 0 0 0 0   3
1 1 1 0 1 0 0 0   ? ? ? ? ? ? ? ?   1 1 1 0 1 0 0 0   3
1 1 0 1 0 1 0 0   ? ? ? ? ? ? ? ?   1 1 0 1 0 1 0 0   3
1 0 1 0 1 0 1 0   ? ? ? ? ? ? ? ?   1 0 1 0 1 0 1 0   3
0 1 0 1 0 1 0 1   ? ? ? ? ? ? ? ?   0 1 0 1 0 1 0 1   3
0 0 1 0 1 0 1 1   ? ? ? ? ? ? ? ?   0 0 1 0 1 0 1 1   3
0 0 0 1 0 1 1 1   ? ? ? ? ? ? ? ?   0 0 0 1 0 1 1 1   3
0 0 0 0 1 1 1 1   ? ? ? ? ? ? ? ?   0 0 0 0 1 1 1 1   3

? ? ? ? ? ? ? ?   1 1 1 1 0 0 0 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   1 1 1 0 1 0 0 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   1 1 0 1 0 1 0 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   1 0 1 0 1 0 1 0   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 1 0 1 0 1 0 1   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 0 1 0 1 0 1 1   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 0 0 1 0 1 1 1   ? ? ? ? ? ? ? ?   2
? ? ? ? ? ? ? ?   0 0 0 0 1 1 1 1   ? ? ? ? ? ? ? ?   2
```

BINARY INTERLACEMENT ARRAY WITH WARP AND WEFT VECTORS

FIGURE 7

The next example shows a *coloured interlacement array* in which the warp and weft colourings are not disjoint but the entire array forms a single *colour plane*.

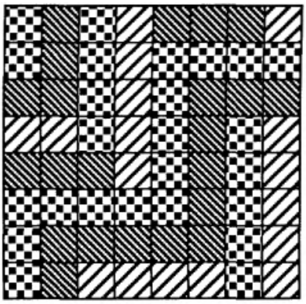

FIGURE 8

4	2	4	3	2	2	2	3
4	2	4	3	4	4	4	4
2	2	4	3	4	2	2	2
3	3	4	3	4	2	4	3
2	2	2	3	4	2	4	3
4	4	4	4	4	2	4	3
4	2	2	2	2	2	4	3
4	2	3	3	3	4	2	3

FIGURE 9

4	2	4	3	4	2	4	3	
1	?	1	1	0	?	0	1	2
?	1	?	1	?	0	?	0	4
0	?	1	1	1	?	0	0	2
0	0	1	?	1	1	1	?	3
0	?	0	1	1	?	1	1	2
?	0	?	0	1	?	1	?	4
1	?	0	0	0	?	1	1	2
1	1	0	?	0	0	1	?	3

BINARY INTERLACEMENT ARRAY
AND WARP AND WEFT VECTORS

FIGURE 10

The last example shows a *coloured interlacement array* which forms a single *colour plane* but also has warp and weft colours which are totally disjoint. It should be noted that, in this case, the interlacement array is completely determined and no intersections are left for the user to specify.

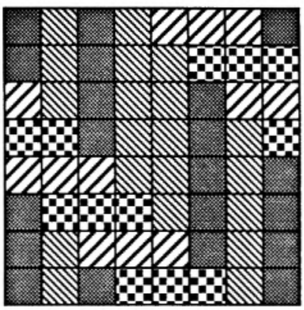

FIGURE 11

5	2	5	2	3	3	3	5
5	2	5	2	2	4	4	4
3	2	5	2	2	5	3	3
4	4	5	2	2	5	2	4
3	3	3	2	2	5	2	5
5	4	4	4	2	5	2	5
5	2	3	3	3	5	2	5
5	2	5	4	4	4	2	5

FIGURE 12

5	2	5	2	2	5	2	5	
1	1	1	1	0	0	0	1	3
1	1	1	1	1	0	0	0	4
0	1	1	1	1	1	0	0	3
0	0	1	1	1	1	1	0	4
0	0	0	1	1	1	1	1	3
1	0	0	0	1	1	1	1	4
1	1	0	0	0	1	1	1	3
1	1	1	0	0	0	1	1	4

BINARY INTERLACEMENT ARRAY
AND WARP AND WEFT VECTORS

FIGURE 13

6. Conclusions.

The "colour and weave" technique for achieving an interesting surface patterning of a woven textile, while still maintaining a stable and well-integrated interlacement structure is extremely versatile and widely used. The most common practice involves the crossing of sets of warp and weft yarns of the same colour, in which case, the intersections between these sets of yarns can be freely chosen by the designer, without regard to the surface colouring. Such intersections are clearly not amenable to automatic specification. The great utility of a computer-aided system for determining the interlacement array and warp and weft colourings which correspond to a given *coloured interlacement array* lies, therefore, in the specification of those components which are unambiguously determinate and the indication of the remaining components which can be freely chosen.

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