A Framework for Fabric Outlook Design Using Latin Squares

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Abstract

This paper presents a supporting framework for the design of fabric outlook in textile industries. The framework is based on the theory of Latin squares. Latin squares have found application in several areas of life especially in agriculture. The model was successfully used to develop dynamic pattern for replicating motifs used for fabric design. The motifs are replicated as symbols in a predefined Latin square order to develop automated design outlook. The Latin square developed outlooks are comparable with the expensive computer graphic designed outlooks. The system allows designers to select available choice motifs which they need for their design. New motifs are continually updated thereby increasing the possible available design outlook. The framework could be implemented in a computer program and will be beneficial to textile industries.

Keywords: Latin square, motif, replication, fabrics, textile, design

1. INTRODUCTION

The history of textiles and fabric design dates back to medieval ages in the development of man. Since then, it has always been the desire of man as he had continually sought for ways of improving the textile and fabric design. Textile making from the onset has always been simply seen as the process of creating designs for woven, knitted or printed fabrics or surface ornamented fabrics. According to (Egware & Edem , 2016), textile design is about creative decoration of fabrics and other allied products for clothing, drapes and furniture. The priority of every Textile industry is to produce clothing with unique fabric designs and outlooks. Textile industries generally had continued to thrive because of the availability of wool and cotton which are the major resources required. Availability of these resources had never been a hindrance to production of textiles. The major challenge that faces textile industries had always been in designing unique fabric outlook that will suit the market. The designs created on the fabric plays an important part in making the fabric more beautiful and more fashionable. It reflects the craftsmanship as well as the customs or culture of the wearer.

Fabric design comes in a wide range of different colors and patterns. Let's take the African fabric called "wrapper" as an example. The "wrapper" is a colorful women's garment widely worn in West Africa. The beautiful designs and patterns on the wrapper are all fabric designs. Prints on fabrics can be created with dye or screen printing, or they can be created by using different colored fibers when the fabric is being woven or knitted together. The benefit of a well-designed fabric outlook ranges from economic importance to social-cultural integration and fashion etc. Before the advent of computer graphics, fabric designs were done by hand, drawing or painting; it was a very slow and expensive endeavor.

The authors in (Egware & Edem , 2016) and (Mathur & Seyam , 2011) are of the opinion that the first textile fabricated by mankind was made by manipulating fibers with the fingers. Today, computers have led to the development of new technology and the awareness and interest in fashion has taken an alarming recognition all over the world. According to (Oppong & Antiaye, 2013), Computers can make the design from the scratch, using a tablet and stylus, with color and texture. With the introduction of computer aided design (CAD) and its many software capabilities, the possibilities are endless. The entire process of designing a fabric is computerized and facilitates the process. Some examples of modern computer software tools for the fabric design industry are; Adobe Photoshop, Adobe Illustrator, Digitiser, Cad.Assyst, plotter, Pattern scanner, i-grafx designer, Digital Fabric printers, Design concept 3D (Andrew, 2004).

The existing systems of designing fabric patterns are mostly textile Computer Aided-Design (CAD) software such as Adobe Illustrator CS6 and Photoshop CS3. Adobe Illustrator has a pattern option dialogue box in which the box consists of design tools with many functions that enables users create new designs or repetitive patterns by selecting any of the options for the desired pattern. The existing systems are expensive to acquire and require trained professionals and skilled fabric designers in order to use them effectively. Furthermore, a good fabric outlook design could take weeks to perfect. All these affect the overall expenditure and investment cost which may not be comfortable for small scale textile industries.

There is therefore need to develop an automated fabric outlook designer which allows a novice designer to select the motif and patterns of choice using the Latin square model as an organized platform to arrange the motifs for aesthetic beauty. This paper presents a framework for developing an automated computer system that generates fabric outlooks.

2. METHODOLOGY
The supporting technology for the framework includes Latin squares and motifs. Latin squares provide an ordered platform for the arrangement of the motifs.

2.1 Latin Square
A Latin square of order n is an n×n matrix containing n distinct symbols (usually denoted by the non-negative integers from 0 to n−1) such that each symbol appears in each row and column exactly once (Jeranfer & Morales, 2009). It can also be defined as an n by n array of cells in which n symbols (letters, numbers, colors, etc.) are placed, one per cell, in such a way that each symbol occurs once in each row and once in each column (Bailey, 2015). Figure 1 shows Latin square of order n = 4 each containing a set of four letters with each letter occurring once in each row and each column.

A	B	C	D
B	A	D	C
C	D	A	B
D	C	B	A

Figure 1: Latin Square of order n =4

2.2 Reduced Latin square

There are different types of Latin squares in literature such as Reduced Latin square, Semi-Reduced Latin square and Symmetric Latin square. The type of Latin square used in the outlook design is the Reduced Latin square. A Latin square is said to be reduced if both its first row and its first column are in their natural or standard order (0,1, ... ,n−1) [1]. For example, figure 2 is a reduced Latin square of order n = 3

α	β	μ
β	μ	α
μ	α	β

Figure 2: Reduced Latin Square of order n =3

2.3 Algorithm for Construction of Reduced Latin Squares

The algorithm below shows the procedure to construct a reduced Latin square of order n.

```
Let n = matrix size
Image_array  = array([n][n] );
count = n;
  for (int i=0;   i  < n ; i++)  //this loops through each row
          {
for (int j=0;  j <n ; j++) //this loops through each column
              {
image_array[i][j]  =  (j + count) % n ; //performs modulo arithmetic
         print  array[i][j];
          }
Enter next line;
  count--;
}
```

The author in (Bailey, 1999) defined the variety-concurrence graph of a Trojan square (which is a spcial type of Semi-Latin square) as a complete k-partite graph with no multiple edges. The implication is that the concurrence of the i^{th} and j^{th} treatment λ_{ij} is equal to 0 or 1. On the same note, we can also define the variety-concurrence graph of a Latin square. A typical variety concurrence graph for a (4 × 4) Latin square with the row number is given in figure 4 as an illustration.

Row 1	**E**	**F**	**G**	**H**
Row 2	**F**	**G**	**H**	**E**
Row 3	**G**	**H**	**E**	**F**
Row 4	**H**	**E**	**F**	**G**

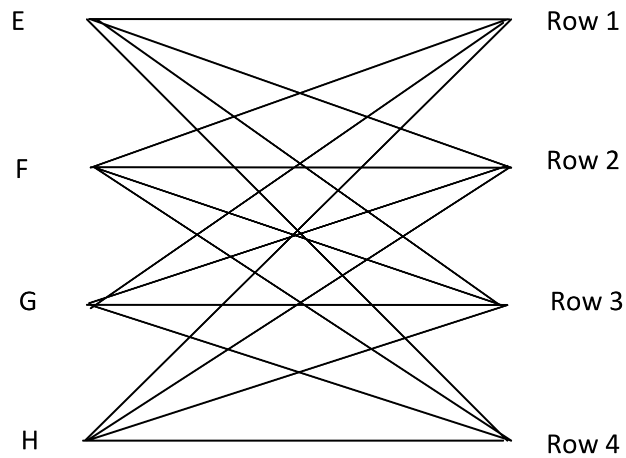

Figure 4: (4 × 4) Latin Square with 2-partite or bipartite variety-concurrence graph

The bipartite variety-concurrence graph shows a 1 to 1 concurrence for each of the letters against their row numbers. This concurrence produces the unique predefined arrangement necessary for the fabric outlook.

2.4 Motifs

Motifs are decorative designs or patterns which are replicated to form a fabric outlook. These motifs could also be said to be the symbols or letters that are used to form a Trojan Semi-Latin square as seen in figures 3 and 4. In this paper, motifs are regarded as images or photos or colorful patterns which are available for the designer to choose. A typical example of a motif is shown in figure 5.

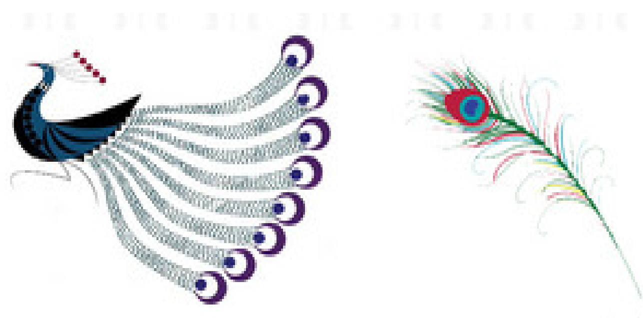

Figure 5: Two sets of Motif symbols

The framework provides an upload for more motifs/symbols. The designer could choose a motif from the list of available motifs. If the designer requires any other special motif, such motif could be uploaded provided the motif is put on the appropriate stipulated programming format.

2.5 Architecture of the Outlook Design System

The Fabric outlook design system will be an online application available especially for designers in textile industries. The system will allow designers to create an account, create designs by selecting the Semi-Latin square size of choice, choose suitable motifs and view the generated design accordingly. The designer can also change a selected design. This is possible because the Semi-Latin square could be randomized according to rows or columns to produce a different design. The architecture of the fabric outlook design system is shown in figure 6.

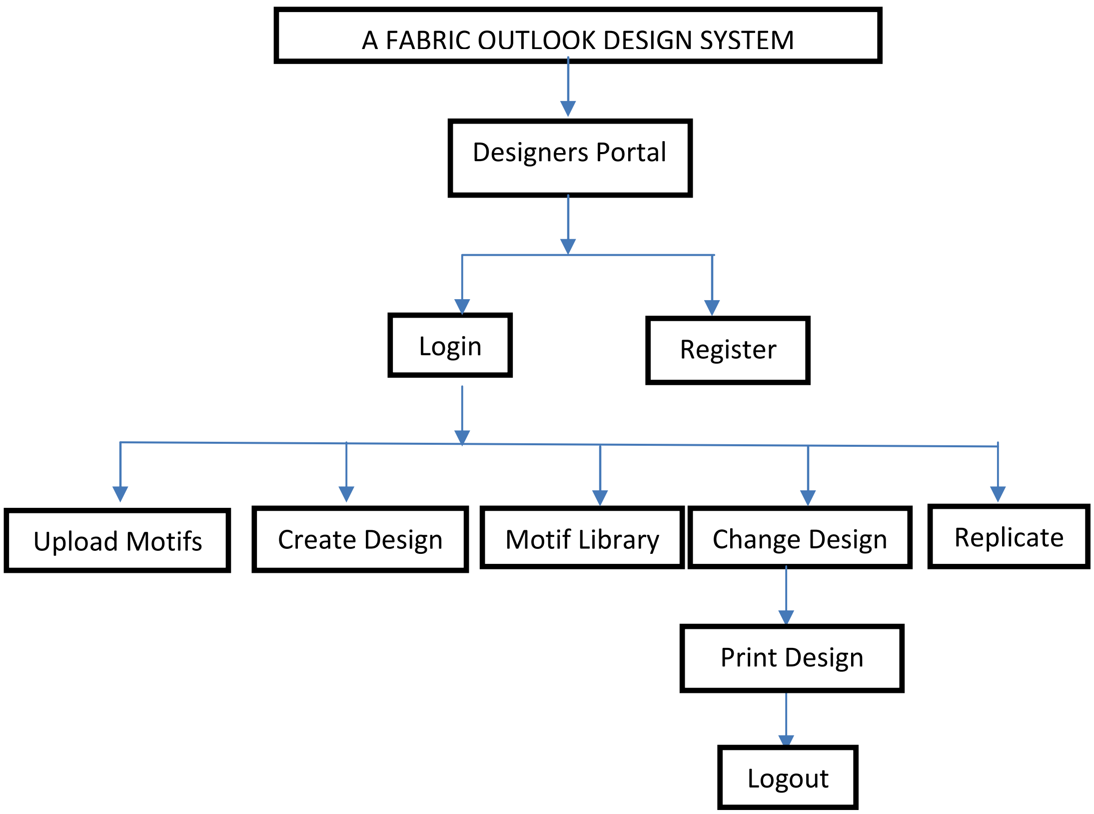

Figure 6: Architecture of the Fabric Outlook Design System

3. IMPLEMENTATION

We shall show an implementation using an example with a (4 × 4) Latin square of order n=4 as follows;
Step 1: We construct a (4 × 4) reduced Latin square with letters A, B, C, D using the algorithm in section 2.02 as follows:

A	B	C	D
B	C	D	A
C	D	A	B
D	A	B	C

Figure 7: A Reduced (4 × 4) Latin square

Step 2: The designer selects four different sets of motifs from a list of available motifs as follows:

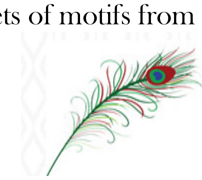

Figure 8: Motif 1 (A)

Figure 9: Motif 2 (B)

Figure 10: Motif 3 (C)

Figure 11: Motif 4 (D)

Step 3: The motifs are used to replace the letters in the Latin square as follows
A = Motif 1
B = Motif 2
C = Motif 3
D = Motif 4

Step 4: The outlook design is created as follows:

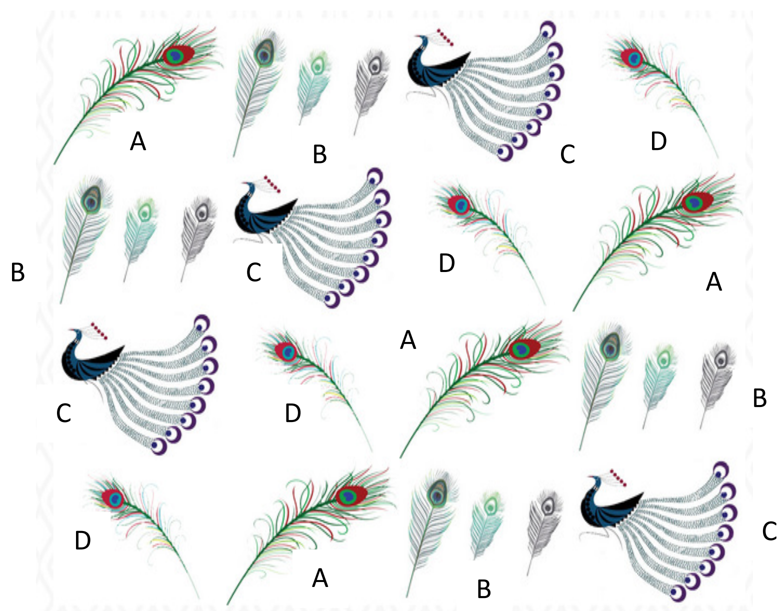

Figure 12: Outlook Design

4. RESULTS

An outlook design could be replicated to n-folds depending on the choice of the deigner. The outlook design constructed in section 3.0 could be replicated into a 4-fold square as shown in figure 13 as follows:

Fig 13: An Outlook Design

5. DISCUSSION

Figure 13 depicts a typical outlook deign which usually takes CAD and sophisticated applications to design. The framework also presents the designer the opportunity to randomize rows or columns to present different species of the same design. Randomizing the rows or columns does not change the design but imply alternates or exchanges rows/columns to produce specie of the same design.

6. CONCLUSION

The framework presents the theoretical backbone of developing an automated fabric outlook design system using the theory of Latin squares. The framework could be automated as an online application using any scripting programming language. If the framework is automated and made available for fabric designers especially in small scale textile industries, it will go a long way to reduce their overhead cost of production and consequently reduce the cost of garments.

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