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Generation of Irregular Satin and Sateen Weaves

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Abstract
Proposed here are some new methods for generating irregular satin and sateen weaves. Irregular satin weaves do not have a regular move number for all rows and columns for a given repeat size. As a result, the ways of creating irregular stain and sateen weaves are quite different and complex as compared to those of generating regular satin and sateen weaves. Usually, it is considered that that lower half of an irregularSatin and sateen weaves have regular move number in left to right or bottom to top direction while the upper half have regular move number in opposite direction. However, it is always true for all types of irregular satin weaves. Some of the irregular satin weaves have two different move numbers for lower and upper halves but others may not have any specific move numbers. Ingeneral, irregular satin or sateen weaves do not have specific move numbers, they are specified only with the repeat size as 4-end sateen, 6-end satin etc. On close study of patterns of existing irregular satin weaves, it is found that irregular satin weaves of specific size can be obtained by deleting certain rows and columns of larger size satin weaves. Based on these findings, we propose here some methods of automatic generation of irregular satin and sateen weaves. Using these methods, irregular satin or sateen weave patterns can be generated automatically in a much easier and faster way.Several new irregular satin weaves of different sizes are also introduced with new notations for easy identification and generation.

Keywords: *Circulant matrix, irregularSatin, irregular Sateen, regular satin, regular sateen, Weave patterns, Automatic Weave Pattern Generation.*

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I. INTRODUCTION

Satin weaves are one of the popular basic weaves used in textile design. Many other different interesting weave patterns are formed by combination of satin weaves. The important characteristic of a satin weave is that in a given or chosen repeat size, there is only one interlacement point in every warp or weft line. As there are fewer interlacement point in a given repeat size, the fabric becomes smooth and lustrous. Satin weaves are of two types depending on whether the floats along the warp lines are more or floats along the weft lines are more. Accordingly, they are called warp face satin and weft face satin or simply sateen. Satin and sateen weaves are the reverse of each other. They are generated or designed in the same way. Satin and sateen weaves can also be obtained by rearranging twill weaves in warp-wise and weft-wise direction and hence they are also respectively known as warp faced rearranged twill weave and weft faced rearranged twill weaves. In [5], some methods for automatic generation of twill weaves basic from left circulant matrices are given in which circulant matrices have only move number 1, circular shift of 1 position. Satin weaves are also classified into two types based on whether the interlacement points are regularly spaced based on a specific order or move number. Satin weaves with regularly spaced interlacement points are known as regular satin weaves or simply satin weaves. These weaves have a specific move number valid for given repeat size. There should not be a common factor between repeat size and its move number in regular satin weaves. More about satin weaves designs and characteristics can be found in [1,2,3,4]. Regular satin weaves can also be conveniently generated from circulant matrices. Some methods of generating regular satin weaves from circulant matrices are given in [6]. There are also some satin weaves in textile design in which the interlacement points are not regularly spaced but has the basic characteristic of a satin or sateen weaves and hence they are called irregular satin or satin weaves. Irregular satin weaves do not have a move number. As these weaves do not have a valid move number, they are specified by the repeat size as 4-end satin or 6-end satin. By 4-end satin, we mean the weave matrix of irregular satin having the size 4x4, and by 6-end we mean irregular satin weave matrix of size 6x6. There is no specific rule to generate irregular satin weaves of any given repeat size. But the most commonly accepted rule to generate irregular satin weaves is that irregular satin weaves have repeat size in even numbers such as 4, 6, 8 etc. and one half of repeat size has a specific move number in one direction and the other half has a move number in opposite direction [7]. If this istrue, there would be different irregular satin weaves for a given repeat size such as irregular satin weaves of repeat size 6 with lower half having move number 2, irregular satin weaves of repeat size 6 with left half having move number 2, irregular satin weaves of repeat size 6, with lower half having move number 3, etc. But only one specific irregular satin weave is known i.e., 6-end satin which is the irregular satin weaves of repeat size 6. In fact, it is found that we can have multiple irregular satin weaves for a given repeat size. We can get 4 different irregular satin weaves in repeat size 4, we can have 6 different irregular satin weaves in repeat size 6. Similarly, we can get many more irregular satin weaves of repeat size greater than 6.

In this paper, we will be discussing more details about the possible structures of irregular satin weaves and then find possible generalizable methods for generating irregular satin weaves. The paper is divided into five sections. In section II, we mainly analyze the structures of existing irregular satin weaves of repeat size 4 and 6. It is found that many different irregular satin weaves can be obtained from the regular satin weaves by deleting a particular row and a column. Section III describes the method of generation ofirregular satin weaves from regular satin weaves. In Section IV, different types of irregular satin weaves satin weaves of size 7 and 8 are given most of which are new irregular satin weaves.Some conclusions are given in Section V.

II. Structure of irregular Satin Weaves

Irregular satin weaves have the characteristics of a satin weave that each and every row or column should have only one interlacement point. However, irregular does not have any specific move number and hence there is no well-defined way of generating irregular satin weaves. The most widely accepted way of drawing irregular satin weave is based on the observation that “Half of the repeat size has a pattern and the remaining half has a different weave pattern”. In other words, irregular satin weaves have regular move number in one half in a particular direction and the other half with a move number in opposite direction. If that is so, irregular Satin weaves can have repeat sizes i.e., even repeat size and odd repeat size. For irregular satin weaves having even repeat sizes, the move numbers can be any even number from 2 to the given repeat sizes. In such irregular satin weaves, the weave structure follows a continuous regular pattern in a repeat size. However, in irregular satin weaves of odd repeat size, there is no uniform weave pattern.

Anirregular satin weave can also be specified by two parameters i.e., repeat size and move number in which the repeat size must be greater than its move number. There is a specific relation between the two which must be satisfied to create an irregular satin weave. The move number must be greater than 1 and less than repeat size. Also, there should be a common factor between the move number and the repeat size. That is, for anirregular satin weave of repeat size M, and move number N, it holds the following conditions.

$1< M <N-1$ and $GCD(M,N)>1$
Where GCD indicates the Greatest Common Divisor.

The minimum repeat size for an irregular satin weave having valid move number is 4. This is because, any repeat size less than 4 does not have a common factor to be a valid move number. In general, a prime number cannot be used as a repeat size of an irregular satin weave. For the minimum repeat size 4, the only valid move number is 2 which is the only factor the repeat size 4 can have. For repeat size 6, the valid move numbers are 2, 3, and 4 which can have a common factor with the repeat size 6. To understand better about the irregular satin weaves, let us analyze the structure of 4-end and 6-end satins and search about the possibilities of their new variants.

Irregular Satin weave of repeat size 4:

Figure-1(a) shows the satin weave of repeat size 5 with move number 2 and Figure-1(b) shows the corresponding graph. Figure-2(a) shows the weave matrix of irregular satin weave ofsize 4 and move number 2 applied horizontally. Figure-2(b) shows the corresponding graph of Figure-2(a). If we carefully observe, it could be seen that the weave matrix of Figure-2(a) is obtained by deleting the 1st row and 4th column. Figure 3(a) is the weave matrix obtained from Figure-1(a) by deleting the 2nd row and 2nd column. Figure-4(a) is a weave matrix obtained from Figure-1(a) by deleting 3rd row and the 5th column. Their corresponding graphs are shown in Figure-(b)s. It can be seen that because of deletion of a row and a column, the continuity of the interlacement points for associated with a move number is lost. However, in certain irregular satin weaves, the weave pattern can be divided into two parts – the lower half and the upper half in which the upper half can be obtained from lower half by flipping in the left-right and up-down directions. Such an irregular weave pattern can have move numbers for a given repeat size. However, there are also irregular satin weaves in which the two halves are not interrelated and hence quite random in nature. Such irregular satin weaves do not have a specific move number.It may be seen that there are different weave patterns of irregular satin weaves for repeat size 4. The same is true for irregular satin weaves any other specific size. To uniquely, identify them we need to introduce a new notation. As irregular satin weaves of repeat size-4 are obtained by deleting a specific row of a regular satin weave size 5 of valid move number, we denote them as (5,k)-r where k denotes the move number regular satin weave and -r denotes the row which is to be deleted to generate an irregular satin weave. Using this notation, we label the Figure-2(a) as (5,2)-1 indicating that it is obtained from regular satin weave (5,2) by deleting the row number 1, i.e., the first row. Similarly, other figures are also labeled accordingly. Figure-3(a) shows the weave matrix of popular irregular satin weave of size 4, and the corresponding graph is shown in Figure-3(b). This weave matrix is obtained by deleting the 4th row and 4th column of the regular (5,3) satin weave matrix.

1.	1.	1.	0.	1.
1.	0.	1.	1.	1.
1.	1.	1.	1.	0.
1.	1.	0.	1.	1.
0.	1.	1.	1.	1.

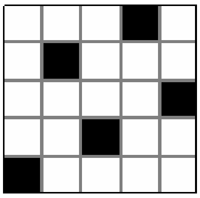


Figure-1(a): Weave matrix of Satin weave (5,2) Figure-1(b): Weave graph of Satin weave (5,2)

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

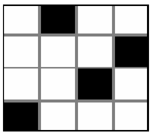


Figure-2(a): Weave matrix (5,2)-1. Figure-2(b): Weave graph of (5,2)-1

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

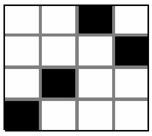


Figure-3(a): Weave matrix of (5,2)-2 Figure-3(b): Weave graph of (5,2)-2
Also obtained by deleting 4th row of regular (5,3) satin.

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

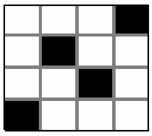


Figure-4(a): Weave matrix of (5,2)-3 Figure-4(b): Weave graph of (5,2)-3
Also obtained by deleting 1st row of (5,3) Satin.

Deleting the 2nd row and the 5th column of regular (5,3) satin, we get another type of irregular (4,3) satin.

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

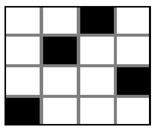


Figure-5(a): Weave matrix of (5,2)-4 Figure-5(b): Weave graph of (5,2)-4

Although, these three weave matrices of irregular satin of repeat-size 4 are different, they give similar weave patterns when repeated in vertical and horizontal directions during weaving with slight change in orientations. Also, we see that all the variants of the irregular satin weaves of repeat size-4 have two columns or rows in which the interlacement points are adjacent. If we analyze the regular satin weaves, we will find that there are no adjacent interlacement points in any two columns or rows. So, in strict sense, irregular satin weaves of repeat size 4 cannot be considered as a satin weave. If such adjacency of two interlacement points is allowed in satin weaves, then the following graph in Figure-6can also be considered as a irregular satin weave of repeat size-3.

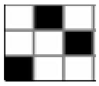


Figure-6: Irregular satin weave of repeat size 3 (3-end satin)

This irregular satin weave of repeat size 3 will be smallest possible irregular satin weave. This is the only possible structure of irregular satin weave of repeat size-3, which can be obtained by deleting the first column and last row of Figure-3(b), or by deleting the first column and last row of Figure 4(b).In the similar line, we can get irregular satin weaves of repeat size 5, by deleting a row and a column from irregular satin weaves of repeat size-6, if adjacency of two interlacement points is allowed. It is not possible to get irregular satin weaves of repeat size -5 without any two interlacement points as in irregular satin weaves of repeat size 3 and 4.

Irregular Satin weave of Repeat Size 6:

As in the case of irregular satin weave of repeat size 4, we can generate irregular satin weave of repeat size 6 from the regular satin weave of repeat size 7. Consider the weave matrix of regular satin weave of repeat size 7 and move number 2 shown in Figure-7(a). The corresponding weave graph is shown in Figure-7(b). If we delete the 1st row, the 6th column which has the interlacing point will be deleted as it will not have any interlacing point. As, 1 row and 1 column are deleted from a 7x7 matrix, the resulting matrix will be of size 6x6 as shown in Figure-8(a), which can be considered as irregular satin weave matrix of repeat size 6 because there is no regular move number in it. It may be noted that the interlacement points in rows 3 and 4 or columns 5 and 6 are adjacent while the interlacement points in other rows and columns are not adjacent. If we want to avoid adjacent interlacement points in the irregular satin weaves, we can do so by interchanging the 5th or 6th column with any of the remaining columns from 2 to 4. We should not consider column 1 for this interchanging process as it will change the interlacement point at the bottom which is considered as starting point of weaving. So, by interchanging column 2 and 6 of Figure-8(a), we get the matrix of irregular satin weave shown in Figure-8(c), in which no interlacement points are adjacent. The corresponding weave graph is shown in Figure-7(d). As this weave matrix or graph is obtained by deleting row-1 from regular satin weave (7,2) and interchanging columns 2 and 6, we add -1[2,6] after (7,2) in the labels of Figures 8(c) and 8(d). That is, we denote the interchanging of columns by enclosing them in a square bracket [ ]. Similarly, we can get another irregular satin weave of repeat size 6 from (7,2) by deleting 2nd row and interchanging columns 4 and 6 as shown in Figure-9(a) with its graph in Figure-9(b). It may be seen that this 6-end irregular satin weave has no adjacent interlacement points as a result there will be no two adjacent interlacement point by repeating it horizontally and vertically to create a fabric. However, in some cases, we get weave matrices shown in Figure -10(a) and Figure-11(a), just by deleting a particular row and its corresponding empty column where there is no two adjacent interlacement point which can be clearly seen from Figure-10(b) and Figure-11(b). The weave matrix of Figure-10 is obtained by deleting 4th row and 7th column of regular satin weave (7,2), denoted by (7,2)-4. Similarly, the weave matrix of Figure-11 is obtained by deleting the 1st row of (7,4). These two weaves will give adjacent interlacement points in their fabric because of the presence of interlacement points in the bottom left and top right corners. If we allow the presence of adjacent interlacement points, these two irregular satin weaves give nice fabric pattern with two adjacent interlacement points at regular intervals. As the main goal of fabric design is create a nice pattern in the fabric, these two can also be considered as semi-regular satin weaves in which lower half and upper half or left half and right half have a specific move number. It can be seen from Figure-10(b), the interlacement points in the left half have move number 2 starting from the bottom left corner and the right half also have the move number 2 starting from the top-right corner. In Figure-11(b), the lower half have and upper half have regular move number 2 when counted respectively from the bottom left and top right corners. If we are interested in generating irregular satin weaves with no adjacent points, then we need to interchange the last column with any appropriate column starting from the 3rd column onwards.We can several irregular satin weaves of repeat size 6 from four different regular satin weaves of repeat size 7 corresponding to the four different move numbers 2,3,4 and 5. From each regular satin weave of valid move number, we can get six irregular satin weaves. So, altogether we should be able to generate 24 different irregular satin weaves of repeat size 6. However, it is found that some of the generated irregular satinweaves are repeated. So, we get only 6 irregular satin weaves in which no two interlacement points are adjacent. Table-1 shows the irregular satin weaves repeat size 6 (6 -end satin) that can be obtained from regular satin weaves of repeat size 7 with different valid move numbers.

$$\begin{matrix}1 & 1 & 1 & 1 & 1 & 0 & 1\\ 1 & 1 & 1 & 0 & 1 & 1 & 1\\ 1 & 0 & 1 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 1 & 1 & 0\\ 1 & 1 & 1 & 1 & 0 & 1 & 1\\ 1 & 1 & 0 & 1 & 1 & 1 & 1\\ 0 & 1 & 1 & 1 & 1 & 1 & 1\end{matrix}$$

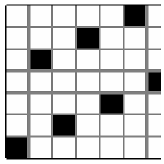


Figure-7(a): Weave matrix of satin (7,2) Figure-7(b): Weave graph of satin (7,2)

$$\begin{matrix}1 & 1 & 1 & 0 & 1 & 1\\ 1 & 0 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 1 & 0\\ 1 & 1 & 1 & 1 & 0 & 1\\ 1 & 1 & 0 & 1 & 1 & 1\\ 0 & 1 & 1 & 1 & 1 & 1\end{matrix}$$

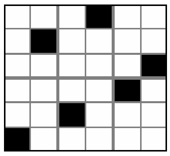


Figure-8(a): Weave matrix (7,2)-1Figure-8(b): Weave Graph of (7,2)-1

$$\begin{matrix}1 & 1 & 1 & 0 & 1 & 1\\ 1 & 1 & 1 & 1 & 1 & 0\\ 1 & 0 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 0 & 1\\ 1 & 1 & 0 & 1 & 1 & 1\\ 0 & 1 & 1 & 1 & 1 & 1\end{matrix}$$

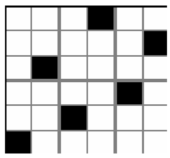


Figure-8(c): Weave matrix of (7,2)-1[2,6] Figure-8(d): Weave graph of (7,2)-1[2,6]

$$\begin{matrix}1 & 1 & 1 & 1 & 0 & 1\\ 1 & 0 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 0 & 1 & 1\\ 1 & 1 & 1 & 1 & 1 & 0\\ 1 & 1 & 01 & 1 & 1 & \\ 0 & 1 & 1 & 1 & 1 & 1\end{matrix}$$

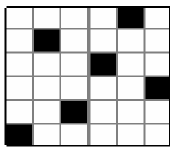


Figure-9(a): Weave matrix of (7,2)-2[4,6] Figure-9(b): Weave graph of (7,2)-2[4,6]

$$\begin{matrix}1 & 1 & 1 & 1 & 1 & 0\\ 1 & 1 & 0 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 0 & 1\\ 1 & 0 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 0 & 1 & 1\\ 0 & 1 & 1 & 1 & 1 & 1\end{matrix}$$

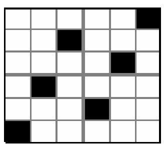


Figure-10(a): Weave matrix of (7,2)-4 Figure-10(b): Weave matrix of (7,2)-4

$$\begin{matrix} 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 & 1 & 1 \end{matrix}$$

Figure- 11(a):Weave matrix of (7,4) -1

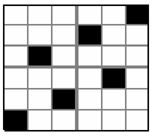
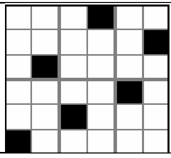
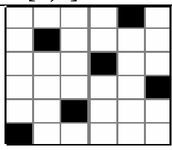
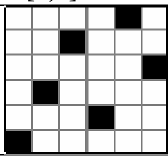
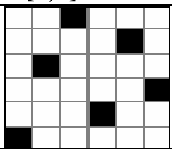
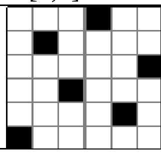
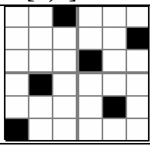


Figure-11(b): Weave graph of (7,4)-1

Table-1: Irregular Satin weaves of repeat size 6 generated from regular satin weaves of repeat size 7.

Type	Irregular 6-end satin weaves with no adjacent interlacement points.					
(7,2)	-1[2,6]	-2[4,6]	-3[2,4]	-4[4,6]	-5[2,4]	-6[2,6]
				Same as -1[2,6]	Same as -2[4,6]	Same as -3[2,4]
(7,3)	-1[2,4]	-2[3,4]	-3[3,4]	-4[4,5]	-5[2,3]	-6[2,3]
		Same as -1[2,4]	Same as (7,2)-2[4,6]	Same as (7,2)-2[4,6]	Same as (7,2)-3[2,4]	
(7,4)	-1[5,6]	-2[2,3]	-3[4,5]	-4[3,4]	-5[5,6]	-6[2,3]
	Same as (7,2)-3[2,4]	Same as (7,3)-6[5,6]		Same as -3[4,5]	Same as (7,3)-1[2,4]	Same as (7,2)-1[2,6]
(7,5)	-1[3,5]	-2[2,4]	-3[4,6]	-4[2,4]	-5[4,6]	-6[2,6]
	Same as (7,2)-1[2,6]	Same as (7,4)-3[4,5]	Same as (7,3)-1[2,4]	Same as (7,3)-6[2,3]	Same as (7,4)-3[4,5]	Same as (7,3)-1[2,4]

From Table-1, we see that we can get only three irregular satin weaves of repeat size 6 from regular satin weave of repeat size 7 and move number 2 i.e., (7,2) by deleting any particular row and interchanging two columns to avoid adjacent interlacement point. From regular satin weave (7,3), we can get only two new and different irregular satin weaves of repeat size 6. From regular satin weave (7,4), we can get only one new irregular satin weave of repeat size 6. From (7,5) regular satin weaves, we cannot get any new irregular satin weaves because all irregular satin weaves generated from it are just the repetitions of irregular satin weaves. So altogether, we get only six different irregular satin weaves of repeat size 6 without any adjacent interlace points from the regular satin weaves of repeat size 6.

III. IRREGULAR SATIN AND SATEEN WEAVE GENERATION

Irregular satin weaves do not have a specific move number and hence there is no generalized rule for creating of irregular satin or sateen weaves of any desired repeat size. But it is assumed that an irregular satin or sateen weave must have the similar characteristic like it should only one interlacement point in each row or a column and at the same time the interlacement points should be distributed two or more wraps or wefts apart. On searching on irregular satin weaves, it is found mainly two irregular satin weaves could be found. One is the 4-end irregular satin weave and the other is the 6-end irregular satin weave. Larger repeat size irregular satin weaves are mentioned in [] but they are not very popular. It is assumed that only one particular irregular satin weave is possible for a given repeat size and mainly only even repeat sizes were considered for irregular satin weaves. However, it is found that there are 4 possible irregular satin weaves in repeat size 4 (i.e., 4-end satins), 6 or more possible irregular satin weaves in repeat size 6 (i.e., 6-end satin). Moreover, we can have irregular satin weaves having odd number repeat size, such as 7, 9, etc. This is quite possible, if we generate the irregular satin weaves by deleting one row and one column from a regular satin weave. For example, if we delete one row and one column from regular satin weaves repeat size 8, we will get irregular satin weaves of repeat size 7. It is found that the most generalized way of generating irregular satin weaves is by deleting a row and a column from regular satin weaves. It can generate many different irregular satin weaves of a given repeat size, which may not necessarily be even. We are interested to generate irregular satin weaves in which there is no adjacent interlacement points as in a regular satin weave. To achieve this, we need to first find the columns in the irregular satin weaves obtained by deleting a row and a column and then exchange one of the columns with one of the remaining columns so that resulting irregular satin weaves do not have any adjacent interlacement points. To detect which two interlacement points are adjacent, we represent the weave matrix generated after deletion in the form of an array or vector. Consider the weave matrix in Figure-7(c) as shown below which is formed by deleting first row and fifth column as shown below. As each row has only one interlacement point, we can easily represent the matrix in an array. Once we represent the weave matric in an array, we can easily find the adjacent interlacement points by finding the successive difference of the elements (i.e, the interlacement points) in the array. Any two adjacent points have successive difference of -1 or 1. So, by simply finding where there is -1 or 1 in the successive difference between elements, we can easily locate the columns or rows having adjacent interlacement points.

Consider the following weave matrix obtained from regular satin weave (7,2) by deleting the first row and fifth column. First row has interlacement point at 4th position (i.e.,column 4), second row has interlacement point at column 2, third row has interlacement point in column 6, fourth row has interlacement point at column 5, fifth row has interlacement point in column 3, sixth row has interlacement point at column 1.

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

If we represent the column numbers of interlacement points in an array by putting the first interlacement point as the first element, second interlacement point as second element and so on, we get the array representing the weave matrix as shown below.

[4, 2, 6, 5, 3, 1]

By taking the successive difference, we get

[4, -2, 4, -1, -2, -2]

We see that there is -1 in the difference array at position 4, which means that the 4th row and its previous row i.e., 3rd row in the weave matrix have adjacent interlacement points and the corresponding elements in the array, i.e., 6th and 5th columns are adjacent. Once we know the rows or the columns having adjacent interlacement points, we need to exchange either of these rows or columns with any of the remaining rows or columns to avoid adjacency of interlacement points. This can be done either row-wise or column-wise. In this paper, we perform column-wise interchange to avoid adjacent interlacement points in an irregular satin weave.

Before performing exchange of columns, we need to know some more facts regarding adjacency of columns in a weave matrix or graph. Consider the graph shown in Figure-12 in which there are four interlacement points shown by the cells filled in black. For a satin weave, usually the interlacement point at the bottom left corner (A) is fixed indicating the starting point of the weave. The other remaining interlacement points, namely the second cell in the top row (B), last cell in the top row (C), and the interlacement point in the last cell just above the bottom (D), are considered to be adjacent to the interlacement point at the bottom. Because these three interlacement points becomes adjacent to interlacement point at the bottom left, when the weave is repeated in horizonal and vertical directions. So, when an interlacement point is present in any of these three locations, it must be interchanged with the appropriate columns so that no two interlacement points are adjacent in the fabric formed repeating the irregular satin weave.

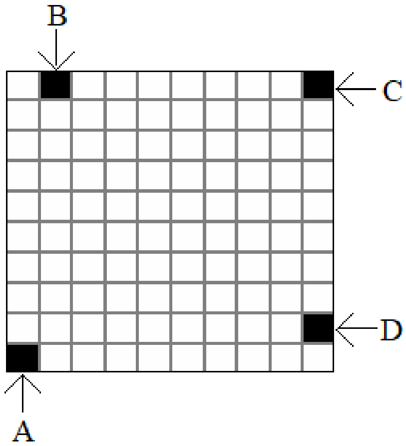


Figure-12: Interlacement points which become adjacent on repetition.

Algorithm to generate irregular satin weaves with no adjacent interlacement points:

It takes a regular satin weaves of specific repeat size and a valid move number and a row number which specifies which row number is to be deleted. Then, it generates an irregular satin weave of repeat size lesser by 1. Suppose, n is the valid repeat size of a regular satin weave, k is a valid move number and r is the row number to be deleted from the specified regular satin weave.

Steps:
1. Get x, the regular satin weave (n,k)
2. Delete the rth row number from x.
3. Find the column in x which has no interlacement point
4. Delete the empty column from x
5. Check if there is any two interlacement points
6. If so, start exchanging any one of the columns with second column onwards
7. Go to step-5
8. Else
9. Return x as the irregular satin weave.
10. End

Using this algorithm, we can generate various possible irregular satin weaves from a regular or irregular satin weave. It may be noted that the input of the algorithm is a weave matrix, which may not necessarily be a weave matrix of a regular satin weave. As usually, we can generate regular satin weaves easily, we take regular satin weave as input. If an irregular satin weave is taken as input, the output may be regular or irregular.

IV. EXPERIMENTAL RESULTS

It is known that irregular satin weaves do not have a valid move number and hence they cannot be generated in the same way we use to generate regular satin weaves. Some of the irregular weaves, especially of even repeat sizes, have regular move number half way in two different directions. In such weaves, one half have a valid move number in one direction, whereas the other half have the same move number in the opposite direction. But this is not true for all irregular weaves having even repeat size. It has also been found that the irregular satin weaves can have odd repeat sizes. The smallest irregular satin weave is the 3-end satin not the 4-end satin. We can also have irregular satin of repeat size 5. These irregular satin weaves (i.e. irregular satin weaves of repat size 3, 4 and 5), will have a pair ofadjacent interlacement points. We cannot get an irregular satin weave without having adjacent interlacement points for repeat size less than 6. Various possible ways of generating irregular satin weaves of repeat size 6 have been given in Table-1. Interestingly, out of 24 ways of generating irregular satin weaves of repeat size 6, only six of them are unique.

Table-2 shows the weave graphs of irregular satin weaves ofrepeat sizes 7 generated from the regular satin weaves of repeat size 8. First row of the table shows the weave graphs of irregular satin weaves generated from the (8,3) regular satin weaves by deleting row -1, row-2, row-3, up to row-7 of the weave matrix of (8,3). The second row of the table shows the irregular satin weaves generated from weave matrix of regular satin weave (8,5). The weaves in this table do not have any adjacent interlacement points and hence no interchange of columns is required. This is true when irregular satin weaves of odd size are generated from regular satin weaves of even repeat size.But for generating irregular satin weaves of even repeat size from the regular satin weaves of odd repeat size, there occurs adjacent interlacement in the resulted irregular satin weaves and hence there is requirement of column or row exchanges to break the adjacency of interlacement points. So, the algorithm given for irregular satin weaves from the regular satin weaves can be modified so that when the regular satin weave of even repeat size is given as input, it can generate the irregular satin weaves by simply deleting a row and a column. This will make the algorithm work faster in generating irregular satin weaves of odd repeat size as it will not require finding adjacent rows in the weave matrix and subsequent exchange of columns in appropriate positions.

Table-3 shows the weave graphs of irregular satin weaves of repeat size 8 generated fromregular circulant matrices of repeat size 9. As the irregular satin weaves to be generated is of even size, after deleting a row and a column, there will be a adjacency interlacement points, one of which need to be exchanged with any other appropriate interlacement point. There are four valid move numbers (2, 4, 5 and 7) for regular satin weaves of repeat size 9. For each valid number in repeat size 9, we can get 8 different irregular satin weaves. The first row shows the irregular satin weaves generated from regular satin weave of repeat size 9 and move number 2. After deleting row number and corresponding empty column, column 2 and 8 are exchanged to get the irregular satin weave in the first cell.

Table-2: Weave graphsfor irregular satin of repeat size 7 generated from valid satins (8,3) and (8,5)

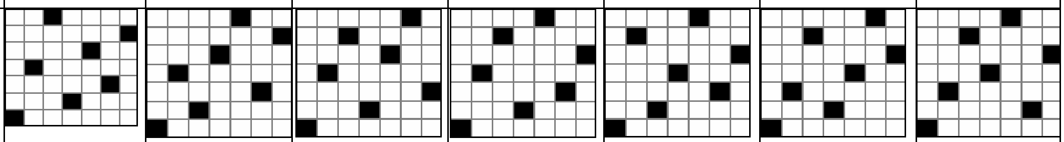
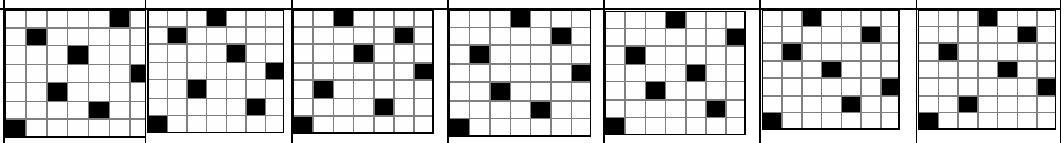
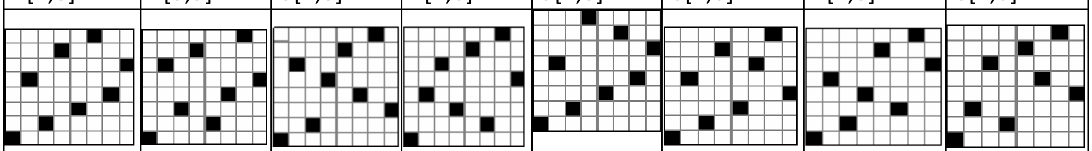
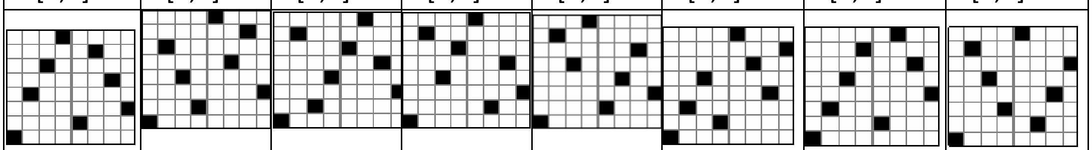
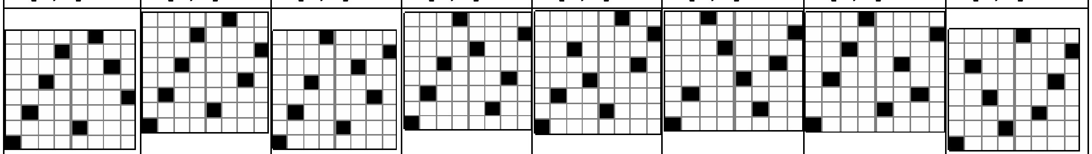
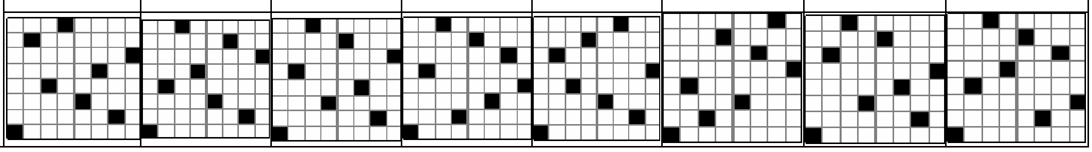
Type	(8,3)-1	(8,3)-2	(8,3)-3	(8,3)-4	(8,3)-5	(8,3)-6	(8,3)-7
(8,3)							
(8,5)							

Table-3: Weave graphs for irregular satin of repeat size 8 generated from satins(9,2),(9,4), (9,5) and (9,7)

	Irregular Satin Weaves of Repeat size 8 (8-end irregular satins)							
(9,2)	-1[2,8]	-2[3,5]	-3[4,8]	-4[2,6]	-5[4,8]	-6[4,6]	-7[4,8]	-8[2,6]
								
(9,4)	-1[2,4]	-2[6,7]	-3[3,5]	-4[4,6]	-5[4,6]	-6[2,8]	-7[2,4]	-8[6,8]
								
(9,5)	-1[6,8]	-2[2,6]	-3[6,7]	-4[4,5]	-5[4,6]	-6[3,5]	-7[6,7]	-8[2,4]
								
(9,7)	-1[2,6]	-2[2,4]	-3[4,6]	-4[4,8]	-5[2,6]	-6[3,7]	-7[2,6]	-8[4,8]
								

In the similar ways, we get the irregular weaves from different regular satin weaves of repeat size 9 at different move numbers. It could be seen it is not determinable which two columns need to exchange after deletion of a row or column of a weave matrix of repeat size 9 for different move numbers. However, once we know, which row is to be deleted and which columns are to be exchanged we can easily generate the corresponding weave matrix or graph of the irregular satin weaves. Also, it is found that for larger repeat sizes, there are two or more options of exchanging columns to generate irregular satin weaves without any adjacency of interlacement points. That is, for larger repeat sizes, the number of possible irregular satin weaves are more.

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V. CONCLUSION

In this paper, structures of commonly used irregular satin weaves of 4-end (repeat size 4) and 6-end (repeat size 6) have been studied. It has been found that there are many possible irregular satin weaves for given repeat size. There are four irregular satin weave structures of repeat size 4 and there are six possible irregular satin weave structures of repeat size 6. In true sense, the irregular satin weaves of repeat size 4 is not a satin weave as they have adjacent interlacement points. If adjacent interlacement points in a satin weave structure, we can have irregular satin weaves of repeat size 3 and 5 as well. In that sense, the smallest irregular satin weave will have repeat size 3 not 4. It has also been found that repeat size of irregular satin weaves can be even or odd unlike the popular notion that irregular satin weaves will have only even repeat size. Also, it is not necessarily true that half of the irregular have a specific move in one direction and the other half in the opposite direction. This is true only for a few irregular satin weaves of a given repeat size. It depends on in which way column or the row of a regular Satin weave have been deleted to generate the irregular satin weave and which columns are exchanged to avoid column adjacency. It is found that generation of irregular satin weaves of odd repeat size does not require exchange of columns and hence is simpler than generation of irregular satin weaves of even repeat size. Many new irregular satin weaves of any repeat size greater than 5 could be easily generated using the algorithm given. This will enable weavers to produce many new fabrics of using many new irregular satin weaves.

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