

High Performance Software Tool for Saree Weaving Using Electronic Jacquards

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Abstract— Adoption of Electronic jacquards to conventional Indian power looms & hand looms, becoming game changer for cost effective production and value creation for their output by adoption of new varieties of designs to suit the ever changing requirements of society. Here with we are proposing a software tool - set of algorithms / procedures useful for textile designers & master weavers for efficient & better adoption of electronic jacquards to Saree weaving. Adoption of Strides provided in C#.Net to implement algorithms resulted in processing of large size designs at phenomenal speeds.

Index Terms— Electronic Jacquard, Loom, Textile Design, Saree, Warp, Weft, Weaving, Stride.

I. INTRODUCTION

Woven textiles like sarees are very common in India, millions of weavers have their lively hood in the production of these materials and number of allied industries / professions like textile designers, card punchers, and master weavers, wholesale and retail outlets are dependent on this business.

A. Weaving Definition

Weaving is the process of interlacing two thread sets, the warp threads (longitudinal) and the filling threads (horizontal). The warp, which is the set of parallel threads running the length of the fabric, is drawn on to the loom during loom preparation. The filling threads are laid in to the cloth structure one row at a time during weaving. The variation of the interlacing sequence of each filling thread with the warp threads is caused by raising a subset of warp threads before inserting filling thread. A varied interlacing sequence for several rows results in a pattern.

B. Electronic jacquards

A ‘Jacquard loom’ is a mechanical loom that simplifies the process of manufacturing textiles complex patterns with punched cards. The computer-controlled loom are called electronic jacquard loom which significantly reduce the down time & the recurring cost associated with changing punched paper designs. Although the machines were initially small, modern technology has allowed Jacquard machine capacity to increase significantly, and single end warp control can extend to more than 10,000 warp ends. This avoids the need for repeats and symmetrical designs and allows almost infinite versatility.

Electronic Jacquard weaving of course uses all sorts of fibers and blends of fibers, and it is used in the production of fabrics for many end uses. The most widely known application of electronic jacquards is related to the woven industry products such as saree, blankets, covers, towels, plastic mats, table mats,

carpets, dress materials, suiting and shirting, labels, furnishing, upholstery, lacs etc.

C. Scope & Motivation

The past decade has brought a revolution in electronic jacquard weaving all over the world. Due to this revolution, the availability of appropriate software tools has become essential to fulfill the demands of textile manufacturers and loom users.

The most common electronic jacquard sizes adopted in different parts of India, range from 448 Hooks to 2688 Hooks. Going for higher hooks electronic jacquard, one can weave wider more detailed designs.

The proposed software tool is developed keeping in mind master weavers, textile designers & weavers engaged in weaving exclusive sarees using Power Looms & Hand Looms fitted with electronic jacquards, fig 1



Fig 1 Power Looms fitted with Electronic Jacquards

II. METHODOLOGY

D. Architecture

Software procedures are identified after thorough analysis of the inputs collected from the master weavers, designers and weavers, located in different parts of Indian states Karnataka, Tamilnadu & Andhrapradesh to simplify design creation & creating value additions in saree creation using electronic jacquard.

The Proposed software tool solves and provides set of algorithms / procedures to perform,

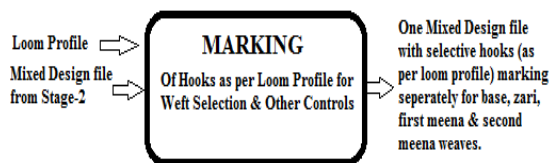
Stage 1 - Pre - processing like repeat setting, joining & border adjustments of design components used in the creation of rich & exclusive saree varieties.



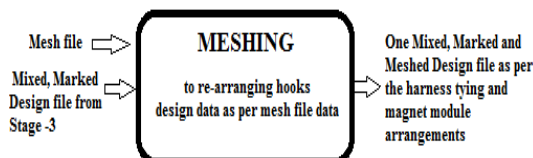
Stage 2 - Mixing /Interleaving /Ornamentation of multiple designs like zari & multiple meena on base/emboss/silk design, as per the loom & electronic jacquard weaving requirements, handling very large images at high speed using the concept called strides.



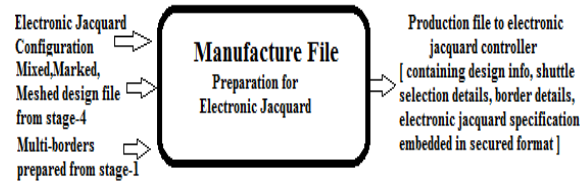
Stage 3 - Box cutting / hooks marking & creation of loom profiles to achieve optimization & creating error free designs.



Stage 4 - Meshing of designs to implement interleaving higher & lower load magnet modules & achieve better weaving performance.



Stage 5 - Proposed novel production file format for electronic jacquards built using master-slave architecture - "One Preprocessed design file" for the complete Saree with multiple borders, saves time & simplifies conventional loom operation.



E. Using "Strides" to Accelerate Speed of Processing

Each textile design is represented as a bitmap image which is a dot matrix data structure representing a rectangular grid of pixels. A bitmap is technically characterized by the width and height of the image in pixels and by the number of bits per pixel. A pixel is a physical point in an image, or the smallest, addressable element in a display device. The address of a pixel corresponds to its physical coordinates.

This tool is developed using Microsoft Visual Studio environment using .NET Framework & C#, a multi-paradigm object-oriented programming language. Traditionally image processing or image related operations are done pixel by pixel using methods like GetPixel(), SetPixel(), but this is a very time consuming process, particularly when large textile images are involved. To overcome this constraint we have developed algorithms which make use of the concept of strides supported in C#.net. A stride is a property where the entire width of a row in the image is held in bytes. This entire stride is copied into memory rather than copying a single pixel into the memory. This technique was proved to be much faster after conducting series of experimental research work. Before using the stride approach it is necessary to create the bitmap of the image and lock the bits of the bitmap externally. Locking ensures that the bits stay in the memory. After locking the bits, the first stride of the image is obtained using Scan0 attribute. This attribute returns the starting pixel of the image as a pointer, which is used for processing the pixel data.

III. IMPLEMENTATION

A. Making : Pre-processing of Design components

Final design of the fabric is prepared from multiple design components. Example, for a saree, refer fig.1, it is composed of Borders, Middle or ground or body with buttas, Pallu or frontispiece, inner end-piece, Blouse & others based on the variety; Designers create these design components and use themselves or provide to the master weavers for the final design preparation. These design components are to be used in proper arrangements, placed at right positions with certain adjustments to suit the required fabric & to the electronic jacquard fitted to the loom.

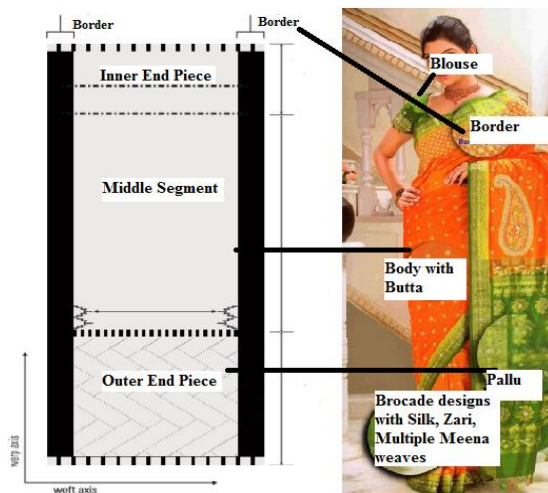


Fig 2 Saree- Arrangement

So pre-processing module has incorporated algorithms to support the following operations to create the final design,

- a) Repeat Setting
- b) Join Design Components
- c) Border Adjustments,

The main screen of this module is shown in fig .3. First Configure the fabric size by setting Hooks & Picks is done.



Fig 3 User Interface to Perform Pre-Processing

Repeat Setting

Using this software procedure, the selected design component can be repeated till the complete length or partial length of the fabric, or sometimes required to be repeated till the indicated pick position. In both cases, the repeat will be truncated once it reaches the fabric length.

Join Component

Once the repeat setting is done, it may be required to attach/join other design component at the specified hook & pick positions with several options.

- a) Join Type -Normal: - Places the new design component at the position selected, so the total hooks /picks are sum of the base design and the new design component.

- b) Join Type -No of repeats: - First repeats the new design component, indicated times (as entered in “number of repeats” textbox) and then join at the specified position.
- c) Join Type -RunToLength: - Working of this depends on the position selected. If the position is right, then the new design component is automatically replicated up to the width / hooks size of the base design. If the position is bottom, the new design component gets replicated height wise up to the height / picks size of the base design.

Border Adjustments

To extend the final design which is derived after done repeat setting and joining additional design components, to the required hooks & picks of the design & loom size, border adjustments are used.

Also, when electronic jacquard purchased, say is of size 1792 hooks, but in the loom we are using only 1536 hooks to derive the design on the saree, so we have to add extra blank design on both sides or one side of the design to make the total hook size of the design matches with that of electronic jacquard.

This software procedure adds or remove border of required size at the specified side of the design. While adding border it will add blank design at the specified position on the base design.

B. Mixing: Interleaving of Design Components

Exclusive saris have elaborate geometric, floral, or figurative ornaments or brocades created on the loom, as part of the fabric. Threads of different colors & materials (silk, cotton, gold & silver zari etc.) are woven into the base fabric in patterns, resulting in a raised effect or brocade; an ornamented border, an elaborate pallu, small repeated buttis over the body etc.

For producing extra weft figured fabrics, ideally the loom should be fitted with a multiple box mechanism such as a 2X1, 2X2, 4X1, 4X2 or a 4X4 depending on the weft color requirement. The power looms used for exclusive saree making generally fitted with this kind box mechanism for weft/shuttle selections, supporting up to four different weft/shuttle colors. In 2X1 & 4X1 looms, same shuttle weave two lines of design (left to right & right to left or alternately), where as in 2X2 & 4X4 looms, each shuttle weave alternately one line of design (left to right or right to left only).

“Mixing” is the term coined by the Author, to the design process involved to implement this ornamentation. Base/Ground, Zari, first Meena, second Meena are the terms used by the designers to refer 4 different shuttles/weft colors. So, correspondingly four pre-processed textile designs should be available.

Mixing refers to super imposing one to three additional designs (Zari, first Meena, second Meena) on the base design for weaving. Super imposing means, interleaving the weave lines of multiple designs to create one final design as shown in the fig < 4 >.

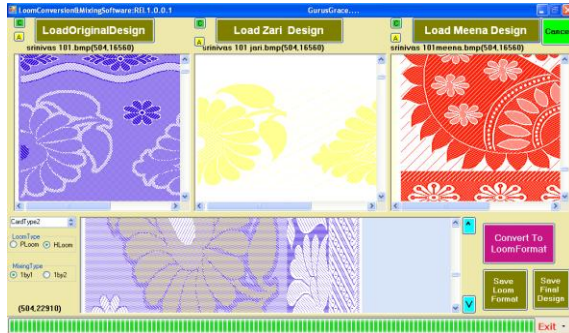


Fig 4 - User Interface to Perform Mixing

So based on the loom type, zari & meena designs should be mixed with the base/ground design. Generally a suitable ratio of ground to figuring threads is selected. The ratio may be 1:1, 1:2, 2:1 or 2:2 etc., depending on the solidity or prominence of the figure required.

It is very important that the weave lines of the Zari, first Meena, second Meena designs are weaved on the base design only when weave lines has design information. That means, if the complete weave line is blank (white color) indicating no design data, then it should not be weaved.

New algorithm proposed for mixing is described below.

Step 1: Read the Mixing type

Mixing type specifies the way of interleaving of threads is done. This interleaving is done using 1by1, 1by2 or 2by2 methods based on the design requirement and loom configurations. In case of 1by1, one weave from base design and one each from the zari & meena design is taken (only if the weave has design information) and same is continued till the complete length of the base design. Similarly in 2by2, two weaves from base & two weaves from the additional designs are taken for weaving only if design information is present. Generally, designers use 2by2 mixing for 2X1 & 4X1 Looms and 1by1 mixing for 2X2 & 4X4 Looms.

Step 2: Application of color to Additional Designs

Optionally, apply the color using the color Dialog provided to zari and/or meena designs individually; the color information is used to identify the weaves in the final design and do certain post processing.

Step 3: Perform Mixing of Base Design with Additional Designs

Algorithm for interleaving pre-processed design components, for 1by1 mixing type, c#.net & mechanism of strides used for implementation,

- i. Create the bitmaps, b1,b2,b3,b4 corresponding to base/ground design, zari design, first meena, second meena.

```
Bitmap b2 = new Bitmap(Zari filename);
```

- ii. Check for format and size, make sure all the design components are of same size & format.
- iii. Create the final bitmap, "finaldesign" to hold the mixed image whose,

- Height = number of picks of base design * N

N = 1, if no zari & meena designs are present

N = 2, if base & only zari design is present

N = 3, if base, zari, meena1 are present

N = 4, if base, zari, meena1, meena2 are present (this may not be the actual height and it will be known only after complete mixing, as we are mixing only where design is present)

- Width = number of hooks base design + 1

One extra hook is taken to store the information related to zari / first Meena / second Meena design, used to indicate the source of the weaves. This information is used by electronic jacquard controller to down the border hooks, for zari / meena designs.

- iv. To use the stride feature to process the images, Lock the bitmaps, so to map into memory and access the memory directly to speed up the mixing process. Ex.

```
//Lock the bitmaps, so to Map into memory and access the memory directly
BitmapData b1data = b1.LockBits(new Rectangle(0, 0, b1.Width, b1.Height), ImageLockMode.ReadOnly, b1.PixelFormat);
BitmapData b2data = b2.LockBits(new Rectangle(0, 0, b2.Width, b2.Height), ImageLockMode.ReadOnly, b2.PixelFormat);
```

- v. Create a Stride of the line 'i' corresponding to base, zari, first meena & second meena and stride of the line 'j' corresponding to the final design. Hence byte pointers are set to video memory at proper lines of image. Ex.

```
byte* oRow = (byte*)b1data.Scan0 + (i * b1data.Stride);
byte* oRow2 = (byte*)b2data.Scan0 + (i * b2data.Stride);
```

- vi. Copy a weave line 'i' from the base design to final design 'j' line, using the stride pointer. Update 'j'

```
for (k = 0; k < b1data.Stride; k++)
{
    nRow[k] = oRow[k];
}
```

- vii. Copy weaveline 'i' of zari design, if design information is present

- Using loop, check every hook of the selected weaveline, set the flag and break the loop if design is found in any hook, else continue.

```

flag = 0;
for (int ii = 0; ii < b2data.Stride - 1; ii++)
  if (oRow2[ii] != 255)
  {
    flag = 1;
    break;
  }
  
```

- If(flag == True), interleave line i, to the final design, and update line 'j' in the final design
- viii. Mark (change to block color) in the last hook position of the weaveline contributed by zari design.

```

if (b2.PixelFormat == PixelFormat.Format24bppRgb)
{
  nRow[b2.Width * 3] = 0;
  nRow[b2.Width * 3 + 1] = 0;
  nRow[b2.Width * 3 + 2] = 0;
}
  
```

- ix. Copy a weaveline 'i' of meena 1 design, if design information is present. (same logic as before).
- x. Copy a weaveline 'i' of meena 2 design, if design information is present. (same logic as before).
- xi. Increment the value of 'i', to select next weaveline in the base & zari design, meena1 & meena2. ('j' is incremented selectively, based on the design details in the additional designs)
- xii. Repeat steps v to xi, for all the weavelines of base design (complete size/pics of the base design).
- xiii. Unlock the image data, to release stride pointers
- xiv. Trim the final design to remove blank part, setting the new picks value as 'j'. So 'j' represents size (number of weavelines) of the final mixed design.

```

//trim the image
finalpic = finalpic.Clone(new Rectangle(0, 0, b1.Width, j),
  
```

- xv. Simulate the final design on the interface, with option to save the image in BMP or Production file format, refer fig < 5 > for sample output, with zoom



Fig 5 - Sample Mixed Design

It is observed, around 30,000 weavelines are required for the complete saree, and found large designs are mixed at phenomenal speeds using this tool, compared to the contemporary software's.

C. Marking: auto HOOK MARKING & Loom Profiles

After mixing, in the final design, there are certain areas where only base design weaves are present, certain areas where base & zari weaves are present, certain areas where base, zari & meena design weaves are interleaved. But the mechanical loom does not know anything about it, so it is required to be informed to the loom, to appropriately use single / multiple weft/shuttles dynamically as per the design. Example: If the design contains the weaves of both base/silk and zari, then loom to be instructed to start weaving using two shuttles silk & zari.

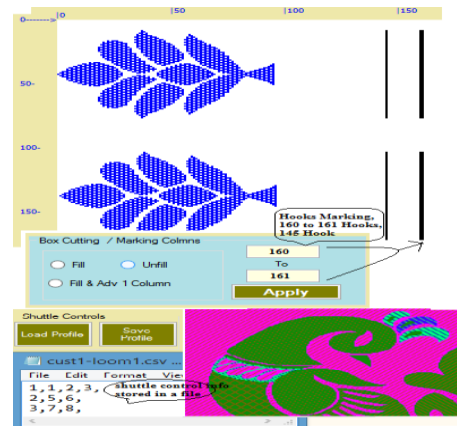


Fig 6 Marking of Hooks, loom profiles

A loom that automatically inserts the weft and can choose from several different wefts (shuttles) needs to be "told" which weft (shuttle) to select. This is most flexibly done by using some of the jacquard hooks as "weft selectors".

To achieve this, Box Cutting/Column/Hooks marking algorithm is proposed. Here specified range of hooks (also referred as ends) in the zari & multiple meena designs are marked. These marked hooks pass control information to the loom mechanism for activating the required wefts/shuttles. Make sure, hooks used for weft control cannot be used as design hooks.

Option is provided to mark the hooks with "advance 1 pick", here markings are shifted one pick earlier. This feature enables the electronic jacquard controller to activate the required shuttle mechanism one pick earlier. Marking is implemented as part of this research work using two methods, fig <6>.

- 1. **Manual Marking:** This option is used, if marking is done before carrying out the mixing of images. Here, option is provided to the user to

load the design and indicate the hooks to be marked, repeat the same for all the 4 designs

2. **Auto Marking:** Here, marking is performed after the mixing process, automatically for all the shuttles.

Algorithm for Hooks Marking:

- i. Read the hook numbers for marking & check they are within the limit of maximum hooks size of the design.
- ii. Apply different colors to the base, zari & meena designs, required to distinguish the weaves after mixing.
- iii. Repeat the following Steps for all the weavelines, ‘i’,

Step 1:

For Auto Marking (design is mixed),
Check weave line ‘i’, if it corresponds to zari / meena weave, then set the flag.

OR

For Manual Marking (no mixing)
Check the presence of design on weave line ‘i’, if design is found set the flag.

Step 2:

If (flag == True) Do the following Actions,
(from the range of hooks selected for marking.)
Repeat: j = start-hook-zari TO end-hook-zari ,
if (“advance 1 pick” is FALSE)
 Mark ‘j’ hook @ weaveline ‘i’
else
 Mark ‘j’ hook @ weaveline ‘i-1’
(repeat above steps for meena1 & meena2 hooks)

Loom Profile Management

There exists a difference in loom type, harness tying and control hooks used for shuttle control from loom to loom.

To ease the designing, facility called loom profile saving and loading is proposed as part of this research work. Using this, before proceeding to the mixing of the pre-processed design components, user can save the profile for a particular loom, which contains information about all the control hooks related to box cutting for base, zari & meena designs. So that designer / master weaver need not remember everything & repeat the same procedure, when new design is tried for the same Loom & harness tying. Profiles are stored in the CSV files (Comma Separated Values). Selection of proper file before mixing and hooks marking, saves lot of time & confusions.

D. Meshing: Tool for Interleaving & Mechanical Efficiency

The arrangement of magnet modules, mapping of pixels in design to hooks and their numbering in electronic jacquard is shown in the fig < 7 >.

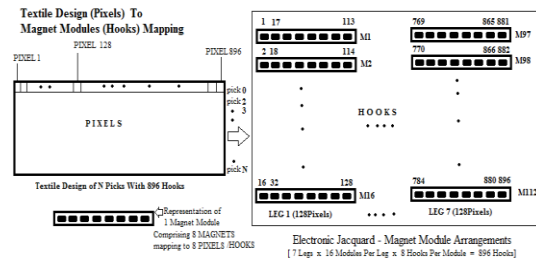


Fig 7 - Mapping Design Pixels to Hooks

This numbering is followed in the conventional jacquards and same is followed in electronic jacquards for easy upgradation & maintenance. Different types of magnet modules are available in the market like M5 M8 based on the load (warp lifting capacity expressed in grams), with higher capacity modules costing more. In saree weaving, there exist few hooks which offer more loads (hooks used for achhu/border control) which demands using of modules with higher capacity, very much required while manufacturing kadiyal type sarees. So, it is a good idea to use combination of higher & lower load modules for efficient working (as of now, they are using the same lower capacity modules for all the hooks in the existing electronic jacquards).

Generally designers reserve first & last 8 or 16 hooks of the design for border lifting / weaving. Let us take the case of 896 Hooks electronic jacquard and assume hook number 1 to 8 & 889 to 896 used for border weaving. Refer figure < 6 >, the hook numbers are not in series for a module, it means hooks 1 to 8 do not corresponds to module 1, rather 1,17,...113 corresponds to first module. So for 8 hooks of design, used for achhu/border control, actually we require to replace lower capacity 8 modules of TypeM5 with higher capacity modules of TypeM8. So totally 16 modules are to be replaced for 8 hooks on both sides and it will be 32 modules if we use 16 hooks on each side.

Also mechanically & for smooth operation (using same type of modules, say M5), it is better if we derive first 8 hooks of the design from the module appearing in the front, M16 & M112 as shown in the figure < 7 >.

Here is a novel method proposed & tool is provided as part of this research work, to use only two modules instead of 16 modules, by allocating the hooks 1 to 8 to module 16 & hooks 889 to 896 to module 112, both are located in the front, and the subsequent new hooks numbering is shown in the fig < 8 >.

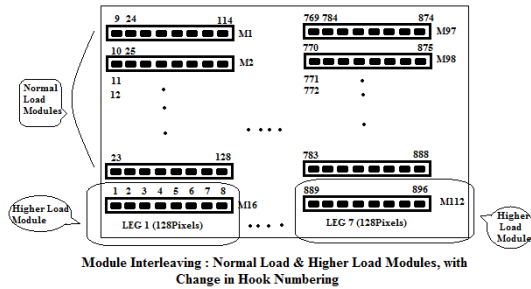


Fig 8 Interleaving of Modules

To implement this, textile designer has to do lot of design pre-processing, which is both tedious, time consuming, error-prone and it varies with design size & number of hooks required for border control. Hence software algorithm is developed to achieve the same result, which eases the designer job. Algorithm for Module Interleaving:

- i. Read the final mixed & marked design file.
- ii. Selecting the suitable mesh file (containing instructions for module interleaving) based on hooks tying and size, say the file “896 1m.txt” for design of 896 hooks with 8 hooks border control, “1536 2m.txt” for design of 1536 hooks size with 16 hooks border control.
- iii. Process the file: The two basic operations are required to implement the required logic, named as ‘S’ & ‘M’ commands. These commands with parameters p1,p2,p3,p4,m & n are explained below:

S p1, p2, p3, p4 : shifts the design (p4 - p3) pixels to the left (p2 - p1) pixels and inserts the shifted out pixels p1 to p2 at (p4 - p3) position.

M p1, p2, p3, p4, m, n : interleave the pixels p1 to p2 with p3 to p4, in the ratio of m to n; take first ‘m’ pixels from p1-p2, then take ‘n’ pixels from p3-p4, continued in the same ratio till the end for all the picks.

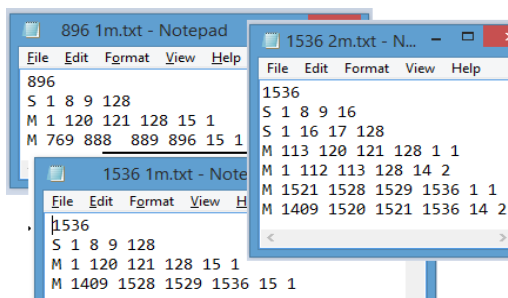


Fig 9 Sample Mesh files

- iv. Mesh file contains, set of these commands with different parameters based on the hooks size & number of hooks for border control, example: 896 m1.txt, refer figure < 9 >. After running the below software procedure, the M16 Module which represents, hook numbers 16,32,48,64,80,96,112,128 in the design now

represent hook numbers 1,2,3,4,5,6,7,8 and M112 module which represents hook numbers 784,..880,896 in the design now represent hook numbers 889,890...896.

```

896
(1st line indicates the size of the input design)
S 1 8 9 128
(Remove the pixels 1to8 & left shift 9 to 128; place the removed 1to8 at 121to128)
M 1 120 121 128 15 1
(Interleave/mesh 1to 120 with 121 to 128 in the ratio of 15 to 1)
M 769 888 889 896 15 1
(Interleave 769 to 888, with 889 to 896 in the ratio of 15 to 1.)
    
```

The commands S & M, and the mesh file handling, with necessary checking of parameter values are implemented as part of this algorithm development.

E. New Production file Format for electronic jacquards using Design Partition method

The final textile design file, after all the processing, mixing, marking & meshing operations, is required to be stored in a new file format understandable by electronic jacquard controller. An ideal production file for saree weaving using electronic jacquards, must accommodate the following data,

- Loom type or configuration Information: Hooks size, arrangement of Hooks (modules arrangement & numbering), configuration of EJCS (electronic jacquard control system).
- Design Information: Image processing cannot be performed at run time by the electronic jacquard controllers, because of its limited computing capability and high speed loom operation. So the pixel data related to the design has to be pre-arranged as per the requirement of electronic jacquard and stored in the final production file.
- Weave/Weft Information: Information about type of weave – base/ground or additional design, is to be stored for every pick. As described earlier, weft information is recorded while mixing in the extra hook.
- Border Details: Pixel data related to the Border design, Size of the Border - number of PICKs & range of HOOKs, provision to accommodate more number of borders in the same file (so that, at run time weaver can choose the required border).
- Security of Design - To provide security to the final design so that nobody can open that file in normal graphics editors and copy the design.

Hence, input to the electronic jacquard is not just the design data, but it is design data with additional data & control information. So it is very much essential to prepare the separate production file for the electronic

jacquard instead of just making it read image file like bmp or jpeg. As part of this research work, new file format (LMK) is proposed and successfully implemented.

IV. CONCLUSION

The proposed software tool developed using VisualStudio, for Windows based systems was delivered to over 100 textile designers & master weavers located in different saree weaving areas of Karnataka, Andhrapradesh & Tamilnadu of India. Necessary changes were made to make it simple & more suitable for the electronic jacquards of the make sai- electronic jacquards. Textile designers gave the feedback, that the new software tool simplifies the operation & reduces their design time. Master weavers found that, they can design themselves with basic design components supplied by the designer and try on their own lot of combinations and weave the sample, saving lot of time, and able to generate lot of value additions to their product. Weavers found, since the lot of pre-processing & information is already recorded in the production file format, it eases loom operation & increases the productivity.

V. ACKNOWLEDGMENT

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