*Applied Mechanics and Materials Vols. 278-280 (2013) pp 1737-1741* *Online: 2013-01-11*
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*doi:10.4028/www.scientific.net/AMM.278-280.1737*

# The Development of Carpet Sampling Machine

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**Keywords:** Carpet Sampling Machine; NC System; Motion Controller

**Abstract.** In order to meet the market demand for carpet sampling, designed a NC control system by analyzing the working principle of Axminster loom, the upper computer program could extract, analyze and process the pixel information from image and to communicate with the lower system instantaneity via Ethernet and send the information of the picture to the lower system. The lower system combines with the Servo control and motion control program, making each part of the system move precisely and coordinately. The system can make carpet sample more efficiently with high quality. The result showed that this control system has practical application value.

## Introduction

With the rapidly development of carpet industry, the quality demand of carpet is steadily on the increase. Markets have higher requirements for carpet quality, color, etc. Carpet designers have to make new design even faster. Carpet sampling is the first procedure before mass production. Traditional proofer was stakeout on the production line, that's need a lot of time and lower the production efficiency. It's a huge waste of both labor and yarns. So the traditional proofer can't match the demand of developing market. At present, there is little research on new carpet proofer. Australia Modra Company developed Mtuft tufted proofer which owns relatively mature technology. It can complete the sampling within one hour.

This paper design a NC carpet sampling machine for Axminster carpet. The machine with friendly interactive interface, can proofing production with complex patterns in less than 1 hour. This proofer greatly shorten the development time of new products, and largely save both design and production costs. The whole system uses a master-slave structure. The upper system was based on PC. On one side, operators can not only load but also design carpet pattern for sampling, on the other side, it can achieved real-time monitor while sampling. The lower system is a servo system which based on Galil motion control system. It can achieve closed-loop motion control of various subsystems. And produce beautiful carpet with variety patterns. This kind of proofer can fulfill the customization needs and highly improve the economic efficiency for enterprises. It is found that this kind of proffer have owns strong market value.

## Design Principle of Carpet Proofer

Axminster-type power loom is capable of weaving high quality carpets with many varying colors and patterns. It cut the yarn to a specified length and buries the yarn into thread layer with "U" or "J" shape, and then consolidates with weft yarn. Axminster loom usually have complex mechanical structure and control system, with long lead time and high cost. So it's uneconomical to sampling on Axminister loom. The proofer discussed in this paper simplifies the structure of traditional Axminister loom. The carpet sampling craft roadmap is shown in Figure1.

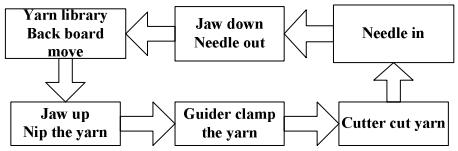


Fig1. Carpet sampling craft roadmap

According to the craft roadmap this paper developed a jacquard control system. The mechanical schematic diagram of jacquard system are shown in Figure 2. The system includes clamping mechanism, cutting mechanism and needling mechanism. And the yarn library is used to stockpile yarns. The proofer needling the yarn into the pore plate according to the pattern. It can break through the limit of patterns, colors. So it can produce the sample which is same as the pattern.

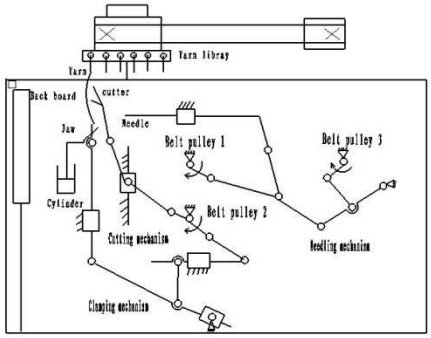


Fig.2 Jacquard system mechanical schematic diagram

**Control System.** By analyzing the color of the carpet pattern, and combine with the position of the color, this paper determines the motion control scheme of lower system; design a strict sequential control with the purpose of making the coordinated operation. In order to make the proofer run steadily and efficiently, this paper adopted Galil motion controller for motor control. At the same time sensing detection device realize closed loop control. The system can control the speed accurately and have high reliability.

**System hardware structure.** The whole system uses a master-slave structure. System hardware structure is shown in Figure 3. The upper system and lower system is communication by Ethernet. The main function of the host system is human-computer interaction, and jacquard preparation which includes pattern design and pattern data conversion. The main function of lower system is to realize real-time closed-loop servo motor control by Galil controller and make the proofer move accurate in accordance with the timing of the various parts. The system need to control 5-axis move independently and coordinately. Servo motor 1 and 2 is responsible for the X and Y direction's movement of back board. The Servo motor 3 is responsible for the movement of the cutter, guider, jaw, and needle. Each motor revolution completes a weaving cycle. By the design of mechanical structure, the system ensuring the precise operation of the components in the different phases of the motor revolution. And this also made it easier to adjust the timing only need to adjust mechanically. Such design highly improved the precision of sampling. Servo motor 4 is responsible for the depth of needling. Operator can adjust the needle depth only by changing the speed of the servo motor. Pneumatic system is responsible for the opening and closing of the jaw and keeps the working space clean meanwhile.

The main advantage of using this kind of structure is that the intelligent control completed in the underlying, so that can greatly reduce the communication between the upper and lower computer data, and to improve the performance of the control system.

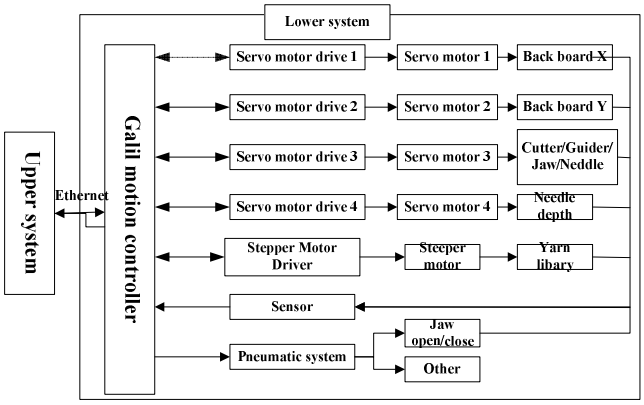


Fig3.Diagram of control system

**Software design of the control system.** The system software is composed of two parts. The host computer software is programming by VB6.0. Combine with API function, VB can achieve multi-threaded control. Specific system functions are shown in Figure 4. Lower computer software is to achieve closed-loop control of servo motor, realize coordination control of multi-motor and complete detection signal processing.

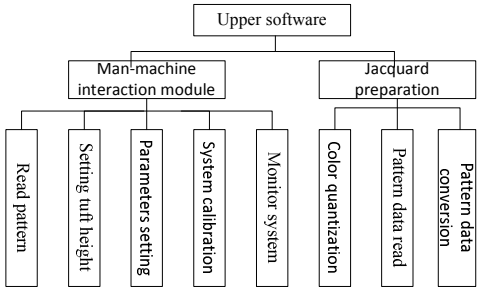


Fig4.Functional view of the host computer system

**The design of man-machine interaction module.** The main function of the host machine man-machine interaction module is to setting system parameters, and calibration of the system. The system parameters set by the API function variable assignment of lower machine storage parameters. The parameters setting mainly includes: determining the position of the respective colors of the yarn in the creel; choosing woven type; setting the type of back board and the number of holes; setting the woven speed etc.. The system correction module set the initial position of the moving parts. It includes correcting mounting position of back board; monitoring the operation situation of each motion parts and testing the sensor and detector apparatus.

**Host computer jacquard system design.** Jacquard preparation system includes the pattern preparation module, as well as the pattern data conversion module. Due to the small range of carpet sample, there have restrictions on the number of yarn colors. Different models proofer have different limit on the number of colors. The proofer design in this paper allows loading carpet pattern with a wealth of color. In accordance with the design of the creels, the machine can produce sample with 20 colors. So the pattern loaded need to have color quantization. In this paper, based on the cluster analysis algorithm to quantify. According to the human eye is sensitive to three colors of RGB, define two colors x, y's similarity definition of its vector difference weighted Euclidean norm distance D (x, y,).

$$D(x, y) = \sqrt{\omega r (Rx - Ry)^2 + \omega g (Gx - Gy)^2 + \omega b (Bx - By)^2} \quad (1)$$

Where weighting coefficients ωr, ωg, ωb is the relative impact factor. According to the literature reference, depending on the sensitivity of the human eye RGB three-color, take ωr =3, ωg = 4, ωb = 2.

Determine the number N for the initial cluster centers. Setting each pixel in the image as a vector, and linked list aligned according to the proportion of each color, and then be obtained pixel cluster center in accordance with the spacing of N. Finally, for each pixel in the color image, calculate the weighted Euclidean distance with each cluster center, and attributable the pixel to the minimum distance cluster. Modify the color of the cluster center according to the content of the image to until clustering center are no longer changes. Finally, split and merge clustering to gain new quantitative image. Compare with other methods, this method can have little color lost, and have smaller quantization distortion. Future more, the processing speed is far faster. When color quantized pattern data converted into pixel information; system will calculate the number of color types, and the number of pixels of each color. The system numbering each color, while setting the position of each of the corresponding color in yarn library.

**Pattern data conversion algorithm.**System downloads pattern data to Galil controller by function "DownloadArray". With the difference of pattern and back board, the system needs to process more than ten thousands of data. Due to Galil controller only have one-dimensional array, and the array space can only accommodate up to 8000 numbers. In order to ensure the computing speed and system operation fluency, massy data conversion and calculation work is completed in the host computer PC.

Since the location of the various colors of yarn in the creel is fixed, so the yarn selection process will be completed by motor revolve to a specified location. Taking the efficiency into account, the system adopts incrementally method to control the motor. That is, control the motor revolves by the difference value of two adjacent colors. In order to prevent the yarn wound together, rotation of the yarn library should not exceed 180 degrees. For example, shown in Figure 5.Suppose the consecutive three-pin is No. 1 No.20 and No.9.So the difference value would be 19 and -11. In accordance with the principle of maximum efficiency, from the 1st to the 20th, the creels would rotation counterclockwise for one unit, and rotation clockwise for 9 units from the color of the 20th to the 9th.

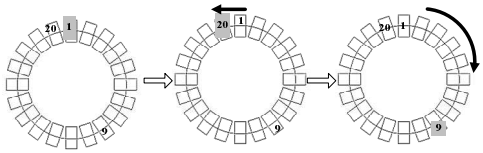


Fig.5 Example of yarn selection

During the waving, the needle is fixed, while the back board is need to motion in X and Y direction. Take efficiency into consideration, this paper design the back board motion in Raster path. Shown in Figure 6.

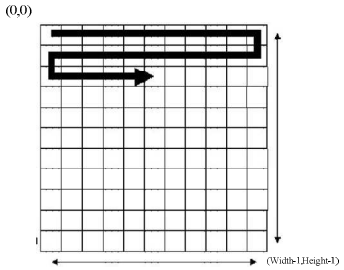


Fig6.Raster paths schematic

**Lower computer control system design.** Lower computer control software including commissioning and calibration procedures, and processing procedures. Commissioning and calibration procedures are to achieve independent movement of each motor. Which is used to testing and adjust the position of the various parts of the system before the formal processing. The software can realization the following actions: Jaw up and down, jaw open and close, cutter in and out, needle in and out. To ensure each components move in accurate pace, this paper analyzed the movement of each part and obtain a movement timing diagram shown in Figure 7.

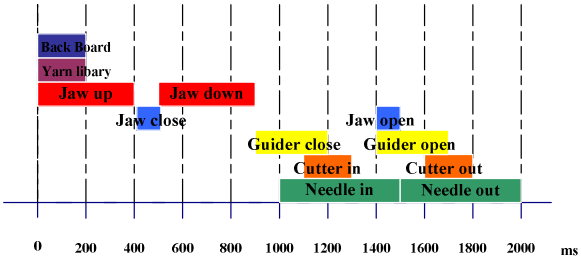


Fig7. Timing diagram of NC sampling machine

## Conclusion

Traditional Axminster carpet sample is proofing in the production line which requires a lot of preparation time, and delay the processing progress at the same time. The CNC carpet proofer designed in this paper overcome the limitations of the traditional Axminster carpet proofing. The system was constructed based on PC and motion controller, designed and developed of a set of control software. Realized pattern data processing and conversion and designed Raster motion path, to reached proofing efficiency maximization. The system is able to achieve high efficiency and high quality carpets proofing and saving a lot of manpower and resources, with a high market value.

## References

[1]Fenglei Zhou.. China Textile. 2005-3,154-156.
[2]Gang Li. Modra Technology：new tufted carpet sample machine . International Textile Leader. 2007,35(4).35-36.
[3]Bingwen Liu.Visual Basic Programming Tutorial. Beijing:Tsinghua University Press,2002.
[4]Shaokun Dun, Haiping Wei.Science Technology and Engineering. Vo1. 11 No. 8 Mar. 2011.1833-1836.
[5]Qingjun Yu, Baochu Yu, Zhenan Tang.Computer Science. Vol_38 NO. 2, 2011.264-266.
[6]Xiangyang Wang, Fengli Hu, Chunhui Liu. Journal of Liaoning Normal University (Natural Science Edit ion) . Vo l. 30 No . 3,Sep. 2007.310-314.
[7]Wenming Zhang, Dongsheng Chen, Xiaowei Huang. Manufacturing Automation. Vol.32, No.12, 2010-12.113-115.
[8]Yue Zhao, huiliang Dai. Journal of Zhejiang University Science. 2006, 7(3).

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10.4028/www.scientific.net/AMM.278-280

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