IMAGE PROCESSING AS A TOOL TO DEVELOP HIGH QUALITY COTTON FABRICS TO GET BIGGER PROFITS

M. Lauber and B. Wulfhorst
Institute of Textile Technology (ITA)
University of Technologie (RWTH)
Aachen, Germany

Abstract

The assessment of Cotton fabrics is not only based on the description of the feel of the fabric and its elasticity, it is also based to a large extent on the subjective characterisation of the visual appearance of the fabric. Digital image processing can be used for carrying out an objective evaluation of specific features or alterations to features.

Particular significance is attached to the connection between the yarn structure and the visual appearance of the fabric. Two aspects are particularly significant: Digital image processing can be used for ascertaining the specific structural differences between fabrics made from different Cotton fibres. This objective quantification of alterations in features represents the basis for further developing the structure of yarns with the final article in mind. Digital image processing can be used for displaying what effects or possible impact modifications in the fibres may have on the intimate blending of the individual components in the yarn. These studies may contribute towards highlighting difficulties in terms of different dyeing behaviour or in terms of other properties, which are dependent on the homogeneity of the intimate blending.

Aided by digital image processing, the analysis of the visual appearance of the fabric clearly proves that the appearance of the fabric can be changed and it can be designed with the desired article in mind by virtue of the choice of fibre fineness combinations. Digital image processing serves as a tool for describing this varying fabric appearance purposively and, thus, for objectively assisting in the development of the article.

Introduction

One of the problems encountered when monitoring processes in textiles applications is the large number of purely visual checks which are performed on the final appearance of the fabric, whether it be during production, in the laboratory or during fabric inspections. In areas where the final appearance of the fabric is categorised into quality classes by carrying out visual inspections, this process of subjective classification proves to be inconsistent time and time again if none of the available staff are adequately trained in this technique. Tests of this type which are not carried out particularly frequently are statistically unreliable. Consequently, the development entails staff being backed up by testing techniques which are appropriately more objective, techniques which are based on image analysis systems.

Nowadays, the advancement in digital image processing allows us to switch the subjective visual analysis of the optical properties of fabrics over to computers to a certain degree, thereby rendering the technique objective. An image is captured using a CCD area camera or, in the case of moving objects, using a CCD line scanning camera. This image is then digitised and analysed in the computer. Generally speaking, a compromise now has to be found between the resolution and the size of the area being analysed.

A sub-area entails the analysis of how knitted fabrics have turned out; this analysis is not only performed in the knitting and in the hosiery mill, it is also undertaken in many spinning mills for quickly assessing the quality of the yarn. In most cases a knitted stocking is manufactured which is drawn onto a table, and then inspected visually. In many cases a comparative analysis of a number of different samples is sufficient.

Specific differences between the structures of different yarns may be highlighted using digital image processing. It can be used for objectively describing what effects or possible impact different fineness of Cotton fibres have on the appearance of woven or knitted fabrics. These studies may contribute towards highlighting difficulties in terms of properties, which depend on the fibrefineness of the intimate blending.

The following studies are based on the analysis of two different pieces of knitted fabric made of 100% cotton open end rotor yarn. The spinning conditions, the yarn count, the knitting and bleaching conditions in both samples are identical. They differ in terms of their fibre counts; on the one hand Mic. 3,6 on the other hand Mic. 4,6.

Analysing the visual appearance of knitwear

A transparent lighting unit was mounted onto a test stand for analysing knitwear. Shots were recorded of the knitwear using a black & white camera and were formed using a maximum of 255 grey-scale values of different levels of brightness (0 = black; 255 = white).

Suitable image processing techniques are used for isolating “clouds” which are darker and lighter than the “normal” average brightness value, and these “clouds” are then examined more closely. The grey-scale values are compared in order to “isolate” the clouds. Three

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relative classes are formed, encompassing a varying range of values. Generally speaking, during a measuring cycle the three classes have equal widths and are defined according to the lightest and the darkest, i.e. the largest and smallest grey-scale values respectively. Characteristic values can be derived from the size, alignment and brightness of the “clouds” and from their distribution across the surface. These characteristic values tell us more about the visual appearance of the fabric.

The following evaluations are based on the analysis of different sections of the two samples, each of which are 45x33 mm² (course direction x wale direction). 10 different photographs were taken of each of knitwear samples “Mic. 3,6" and “Mic. 4,6", and these were then evaluated statistically so as to enable us to draw a conclusion on the overall impression. Figure 1 illustrates one example of a black & white picture with the corresponding “cloud-isolation” for both samples.

Whilst the light/dark fields in sample “Mic. 3,6" are essentially course-oriented, they have a greater expansion in the direction of the wale than the corresponding fields in sample “Mic. 4,6". This causes a more disturbed appearance. In the course direction, these areas appear shorter than the same areas in sample “Mic. 4,6". The light and dark areas in sample “Mic. 4,6" are clearly more elongated. The alignment of the light/dark fields in both samples is highly course-oriented. The distance of two neighbouring light or dark areas in course-direction as well as in wale-direction is shorter than in sample “Mic. 3,6". Altogether the contrast between the light, the “normal” and the dark areas in Sample “Mic. 3,6" is much higher than in Sample “Mic. 4,6". Sample “Mic. 4,6" appears to be brighter and more homogeneous. It is apparent that significant differences may occur, depending on the fibrous material used.

Analysis of the grey-scale values

Figure 2 illustrates the percentage distribution of the light and dark fields in relation to the normal areas for both samples. As expected, an analysis of a number of different sections revealed that the distribution of light, dark and “normal” areas is almost identical for both samples. It is evident that there is no significant difference in the overall impression of the two different samples in terms of area distribution. Sample “Mic. 4,6" has somewhat fewer light and dark areas that means a larger number of “normal” areas, i.e. mid-grey areas. It is important to note here that the difference between light, dark and “normal” areas describes a relative difference within a section of knitted fabric. A comparison of the grey-scale values enables us to determine the general differences which exist between the overall brightness of sample “Mic. 4,6" and that of sample “Mic. 3,6".

It can be clearly seen that knitted fabric sample “Mic. 4,6" is altogether lighter than sample “Mic. 3,6" because the grey-scale values of the light, “normal” and dark areas are clearly higher.

In addition, the contrast between the light, “normal” and dark areas is also of particular interest for the purposes of the description of the visual appearance of the fabric. This is due to the fact that a high level of contrast impairs the visual appearance of the fabric to a much greater degree. Figure 3 illustrates the contrast between each of the different lightness areas as a standardised grey-scale value. The “normal” areas have a value of 1. It is clear that there is a greater contrast between the individual areas in knitted fabric “Mic. 3,6" than in knitted fabric “Mic. 4,6".

While the area-based distribution (Fig. 2) in both knitwear samples is nearly comparable, the lighter impression of knitwear sample “Mic. 4,6" is not only described by the lower number of dark areas, it is described above all by the altogether higher, i.e. brighter, grey-scale values and the lower contrast. In addition, this also reflects the more homogeneous appearance of sample “Mic. 4,6".

Analysis of the mean distance between two neighbouring “clouds”

Figure 4 illustrates the distance between two neighbouring or related “clouds” in wale- and in course-direction. The distance of two neighbouring light areas in course- and wale-direction of sample “Mic. 4,6" is shorter as well as the distance of two neighbouring dark areas in comparison to sample “Mic. 3,6". The mean distance between two neighbouring “clouds”, independent if it is a dark and a light or two dark or two light areas, marked out as average-total, in sample “Mic. 4,6" is shorter as well as between two light or two dark areas.

Relationship between the number and size of light and dark areas

The relationship between the number and size of light and dark areas is also important in comparison with the percentage distribution, the grey-scale values of the areas and the mean distance between two neighbouring “clouds”. While the overall surface area of dark areas in sample “Mic. 3,6" is virtually identical to sample “Mic. 4,6", the overall number of areas is lower, however (332,42/313,19 mm²; 55,7/60,6). Consequently, the dark areas in sample “Mic. 3,6" are, on average, 14,6% larger than those in sample “Mic. 4,6" (6,08/5,21). The total number of light areas in sample “Mic. 3,6" is lower than that in sample “Mic. 4,6" (53,9/71,4) but at the same time the total area of light areas is approx. 16,8% larger (676,5/579,41). Therefore, the average area size of light clouds in sample “Mic. 3,6" is approx. 65,7% greater than in the case of sample “Mic. 4,6" (13,47/8,13).

Furthermore, the number of light and dark areas is also of particular interest in terms of their size (Fig. 5). Each of the surface areas of the “clouds” are categorised in classes, i.e. the area details relate to an average surface area size. The average surface area of 1.5 mm² encompasses all of the areas between 1,0 mm² and 2.0 mm², for example. Sample “Mic. 4,6" clearly contains more smaller light areas and fewer mid-sized areas than sample “Mic. 3,6". The ratio of small dark areas to large dark areas for both samples is virtually identical. Sample “Mic. 4,6" has more small-sized and a lower number of mid-sized and great dark areas.

<u>Orientation of the dark and light areas</u>

Surface area and frequency distribution alone are not sufficient for describing the visual appearance of the fabrics. The orientation of the “clouds” serves as an important criterion in this regard. The orientation of the light and dark areas is described by means of characteristic values, which are derived from the quotient, which in turn is derived from the maximum length and width elongation (stitch wales/stitch course) of each “cloud”. These characteristic values are categorised into evaluation classes. Class 10 contains “clouds” with a marked orientation (i.e. elongated or narrow). Accordingly, the quotient lies between 0 and 0.1 (in class 9 it is between 0.1 and 0.2 etc.). Class 1 contains “clouds” which are virtually equidistant in terms of their length and width, such as circles or squares.

The relationship between the number of objects in a class and the overall number of objects serves as an indicator of the frequency of the objects within this class. The distribution of object frequency on a class-by-class basis, in turn, provides information about the distribution of the “cloudiness” within the tested area. It is suitable for a comparative analysis of different samples of knitted fabric.

The object frequency is illustrated in Figure 6 in relation to the orientation of the dark and light areas, with one analysed sample photograph of each. The course orientation of the light and dark areas in both samples is marked. Compared to sample “Mic. 3,6", sample “Mic. 4,6" has virtually no wale-oriented light areas. Given the fact that sample “Mic. 4,6" is generally lighter than sample “Mic. 3,6", the very distinctive course orientation, i.e. its barriness, is not as visually apparent as it is in sample “Mic. 3,6". The dark areas in sample “Mic. 4,6" are also course-oriented for the most part. However, there are more light and dark areas detected in sample “Mic. 3,6", which are wale-oriented and which are virtually equidistant in terms of their lenght and width. Examined generally, there is a significant difference between the two samples when these characteristic values are analysed on their own.

The inter-related assessment of object frequency (Fig. 6) and distribution of surface area (Fig. 5) reveals that the light areas in sample “Mic. 3,6" are brought about by individual shorter light or thin pieces of yarn. While this sample contains more pieces of yarns of equal length, albeit larger pieces, they are both oriented in both the course and the wale direction. Shorter thin and thik pieces of yarns are more likely to be incorporated into successive stitch courses than longer pieces of yarn. As a result, the switchover between light, dark and “normal” areas takes place at shorter intervals. This random distribution causes greater agglomerations in both light and dark areas, in turn resulting in areas which are more wale-oriented than those in sample “Mic. 4,6". The large number of light mid-sized areas in sample “Mic. 3,6" would suggest that these areas are also wale-oriented. This greater agglomeration of light, larger areas is more striking than the many small light areas in sample “Mic. 4,6".

<u>Relationship between the course orientationof the light and dark areas</u>

Alongside defining class-related object frequency, it is also of interest to derive information on how the light and dark areas are oriented in relation to the whole knitted fabric. Therefore, we will now describe the relationship between the course orientation of the light and dark areas for both samples. A distinction is drawn here between area and number-based orientation (Fig. 7).

The relationship of the area-based course orientation means that the sum total of all of the individual areas, which are essentially course-oriented, is described in relation to the total area of all of the light and/or dark areas. This characteristic value serves to illustrate the direction in which the appearance of the ascertained feature changes is more striking. Accordingly, a 50% orientation would signify a uniform distribution. This could express itself, on the one hand, in the form of circles and squares, for example; on the other hand, this could also suggest that there are just as many elongated areas as high areas of the same size. Therefore, it is always important to analyse the object frequency, at the same time, in relation to each of the individual classes.

The course orientation is also defined at the same time in terms of numbers of areas, in the form of the sum total of the number of objects in the course direction, in relation to the total number of all of the light and dark areas. This characteristic value shows the direction in which more areas are oriented. Combined with information on orientation in terms of area, a conclusion can be drawn on the degree to which a certain feature is apparent in a given direction. If both characteristic values reflect a more marked percentage orientation in one particular direction, this orientation is intensified. Long, flat areas or high, narrow areas, which are virtually the same size, cause this. If there is a significant difference between orientation in terms of areas and the comparable value for numbers, the fabric will contain areas which differ in size but which are virtually identical in terms of their length and width extension. [Example: 2 elongated areas (1x5 mm² => course-oriented) and 2 areas which are the same length but which are higher (10x5 mm² => wale-oriented) => course-oriented: number-based: 50%, area-based: 9%; wale-oriented: number-based: 50%, area-based: 91%].

These characteristic values are illustrated in Figure 7 for light and dark areas. Both samples “Mic. 3,6" and “Mic. 4,6" have very course-oriented areas. The quality of the area-based features of the orientation can be compared with the quality of its number-based features.

The one-sided course orientation, which is based simultaneously on the general area and on the number of areas, indicates a marked degree of “barriness”. An analysis of the characteristic values for the light areas reveals in particular that these areas are also comparable in terms of their size.

The uniformity or the degree to which a feature change occurs in one given direction is described by the variation coefficient (Fig. 8). These characteristic values are derived from the 10 analyses performed on the various sections of sample fabric. It is apparent that sample “Mic. 4,6" contains areas which are not only more course-oriented, the variance in its orientation is also clearly lower than in the case of sample “Mic. 3,6". This serves as an indicator of what is optically a very accentuated degree of barriness. The degree of “cloudiness” in knitted fabric “Mic. 3,6" is more varied. This also causes the fabric to appear more disturbed.

Summary

The analysis of the visual appearance of the fabric, with the aid of digital image processing, clearly proves that the overall character of the knitted fabric made by a Cotton fibre with the fineness of Mic. 4,6 is more homogeneous. The appearance of the fabric can be changed and it can be designed with the desired article in mind by virtue of the choice of fibre fineness. Digital image processing serves as a tool for describing this varying fabric appearance objectively and, thus, for objectively assisting in the development of the article.

The analytical method presented here is also suitable for objectively analysing the appearance of woven fabrics. The evaluation algorithms are comparable with those explained. These types of studies play a role part in enabling us to analyse the influence of various fibrous materials and spinning conditions on the structure of the yarn, and thus on the visual appearance of the manufactured fabric to choose the optimal Cotton fibre to get bigger profits.

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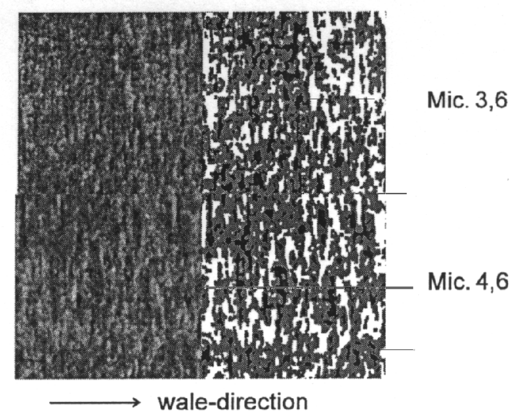

Figure 1. Percentage distribution of „cloudiness“ relative to the total test surface

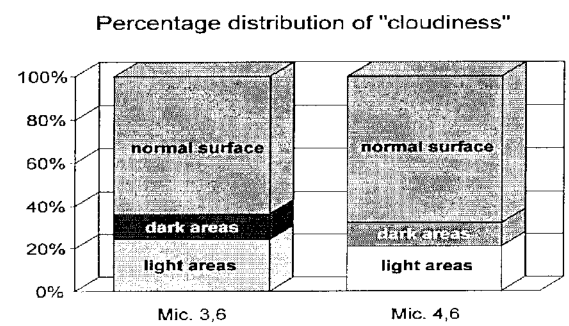

Figure 2. Percentage distribution of „cloudiness“ relative to the total test surface

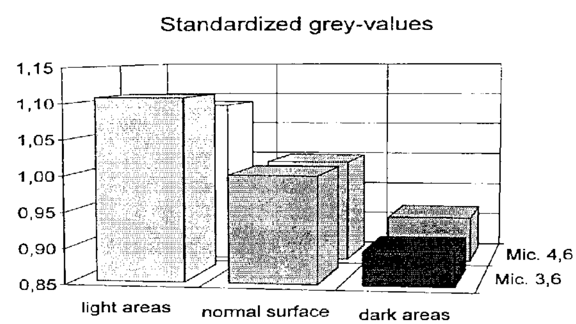

Figure 3. Comparison of the standardised grey-scale values

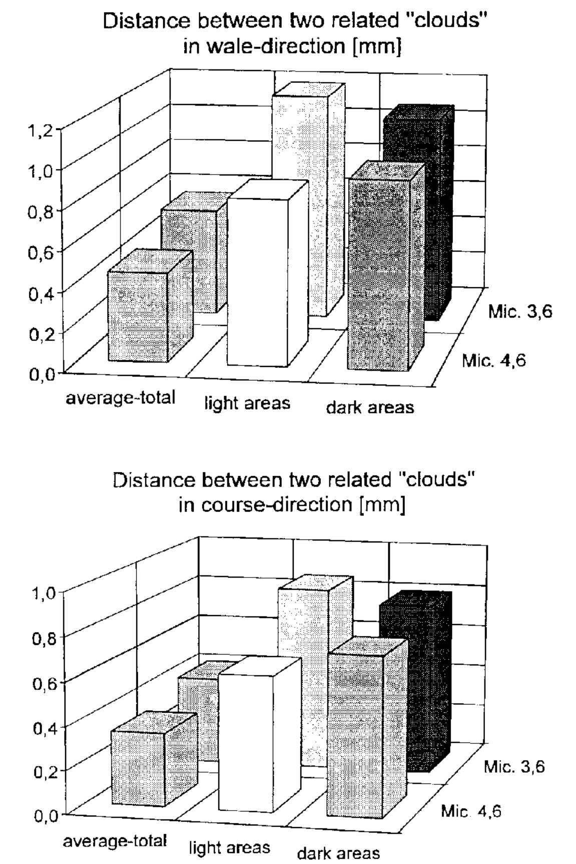

Figure 4. Comparison of the mean distance between two neighbouring light or dark areas

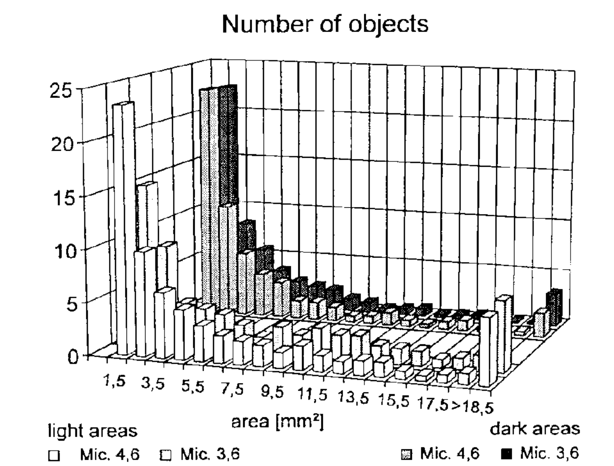

Figure 5. Relationship between the number and the size of light and dark areas

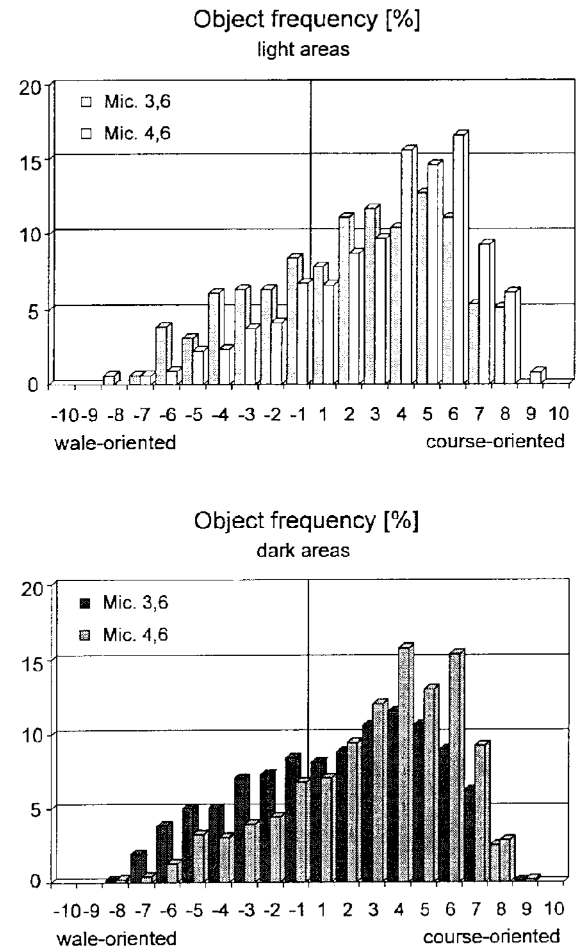

Figure 6. Orientation of „cloudiness" in knitted fabrics

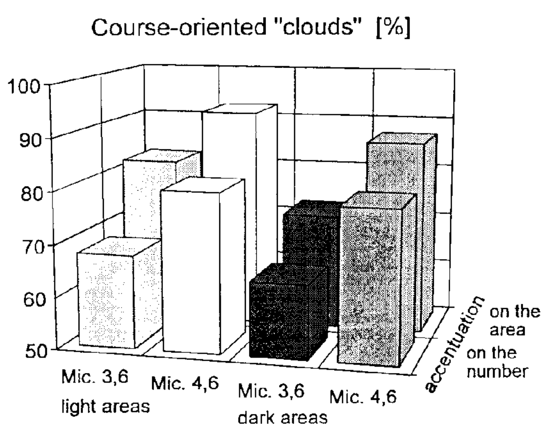

Figure 7. Relationship between the course-orientation of the „cloudiness" of light and dark areas

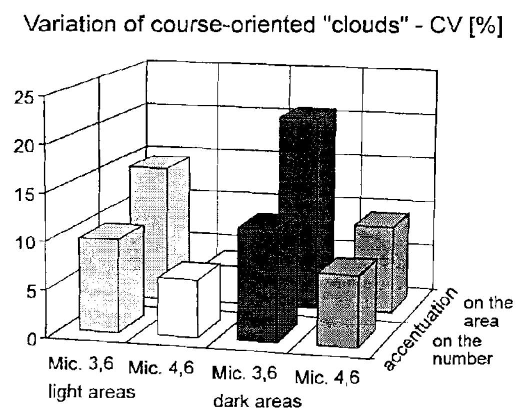

Figure 8. Variation of the relationship between the course-orientation of the „cloudiness“ of light and dark areas