A study on the objective evaluation of wrinkle properties of fabrics by image processing system

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学位授与の題目	A STUDY ON THE OBJECTIVE EVALUATION OF WRINKLE PROPERTIES OF FABRICS BY IMAGE PROCESSING SYSTEM (画象処理システムによる布のしわ客観評価に関する研究)
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学位論文要旨

Wrinkle resistance of fabrics is one of most important factors, which affects the aesthetic and easy care properties of clothing. This dissertation firstly describes the method evaluating the appearance of fabric-wrinkling replicas objectively by image processing. Model of calculating the gray level is proposed. Results indicate that the wrinkle can be reliably measured using the distribution of gray level and the ratio of surface area, the ratio of X-direction length and the one of Y-direction length of surface profiles. All parameters with wrinkling fall on good logarithmic functions, which have high correlation coefficients. All parameters can quantify the wrinkle of replicas with AATCC grades. The profile lines of surface are also analyzed with the method of Fast Fourier Transform. Amplitudes of five grades are obviously different when $f \leqq 0.1$ (1/pixel) and the very small amplitude shall be neglected when $f > 0.1$ (1/pixel), because it is mainly caused by the sensing

noise or intrinsic surface roughness made by the yarn interlacing, etc..

The image processing systemsecondly combined with the slit beam projecting technique is used, and three-dimensional image of the wrinkle of fabrics is obtained by the method, in which there is no influence on the results from the colors and the patterns of fabrics, and the fabric wrinkles can be evaluated and analyzed objectively. The parameters, such as standard deviation of height values of surface profiles, increasing ratio of surface area, one of surface length, and fractal dimension of surface, are defined and suggested to evaluate and characterize the fabric wrinkles. There are logarithm relationships between the parameters and the wrinkle grades of standard replicas, and their correlations are high, too. There is a good agreement between the subjective appraisal and the objective evaluation results for the fabrics. All parameters with wrinkling fall on good logarithmic functions, which have high correlation coefficients and can quantify the wrinkle of replicas and fabrics. The measurement results are not affected from the colors or the prints of fabrics, including those with sharp color contrasts.

And then,the decomposition and analysis of wrinkle profiles (signals) utilizing the wavelet transforms are presented. The Continuous Wavelet Transform (CWT) is used to analyze their wavelet coefficients C, which indicates the similarity closely correlated with the wavelet, and their wavelet power spectra. The signal can be decomposed into an approximation a_5 and

details d_n with the Discrete Wavelet Transform (DWT), and 3-D images of the fabric wrinkles decomposed is obtained, proving a convenient format for the analysis of wrinkles and identifying the characterization of wrinkles. The analysis of wrinkle properties of AATCC replicas and fabrics are performed with this method. The plots analyzed with CWT gives a clearer picture of what's happening with the signal, highlighting the periodicity. With the increase of wrinkle degree, the powers also become larger, and the periods on which the peak of the most powers appears decrease. The irregular and various wrinkles in shape, size and number are intermingled or coexist in the same wrinkled fabric, and the complexities of wrinkles will increase with the increase of wrinkle degree. A wrinkle signal can be decomposed into an approximation a_n and the details d_n. The wrinkle appearances mainly depend on its approximation a_5. In wrinkle grades 1 and 2, they are also affected by the details d_4 and d_5, but they are hardly influenced by d_4 and d_5 in the wrinkle grades 3,4 and 5.

Since the wrinkle properties of fabrics mainly depend on the physical and mechanical performances of fibers, yarns and fabrics, it is important to study the relation between them. More objective and precise evaluating methods should be used in assessing the fabric wrinkle by image processing system and slit beam projecting technique. Finally, the relationships between the wrinkle properties of fabrics and the behavior of yarns and fabrics are investigated. Changes in humidity and fabric density can affect

fabric properties such as wrinkle recovery by changing the mechanical properties and the viscoelastic and frictional behavior of the yarns. Hence the sequence of ambient conditions during actual wearing and during testing could influence the wrinkle properties of fabrics. Since wool fabrics have higher moisture absorbent quality, the effects of altering the yarn density and sequence of humidity on wrinkle properties will be considered, and the humidity is changed from 35 to 85% RH at interval of 10% RH. The wrinkle properties of wool fabrics with the different warp and weft densities at changing of humidity are also measured. Among parameters, only *2HB, LT* and *EMT* have the higher correlation coefficients at 1% significance level, and *RT* has one 5% significance level. There are high correlations between the wrinkle grade and elastic modulus, elastic recovery percentage of yarns at 1% significance level. The cover factors of fabrics affect the wrinkle grades, and the wrinkle grades of fabrics having larger cover factors (> 290) are higher than those having smaller ones (< 290). However, the degree of influence also depends on the humidity. When the humidity is or is lager than 55% RH, the affect from cover factor is significant; but the affect is not significant when the humidity is or is less than 45% RH. There is higher correlation coefficient between wrinkle properties and humidity at 1% significance level. The wrinkle grades decreases with increasing the humidity from 35% RH to 85% RH.

学位論文審査結果の要旨

当該学位論文に関し，平成 15 年 1 月 23 日，第 1 回学位論文審査委員会を開催し，提出された学位論文及び関連資料について詳細に検討した。平成 15 年 1 月 30 日の口頭発表後，第 2 回学位論文審査委員会を開催し，慎重に協議の結果，以下の通り判定した。

本論文では，画像処理システムおよびスリットビーム投影技術により，布のしわ客観評価方法について詳細に検討し，布の色，柄などの影響を受けずに，新しい実験方法，計算モデルとパラメータを提出し，客観評価が可能となった。初めに，画像処理システムにより標準レプリカのしわ等級を評価し，新しく定義したパラメータ：G_{xd}，R_A，R_{Lx}，R_{Ly} などで検討した。高速フーリエ変換（FFT）で表面曲線のしわ性能およびスペクトルを分析した。しわの表面高さの各パラメータ：Z_{SD}，η_A，FD と標準レプリカ等級との間にはよい対数関係があり，相関も高い。織物に対する主観評価値と客観評価値とはよい一致性を示した。ウェーブレット変換法はしわの分析と評価に便利な方法で，AATCC レプリカ及び織物のしわ性能の分析に有効であり，しわの詳しい形態と特徴を分析することができた。最後に，糸，織物の基本力学物性および実験条件などと布のしわ性能との関係を明らかにした。以上のように本論文は独創性に富み，得られた成果は新しい布開発へと応用可能であり，その工学的価値は高いと評価出来る。

以上より，本論文は博士（工学）論文に値すると判定する。