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A Study on the Color Change in a Union Fabric simulated using a 3-dimensional CAD Software and Image Analysis

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Abstract

Colors of textile products or fashionable clothing play one of the most important roles. From the point of visual cues, the realism of an image is the result of a good interaction of local light scattering or transmittance model applied. A 3-dimensional CAD software was used to construct a solid plain fabric model. In order to simulate a union fabric with different warp and filling colors, rendering was performed on the fabric model. It was demonstrated that the iridescent effect, pearl effect, or superficial color change effect of the union fabric during wearer's movement could be explained using the fabric models at inclined fabric positions during viewer's observation.

Key Words : Surface color change, Union fabric, 3-dimensional CAD software, Image Analysis, Plain weave.

I. Introduction

Visually realistic fabrics, generated using CAD(Computer Aided Design), are important for fashion, textile design, interior design, human animation, and other technology sectors. Techniques for visualization and modeling of woven fabrics and knitted fabrics have been proposed in literature.

Jojic et al.[1)] presented computer vision techniques for building dressed human models using images by firstly developing an algorithm for three-dimensional body reconstruction and texture mapping using contour, stereo, and texture information from several images and deformable super-quadrics as the model parts, and by secondly adopting a vision technique for analysis of fabric draping behavior, which allowed for estimation of cloth model parameters, such as bending properties, but can also be used to estimate the contact points between the body and fabric in the range data of dressed humans. The complexities in human body and fabric interactions pose many problems, for example, in reconstructing 3-dimensional multi -part objects from visual cues. They defined the problem of reconstruction of a human body in an arbitrary posture as the problem of 3-dimensional shape estimation of an object consisting of several parts that may partially or completely occlude each other from some view points.

Particle-based models and articulated models are increasingly used in synthetic image animation applications. Evolutionary techniques can contribute to the resolution of problems at the border of image analysis and image synthesis domains, where optimization methods tend to play an increasing role and evolutionary techniques bring about interesting new possibilities, notably through their abilities to cope with large numbers of unknown variables or noisy data, to use heterogeneous cost functions, and to find families of solution rather than a single optimum. Motion realism may only be achieved through the explicit use of physical laws to build physically realistic or plausible image sequences.[2]

The simulation of worn-out[3] fabrics is another fascinating topic as readily demonstrated by one of the fashion trends, 'earth-colored mock solids on linen and wool base, heathered or with a slightly grated surface of a dusty effect'.[4]

Texture is one of the central issues in computer vision, having two components of texture description and texture analysis. Users of textures in computer graphics sometimes come from artistic professions such as architecture, industrial design, movie animation or other non-mathematical fields. If description of texture and synthesis are given in terms of complicated formulae and processes, users may not completely understand and employ them.[3] Furthermore, in purely statistical techniques, once parameters of a procedure are determined, we cannot revise them. This makes it so difficult to govern the synthesizing procedure that we cannot evaluate in advance the finally synthesized texture. It appears that application of such existing methods is limited within particular types of textures.

Other facets of the simulation studies involve works on animating wrinkles on clothes. If there are no wrinkles on clothes worn by a person, it might not look very realistic. Hadap et al.[5] reported a method to simulate a realistic wrinkles on clothes without fine mesh and large computational overheads. Cloth has very little in-plane deformations, as most of the deformations come from buckling. This can be viewed at as area conservation property of fabrics. Wrinkles add life to garments in fashion. Wrinkles are important for visual realism. In order to capture realistic wrinkles on a real-life garment, from a mere geometric view-point, the number of triangles required can be easily upto a hundred thousand. Such a large number of triangles put cloth simulation off from interactive speeds, even with adaptive time steps.

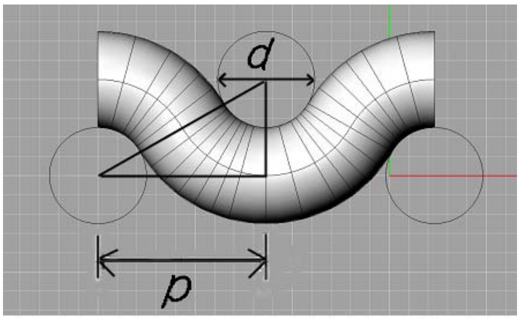
Union fabrics often comprise differently colored warp and filling yarns. For example, a union fabric of red warp yarns and blue filling yarns may sometimes exhibit iridescent look, or superficial color change, when viewed from various observing angles or positions. This phenomenon is often experienced during a fashion show as if the surface color of the mixture fabric draped over a walking model is partially changing from one color to the other.

In order to prepare more realistic fabric models, a three-dimensional model based on a plain weave structure having warp yarn and filling yarn, assuming round cross-section monofilament yarn, with striking contrast in color, was rendered using a CAD program, Rhinceros®(Robert McNeel and Associates, Seattle, USA). The model fabric was rotated consecutively, at a certain angle interval, to allow for angled view from an observer position or a viewing camera. Image analysis procedure was performed on each image of the corresponding fabric angle.

II. Experimental

1. 3-dimensional yarn modeling

The yarn is modeled as a round monofilament yarn in this study. It is assumed to be uniform throughout its length. Plain weave is the simplest of all weave interlacings where the odd warp yarn operate over one and under one filling yarn throughout the fabric with the even warp yarns reversing this order. A plain weave does not necessarily result in a plain surface effect or design in the fabric. Variation of yarn linear densities and/or yarn spacing variations can produce rib effects shown in taffeta, faille, and grosgrain, while the use of color pattern for warp and filling yarns result in color and weave effects.



<Fig. 1> Plain weave model

It is assumed that the plain fabric model follows a balanced weave, where d is the diameter of a yarn, p is the pitch between neighboring two yarns, and $p = \sqrt{3}d$.<Fig. 1>

In this study, warp yarn diameter was set to 0.8 mm, and filling yarn diameter to 1.0 mm. Total length x width of simulated fabric is 3.1 x 3.1 cm.

It is necessary to obtain the tangents to the curve of the central yarn axis to further place the circles that define the yarn cross-section.

2. Rendering

In the material property selection menu of the 3-dimensional CAD software, the RGB (Red, Green, Blue) values of warp yarn were set to 255, 0, 0, the 'Gloss' to zero, and the 'Transparency' to zero. The RGB values of filling yarns were set to 0, 0, 255, with the other two factors the same.

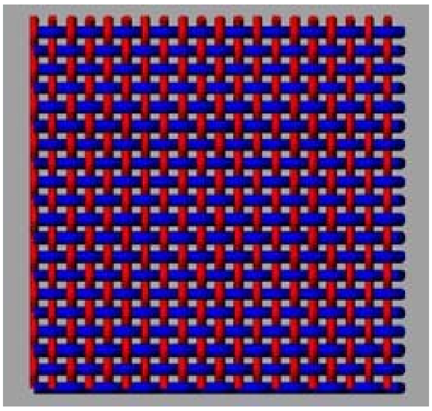
The modeled fabric sample is viewed from top position for rendering using an imaginary camera of 35mm focal length, looking straight down. The sample is assumed to be placed on a flat table top for 0 degree rotation. The sample is then inclined at specific angles of 15, 30, 45, 60, and 75 degrees subsequently for observation and rendering, with the central line of the fabric model, which is parallel with the warp yarn direction, as a rotation axis.

3. Image Analysis

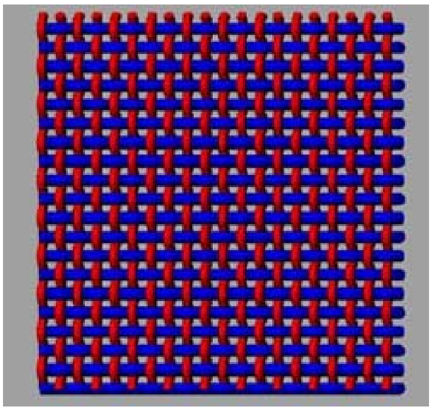
Obtained rendered images of fabric samples are analyzed using an image analysis software (ImageJ, NIH, USA). The ratio of red versus blue histogram in the ROI(Region of Interest) in the image is calculated. ROI is selected to exclude the selvage warp/filling yarns for image analysis.

III. Results and Discussion

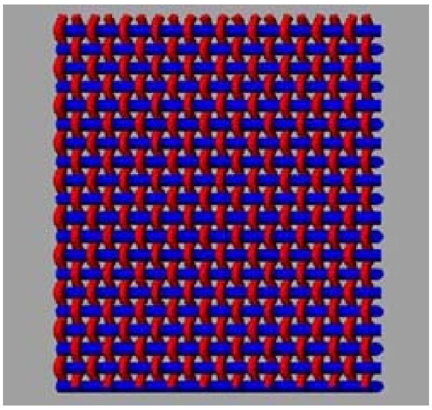
Obtained rendered images of simulated fabrics are shown in <Fig. 2a-e>. As the inclination angle of the model fabric increases, the red colored warp yarns become more distinguished. The color of the rendered image of the model fabric approaches toward more reddish by visual inspection. This could be an explanation of the visual phenomena readily experienced by viewers during movement of a clothed model, whose fabric comprised of union fabric with differently colored warp yarns and filling yarns.



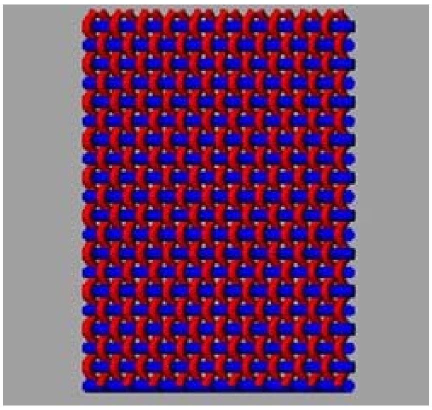
<Fig. 2a> Rendered image of simulated fabric, 0 degree.



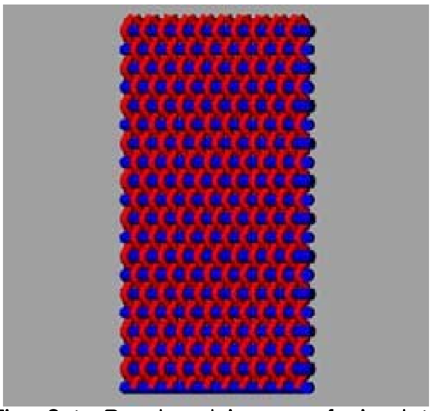
<Fig. 2b> Rendered image of simulated fabric, 15 degree rotation.



<Fig. 2c> Rendered image of simulated fabric, 30 degree rotation.



<Fig. 2d> Rendered image of simulated fabric, 45 degree rotation.



<Fig. 2e> Rendered image of simulated fabric, 60 degree rotation.

RGB histogram results are shown in <Table 1>, obtained from the image analysis using color histogram function of the ImageJ software. Some of the data are omitted for clarity.

<Table 1> Partial histogram values of RGB's of rendered image of simulated fabric.
(unit: pixels(for R, G, B), 45 degree rotation result selected as an example)

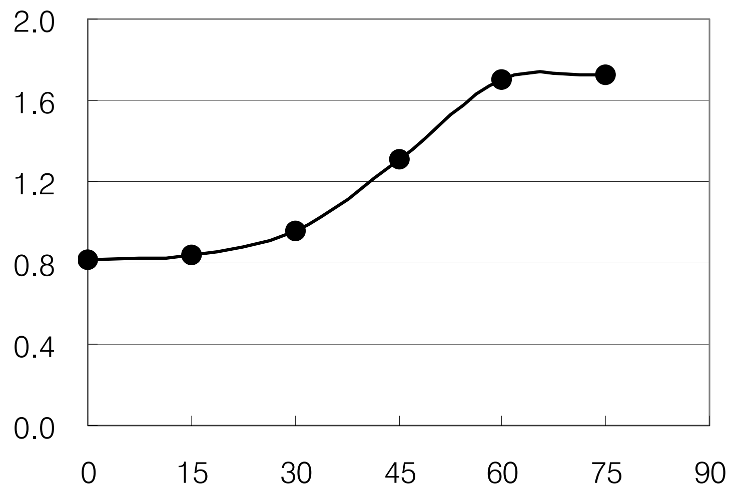
Intensity	red	green	blue
...	(deleted)...	...	...
93	181	0	81
94	161	0	54
95	211	240	280
96	195	0	51
97	378	248	149
98	158	0	111
99	169	0	67
100	203	51	61
101	157	0	65
102	147	9	72
103	175	0	62
104	139	0	67
105	164	14	76
106	162	0	70
107	160	4	110
108	135	0	97
...	(deleted)...	...	...
237	346	0	243
238	428	0	305
239	372	0	268
240	350	0	286
241	319	0	319
242	322	0	308
243	272	0	330
244	286	0	314
245	275	0	337
246	267	0	347
247	256	0	471
248	246	0	520
249	260	0	467
250	215	0	426
251	239	0	416
252	223	0	374
253	162	0	239
254	20	0	43
255	0	0	0
Sum	47087	6149	35961

<Table 2> summarizes the red and blue histogram analysis results with the calculated red/blue ratio. It is readily shown that the decreasing tendency of blue pixels is stiffer than that of red pixels of warp yarns with the increase of rotation angle of the fabric model, thereby the red/blue ratio increased.

As shown in <Fig.3>, the calculated values of ratio of red/blue area in the corresponding images are plotted against the angle of fabric model rotation. As the ratio of red/blue area increased with the angle increase, perceived dominant fabric color will change from blue to reddish. This may explain the 'iridescent' effect or pearl effect of the colored yarn union fabrics in general.

<Table 2> Red(R) and blue(B) summation values and red/blue ratio

Angle	Red	Blue	red/blue ratio
0	57,028	69,757	0.818
15	56,721	67,610	0.839
30	52,780	55,153	0.957
45	47,087	35,961	1.309
60	35,964	21,149	1.701
75	19,499	11,313	1.724



<Fig. 3> Ratio of Red/Blue area vs. angle of fabric model rotation.

IV. Conclusions

From the point of visual cues, the realism of an image is the result of a good interaction of local light scattering or transmittance model applied. More complex materials such as fabrics, anisotropic painting materials, skins, traditional methods seem to be inappropriate for realistic appearance visualization. Therefore, even though the process might be computationally burdensome, a 3-dimensional fabric model using a NURBS based CAD software was constructed and rendered.

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In order to simulate a union fabric with different warp and filling colors, rendering was performed on the fabric model. Image analysis of the surface color change was performed when the model fabric was rotated with the imaginary camera position was constant. It was demonstrated that the iridescent effect or pearl effect of the union fabric during wearer's swift movement could be explained using the fabric models at inclined fabric positions during viewer's observation.

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