SENSING THE FABRIC

To simulate sensation through sensory evaluation and in response to standard acceptable properties of specific materials when viewed as a digital image

LIVERPOOL JOHN MOORES UNIVERSITY

Pat Dillon & Wendy Moody
Fashion & Textile Design, School of Art
68 Hope Street, Liverpool L1 9EB
Tel: 0151 231 5088
Email laswmood@livjm.ac.uk; dvapdill@livjm.ac.uk

Rebecca Bartlett, Patricia Scully, Roger Morgan & Christopher James
School of Engineering
Byrom Street, Liverpool L3 3AF
Tel: 0151 231 2054: Email: r.morgan@livjm.ac.uk

ABSTRACT

This paper describes initial investigation of ideas for developing and refining current haptic parameters and interfaces for use in the textiles and related industries. A simple force-feedback mouse has been programmed to represent some of the more obvious tactile issues in fabrics. An evaluation study has been made of five different fabrics, and numerical values have been assessed for tactile parameters according to a new set of semi-quantitative descriptors. The results are discussed, and are displayed as a demonstration.

Keywords

Textiles & related industries, haptic, tactile evaluation.

INTRODUCTION

The Textiles, Fashion and Interior industries have become increasingly aware of the need to enhance the sensory experience for the potential customer when observing highly tactile images, using the Internet or other technological means. In order to engage this creative sector in fully utilising such technologies as a tool for viewing and marketing of textiles, and for general communication within the industry of textile trends, fabrics, and related imagery, both for clothing and for interiors, we need to introduce other senses, notably the sense of touch, to the overall experience.[1, 2] This will also help to reduce visual overload in a highly visual <u>and</u> tactile industry![3, 4]

The aim of this project is to develop an intuitive visual and haptic communication system using the standards and expectations of the textile and related industries with particular regard to professional aesthetic, and psychological perspectives, and the working methods of the industry.

The creative, unpredictable and seductive working methods and minds of textile professionals offer a challenge to engineering and programming expertise. In particular, it is necessary to put quantitative evaluations on various parameters which are widely understood in the textile industries, but which are at present mainly qualitative. The development of a textiles industry focussed virtual multi-modal system is thus a stimulating problem. It also invites refinement of texture simulations, which at present are often too crude to be convincing.

METHOD

One of a fashion designer's most important skills is to understand the relationship between garment cut and fabric behaviour and performance, as well as making correct commercial choices, responding to current trends in shape and fabric types, all determined by market level. There are five integral factors that are essential in fabric selection process, they are weight, thickness, shearness, drape and stretch. A fabric's aesthetic quality is also obviously as important.

These integral factors will all need to be considered in developing a supporting multi-modal system.

The first phase of the work has concentrated on setting up representations of simple mechanical variables using existing hardware and established software tools[7]. Logitech's Wingman mouse has been chosen as a low-cost haptic interface device. It can be programmed to simulate the surface properties of highly directional fabrics such as corduroy and velvet, which have relatively large-scale texture.

Sensory evaluation studies of products are often used in the industry to gain an understanding of consumer products and find ways to improve or market them. In the present work a small-scale Touch Evaluation Study of five different fabrics has been developed for the Wingman Mouse. Measurements were primarily based on how the mouse is used for touching, i.e. touch-stroke.[5, 6, 7]

Touch Evaluation

A procedure was developed to allow a restricted form of tactile evaluation which would simulate as closely as possible the conditions under which the Wingman mouse would be used. This procedure is summarised below. It is important to note that the evaluator has previous experience with fabrics, and also that she is female, as both of these issues may affect the tactile perception:

1. Swatch samples laid out flat on a table and taped down.
2. Evaluated using clean washed hands.
3. Evaluation consisted of visual and touch, blindfolded and visual evaluations.
4. Contact with fabric: up, down, left and right directions, except for some stretch evaluation.
5. Contact was made using all five fingers of right hand, primarily the three middle fingers due to their longer length, and therefore longer contact time with the fabric, contact being made primarily at the distal to the finger tip region of the fingers.

Parameters to be addressed are summarised in Figure 1. It should be noted that the numerical value, though intended to be systematic and quantitative, is on an arbitrary scale of value from 1 to 15. Results are shown in Figure's 2, 3, 4, 5, and 6.

FIGURE 1: Touch Evaluation Study for Wingman Mouse

Definitions and Scales for Handfeel Properties

Property	Key	Reference			Physical Parameters
Stiffness *[3]	**S**	Pliable	← →	stiff	Shear Modulus
Depression Depth	**DD**	high	← →	low	Bulk Modulus
Depression Resilience/Springiness	**R**	slow	← →	fast/springy	Young's Modulus, Damping
Tensile Stretch *[1] *[3]	**TS**	no stretch	← →	high stretch	Shear Modulus
Tensile Extension speed recovery *[1] *[3]	**TES**	slow	← →	quick	Damping
Hand Friction/Slipperiness	**HF**	slip/no drag	← →	drag/slippy	Coefficient of Friction
Roughness (overall surface)	**R**	smooth	← →	rough	Small-scale Surface Texture
Gritty	**G**	smooth	← →	gritty	Medium-scale Surface Texture
Lumpy [, i.e. Overall: bumpy, embossed, fiber bundles]	**L**	smooth/not lumpy	← →	lumpy	Large-scale Surface Texture
Grainy	**G**	smooth	← →	fuzzy/nappy	Medium-scale Surface Texture
Softness of surface	**S**	soft	← →	hard	Reciprocal of Modulus
Ribbed/Ridges (length	**R**	small	← →	large	Dimensions
Fuzziness	**FZ**	bald	← →	fuzzy/nappy	Force Displacement Graph
Furriness	**FR**	light	← →	heavy	Force Displacement Graph
Temperature *[3]	**T**	cold	← →	warm	Thermal Diffusivity
Thickness *[3]	**TH**	thin	← →	thick	Dimension
Moistness *[3]	**M**	dry	← →	wet	Water Absorption, Thermal Diffusivity
Weight *[3]	**W**	light	← →	heavy	Mass Per Unit Area
Noise Intensity *[3]	**NI**	soft	← →	loud	Sound Frequency/Intensity when Touched
Noise Pitch *[3]	**NP**	low/bass	← →	high/sharp	Sound Frequency/Intensity when Touched
Shearness *[3]	**S**	transparent	← →	non-transparent	Optical Properties
Drape *[2] *[3]	**D**	high	← →	low	Modulus

*[1] Measurements based on two-handed evaluation ; *[2] Measurements based on two-handed evaluation of holding fabric up to a light source where considerations for use would then be made, whether it is a fashion or interior fabric; *[3] Properties which will require visual/other support to any Wingman.

FIGURE 2: Corduroy -Small Barrel (100% cotton), Colour: Brown
End use: Clothing, Furniture Covering

KEY – SEE FIGURE 1

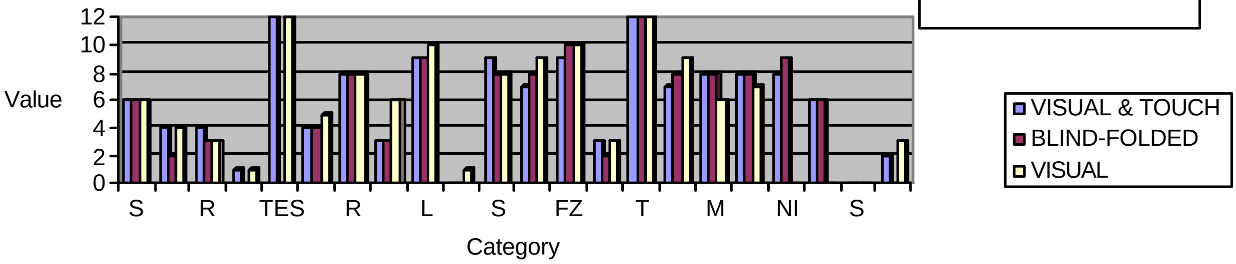


FIGURE 3: Corduroy -Large Barrel (100% Cotton), Colour: Silver grey and cream
End use: Furniture covering, Clothing

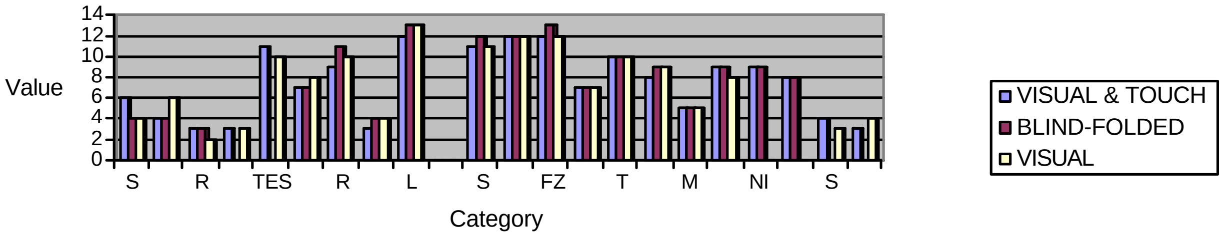


FIGURE 4: Velvet (100% Viscose), Colour: Bottle Green
End use: Clothing, Interiors

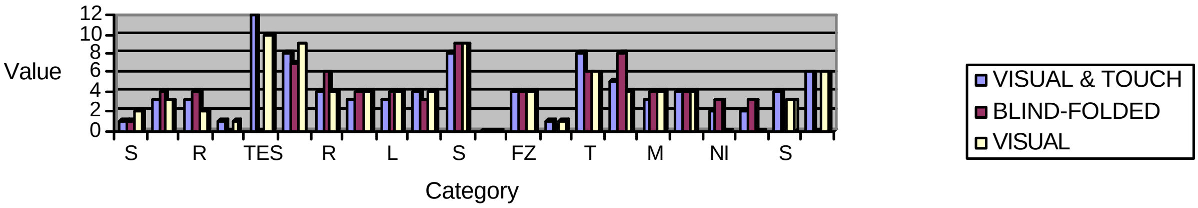


FIGURE 5: Random Patterned Velvet (37% Viscose, 63% Acetate), Colour: Silver grey and golden brown
End use: Interior, Furniture covering

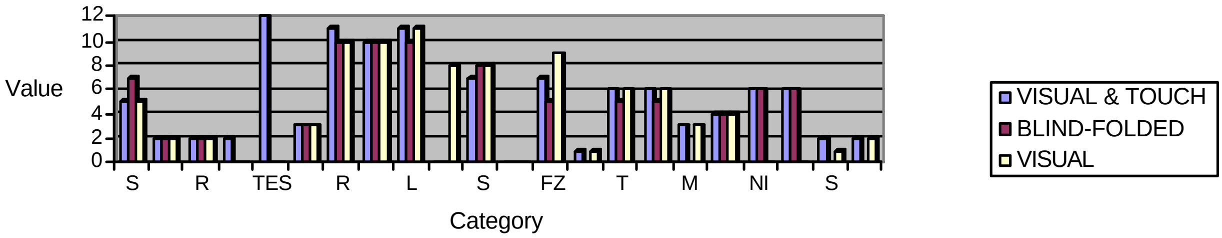
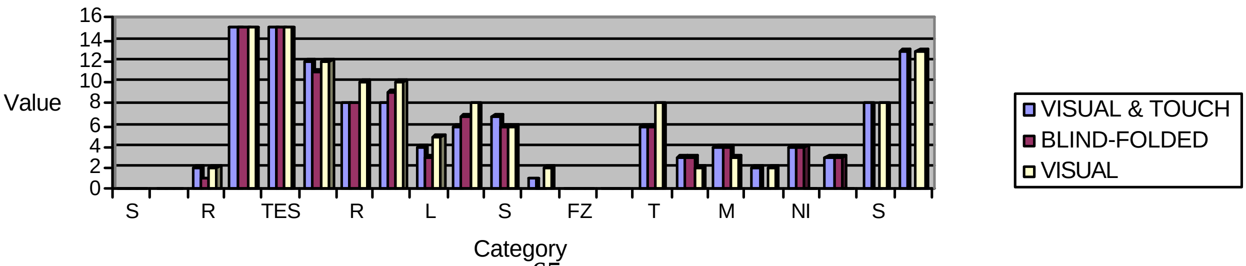


FIGURE 6: Stretch Fabric (57% Tactel, 31% Polyester, 12% Lycra)
End use: Clothing



Issues from Evaluation

The results of evaluations of several fabrics with very different surface textures are shown in Figures 2-6. Several issues emerged as relevant to the study, and these are summarised below:

1. Light reflection on fabric could affect measurements of the amount of roughness, graininess, etc. from a visual perspective.
2. It was found that being blindfolded gave a stronger tactile feeling (i.e. single modality). However visual and touch evaluation was enhanced through experience when the evaluator realised this.
3. It could be said that the colour of the fabrics interfered with the evaluator's decisions.
4. A time gap between each category of evaluation needs to be put in place to avoid any confusion or repetition of results.
5. Printed or woven patterns enhance the perception of texture.
6. Visual perception can distort a subjective property i.e. softness, especially if an evaluator has no experience with fabric.
7. In some fabrics such as velvet, the feel of the pile changes when direction of touch changes. In effect the pile has memory.
8. The Stretch quality has properties which allows it to stretch in all directions.
9. It could be said that printed imagery (stretch and random patterned velvet) enhanced the visual perception of texture.

Other issues to be considered:

1. The Wingman mouse could be a good communicator for furnishing fabrics due to the manner in which some of these fabrics are evaluated i.e. through a touch-stroke. However this manner of handling a fabric is limiting for fashion professionals. Fashion fabrics are usually evaluated to acknowledge their properties and realise the potential of their use, using the action of rubbing the fabric between the fingers, on both sides of the fabric.
2. It presents problems in developing correct and effective simulations of fabrics due to the properties that cannot sufficiently be felt through touching the fabric using the mouse, i.e. thickness and variable stretch directions. Different handling techniques/mannerisms are required for measuring certain properties.
3. This is mirrored in the expectations of the textile and related industries. Primarily, the Wingman fails to replicate the manner in which the textile industries naturally handle a piece of fabric and feel its textures, for evaluation, and end-use(s) considerations. Modification would therefore be required, so as to replicate better the overall general evaluation of fabrics.
4. The visual display of fabrics and texture in a virtual environment would basically fill-in the properties missing from the evaluation through touch variables translated into physical, haptic parameters. This is another area that will require development.
5. Some fashion fabrics, when touched by hand will not feel the same as when they are on the body. This could confuse and distort a buyer's view if they have no experience of the fabric, which is rare, or especially with a consumer if they have no knowledge. A good example of such a fabric is crepe, which has a very grainy surface quality.
6. The force-feedback facility could be useful for feeling and viewing stretch fabrics, and maybe weight.
7. Gender could also be seen to have an impact on expectation of a haptic user, and dependent upon their previous experience with fabrics. Women tend to be more tactually aware compared to some men, an impression of a type of fabric may therefore be "enough" information for a man but be inadequate for a woman. This difference has actually been found by comparing the impressions of the authors of this paper. As well as gender issues, social and cultural factors, past experiences, memories and experience with fabrics have bearing on the responses given by the participants in previous evaluation studies. This is especially true of the sensory observations made by consumers where they demonstrated preconceived notions, without any solid experience in the subject they are actually dealing with, i.e. fabric. [5]
8. Also, *'the differences show that women have applied their knowledge and previous experiences in the handling of textiles. However, the differences could also be explained by "heavy handedness", which would account for the higher values assigned by the men to weight, roughness, and softness. In other words, the men found fabrics to be heavy, rough and soft, which the women found to be light, smooth, and hard.'* [5] ***sic***
9. Those trained in textiles and its related industries, whether male or female, have an appreciation and understanding of fabric, shape, gender and market needs. Previous tactile evaluation studies have been created by comparing the tactile properties with the physical properties in the hope that the tactile/perceptive results given by test subjects would correspond with the physical characteristics. It has been shown that those who had the relevant experience gave results, which were very close. [5]

10. Some parameters of fabrics can be identified with simple physical variables [5, 6, 7]. Other parameters are more complex and will require more than one variable to define them. Figures 1, 2, 3, 4, 5 and 6 illustrate aspects of the problems to be solved.
11. Consideration should also be given to the material from which the shell of the haptic device is made. Conventional mice are made of a thermoplastic material, which although appropriate from an engineering viewpoint, may not be the best material to present tactile information to the user. Materials with different properties could enhance or decrease the value of tactile sensation.

DISCUSSION

It may never be possible to simulate the tactile impression of a fabric entirely, but it may be possible, by concentrating on the more important elements, to convey an adequately accurate impression, at least for professionals and those who are familiar with fabric technology. It should be noted that everyone can recognise their friends' voices on the telephone, despite the poor bandwidth of a conventional phone line, and that everyone can recognise a familiar face, even in a black-and-white photograph, so some degree of approximation is obviously acceptable.

What this project hopes to achieve is a definition of what is really essential to convey the 'feel' of a fabric, together with a set of quantitative or semi-quantitative values which can be used as descriptors. Some of these will then be implemented to control a haptic interface device.

In the longer term it may be possible to investigate the mental processes involved in tactile sensations. Such work might include magnetic resonance imaging of the brains of volunteer subjects given samples of textiles to look at and to feel.

FURTHER WORK

Of the physical parameters suggested, the mechanical variables (elastic moduli, stress-strain curves, friction coefficients, surface profiles and mass) can in principle be simulated by a suitable haptic interface device. Properties related to sound are relatively easy to add. Thermal properties and those related to air and water vapour, are outside the capacity of a haptic device, and would require the addition of a controllable thermal element such as a Peltier refrigeration module. [8]

To develop this research, a panel of industry acknowledged experts is currently being formulated to develop a British Industry Standard Tactile Evaluation Study in association with a major manufacturer of fabric and care products. It should also have a number of visually impaired individuals on the panel. The panel's acute sensory, psychophysical and physical relationship to textiles and texture will be evaluated and a definitive Fabric Language produced. This will be recorded in the form of a database to define touch variables based on the identification and evaluation of the physical parameters and perceptive responses to touching a piece of fabric or texture, handle evaluation and other industry expectations. This evaluation will then be used to develop an industry focussed, haptic interface, and establish what is essential in the definition of 'feel'. Ideas for development of a prototype interface device are already being considered.

CONCLUSION

Through using sensory testing techniques for a touch evaluation study, as discussed earlier, and focussing on the needs of the textile and related industry professional, in principle such information can be translated using existing engineering and programming languages within current haptic devices, i.e. intensity scale translation from touch variables into a database of programming intensity scale parameters. This will add to the necessary refinement in the simulation of sensation in response to a specific fabric, when viewed as a digital image. Such evaluation and refinement is imperative, *'We might even end up with haptically-enhanced interfaces that are in fact harder to use than standard ones and haptics may become just a gimmick rather than the key improvement in interaction technology that we believe it to be.'* [9]

This paper is concerned with haptic issues. It must be remembered, though, that even the visual representation of fabrics has proved a complex task in textile research. It may take till the end of this decade before a successful visual and haptic communication system is actually achieved.

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