Colour Systems for the Analysis and Definition of Surface Texture, and its Effect on Colour Appearance

Quantifying the effect of Texture on Colour Appearance

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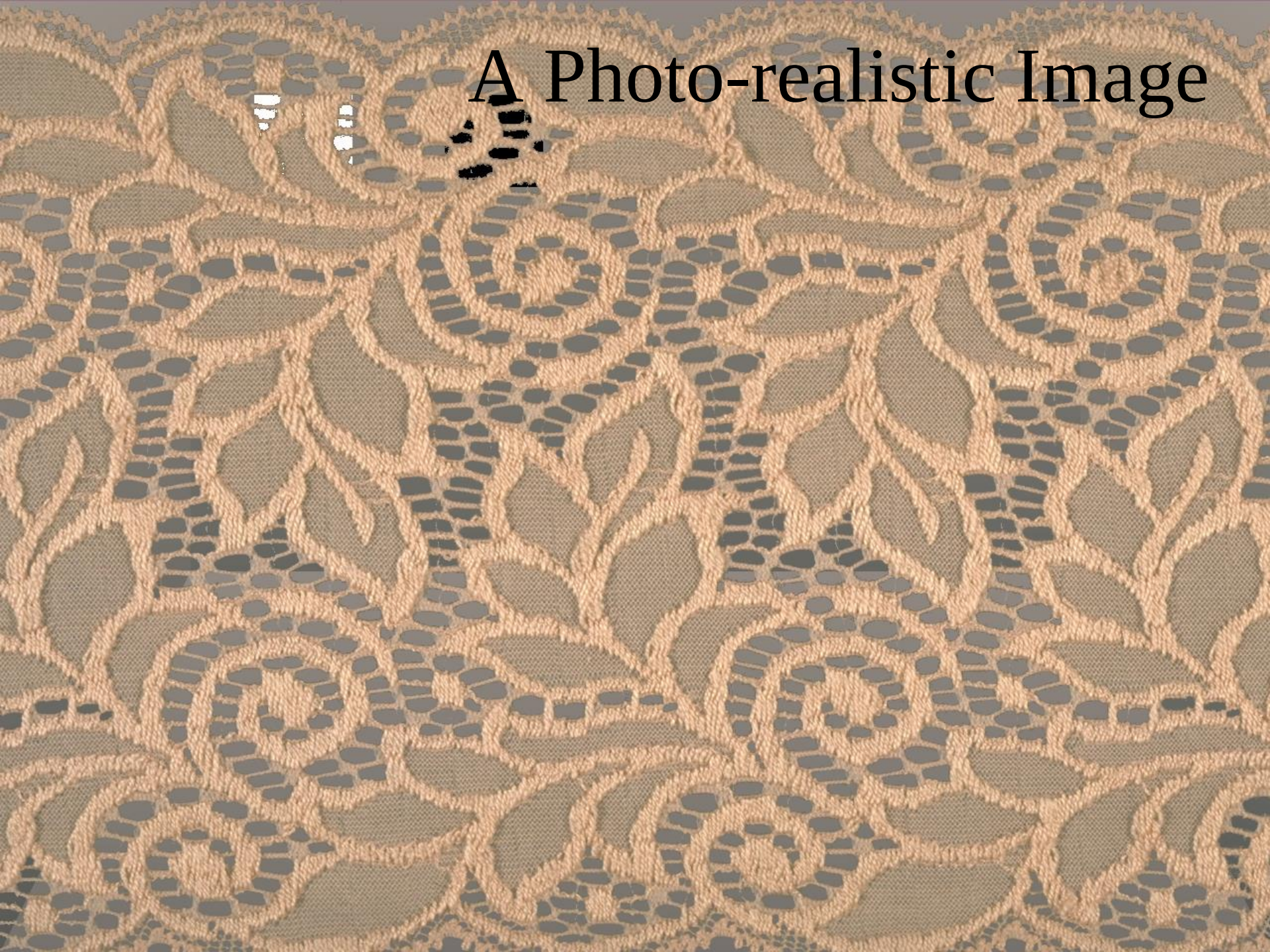
Texture Rich Photo-Realistic Images

Contain :-

- The Micro-Level Colour Differences which represent Texture.
- Spatially distributed objects and object components.

A Photo-realistic Image



A Different Type of Image

Texture Rich Imaging Systems

- CIE Co-ordinate defined point-colour.
- The Micro-Level Colour Differences which represent Texture.
- The Contents of a Photo-Realistic Image.
- CIE Co-ordinate based Image Storage and Analysis Strategies.

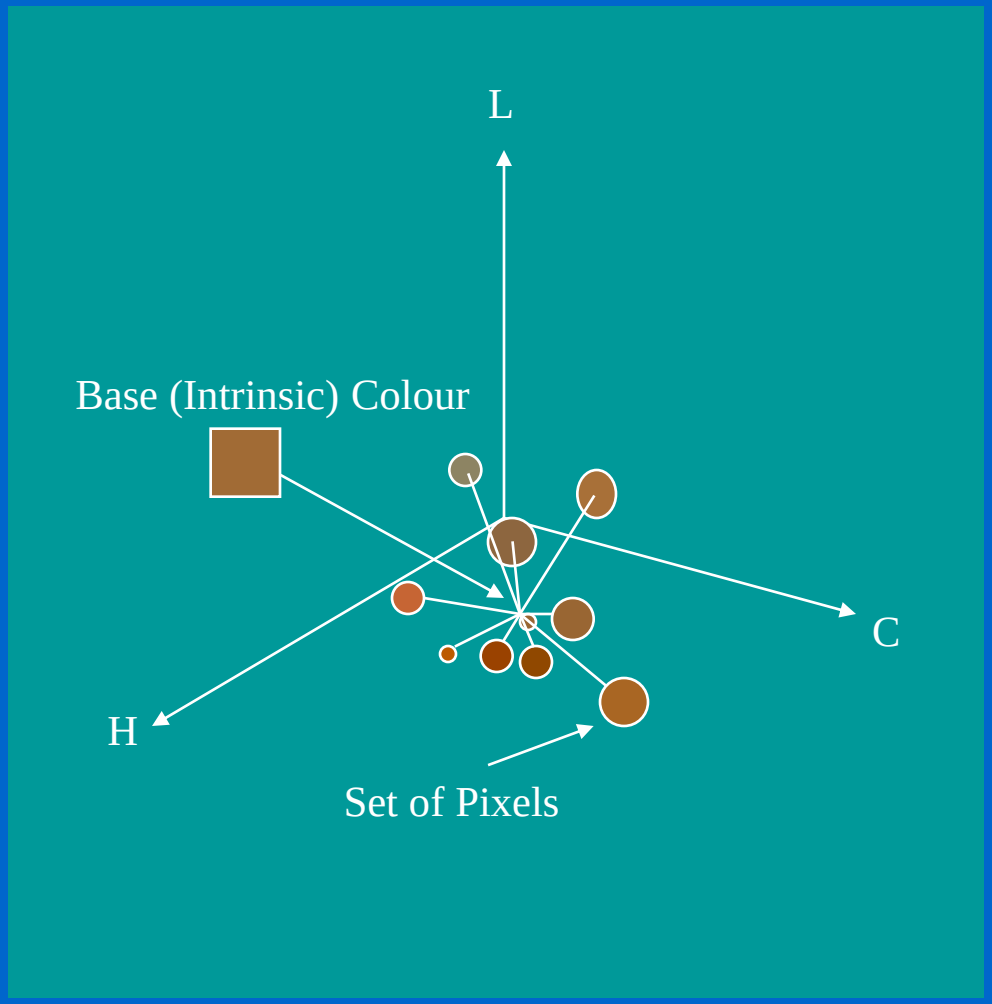
Image Analysis

- Logical Objects within Images have clearly defined easily separated Colour-Sets.
- The Key Discriminating Variable is Hue.
- Automatic Object Differentiation has proved to be highly effective, based on Delta H, Delta C and Delta L, using controlled band-widths.

Colour-Set membership in a Vector Space

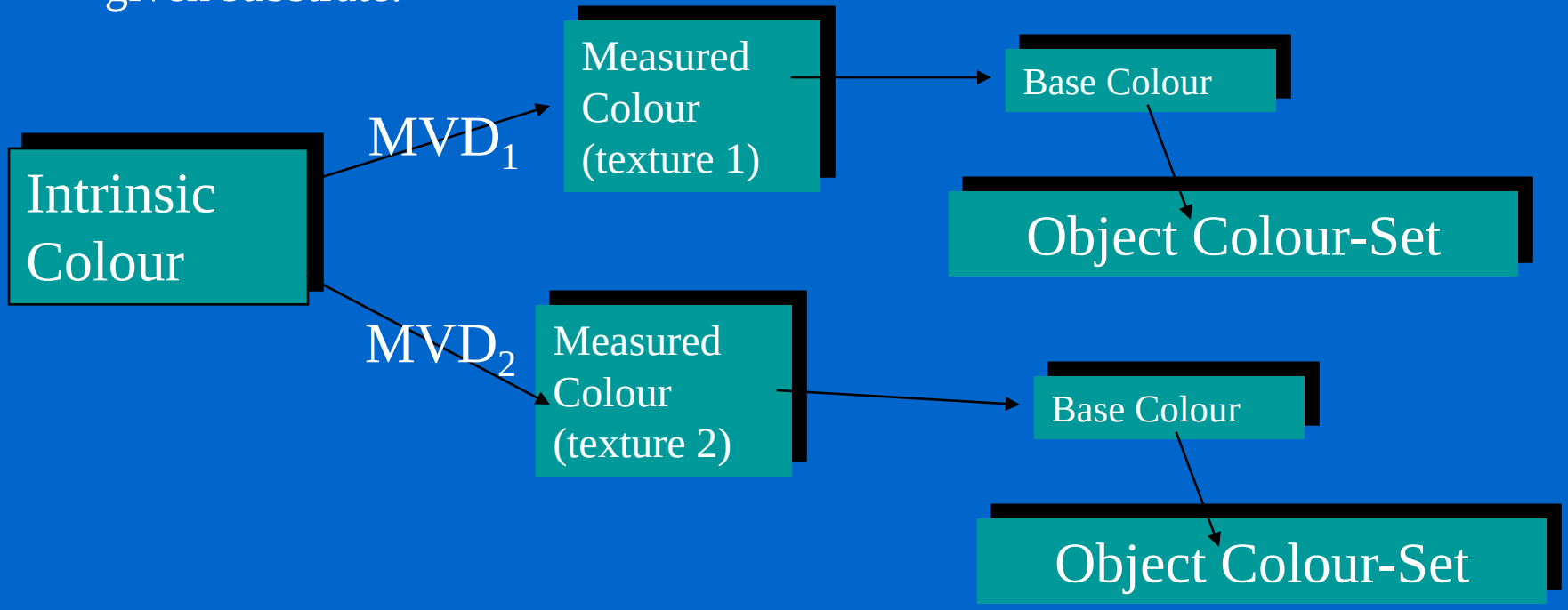
Each of several thousand colour definitions is represented, as a set of n pixels, at a distance H,C,L from the base-colour.

Point Colours Form a Variable Density Cloud, round the base-colour definition.



Intrinsic Colour and Colour Appearance

- *Intrinsic colour* is defined as a central property of the colorants present (product colour specification).
- *Colour Appearance* is produced by applying the intrinsic colour to a given substrate.



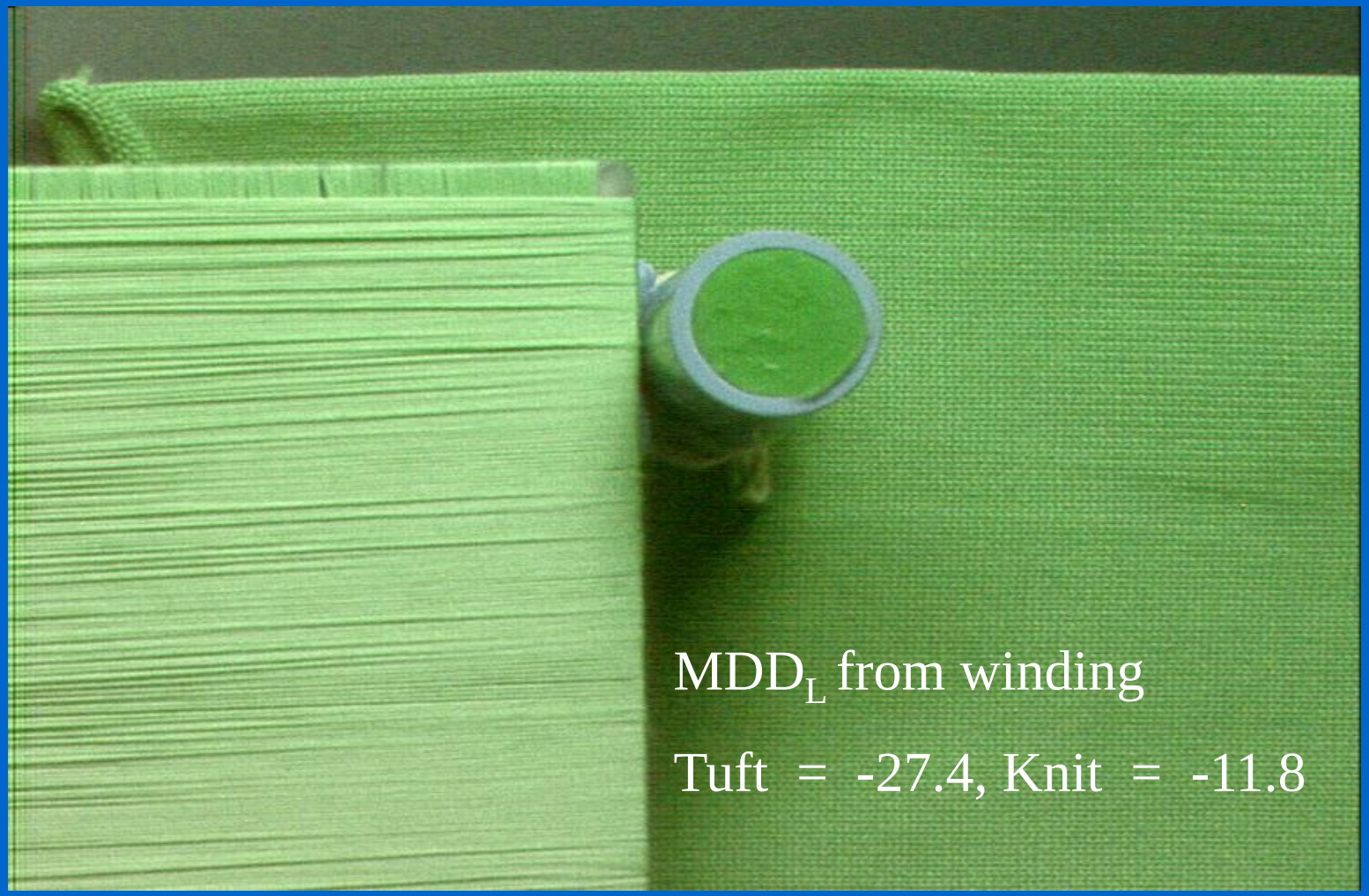
Measures of Texture Appearance

MCI (Mean Colour Identity) reduces to a single colour identity the combined effects of an array of point-colour specifications.

MDD values express, for each dimension of colour difference, whether the texture appears lighter, darker, brighter, duller etc. than expected. They register and define *single dimensional displacements or deviations from some intrinsic colour definition.*

An MVD value expresses the vector displacement in three dimensions of colour-space that links intrinsic colour to colour appearance. The intrinsic colour from which the MVD is calculated may be a measured colour specification, or be derived by visual matching.

Colour appearance variation



Deriving a value for Texture colour appearance

A single CIE colour specification (the MCI value) is calculated from many pixel colour specifications.

The pixel colour specifications come from a visually and numerically correct image of the texture.

A visually and / or numerically correct colour appearance is derived from a -

- Colour measurement (if the sample can be measured)
- A visual matching
- Calibration using a measured image-colour ‘hitching post’.

Measuring MCI, MDD and MVD values

MDD and MVD values represent the displacement in CIEL*a*b* colour-space of a texture relative to the reference intrinsic colour.

They are measured by comparing the MCI values of two textures, which are derived from image content.

They are characteristic of a given texture, and are constant across large volumes of colour-space.

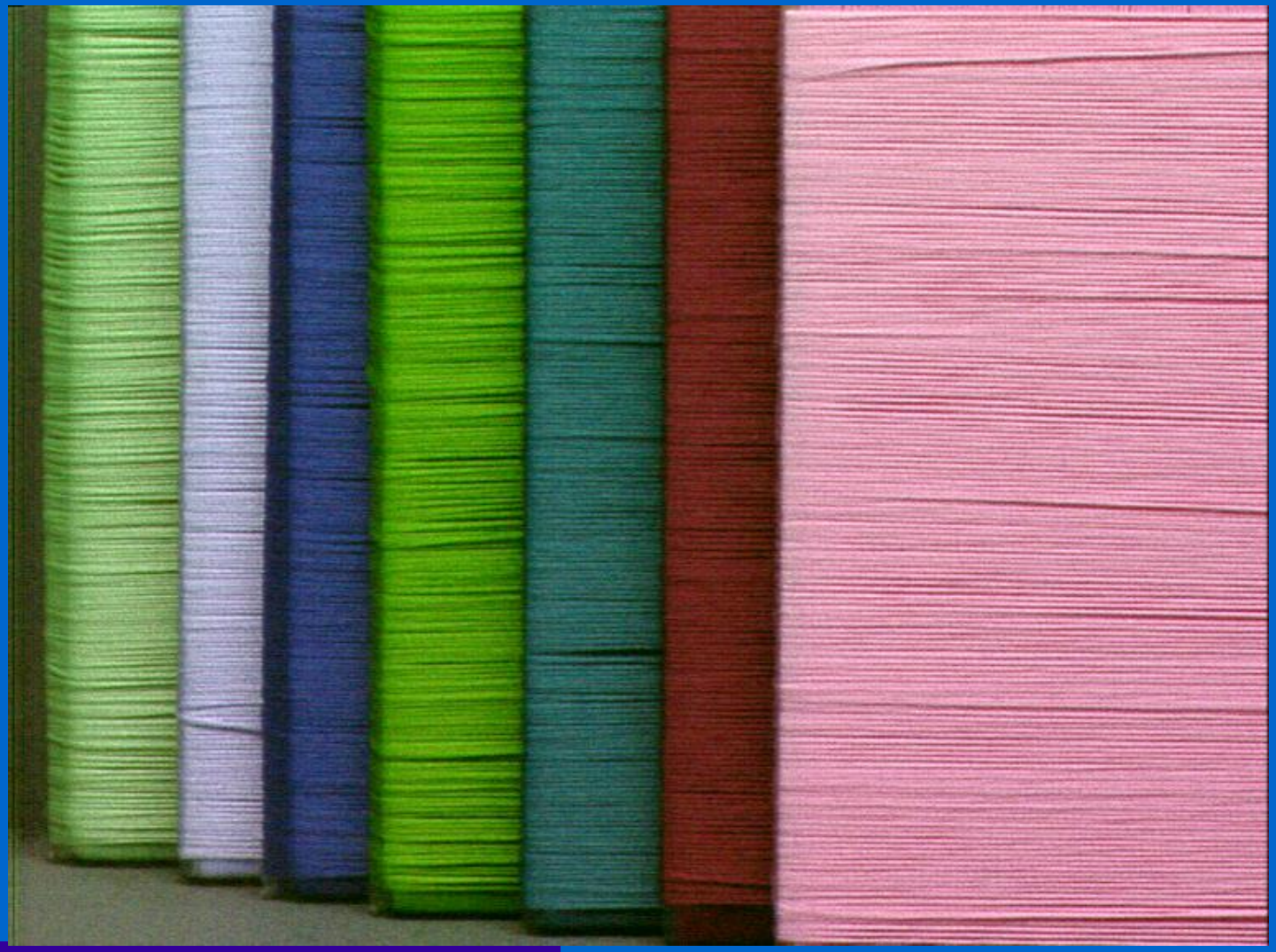
Validation using Imaged Textures

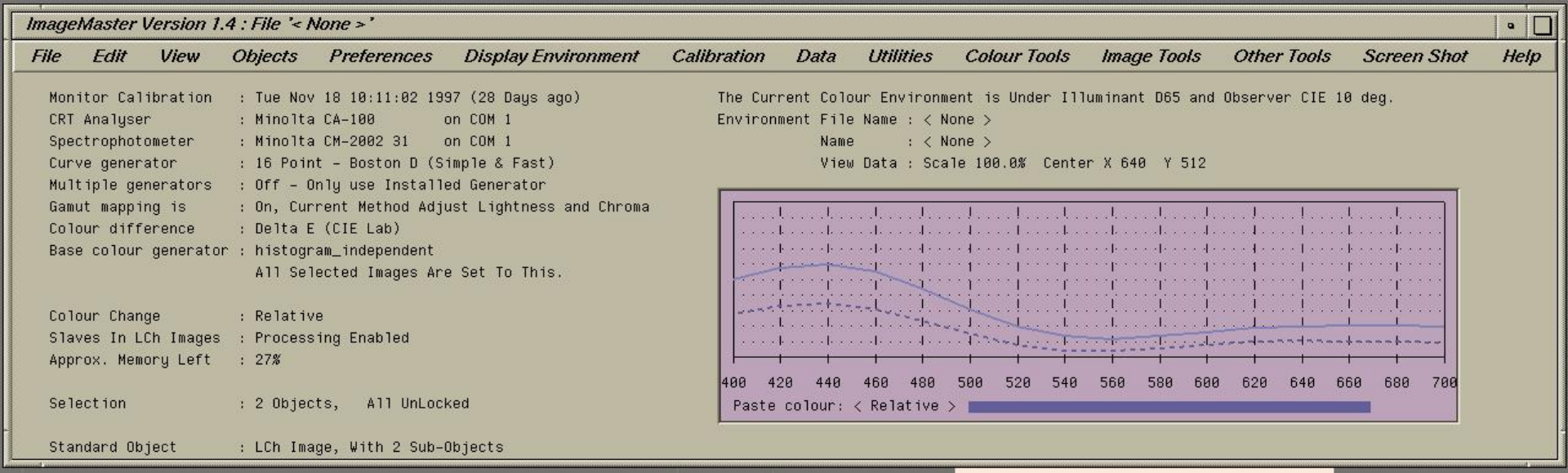
Observer trial validation was used to test for constant MVD with constant texture.

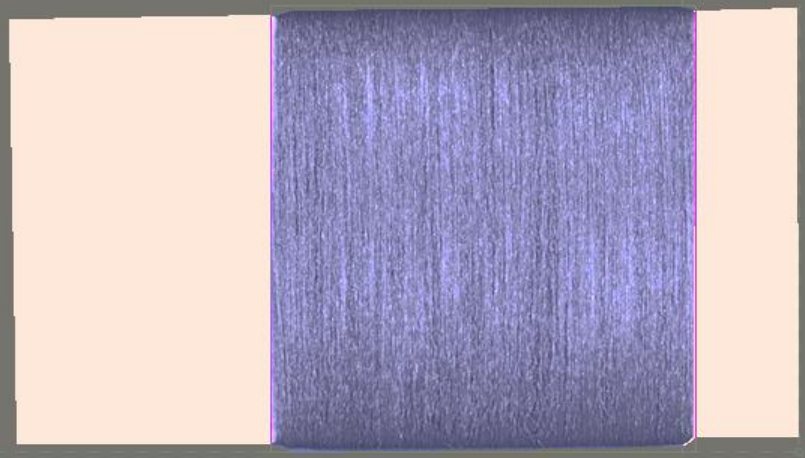
63 individual yarn winding samples widely distributed in colour-space have been shown to have an MVD of Zero to a common reference winding [EPSRC Final Report].

60 samples were made in three different textures, each texture was fabricated from a single yarn, using 20 different colours. The results are examined further in this account.

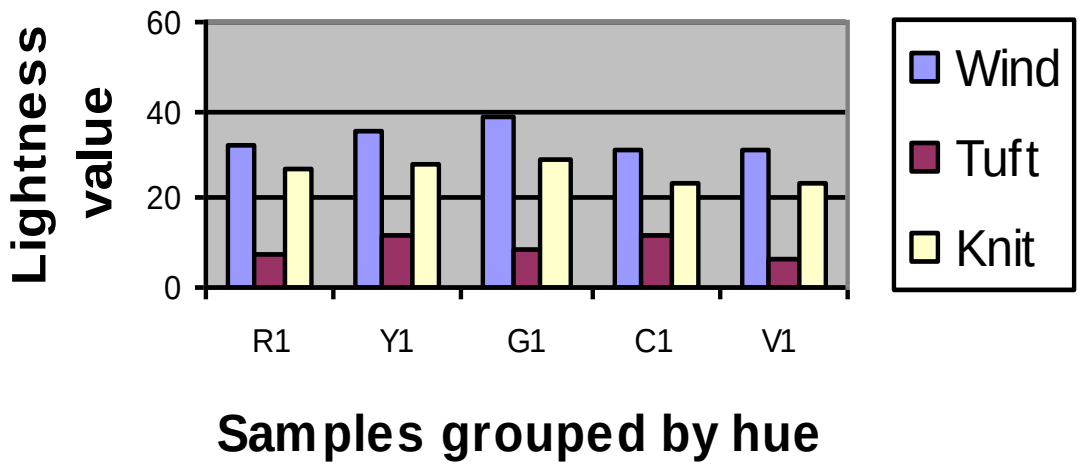
Yarn winding test colours

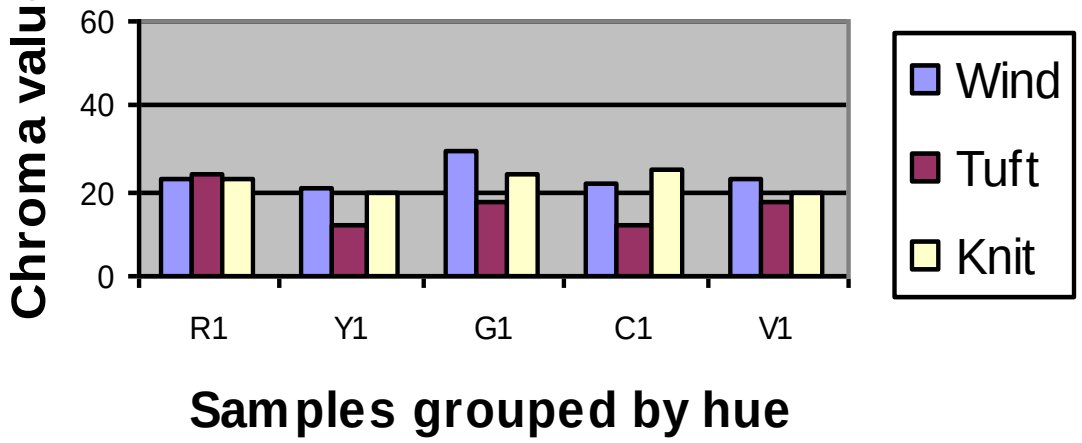






- Orientation
- Effects

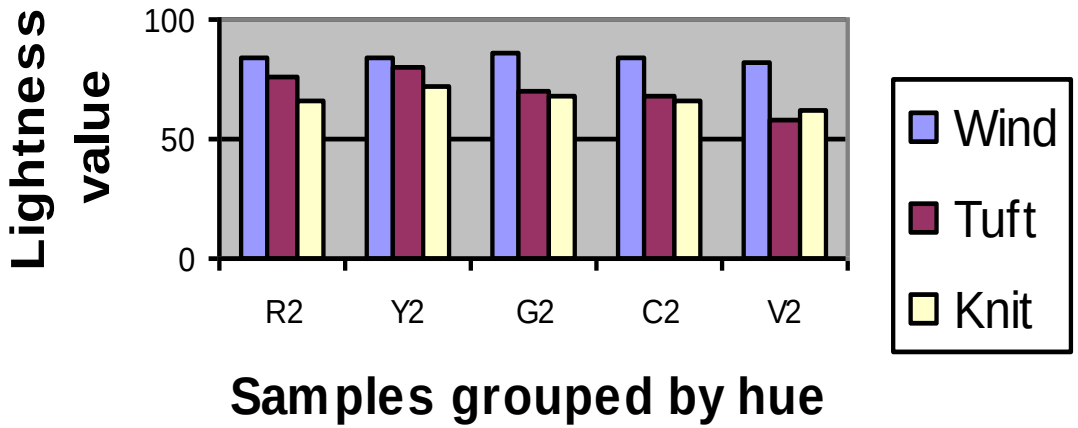




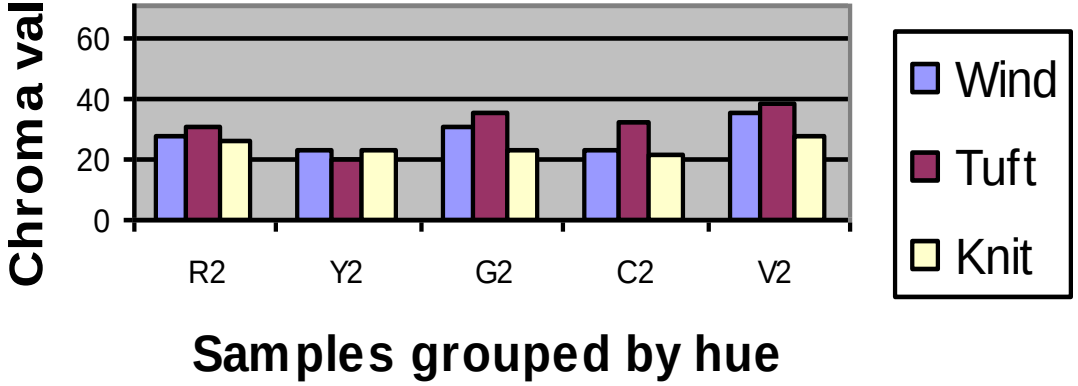
Results for samples with intrinsically low lightness and low chroma

MDDc is negative for tufts

Variation of Lightness with Texture

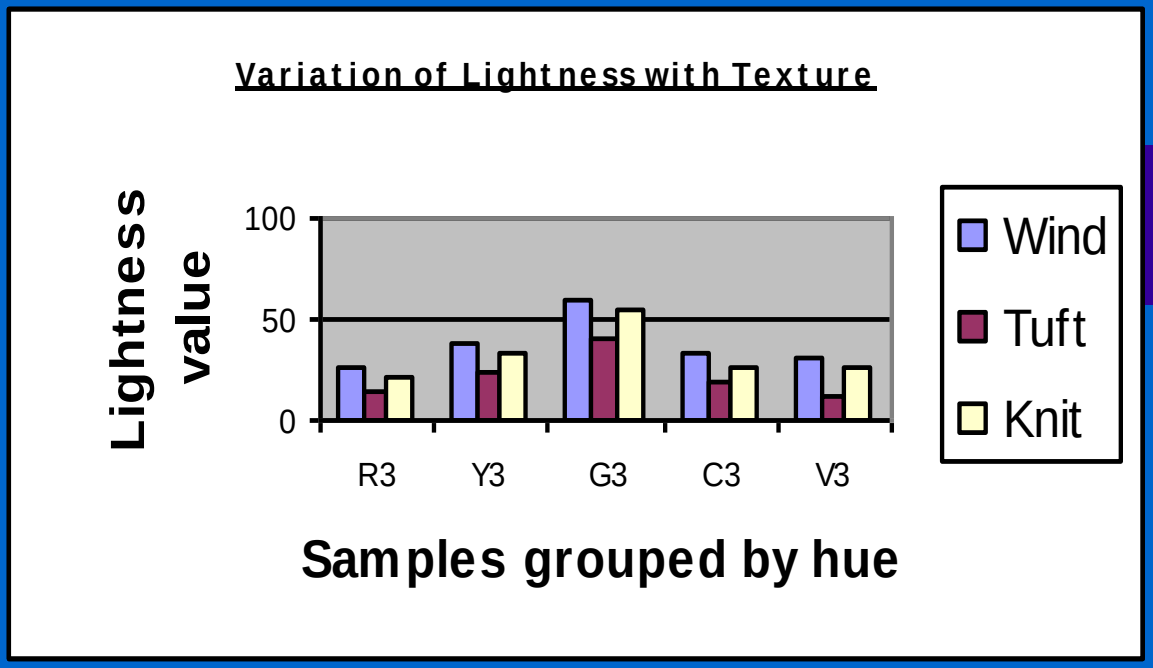


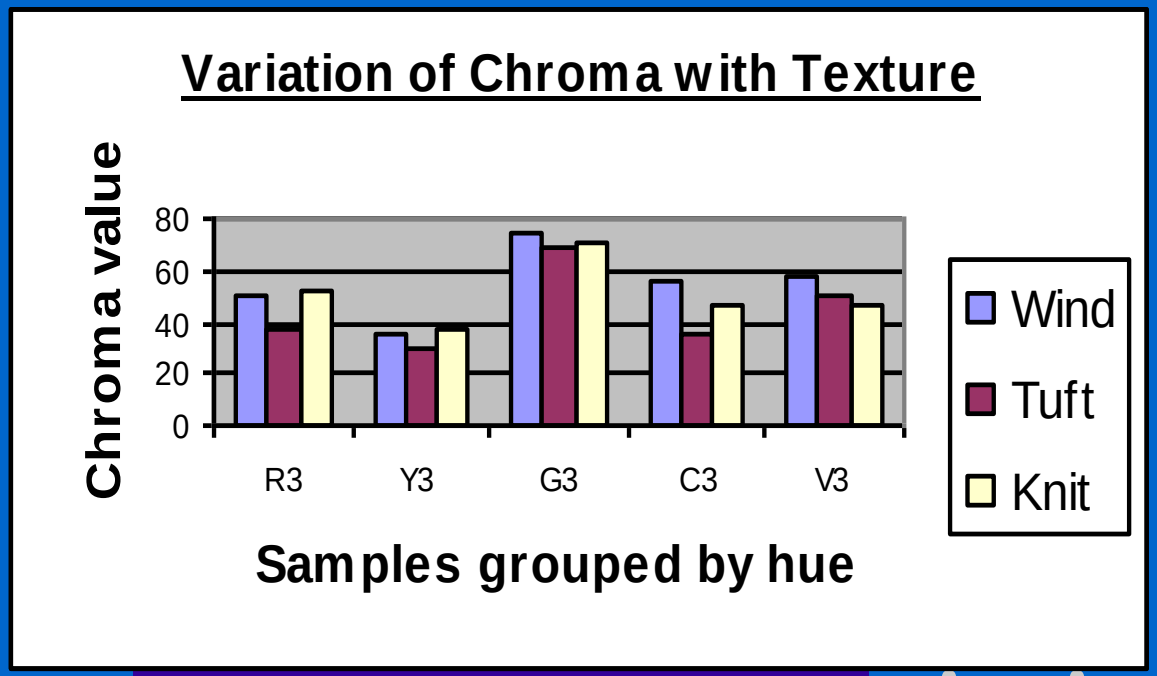
Variation of Chroma with Texture



Results for samples with intrinsically high lightness and low chroma

MDDc is now positive for tufts

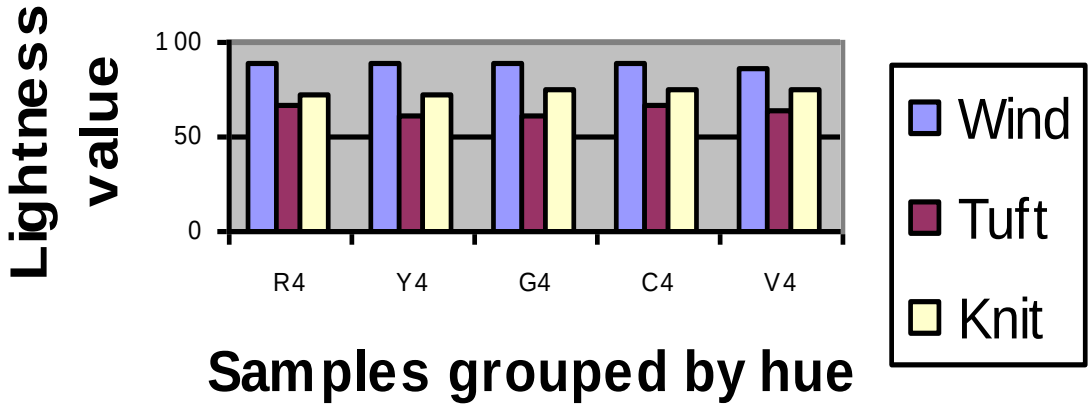




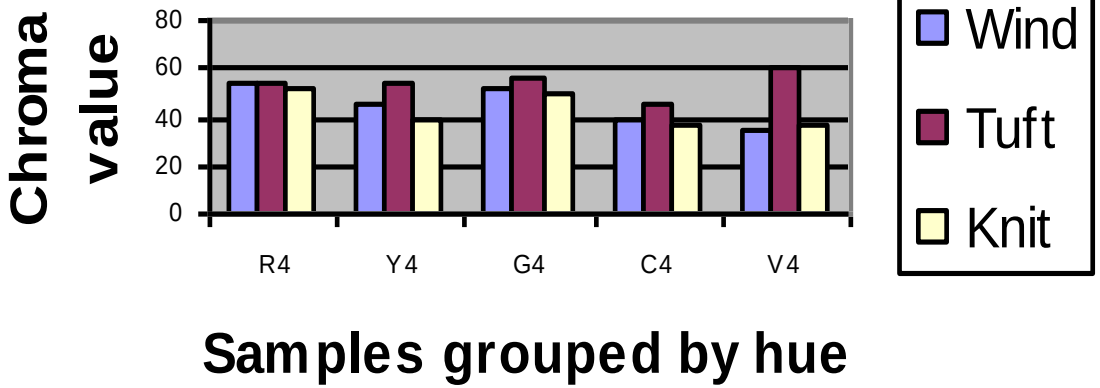
Results for samples with intrinsically low lightness and high chroma

MDDc is again negative for tufts

Variation of Lightness with Texture



Variation of Chroma with Texture



Results for samples

with intrinsically

high lightness

and high chroma

MDDc

now has increased positive value

for tufts

compared to low lightness samples

Overall derived and measured MDD values

Values derived from visually matched images

TEXTURE TYPE	MDD_L	MDD_C	MDD_h
Tufts	-19.56	-1.15	1.88
Knits	-11.06	-2.82	-2.45

Values derived from spectrophotometric measurements

TEXTURE TYPE	MDD_L	MDD_C	MDD_h
Tufts	-15.0	-2.45	1.18
Knits	-3.54	-1.70	-1.09

Individual variations with lightness and chroma

MDD Trends from reference texture for individual lightness and chroma groups.

MDD values for samples with Low Chroma

TEXTURE	Low lightness			High Lightness		
	MDD_L	MDD_C	MDD_h	MDD_L	MDD_C	MDD_h
Tufts	-17.25	-5.00	1.12	-13.83	3.32	2.20
Knits	-10.43	-3.20	-2.32	-17.43	-3.82	-0.64

MDD values for samples with High Chroma

	Low lightness			High Lightness		
	MDD_L	MDD_C	MDD_h	MDD_L	MDD_C	MDD_h
Tufts	-15.12	-10.35	1.34	-24.89	9.18	1.96
Knits	-5.56	-3.86	-1.94	-13.85	-2.38	-3.84

Conclusions

MCI (*Mean Colour Identity*), MDD (*Mean Directional Deviation*), MVD (*Mean Vector Deviation or Displacement*), and Intrinsic Colour, are introduced as measures of colour appearance change with varying texture.

They are shown to relate texture and colour in analyzable ways.

A tentative start has been made on image based colour analysis

The role of texture in colour appearance may prove to be measurable.