Predicting Perceptions: Proceedings of the 3rd International Conference on Appearance, pp. 25-28, Edinburgh, UK, ISBN 978-1-4716-6869-2, April 2012.

Predicting and Measuring the Perceived Texture of Car Paints

Eric Kirchner
AkzoNobel A&AC
PO. Box 3
2170 BA Sassenheim,the Netherlands
+31 713083168
Eric.Kirchner@akzonobel.com

Jyotsna Ravi
AkzoNobel A&AC
Plot#62P, Hoskote Industrial Area
Bangalore 562 114, India
+91 80 22896 717
Ravi.Jyotsna@akzonobel.com

ABSTRACT
In this paper, we describe new methods to predict and measure the perceived texture of car paints. Previously, we have shown that the perceived texture of car paints can best be described by two parameters, Glint impression and Diffuse coarseness. The actually perceived texture is a combination of these, depending mainly on the relative contributions of diffuse versus directional lighting. Commercially available instruments have been developed to accurately measure these texture parameters. As a next step, the paint industry requires a texture model that uses the paint composition as input and produces predicted values for the texture parameters as output. We describe two different types of texture models, which are based on either physical considerations or on a simple statistical approach. We compare the accuracy of the models with the visual accuracy of assessing texture.

Categories and Subject Descriptors
I.2.10 **[Vision and Scene Understanding]**: Texture

General Terms
Measurement.

Keywords
Texture, Optical models, Effect coatings, metallic coatings.

1. INTRODUCTION
For quality control (QC) in the Automotive and Car Refinishes industry, accurate color measurement is crucial. But since a large majority of modern car paints contain metallic and/or pearlescent pigments, apart from color, also visual texture contributes to the appearance of car paints. We have shown that the texture of car paints can be characterized by using two different texture parameters [1] [2]. Under diffuse illumination conditions, at an arm length distance, metallic and pearlescent coatings show a type of irregular light/dark pattern that we have called Diffuse coarseness (Figure 1). But under intense unidirectional light, the same coatings show a sparkling effect formed by many tin y, but very intense light spots that are strikingly brighter than their surrounding (Figure 2). This type of texture was called Glint impression, and often it is strongly dependent on illumination and observation angles. Glint Impression is visible under intense unidirectional illumination conditions only.

Predicting Perceptions: The 3rd International Conference on Appearance, 17-19 April, 2012, Edinburgh, UK. Conference Proceedings Publication ISBN: 978-1-4716-6869-2, Pages: 25-28

Under outside conditions, Glint impression can be thought of as the texture seen under a sunny sky, whereas Diffuse coarseness corresponds to an overcast sky. We defined and quantified these parameters in psychophysical studies [1] [2]. Based on this work, and in collaboration with BYK-Gardner GmbH and Merck KGaA, an instrument was developed that is able to measure the texture parameters. The BYK-mac® instrument integrates a digital camera and a multi-angle spectrophotometer. For Glint impression observed at an y angle between 25° and 75° from gloss angle, the accuracy of measurements as compared to visual assessments varies from 0.51 ± 0.04 to 0.65 ± 0.05 units on a scale from 1 to 9 [3]. Using this instrument in combination with psychophysical studies, studies were published on e.g. the effect of texture on perceived color differences [2], and on the total appearance of car paints [4] [5] [6]. We note that a different, but related set of texture parameters has been introduced by BYK-Gardner GmbH [7] [8].

2. OPTICAL TEXTURE MODEL
Industrial QC requires that corrections in paint composition can be calculated to bring a paint batch within color specifications. Also color matching applications require that using a known paint composition as input, the resulting reflection curves can be calcu lated. To this goal, predictive models were developed already in the first half of the previous century. The most widely employed example is from Kubelka and Munk [7].

With the introduction of the BYK-mac, it became possible to include texture measurements in industrial QC and color matching (Figure 3), thereby solving long standing problems in e.g. QC [9]. Similar to the case for color, this would be best solved by mathematical models that calculate accurate texture values, based on input parameters that specify a paint composition. A straightforward approach would be to derive a physical/optical model. However, such derivations are complicated due to the dispersive nature of coatings. Metallic and pearlescent pigments show particle size distributions. They are oriented in the paint according to orientation distributions, which in turn depend on the particle sizes. Taking such factors into account in ph ysically based texture models soon led to large inaccuracies in the texture predictions.

3. STATISTICAL TEXTURE MODEL
When physical texture models were found to be not accurate enough for practical use, we turned to a different approach. We collected parameters related to coating composition. This included parameters specifying the total concentration of effect (i.e., metallic or pearlescent) pigments,

but also reflection values and CIE-Lab coordinates as predicted using conventional reflection models (e.g. Kubelka-Munk). We added absorption K and scattering S parameters of such models, summed over different types of pigments. Man y of these parameters depend on measurement geometry, leading to an increase in the total number of parameters. With statistical techniques, we correlated all parameters with the measured texture values that we wanted to be able to predict.

Removing all parameters that apparently do not contribute to prediction accuracy, we found that only the parameters listed in Table 1 need to be accounted for in the model for Diffuse Coarseness. The complete Statistical Texture Model was then formed by taking a linear combination of each of these parameters. The pre-coefficients were found by fitting results on
1826 samples of car coatings. For deriving the corresponding model for Glint Impression, a very similar strategy was followed.

Table 1. Specification of terms in the Statistical Texture Model for Diffuse Coarseness

Terms		Remarks
constant	C	C is the summed concentration of non-effect pigments
$\sum c_i K_i$ (i: metallic pigments)	$\sum c_i S_i$ (metallic pigments)	Summation of K, S values for metallic pigments only
$\sum c_i K_i$ (i: pearl pigments)	$\sum c_i S_i$ (pearl pigments)	Summation of K, S values for pearlescent pigments only
$\sum c_i K_i / \sum c_i S_i$		Ratio of the summation of K and S values of the entire formula
$\sum 1/R_\lambda$	$\sum R_\lambda$	Predicted reflection values R, summed over wavelength λ.
$\sum R_\lambda^{1/2}$	$\sum R_\lambda^2$	
L*		Predicted lightness value

Table 2. Accuracy of the Statistical Texture Models, compared to accuracy of visual assessments

Parameter	Model accuracy	Visual accuracy
Diffuse Coarseness	79%	84%
Glint Impression 25°	71%	81%
Glint Impression 45°	76%	87%
Glint Impression 75°	83%	90%

The resulting accuracy of the models is shown in Table 2. The accuracy is expressed as the percentage of predictions in which the model prediction and the BYK-Mac measurement value differ by less than 1 unit, on texture perception scales that run from 1 to 9. In the last column of Table 2, we show the corresponding percentages for visual assessments of texture.

4. CONCLUSIONS

Our attempts to optically predict texture values, using paint composition as input, did not yield accurate results. But when basing the models on a statistical analysis of terms that could contribute to texture, models were found that do show reasonable prediction accuracy. The accuracy of the models is not as good as the accuracy of a visual assessment, as shown in Table 2. But the difference is not dramatic, especially not when one realizes that visual assessments require the paints to be produced, applied, dried and assessed. Running the statistical texture models is a much faster procedure, and already leads to adequate predictions of texture properties of car paints.

5. REFERENCES

[1] Kirchner, E., van den Kieboom, G.J., Njo, L., Supèr, R. and Gottenbos, R. 2007 Observation of visual texture of metallic and pearlescent materials. *Color Res. Appl.* 32 (August 2007), 256-266.
[2] Kirchner, E., Dekker, N., Supèr, R., van den Kieboom, G.J. and Gottenbos, R. 2009. Quantifying the influence of texture on perceived color differences for effect coatings. *Proceedings of the 11th congress of the International Colour Association*. (Sydney, Australia, September 28 –October 2,2009).
[3] Kirchner, E., van den Kieboom, G.J. and Supèr, R. 2008. Accurate measurement of sparkle for effect coatings. *Proceedings of the AIC Interim Meeting.* (Stockholm, Sweden, June 15-18, 2008). Paper No-12.
[4] Dekker, N., Kirchner, E.J.J., Supèr, R., van den Kieboom, G.J. and Gottenbos, R. 2011. Total appearance differences for metallic and pearlescent materials: contributions from color and texture. *Color Res App* 36 (February 2011), 4-14.
[5] Huang, Z., Xu, H., Luo, M.R., Cui, G. and Feng, H. 2010. Assessing total differences for effective samples having variations in color, coarseness, and glint. *Chin. Opt. Lett.* 8 (July 2010), 717-720.
[6] Huang, Z., Xu, H. and Luo, M.R. 2011. Camera-based model to predict the total difference between effect coatings under directional illumination. *Chin. Opt. Lett.* 9 (September 2011), 093301-5.
[7] Klein, G.A. 2010 *Industrial Color Physics*. Springer, New York.
[8] Kigle-Böckler, G. 2009 New and innovative testing technologies for effect finishes. *Proceed ings of the 11th congress of the International Colour Association*. (Sydney, Australia, September 28-October 2, 2009).
[9] Longley, W.V. 1995. Automotive color certification. *Color Res. Appl.* 20 (February 1995), 50-54.

Figure 1. Two car paint samples under diffuse lighting conditions. The samples differ in the texture parameter Diffuse Coarseness

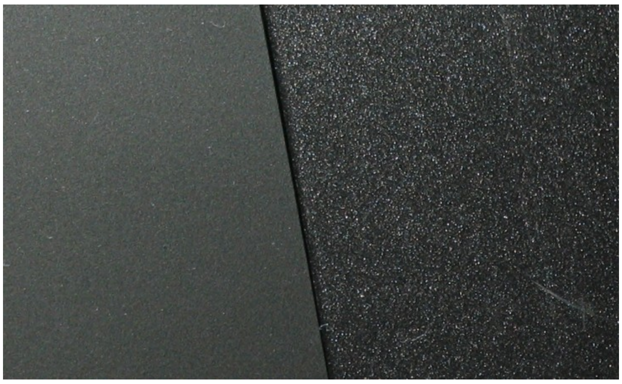

Figure 2. Under intense spot light, a texture difference appears in the parameter Glint Impression.

Figure 3. “Color matching” under a spotlight actually requires assessing both color and texture.