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CARPET EVALUATION BY IMAGING

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Abstract: Carpets suffer an appearance loss with use. Carpet manufacturing companies, before marketing their product, are interested in determining the life of a carpet and the appearance change the carpet undergoes at different wear levels in order to test it acceptability in the market. Traditionally, carpet samples have been tested mechanically and their evaluation process, obviously involves a lot of subjectivity, is time consuming and is often unreliable. This study reviews the image techniques which eliminates instrumental testing in carpet evaluation.

Key Words: Image, carpet, evaluation.

Görüntü İle Halı Değerlendirme

Özet: Kullanım ile birlikte halı yüzeyleri eskiyerek görünümlerini kaybederler. Halı üreticileri, ürünleri pazarlamadan önce ürünlerinin ömürlerini ve görünüm kabiliyetlerini, pazarda şanslarını test edebilmek için, farklı kullanım şartları için tanımlamak isterler. Bu değerlendirme işlemlerinin çoğu zaman alıcı ve güven seviyeleri düşüktür. Bu çalışma, bu değerlendirme işlemini daha kısa sürede fiziksel testler yerine görüntüleme teknikleri yapmayı hedefleyen teknikleri değerlendirmektedir.

Anahtar Kelimeler: Görüntüleme, halı, değerlendirme.

1. INTRODUCTION

Carpets suffer an appearance loss with use. Carpet manufacturing companies, before marketing their product, are interested in determining the life of a carpet and the appearance change the carpet undergoes at different wear levels in order to test it acceptability in the market. Traditionally, carpet samples have been subjected to simulated wear on the drum and also by actual foot-walk. These worn samples are then assessed by a group of experts. The evaluation process, obviously involves a lot of subjectivity, is time consuming and is often unreliable.

Carpets in use show a change in appearance due to the wear it is subjected to. The tufts in a new carpet are periodically arranged and are laid in one direction. But with use the tufts is flatten and gets mat. Moreover the reflectance behavior of the carpet changes because the lay of the piles is no longer uniform, making it unaesthetic.

The need for proper instrumentation to eliminate the subjectivity involved in carpet evaluation has been felt. In the past two to three years a lot of work has been done in developing an expert system using Image Processing Techniques. The previous studies talk about tuft isolation, tuft size distribution, changes in reflectivity of the carpet, change in periodicity, etc.

This paper first talks about some of the techniques that have been used in previous studies for carpet evaluation. The development of any expert system for carpet images. This paper discusses about the techniques that can be used to construct a three dimensional surface using the two dimensional images captured by the video camera.

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2. LITERATURE REVIEW

The image capture method may differ from person to person and is not being discussed in this paper. Also the method of image storage or the microprocessor system used for analysis is not being discussed. It is assumed that the reader already has an captured image, stored in pixel form, for analysis.

The operations that image can be subjected to can be broadly classed into the following three categories:

a) Point Operations: These operations work on individual pixel and use the information associated with that pixel alone.
b) Neighborhood Operations: These change the value of a pixel taking into account the information of the neighborhood pixels.
c) Global Operations: These are operations which effect all the pixels in the image.

2.1. Use of Transfer Function

In this technique the value associated with each pixel is modified using a transfer function. This can be done to equalize the brightness in the image. Histogram Equalization is one such process (Sobus et al 1991), which helps in increasing the contrast in regions of high gradients in gray scale level. The brightness re-scaling transfer function could be as simple as:

$$\mathrm{NEWVALUE} = \frac{\mathrm{RANGE} \times (\mathrm{OLDVALUE} - \mathrm{MINVALUE})}{(\mathrm{MAXVALUE} - \mathrm{MINVALUE})}$$

2.2. Frequency Thresholding and Binary Image Formation

The image obtained is usually a gray scale image. The image is hence complicated to analyze. For the sake of simplicity, the gray scale image is converted into a binary image, a black and white image. The black and white image is useful in that many Boolean operations can be performed on them. The binary image is obtained by a process called as Thresholding. All pixels above a certain brightness are set to white and those below it are set to black, thus giving us a black and white image (Jose et al 1986).

2.3. Erosion and Dilation

These are binary operations which work on a binary image. Say, we have to tufts which are touching at a place and we need to separate the two, then the tufts are subjected to erosion, that is the boundaries of the tufts are separated and then the tufts are Dilated back, that is their sizes are once again increased, the result of erosion followed with dilation is the creation of a gap between the two tufts. This process is called Opening (Sobus et al 1992, Wu et al 1990, 1991).

2.4. Skeletenization

This is the extreme case of erosion. Here the feature in the image is eroded till the feature is just one pixel thick. Xu et al (1992) use this technique for the measurement of fiber crimp.

2.5. Co–Occurrence Analysis

This is a global technique which summarizes the weighted (no. of times a particular gray level occurs) inputs from the entire image. This has been dealt with in detail in (Sobus et al 1991).

2.6. Covariance Analysis

In this a copy of the image is moved with respect to the original image in small steps. At each point the number of overlapping black pixels (say) are counted. A plot of the area of overlap and the distance traversed is plotted. If the image is truly random we obtain a straight line, but a presence of periodicity gives us a sine-like curve. When images of new carpets are subjected to this analysis then due to the periodicity of the tufts we get a sine-like wave. When the carpet is subjected to wear they lose this periodicity. Information regarding the loss in periodicity of the carpets indicates the wear that a carpet has undergone (Sobus et al 1992).

2.7. Watershed Technique

A distance map is created, in which the brightness of the gray pixel is a measure of how far the corresponding binary pixel is from the outer periphery. Here the image is repeatedly eroded to get ultimately eroded sets which are than dilated. This results in the separation of the edges (e.g. tufts).

2.8. Edge Detection and Image Sharpening Using the Laplacian Operator

One of the basic requirements of a carpet evaluation system is the ability of the system to detect the edges of the tufts. The Laplacian operator is of the following form:

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

When a Laplacian operator is applied to an image, the result is a derived image in which edges, lines and point discontinuities appear and uniform areas are suppressed.

If the Laplacian of the image is added to the original image, it has the effect of enhancing the image. The overall contrast of the image is reduced.

2.9. Correcting Image Defects

The defects in the images can either be random or periodic. The random noise can be removed by averaging multiple of the same position (Russ 1990). Defects can also be removed by neighborhood averaging. Here the value of each pixel is replaced by the average value of its eight nearest neighbors. Median filtering is another method in which the value of each pixel is replaced by the median of the values of the current pixel and its eight nearest neighbors.

3. EXTRACTION OF 3-DIMENSIONAL INFORMATION FROM IMAGES

Computer Vision is the field which deals with the extraction of structural details from images. This certainly is the toughest part, but it is also of immense value. Not much work has been done in the application of Computer Vision to Carpet Evaluation (Brown 1988).

The techniques used for structure extraction can basically be classed as under:

A) Interpreting a Single Image.

i) Finding the edges ,junctions etc. From the line drawing.

ii= Interpreting surfaces from the single image.

B) Interpreting Multiple Images.

The techniques for 3-dimensionel information extraction are discussed and it has been explained how they can be used in the development of carpet evaluation systems (Gonzalez 1987).

3.1. Shape From Shading

Shading can provide a lot of information about the surface orientation in three dimensions. The development of the Image Irradiance Equation is the first step. Woodham (1981) discussed this in detail. The reflectance characteristics of a surface can be represented as a function of (***i, e, g***) where

i is the angle of reflection,

e is the angle of reflection, and

g is the angle between the viewer and light source.

The irradiance equation gives us the surface normals at each point of the image. These normals can be used to interpret the carpet three dimensionally. The image irradiance equation can be calculated for standard shapes and then the image irradiance function for the image can be compared with them. A match would indicate a surface similar to that standard surface in the region for which the match is found. The finding of the image irradiance equation is still a problem and is yet to be satisfactorily resolved, before it can be actually applied.

3.2. Interpreting Line Drawings

Barrow and Tenenbaum (1981) talk about an algorithm to interpret line drawings. They propose a three step process.

The first step involves the identification of all discontinuities, and then to classify these as either discontinuity boundaries or as external boundaries. The classification is attempted using two cues the local cues as the line junctions and the global cues such as symmetry and parallelism. They claim that if two lines are parallel then it can be assumed that both represent similar space curves. If an image is symmetric then it could be approximated as generalized cylinders.

After the lines have been classified, the next step involves the 3-demensional interpretation of these lines subject to the following constraints:

i) Surface Smoothness: A smooth curve in the image is assumed to correspond to smooth space curve. They define the smooth curve to be one in which the curvature chance is a minimum. If an elliptical image is developed subject to the above constraint then we get a long spiral is not what is required. Therefore, another restriction is applied that the plane should have a minimum out of its plane.

ii) The above assumption fails to reproduce surfaces from polyhedras. Therefore another assumption is made called the Generalized Position Assumption. This says that if we have a straight line in the image then it can be assumed that it corresponds to a straight line in the space curve.

3.3. Interpreting Shape From Texture

Texture refers to the image intensity level. This is likely to be a property of the three dimensional surface of the body. It can provide strong cues regarding the orientation and the depth of the surface. Even if we assume that there is a mechanism to interpret surfaces from texture, we have a problem in that we can multiple surfaces which can give the same image.

Texture may be attacked from various points, we may search the image for texture ‘primitives’ – a picture of a brick wall for example, is made up rectangular primitives. In the case of carpets one expects to have a circular primitive due to the shape of the tuft. An initial primitive may be circular. As the carpet is subjected to wear the primitive shape may change by losing its circularity. This change in the primitive can be used as a measure of wear level while assessing the carpets (Spivak et al 1988).

From the view point of shape extraction, the most direct approach is to determine the texture gradient. The texture gradient is the direction of maximum rate of change of size of a projected texture primitive and can provide obvious information about the orientation of observed surfaces (Boyle 1988).

3.4. Interpreting Shape From Stereo

The depth information which is missing in the two-dimensional images that we have can be obtained if we have two images of the same object from two different locations of the camera. Two separate image views of an object of interest are taken into account. The distance between the centers of two lenses is called the baseline, and the purpose is to find the coordinates (X,Y,Z) of the point “w” given its images (x1,y1) and (x2, y2). It is assumed that the cameras are identical and the coordinate systems of both cameras are perfectly aligned, differing only in the location of their origins. It can be shown from simple trigonometry that the depth Z can be given by the following equation (Wood et al 1989).

$$Z = \alpha - \frac{\alpha B}{(x_1 - x_2)}$$

3.5. Shape From Stereo-Photometry

This is similar to spectroscopy. The being that here the light source is moved between successive images. The images differ due to the change in angle of incidence of the surface and hence the images can be used to get the reflectance contours which can directly give us the surface shape (Wilding .et al 1990)

All the techniques discussed above can be applied to carpets. The contour diagrams can be obtained. By just studying the three dimensional shape change that a carpet tuft has undergone one can decide on the wear of the carpet. The carpet wear can thus be quantified, eliminating the subjectivity involved in carpet evaluation to a great extent.

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