Glass/Metal Classification

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***Abstract*—In this paper a classification method for glass/metal classification based on Gray Level Co-occurrence Matrix (GLCM) is presented. GLCM is calculated from the given images. Then the statistical features contrast, dissimilarity, homogeneity, Active Shape Model (ASM), energy and correlation are calculated from the GLCM in different combinations. The output is given as input to different classification models such as Random Forest (RF), K Nearest Neighbours (KNN) and Support Vector Machine (SVM) to compare which one gives a more successful accuracy rate. Empirical results have given an accuracy rate of 0.55 approximately.**

***Index Terms*—gray level co-occurrence matrix, material classification, materials**

I. Introduction

Materials are a part of everyday life. Classification of these materials from their appearance is a challenging problem, especially if illumination conditions are permitted to change and the background is not stable. A material's appearance can vary considerably as these conditions change. To overcome this issue, binary bit-masks are applied to input data.

In this project, the class count of materials to be classified has been reduced to two classes, glass and metal. Distinction between these two classes are discussed in following sections.

During developing the classification method, different feature extraction methods are studied. An empirical investigation is conducted to show how the classification accuracy varies with different methods are discussed in following sections.

II. Glass and Metal: Terminology

In material engineering, glass is a subclass of *ceramics*. Ceramics are generally made by taking mixtures of clay, earthen elements, powders, and water and shaping them into desired forms. Once the ceramic has been shaped, it is fired in a high temperature oven known as a kiln [1]. Often, ceramics are covered in decorative, waterproof, paint-like substances known as glazes. The crystallinity of ceramic materials ranges from highly oriented to semi-crystalline, vitrified, and often completely amorphous and transparent (glasses) [2].

On the other hand *metals* are a main class in material taxonomy. They are opaque and lustrous (or shiny) elements that are good conductors of heat and electricity. Most metals are malleable and ductile, and are generally more dense than the other pure solid material. When something is malleable, it means that they can be molded. Ductile means that the material can be stretched into a thin wire [3].

III. Methodology

The studied method for classification is built based on Gray-Level Co-Occurrence Matrix (GLCM) and by applying Random Forest (RF) as classifier.

A. Gray-Level Co-Occurrence Matrix

A co-occurrence matrix, also referred to as a co-occurrence distribution, is defined over an image to be the distribution of co-occurring values at a given offset. Or it represents the distance and angular spatial relationship over an image subregion of specific size.

The GLCM is created from a gray-scale image. It calculates how often a pixel with gray-level (grayscale intensity or Tone) value i occurs either horizontally, vertically, or diagonally to adjacent pixels with the value j [4].

B. Random Forest Classifier

Random forests or random decision forests are an ensemble learning method for classification, regression and other tasks that operates by constructing a multitude of decision trees at training time. For classification tasks, the output of the random forest is the class selected by most trees.

Each tree is grown as follows:

- If the number of cases in the training set is N, sample N cases at random - but with replacement, from the original data. This sample will be the training set for growing the tree.
- If there are M input variables, a number m<<M is specified such that at each node, m variables are selected at random out of the M and the best split on these m is used to split the node. The value of m is held constant during the forest growing.
- Each tree is grown to the largest extent possible. There is no pruning.

IV. Studied Method

Main system is formed of two general steps which include feature extraction and classification. Further information is given in following sub sections.

A. Feature Extraction

In this project the used data is taken from Flickr Material Database (FMD) [5]. Since this is a classification problem only in between glass and metal materials, a subset of the whole data set is used.

The first approach to feature extraction was to apply Principal Component Analysis (PCA) to given images. Unfortunately the backgrounds from images created unneeded features. After discussion with advisors, without further ado, bit masks are applied to the input images which are taken from the FMD as well, so that point of interest would be more precise.

Then, GLCM is applied to gray-scale read masked images. Since after the masking operation the background pixel have become black, the first column and row of the GLCM is discarded to get rid of the co-occurrences that involve background pixels. Next, the GLCM is normalized so that the sum of its elements is equal to 1.

Later on,a feature is computed of a grey level co-occurrence matrix to serve as a compact summary of the matrix. The properties are computed as follows [6]:

- contrast: $\sum_{i,j=0}^{levels-1} P_{i,j}(i-j)^2$
- dissimilarity : $\sum_{i,j=0}^{levels-1} P_{i,j}|i-j|$
- homogeneity : $\sum_{i,j=0}^{levels-1} \frac{P_{i,j}}{1+(i-j)^2}$
- ASM : $\sum_{i,j=0}^{levels-1} P_{i,j}^2$
- energy : $\sqrt{ASM}$
- correlation : $\sum_{i,j=0}^{levels-1} P_{i,j} \left[\frac{(i-\mu_i)\ (j-\mu_j)}{\sqrt{(\sigma_i^2)(\sigma_j^2)}} \right]$

B. Classification

In classification step, the derived GLCM feature vectors are given as inputs to different classification models to test out which model is more consistent with the used data set. These models are RF, K Nearest Neighbors(KNN) and Support Vector Machine (SVM).

TABLE I
ACCURACY RATES ACCORDING TO MODELS

Model	Accuracy Rate	Standard Deviation
RF	0.64	0.03
KNN	0.50	0.05
SVM	0.60	0.06

Although SVM gives an accuracy rate 0.70 for a specific case, in general, RF classifier works more accurately. This specific case is when options for GLCM is homogeneity and energy.

Classification performance is done by cross validation. The performance metric is the correct prediction of image classes.

V. CONCLUSION

Material classification based on texture and gray-scale relation is a valid method according to the accuracy rates. Due to data set selection, random forest classification ends up with the best result among other models. Although, a more stable data set which has a specific region of interest for the materials could end up with a better result. This can be another research topic for interested researchers [7].

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