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An Approach on Determination on Coal Quality using Digital Image Processing

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ABSTRACT
Worldwide coal in the 21st century will be influenced by concerns about the effects of coal combustion on the local, regional and global environment and on human health. Reliable coal quality data can help decision maker to better assess the risks and limit the possible environmental degradation and impact on health. Although millions of coal analysis have been performed worldwide, existing national quality databases are generally of limited use because much of the data are not readily accessible; geographic coverage are not comprehensive; analytical data may not be accurate; samples may not be representative, or current. This paper attempts to gives a fast, accurate, user-friendly and computerized method for analysis of coal quality using techniques of digital image processing for its better utilization.
Keywords – Coal Quality, Coal Composition, Digital Image Processing, Saliency Map

I. INTRODUCTION

The rock that we refer to as coal is derived principally from decomposed organic matter (plants) consisting primarily of the element carbon. When coal is burned, it produces energy in the form of heat, which is used to power machines such as steam engines or to drive turbines that produce electricity.

"Coal quality" is the term used to refer to the properties and characteristics of coal that influence its behaviour and use. Among the coal-quality characteristics that will be important for future coal use are the concentrations, distribution, and forms of the many elements contained in the coal that we intend to burn. Knowledge of these quality characteristics in coal deposits may allow us to use this essential energy resource more efficiently and effectively and with less undesirable environmental impact.

Our objective of work is to analyse the quality of various coals based on their compositions and find which coal is suited best for which kind of industry. Also coal analysis helps in determining the rank of the coal along with its intrinsic characteristics**.** Furthermore, these data will be used as the fundamental consideration for future concerns, for instance: coal trading and its utilizations.

1.1 COAL COMPOSITION

Coal is classified into three major types namely anthracite, bituminous, and lignite. However there is no clear demarcation between them and coal is also further classified as semi- anthracite, semi-bituminous, and sub-bituminous.

Coal is composed of complex mixtures of organic and inorganic compounds. The organic compounds in coal are composed of the elements carbon, hydrogen, oxygen, nitrogen, Sulphur, and trace amounts of a variety of other elements. Each type of coal has a certain set of physical parameters which are mostly controlled by moisture, volatile content (in terms of aliphatic or aromatic hydrocarbons) and carbon content. The most basic analysis carried out to determine characteristics of a coal is called proximate analysis.

Broadly percentage of Carbon, Hydrogen, Oxygen, and Ash for different ranks of coals are summarized here indicating progressive changes:

Table -1: Percentage compositions of Carbon, Hydrogen, Oxygen and Ash in various coal types.

	Lignite	Bituminous	Semi Anthracite	Anthracite
Hydrogen %	*5.5	5.5-6	4.8-5	<2.8
Oxygen %	*20	8-18	3-8	<3
Ash%	<5*	3 to 12	10 to 20	10 to 20
Carbon %	25-35	46-86	87-98	87-98

II. PROPOSED METHOD

There are various standards for the quality classification of coal into various ranks. Basically, two parameters, *fixed carbon content* and *calorific value* are used for this classification. These systems serve well for the general utilization of coal by the metallurgical coke industries (e.g., Steel), who are interested in the fixed carbon content and coking ability of coal, and by power generation industries, to whom the heating ability is of primary concern. Many existing methods of classification are based on the reflectance of coal.

The current practice of coal sample analysis is a very time-consuming process because number of coal samples from different regions need to be taken. Each sample is manually inspected by an analyst and it takes almost a full shift for an operator to inspect one sample. Such operators are scarce and the overall operation is repetitive, strenuous, subjective and often not very accurate. Moreover, the number of samples per day is much too high compared to the number of trained operators and the microscope systems available. Keeping this in view, the following objectives were laid down for the project:

(i) To standardize the analysis on an objective basis;
(ii) To automate the analysis of the samples to a high degree.

The proposed solution to the problem was sought with the help of digitized images of the coal. The classification of the different constituent parts has been done by using an algorithm, and once the different components have been reliably separated, the computation of relative proportions is straightforward. The methodology can be explained by a simple flowchart as shown below:

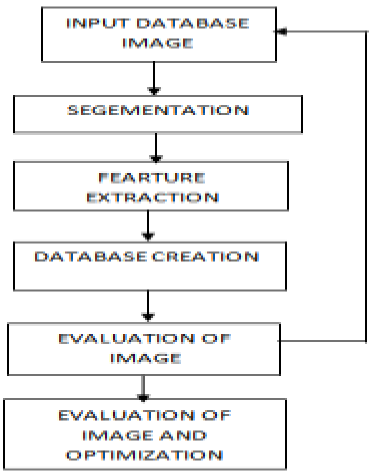

Chart -1: Flow chart of proposed method

The steps followed in the analysis of the coal images are described as under:

A. Dataset collection

Data set collection will form a primary step in the method. Here we will collect the dataset of various coal images. This step will decide the accuracy of our system, because the better the dataset, the better outputs we will get.

B. Segmentation using Saliency Map Technique

Each dataset image will be given to a saliency map algorithm to find out the region of interest. Saliency maps have been widely used in the recent years for Computer Graphics applications, mostly in order to save computing time in rendering algorithms. Video coding applications have also emerged, keeping a better image quality in salient areas. The computation of saliency maps for Low Dynamic Range (LDR) and High Dynamic Range (HDR) images is efficient.

C. Feature extraction

Once the image is segmented, then features of the image will be extracted. Features of the image will include the area, shape, texture and more.

D. Database creation

After feature extraction, each of the features would be saved in the database along with the type and composition of the coal image. The database once formed will be referred every time the new sample of coal is been tested.

E. Evaluation of the image

The test image will then be given at the input and the classification algorithm will be applied to get the type of the image and the composition in it. The type of the image will be classified according to the features.

F. Result evaluation and optimization

The final images obtained will be evaluated and optimized by comparing to actual database collected for the project. The accuracy of the method will depend upon elaboration of the dataset collected.

III. DIGITAL IMAGE PROCESSING METHODS

In this project work we work on digital images (X-ray images) of coal samples on MATLAB software. There are several approaches or techniques for processing of images, the relevant one used are described below.

3.1 Image Acquisition

Image acquisition in image processing can be broadly defined as the action of retrieving an image from some source, usually a hardware-based source, so it can be passed through whatever processes need to occur afterward. Performing image acquisition in image processing is always the first step in the workflow sequence because, without an image, no processing is possible. In this work, the digital coal images are captured using x-ray machine. These x-ray images are being processed upon to extract features.

3.2 Image Segmentation

Image segmentation, which divides an image into foreground and background, is an important task for several applications in vision area such as object detection and classification. To achieve this automatic image segmentation, we incorporate saliency map for an image as an initial cue for image segmentation.

Saliency map has its root in Feature Integration Theory [2] and appears first in the class of algorithmic models. It includes the following elements (see Figure 1):

(i) An early representation composed of a set of feature maps, computed in parallel, permitting separate representations of several stimulus characteristics.
(ii) A topographic saliency map where each location encodes the combination of properties across all feature maps as a conspicuity measure.
(iii) A selective mapping into a central non-topographic representation, through the topographic saliency map, of the properties of a single visual location.
(iv) A winner-take-all (WTA) network implementing the selection process based on one major rule: conspicuity of location (minor rules of proximity or similarity preference are also suggested).
(v) Inhibition of this selected location that causes an automatic shift to the next most conspicuous location. Feature maps code conspicuity within a particular feature dimension.

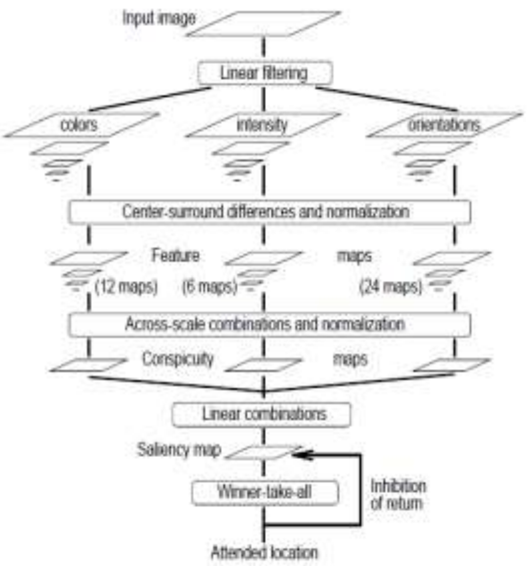

Figure 1: The architecture of Itti & Koch model. (Figure adapted from L. Itti, C. Koch and Ernst Niebur (1998)

The saliency map combines information from each of the feature maps into a global measure where points corresponding to one location in a feature map project to single units in the saliency map. Saliency at a given location is determined by the degree of difference between that location and its surround.

3.3 Feature Extraction

A) Edge Detection

Edges characterize boundaries and are therefore a problem of fundamental importance in image processing. Image Edge detection significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. Since edge detection is in the forefront of image processing for object detection, it is crucial to have a good understanding of edge detection algorithms.

It has been shown that the Canny's edge detection algorithm [3] performs better than all these operators under almost all scenarios. Evaluation of the images showed that under noisy conditions Canny, LoG (Laplacian of Gaussian), Robert, Prewitt, Sobel exhibit better performance, respectively. 1. It has been observed that Canny's edge detection algorithm is computationally more expensive compared to LoG (Laplacian of Gaussian), Sobel, Prewitt and Robert's operator.

B) Histogram

A histogram is the depiction of the distribution of the gray-levels in an image. A low contrast image would have the distribution concentrated in a small area. By manipulating the histogram, the image can be enhanced. Sliding of the image is simply adding (or subtracting) a constant value from the gray-scale value of each pixel. Sliding the histogram produces the effect of adding constant brightness (or darkness) to an image. Histogram stretching is the multiplication (or division) of a constant value to all the pixel values. These operations result in a "better" image with well-balanced contrast characteristics. However, it must be noted that a visually "better" image may not be the goal of the operations. For example, a high contrast image may be necessary to highlight a small feature of interest in the image. The ultimate goal of use of the image must always be kept in mind before applying any enhancement operations to an image. Care should always be taken to make sure no important information is lost in the filtering operations.

3.4 Image Classification

The problem is a large and complex one, it makes sense to first try a simple method to see what performance can be achieved. We propose to use k-nearest neighbour approach [4] as a classifier in this work. An object is classified by a majority vote of its neighbours, with the object being assigned to the class which is most common amongst its *k* nearest neighbours. The motivation for this classifier is that patterns which are close to each other in the feature space are likely to belong to the same pattern class. The neighbours are taken from a set of samples for which the correct classification is known. It is usual to use the Euclidean distance, though other distance measures, such as the City block, Cosine distances could be used instead. In this work we have used three different distance measures viz., Euclidean, City block and Cosine distance measure to study the effect on classification accuracy.

III. CONCLUSION

On the basis of the above applications and methods, it is proposed to characterize coal samples using imaging techniques. Images of statistically valid coal samples will be collected from the standard database and will be suitably segmented using above methods. These segmented images will be further used for feature extraction where we will extract feature and classification. Lastly the results will be evaluated based on the formed dataset and displayed.

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