Determination of Percentage of Mineral in Beach Sand Using Digital Image Processing Techniques

PMDGSK Abeyrathna, IMMS Bandara,GARanaweerasinghe, K Tharmakulasingham and *LPS Rohitha

Department of Earth Resources Engineering, University of Moratuwa, Sri Lanka.

*Corresponding author-rohithasudath@yahoo.com

Abstract: Determination of percentage ofmineral is extremely important in beach sand mining industry. To select a site for extraction and processing heavy minerals it is important to assess the rough concentrations. The traditional methods are time consuming, costly, high labour intensive and difficult to handle the equipment. A method was developed to determine the percentage of minerals in raw sand by Digital Image Processing. HSV colour space was selected due to its wide range when compared to other colour spaces. Non over lapping samples were analyzed in this research. Most appropriate background was selected using colour analysis of HSV values. Background was differentiated from the minerals by using HSV values. By analyzing the pixels, area occupied by the minerals can be determined and using weight to area relationship, the weight percentage of minerals can be identified. Validation was carried out and using the statics accuracy was estimated. There are some limitations despite the benefits.

Key words: Mineral percentage, Digital Image Processing, non- overlapping, HSV Value

1. Introduction

n this research, a method is described to determine the percentage of minerals by Digital Image Processing. Currently there are various industrial methods to separate beach sand such as gravitational methods, electrostatic methods (Sa,1989), magnetic methods etc. (San,1985) Traditional mineral percentage identification methods are time consuming, need large amount of sand sample for separation, handling of those equipment is very hard and costly. Using these methods for testing purposes like measuring mineral percentage is ineffective. As a solution a software was designed to overcome these limitations.

Colours have been used for identification and classification of property since the computer technologies have supplied consistent color definitions (Gökay and Gundogdu, 2008). Grains can be differentiated using on the basis of their differing reflectance.

With the development of technology image capturing technology has also developed and image processing methods have taken their place in

many disciplines as standard measurement and evaluation method. Capturing images quickly, detection of color and physical size over image, advantage of analysis in short time made image processing methods superior over conventional analysis methods.

In this research the colour properties of minerals analyzed using Digital image processing technology for BEACH sand minerals. Pulmudei beach sands are the source material and a method was developed to determine mineral percentages. There are several minerals such as Ilmanite, Garnet, Rutile, Quartz, Zercone and Magnetite in the beach sand. But Ilmanite, Garnet, and Quartz have been used for this analysis at the initial stage. Single software have been developed that can determine each mineral percentage of a particular area in beach sand sample, which would be very efficient for surveying purposes. This software can be used as primary analyzing tool.

2. Methodology

Software was coded with the aid of **Matlab** software and following functions were used.

Table - 1Matlab functions used for software development

Functions	Task
Imread	This function read the selected image and stored it into 3D matrix in RGB colour space
Imshow	This function displays the stored image in a new window
Impoly	This function allows to select the part of the image using polygon
rgb2hsv	This function convert RGB colour space to HSV colour space
createMask	Create a mask using binary image on selected portion using impoly
Imhist	Create histogram on selected colour space and store its values and number of pixel in a matrix
uint8	Data type which is used to store image pixel values
num2str	Convert numbers in to strings this allows numbers to display in a static text
Cat	Link number of arrays or matrix along specified dimensions
size	Stores size of the specified dimensions

For validation purpose pure Quarts, approximately 88% of garnet and 97% of Ilmenite were taken.

Prior to capturing the photographs, all sand samples were oven dried for 2 hours at 105°C in order to reduce the moisture effect on the reflectance and hence affect results. Also wet particles can make lumps and lead to error.

Non overlapping samples were used to this experiment. So proper background selection is most

important for effective and accurate analysis. Proper background was selected using following method with the aid of developed software.

Yellow, blue, green, black, and white colours were selected as background and HSV values were obtained. Then the HSV values of Quartz, Ilmanite, and Garnet also were obtained. Charts below shows the analysis of "H", "S" and "V" values of minerals and blue background colours

Figure 1. Blue background with Quartz

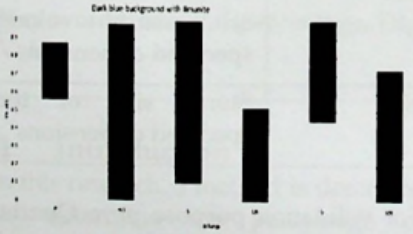

Figure 2. Blue backgrounds with Imanite

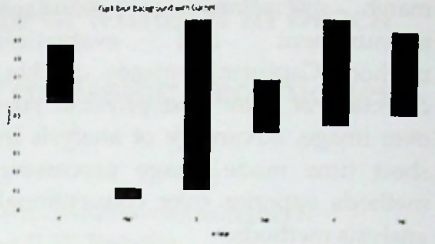

Figure 3. Yellow backgrounds with Ilmenite

Figure 4. Yellow backgrounds with Quartz

Figure 5. Yellow backgrounds with Garnet

There are no HSV values in that blue background which does not overlap with the HSV values of minerals except Garnet. Then this background was rejected. Other backgrounds have same problems and they have been rejected except yellow.

Yellow background was selected as background colour and non-overlapping samples reconstructed due to impurity of sampling minerals

prepared with following composition.

Table 2. Actual mineral weight and resulted weight from software

GARNET		ILMANITE		QUARTZ	
W1	W2	W1	W2	W1	W2
0.9	1.0	1.0	0.9	1.2	1.1
2.6	3.3	0.0	0.5	0.4	0.0
0.0	0.1	1.6	1.7	0.1	0.0
0.9	0.5	1.2	0.9	0.6	0.7
0.9	0.7	0.8	0.4	1.0	1.3
0.9	0.6	1.5	1.6	1.3	1.8
1.3	1.4	0.0	-0.2	0.2	0.2
0.0	-0.1	1.0	0.7	3.0	2.9
1.1	2.2	0.4	0.3	1.0	0.5
1.4	1.8	0.0	0.2	1.2	1.1
1.3	0.8	1.9	2.5	1.7	1.9
0.9	0.7	1.0	0.9	0.2	0.1
0.0	0.0	1.2	1.1	2.0	1.9
0.7	0.3	1.9	1.6	1.1	1.4
0.0	0.3	1.6	1.7	1.1	1.0
0.4	0.3	1.5	1.8	1.1	0.9
0.0	1.3	0.4	0.4	1.5	0.2
0.9	0.4	0.8	0.8	1.7	1.9
1.1	0.9	1.0	0.7	1.2	1.3
0.4	0.4	1.6	1.2	1.7	1.7
0.9	0.7	1.0	0.8	0.6	1.0
0.7	0.3	1.0	1.1	1.3	1.7
1.8	1.9	0.0	-0.1	0.3	0.3
0.9	0.4	0.0	0.2	2.1	2.4
1.8	1.3			1.2	1.6

W1- measured weight, W2- actual weight

Those samples containing with 3g were prepared on the A4 size sheet. Photographs were taken by reducing shadow effect under florescent light condition by maintaining appropriate height. The accuracy of results highly depends on the resolution of the camera. Since sand particles are very small in size it is crucial to use camera with high resolution to get particles detail in the images. DSLR camera with 24 million pixels has been used to increase the accuracy. More details can be obtained in the image and analysis becomes more accurate.

All photographs were introduced to the software and relevant areas were obtained. Entire area of three minerals should be equal to hundred if it is not, it should be adjusted as follows;

Relationship between the area and weight was obtained by drawing graphs between reconstructed weight and area as follows,

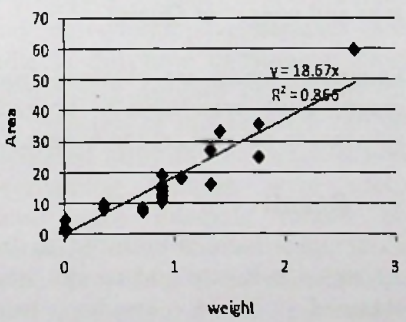

Figure 6. Relationships between area and weight of garnet

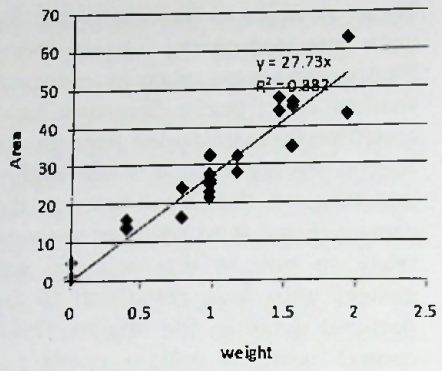

Figure 7. Relationships between area and weight ofilmanaite

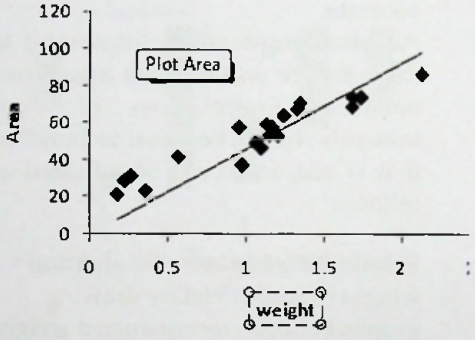

Figure 8. Relationships between area and weight of Quartz

Equations which are obtained from graphs have been used to upgrade software to convert area to weight.

3. Result

25 samples were introduced to the upgraded software and results were obtained. Those results were subjected to hypothesis test between measured weight mean and mean weight which was obtained from software by using minitab software. Hypothesis test accepted and it was made sure that there is no significance difference between two means.

4. Discussion

There are lot of problems which can be identified with regard to each step. One of the main problemswith non-overlapping samples is sample size. Large quantity of samples cannot be used and it requires large space to spread the minerals. But reducing the sample size will reduce the accuracy of the software, since it is hard to identify minerals in the images. Also the background colour should be selected in a way to differentiate the minerals from the background. Green, blue, yellow, black and white colours have been analysed and selected yellow colour as the most suitable, where the HSV values of yellow colour background is very much different from the three minerals used in validation.

During the study light conditions are not maintained as standard, so when using in another condition the background and minerals HSV values should be changed in the software. These values can be given as inputs.

Appearance of shadow effect is a major problem in digital image processing. Shadow effect is eliminated by conducting the image capturing in the noon time.

When taking photographs the camera axis should be vertical, otherwise disorder of image geometry will happen. This may leads to errors. Since image capturing systems have not been used there may be such error in the program.

Due to errors in scales, sticking of mineral and loss of minerals, actual

weight of samples may be different from estimated samples. Also human errors may lead to errors in weights.
Errors may happen in the images mainly due to shadows and illuminations. Shadow may be visible as dark colour and illumination as white dots in the images. Thus images may not represent the actual mineral distribution.

While capturing the images blurring of images can occur and thus affecting the quality of images. Images with high blur are not suitable for image analysis. Since photos are taken as hand held there were possibility of blurring of images.

Since Ilmenite and Garnets are not pure and mixed with quarts, the weightages should be adjusted before analyzing. Here Imenite is 97% pure and Garnet is 88% pure.
User friendliness is the main problem we can find in this software, but that problem can be overcome in later stages in further developing of the software. Matlab GUI is used in this software and according to this coding calculating process takes very long time. Larger the size of the image, longer the time taking for process as well as much higher quality images in this test memory requirement is much higher.

The accuracy of results highly depend on the resolution of the camera. Since sand particles are very small in size it is crucial to use camera with high resolution to get particles detail in the images. A camera with 24 million pixels has been used to increase the accuracy. More details can be obtained in the image and analyzing becomes accurate.

There are several mineral types in raw mineral sand such as quartz, ilmenite, rutile, zircon, monozite and small percentage of silimanite, due to the radioactive nature of zircon and monazite those are not considered in validation purpose. The percentage of silimanite is very small. Also since Rutile and Ilmenite has almost same colour due to the limitation of the software, it cannot be differentiated from the software. So only Ilmenite, garnet and quartz are taken in to validation purpose.

5. Conclusions

Image processing technique can be used for the determination of mineral percentage with certain degree of accuracy. But there are certain limitations in using this software.
There are no possibilities to use overlapping samples in this method and non-overlapping samples are suitable but time consuming. Non overlapping samples of mixture of key minerals of this research can be identified using this software. If non overlapping samples were used, same color minerals cannot be identified using the software. Since colour properties of the minerals are used same colour mineral percentage cannot be measured from the software.

Due to the illumination of minerals, the images is not representing the actual minerals. Illumination can be eliminated up to a certain level using image capturing techniques.

Acknowledgements

Authors are thankful to Dr. AMKB Abesinghe, Head of the Department of Earth Resources Engineering, University of Moratuwa and Dr. H.M.R. Premasiri, Senior Lecturer)of Department of Earth Resources Engineering, University of Moratuwafortheir support for this research.

References

Deliormanlı,A.H. Onur,A. H. KarakuşD.andKonak.G. 2010, Size and shape analysis of mineral particles using image processing technique". The Journal of "ORE DRESSING.

Arash A, 2005. "Color Image Processing Using Principal Component Analysis".Mathematics Science of Sharif University of Technology.

Atasoy, Y., and D. J. Spottiswood.1995 "A study of particle separation in a spiral concentrator." Minerals engineering 8.10 : 1197-1208.

Babu, N., N. Vasumathi, and R. BhimaRao.2009 "Recovery of ilmenite and other heavy minerals from teri sands (Red sands) of Tamil Nadu, India." Journal of Minerals and Materials Characterization and Engineering : 149.

Burt, R. O. "assisted by Mills, C.,1984, Gravity Concentration Technology.

Case study in effects of color spaces for mineral Identification:
Nurdan A. B, Yılmaz N and KansunG 2010, , approximation of grain size from images of noncohesivesediment;D. Buscombe

Chaira, and Ray, 2003. Fuzzy approach for color region extraction Patter Recognition 24, 1943:1950.

Chiques, G., 2005, Spectral Characterization of Sandy Beaches in Western Portion of Puerto Rico: Mayaguez Campus, University of Puerto Rico, Department ofGeology, Unpublished Graduate paper, 65p.

Faloutsos,J., and Manolopoulos, 1997. Analysis of the n-dimensional quadtree decomposition for arbitrary hyperrectangles. IEEE Transaction on Knowledge and Data Engineering 9, No. 3, 373-383.

Ferguson, D. N. 2010 "A basic triboelectric series for heavy minerals from inductive electrostatic separation behaviour." Journal of the South African Institute of Mining & Metallurgy 110.2 : 75.

Jayawardena D, 1984 "The present status of the development of mineral resources in Sri Lanka.".

Joel R. Jackson and Sanmati, S. Kamath 2006. "Color image segmentation in RGB using vector angle absolute difference measures". 14th European Signal Processing Conference (EUSIPCO 2006), Florence, Italy, September 4-8,.