Detecting Fertilizer Adulteration using Smartphone Technology (ST) and Digital Image Processing (DIP): A Study

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Abstract: ***Smartphone technology (ST) and Digital Image Processing (DIP) have changed the lifestyle and business models in all sectors including agriculture. Researchers are taking an interest in applying ST and DIP in the agriculture sector to make production efficient, effective, and low-cost. One of the important factors for improved agriculture production is the pure and appropriate use of different fertilizers. Unfortunately, In Bangladesh, fertilizers are being adulterated during the distribution process. In this research, Color image histogram analysis and different statistical features like Average Intensity, Average Contrast, Smoothness, Third Moment, Uniformity, and Entropy of DIP have been used to detect adulterated fertilizer using a Smartphone camera at the farmer level while buying. Above properties are computed both for pure and adulterated fertilizers for comparison using MATLAB software. By the results of our research, we can easily identify pure and adulterated fertilizers which are quite similar to lab tests.***

Keywords: Smartphone Technology, Digital Image Processing, Color Histogram, Statistical Feature of Image

1. Introduction

With the outstretched demand for food with a thriving population, digression in arable land, weather change, and political transience of Bangladesh, the agro-industry suffice to investigate for a new process to raise productivity and sustainability. The use of pure and proper fertilizers is one of the most important factors for increasing the productivity of the land. But in Bangladesh, fertilizers are adulterated in many ways as the price of fertilizers is increasing day by day. This has evolved in researchers from many disciplines examining methods to include new technologies and legibility in the agrarian systems. There are many requirements for proficient and appropriate techniques of cultivation, qualifying farmers to put trifling inputs for sublime production. The use of Smartphone technology (ST) and Digital image processing (DIP) in agrarian systems is one of such techniques that are assisting farmers in convening both the above requirements. It can assist in enhancing the farming drills by using ST tools, which annex farmers to admit measure, and monitor farming drills, such as using pure adequate fertilizers. In many parts of Bangladesh capitally in the peasant venue, this kind of data is infrequent, and the cost of attainment of these techniques is also not known by the farmers. The bare eye espial of specialists is the main accession held in practice for the detection and identification of adulterated fertilizers. Nowadays Smartphones and the Internet are used by farmers who can easily use ST if there is no expert present [1]. The breeze towards Smart farming techniques is contingent on location-specific data together with the taking of many image databases [2].To get information from the given data process, the outcome of the data input process is computerized. The texture used for segmentation is to sunder one object with another object, then for texture classification. Operation of a pixel is an image processing operation that sketches the relationship of each pixel that swing on the pixel itself. From a histogram, it can be known the frequency of emersion relative (relative) of the intensity of the image. The histogram can also indicate the brightness and contrast of an image. A histogram is a simple process of getting textures, it is favorable to obey the stretch of color intensity, Ordain the boundaries of object severance from the background and deliver the percentage of color and texture composition. We can't be used to infer the form of the object by histogram because it does not gleam the pixel color position arrangement. Clop retrieval in digital image processing is employed so that computers can recognize objects like humans perceive the image. When detecting the same texture from diverse images, it can be terminated that the image has the same features. In this research, we will be determined the value of Average Intensity, Average Contrast, Smoothness, Third Moment, Uniformity, and Entropy of the pure and adulterated. The histogram ascertains the characteristics of the image, for example, a narrowly arranged histogram alluded to the less contrast image. Features like mean, variance, skewness, and entropy can be extracted. Other features which are archived, in the histogram are the maximum, minimum, median, and range. For texture segmentation, the tidings of this histogram are used as features [3]. Histogram equation is a well-known feature compensation tool that has been well sought after and practiced in image processing for normalizing digital visual features of images, such as brightness, contrast, gray-level scale, and so on.

The use of DIP techniques is one method that these data sets can be customary to support by providing high-quality pictures to be used for detecting and then taking proper steps. The techniques can be used to enhance agricultural production, by improving accuracy and consistency of processes while reducing farmers' manual monitoring. Often, it grants pliancy and successfully alternates the farmers' ocular decision-making. As visual identification is labor intensive and less accurate. So farmers can directly take proper steps such as how much fertilization is needed for the land very quickly. The proposed system is a software solution for the automatic detection of adulterated fertilizer using a Smartphone

2. Methodology

As mentioned earlier, to identify the adulterated fertilizer smartphone has been used for capturing the image and will classify the image according to color image histogram analysis and statistical features extractions of Digital Image Processing.

Using the two-dimensional function f (x, y) where x & y is the field coordinate, We can define an image, and the magnitude of the function f (x,y) at a point (x, y) is called the light intensity of the image. Through sampling and quantizing the digital image has been processed. By doing the sampling process & quantizing, a picture of continuous has been changed to be discrete. To convert the image coordinates into a discrete nature we can use a sampling process and the result will give pixels i.e. elements of a digital image. The method of imposing an intensity value on each pixel is the quantizing process. The ratio between the brightest and darkest parts of the intensity of pixels is called the contrast of an image and is usually defined by the dynamic range. For the information about the contrast and the overall intensity of the distribution of an image histogram has been used. Regarding the input images function f (x, y) and it consists of a discrete gray level in the dynamic range [0, L-1] [4]. Histogram analysis of Color Image is easy to calculate in software and also we can simply implement it in hardware economically [5].

Mingling rows of an image settled adjacent to the other rows in succession can build a vector of an image. Because some objects have certain patterns the texture is used as an image recovery feature. Between the values of the intensity of recited adjacent pixels in a broad area more than the way of the relationship, the texture shows the mutual relationship. Now a day we apply texture in the textile industry, painting cars, carpet usage, and image analysis in medical science, and remote sensing. [6] We have used this in agriculture. In general, based on color, texture, and shape features that are used distinctly or in combination are the classifications of images. Among those features color features are most dominated. Color indexing is used for comparing an image query to images in the database which is the main objective.

The findings of text on in the outcome of color quantization and edge orientation quantization are our next stage. In our research for increasing texture discrimination, element size is used, as only at texture boundaries texture gradients have been found [7]. The histogram displays a graph that can narrate the method of extending pixel intensity values. The number of gray levels (symbol L) commences from 0 to 255 in grayish-scale imagery. A collective RGB component is applied for color images. The frequency of every intensity value that comes across the pixels can be detected in the image histogram. Gray scale imagery is an image that uses color on a gray color level. We detect identical intensity in gray, the sole color in the RGB plane with red, green, and blue materials.

To express the intensity value for every pixel as a solitary value, the gray-shaded image is required whereas in the color images it requires three intensity values for every pixel. In digital images the histogram is the statistical probability distribution of each gray level. Operation on the histogram is needful for flourishing the brightness, stretching contrast, brightness and contrast combination, reverses the image, linear mapping, gray level cutting, and histogram exclusion [8]. Image segmentation is the principle of many crucial image processing systems. The Mentioned color segmentation system which buckles color and textures feature as segmentation feature, banishes the non-fertilizer part. Usually, we get frequency domain errand of the data by the transformation of an image. Using zonal filtering the transform features of an image is turned out. For boundary and edge detection the high frequency components are used normally. When the input data originates in the transformed coordinate, transformation is important for feature extraction [9]. Quantization is a way where the number of bins is retrenched by adopting colors that are analogous to each other and keeping them in the same bin in color histograms. The Perplexity of the algorithm can also be abated by using these texture features. In a histogram analysis, three images contain different textures [10].

Average intensity

Digital images are displayed as a set of intensities. An important consideration in presenting image processing results is the ability to discriminate between different intensity levels by the eyes. The Brightness of a gray scale image is the average intensity of all pixels in an image. For measuring average intensity we have used the following equation:

$$m = \sum_{i=0}^{L-1} z_i p(z_i) \quad (1)$$

Where ***z*** indicates the intensity of a random variable, the histogram of the intensity levels in a region is ***p (z)*** , L represents the number of possible intensity levels.

Average contrast

Average contrast helps us to distinguish among the objects in an image easily. We get many distinct intensity values in high contrast images. And for low contrast, there are few distinct intensity values. For good contrast, an image should have widely spread intensity values and a large difference between minimum and maximum intensity values. Many different equations exist for contrast. For Example,

$$Contrast = \frac{Change\ in\ luminance}{Average\ luminance} \quad (2)$$

For our research work standard deviation (σ) has been used to find the average contrast.

Smoothness

An approximating function that attempts to capture important patterns in the data, while leaving out noise or other fine-scale phenomena smoothing plays a vital role in statistics and image processing. In the smoothing of an image, the data points of a signal are modified so individual points because of noise are lessened, the points are increased leading to a smoother signal that is lower than the adjacent points. For measuring smoothness we have used the following equation:

$$R = 1 - \frac{1}{(1+\sigma^2)} \quad (3)$$

Where R is for relative smoothness and the value will be zero (0) for a region of constant intensity and approach to one (1) for regions with large excursions in the values of its intensity levels. Sigma square(σ^2) is the variance.

Third Moment

After segmentation, the moment is very useful to describe objects. Image moments include area (or total intensity), its centroid, and information about its orientation which are simple properties of an image. We have used third moment as it tells about the skewness that is the asymmetry of the mean intensity. The equation for calculating the third moment is,

$$\text{Third Moment} = \sum_{i=0}^{l-1}(z_i - m)^3 p(z_i) \quad (4)$$

This measure is 0 for symmetric histograms; positive by histogram skewed to right about the mean negative for the left. Values of this measure are brought into a range of values compared to the other five measures by dividing the third moment by $(L-1)^2$; the same divisor we used to normalize the variance.

Uniformity

For measuring the drop-off in illumination at the edges of the image as well as other types of image illumination we use uniformity. We defined it as follows:

$$U = \int_{i=0}^{L-1} P^2(z_i) \quad (5)$$

Where *P* is the histogram and *z* is a random variable and *L* is the intensity Level. Uniformity's maximum value is reached when all intensity level is equal and decreases from there.

Entropy

Entropy is a scalar value that is the representation of gray scale image. It can be used to characterize the texture of the input image as it is a statistical measure of randomness, define by the following equation,

$$e = -\sum_{i=0}^{L-1} p(z_i) \log_2 p(z_i) \quad (6)$$

Where *z* is a random image and $p(z_i)$ is the histogram.

In our work, the histogram features considered for the histogram models of the probability distribution of intensity levels in the image are based on statistics. The characteristics of the intensity level distribution for the image encoded these statistical features. A high mean will be found in a bright image and a dark image will have a low mean.

3. Result & Discussion

For effective, efficient, and higher levels of food production, appropriate use of pure fertilizer is paramount. Unfortunately in Bangladesh fertilizer get adulterated during the distribution process, which result in lower production in the short term and degradation of soil nutrients property in the long term. Ideally, it is required a non-chemical sample testing at farmers' levels for adulterated Nitrogen, MoP (Muriate of Potash), TSP(Triple Super Phosphate) & Gypsum fertilizers as these are the most used fertilizer in Bangladesh. Although this can be done by chemical testing this process is complex, at the farmer's level this may not be possible. So we have wished to find an easy way of identifying the adulterated and original fertilizer. For our research work, we have mixed some adulterating materials with the original fertilizer that we have collected from the market. The Smartphone has been used for taking image as this is our main goal. We took picture from three different distances for adding a variation of taking the picture from different distances and using MATLAB programming we found different RGB histogram plans as well as average intensity, average contrast, smoothness, third moment, uniformity, and entropy which are discussed already. All results and comparisons are given successively below:

Color Image Histogram Analysis

From Figure 1, 2 can see all the images RGB plane are almost the same related to the fertilizer (MoP) whatever the distances are. Figure-3 & 4 is the RGB plane of adulterated MoP fertilizer. The figures have a different RGB plane from pure fertilizers. So we can differentiate between the original and adulterated ones. The Same tests have been done for Nitrogen, TSP (Triple super Phosphate) & Gypsum. And in everycase we have found disimmilarities betweent pure and adultreted one. To avoid reduddency we didn't put the MATLAB results of those images in this paper.

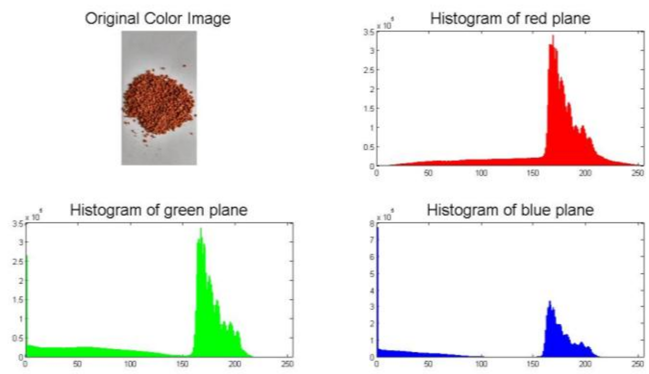


Figure 1: RGB plane of MoP Fertilizer at Distance 10 inch

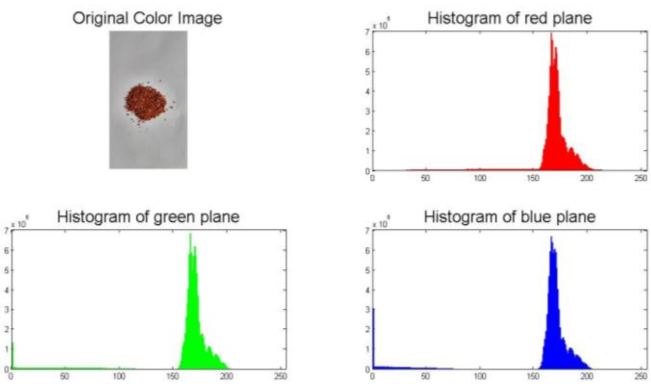


Figure 2: RGB plane of MoP Fertilizer at Distance 15 inch.

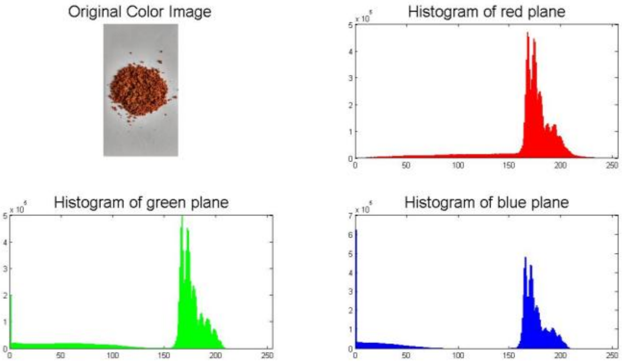


Figure 3: RGB plane of MoP Adulterated Fertilizer at Distance 10 inch

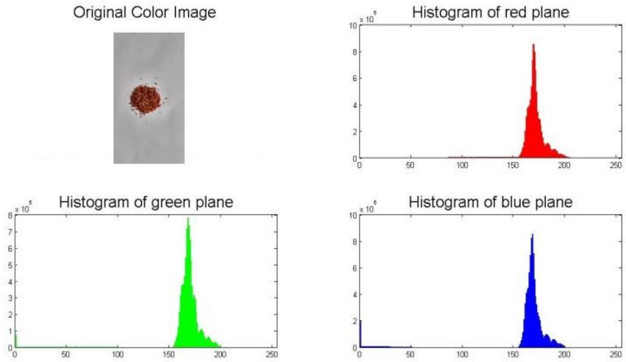


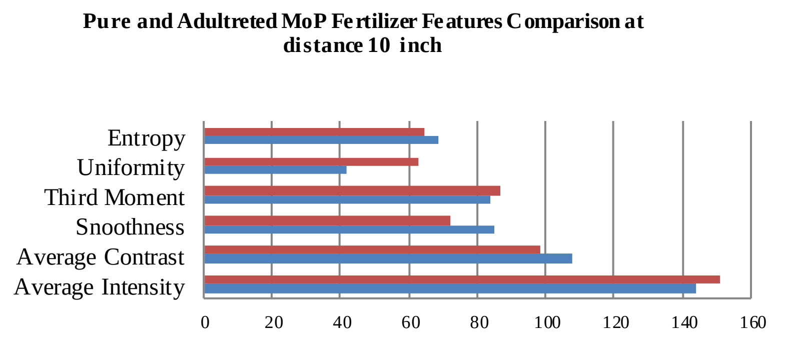
Figure 4: RGB plane of MoP Adulterated Fertilizer at Distance 15 inch.

From the image histogram plans, we can differentiate between original and adulterated fertilizer but the accuracy is not so well. Because when we took the images the images may not be appropriately taken. Again camera resolution is also a main factor. High-resolution camera phones give better images. That's why we have calculated the average intensity, average contrast, smoothness, uniformity, third moment, and entropy of the images.

Statistical Values of Images: Average Intensity, Average Contrast, Smoothness, Third Moment, Uniformity and Entropy

To calculate average intensity, average contrast, smoothness, uniformity, third moment, and entropy we have used the statistical approaches and the equations use for this have been discussed in the earlier. We have used MATLAB functions to calculate those values.

To compare the pure and adulterated ones we have also plotted the six features value in figure 5 & 6. Each figure is for a certain distance. As we have said before we have taken pictures from two different distances (10″ & 15″) using the Smartphone camera.



	Average Intensity	Average Contrast	Smoothness	Third Moment	Uniformity	Entropy
Adultrated	150.8606	98.5978	72	86.979	62.7	64.423
Pure	144.0133	107.632	85.2	83.667	41.7	68.885

Figure 5: Pure & adulterated MoP Features Comparison at a distance of 10 inch

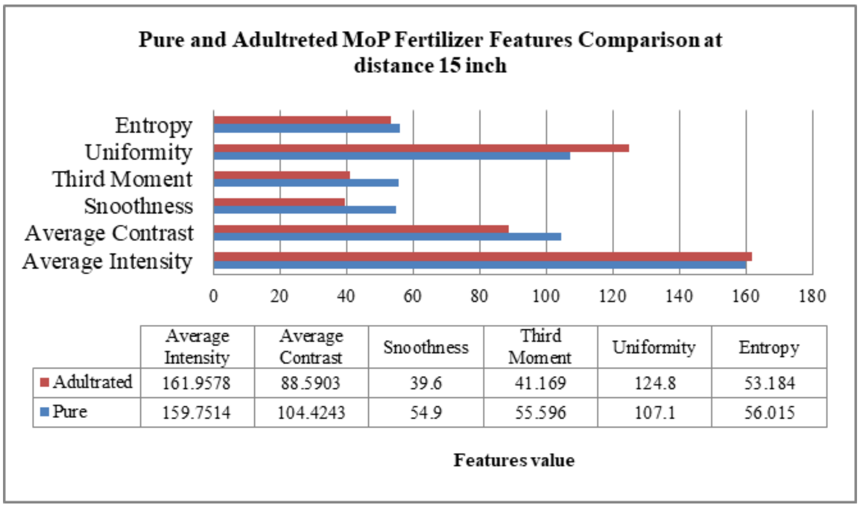


Figure 6: Pure & adulterated MoP Features Comparison at a distance of 15 inch

Table 1: Feature values of TSP at a Distance of 10″

	Pure	Adulterated
Average Intensity	163.4601	160.9613
Average Contrast	89.6778	97.266
Smoothness	40.6	47.7
Third Moment	125.76	134.06
Uniformity	69.2	59
Entropy	56.1	58.622

Table 2: Feature values of TSP at a Distance of 10″

	Pure	Adulterated
Average Intensity	163.0205	164.5927
Average Contrast	129.45	128.3088
Smoothness	142	140
Third Moment	129.9	123.52
Uniformity	141.2	144
Entropy	107.756	107.022

Consider the chart in figure 5. For making this chart we took images of pure and adulterated MoP fertilizer at a distance of 10inch. And value of the features we have got using MATLAB programming are different for pure and adulterated ones. But with the naked eye observation, this is not possible to differentiate from one to another. The Same work has been done also for TSP (Results are on Table 1 & 2), Nitrogen, and Gypsum. So we can say we are quite successful in our research work.

4. Conclusion

In this work, we have tried to find the Color images histogram plans, and statistical features. Where two cases of fertilizer images were used: pure and adulterated. The statistical features such as average intensity, average contrast, smoothness, uniformity, third moment, and entropy values are different as we wished to do so. We are quite satisfied with our work. From our study on different fertilizers, we can say that we can implement it in our agriculture sector. This paper presented a study on using image processing techniques used in an agricultural context. Employing these processes like segmentation, feature extraction, and clustering can be used to interrogate images. The main problem we have faced to do this work is the 'collection of images' because as we have used a Smartphone camera there is a problem with resolutions. Different mobile companies with the same resolution don't give the same picture information. Again when we took the picture our hand was shaking sometimes. That's why sometimes we do not get the appropriate values for comparing between features. Moreover, we make the adulteration by ourselves. But in the market, the adulteration process may be different so sometimes our process may not work.

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