"Performance Evaluation of Contemporary System for Classification of Synthetic Images"

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***Abstract*— Recent classification system of images focuses on Natural (e.g photographic) images and synthetic/artificial (e.g non-photographic). In automatic image identification classification of images based on description is important and challenging problem. For natural and synthetic image classification an algorithm has been developed. From the raw images data in order to exploit the difference of color pattern and spatial correlation of pixels in synthetic and natural images some features are extracted. These features have poor accuracy If these features are used alone they may have poor accuracy but can form a more complex and accurate global classifier when combined together, and their precision can be boosted. We will use low-level image features such as Color map, edge map, energy level, Threshold ratio & nearest neighborhood classifier for classifying the image into natural and synthetic in our image classification algorithm.**

Key Words:- Natural image, Synthetic image, Edge map, Color map, Energy Level, Threshold value

I. INTRODUCTION

Images created entirely by digital means are growing in importance. These synthetic images are an important means for recording and presenting visual information. The accurate classification of these images – such as icons, maps, figures and charts is more important. With the help of the web, images are being used not just to communicate content but also for formatting,alignment and decoration. An image classification system can improve image search and retrieval engines and can act an input filter for downstream web processing as well as image understanding systems. On the other hand, very often a Natural image deals with real life objects and subjects. These have usually textures, smooth angles, larger variety of colors but less saturated[1] & [2].

For an human being, distinguishing between a photograph and a graphic is almost always an easy task. It is often just matter of a glance. Unfortunately it is not for a computer, there is not a simple and easy feature to just extract and process. Number of color, edge map & edge location energy level, & threshold ratio is derived from the raw data available from the picture in various ways. Those features must be then combined together in order to build a good classifier. since if they used seperately, they can lead to poor or even bad results.The purpose of an image classification system is to classify images into different classes. An ideal system should be able to discern different images with no hesitation just like an human being. Unfortunately, sometimes the classification task is hard and ambiguous even for an human[3]. This makes the problem even more challenging. In this project, a binary classifier will be developed. The two classes involved in the classification shall be *Natural* and *Synthetic* images. From an image, the classifier will extract and analyze most of the relevant features and combine them in order to generate advance image classification system.

II. Image Dataset

The choice for creating the database was JPEG images. This was made because of a main assumption, since images can be compressed in a different way, the classification algorithm has to be tuned accordingly to each format, multiple factors have been taken into account such as the altered/reduced palette and the noise added while compressing/resizing. Therefore a mixed dataset can not be used with a single classification method. *GIF* and *PNG* formats are very popular formats for synthetic images but less used for encoding photographs. *JPEG* is almost always a better choice for transmissions of true color images over the internet, especially photographic ones.Most of the image are down loaded from web site & some are directly capture from digital camera [4]& [5]. A balance dataset was created taking 500 synthetic & 500 natural image and the image is resized into 256*256.Images are hand-labeled as natural and synthetic image The main step in order to be able to classify an image is to extract numerical features from the data. These common features will be then combined/compared in various ways according to the classification methods.

III. Image features & Their effects

The features used in classification system are energy level, color map, edge map, threshold. & Nearest neaighourhood classifier. The main step in order to be able to classify an image is to take numerical features from the dataset.If these features are joined together, gives good performance and level of accuracy is increased. In the following section of paper I will describe & studied the effect of single feature in classifying the images as natural & synthetic.

IV. Effects of features

Transition of color from pixel to pixel have different types in photographs (Natural image) and graphics (Synthetic image). Natural images shows objects of the real world, and in such a context, it is not common to find regions of constant color because they may have different shades and texture. When the process of picking a photograph is taken some noise is added to the subject and neighboring pixels have different RGB values (even if they are having same color). It is possible to exploit these simple features related to colors by extracting and analyzing the features. Photographs are having more color than graphics. Because synthetic images have large uniform regions with the same color. On the Web in particular, graphics with less color are popular because they compress in a better way. The different colors of an image is extracted but it cannot be used directly as metric because the raw number depends also on the size of the image. Hence a metric is used more accurately: the rate between the number of different colors and the number of total pixels[7] & [8]. Color map of input image is plot for black & white image histogram(gray) of image is calculated for color image extended histogram is used .The fig 1.1a & 1.1b show the color map Natural image & synthetic image

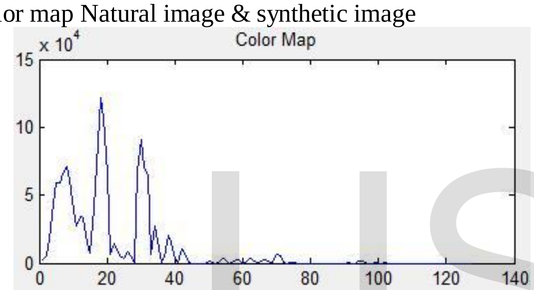


Fig 1.1a

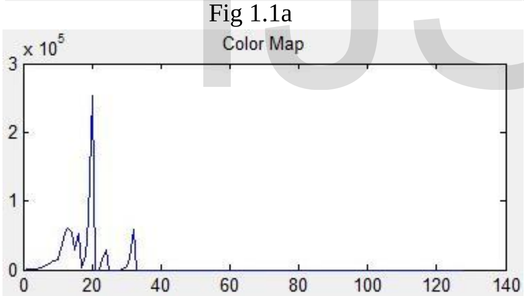
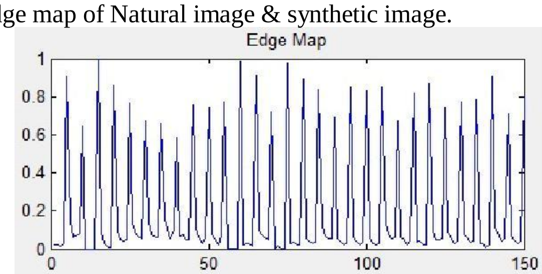


Fig 1.1b

For edge map edges of image is taken and from edge location edge map is created. The fig 1.2a & 1.2b show the edge map of Natural image & synthetic image.



NCS

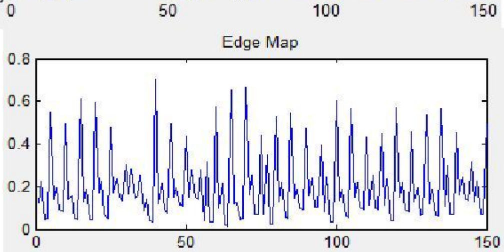


Fig 1.2b

For high level accuracy color map & edge map is taken into consideration. 300 natural and synthetic images are separately analysed for color map and edge map. If the color map value falls in the range 0 to 30 then image is classify as synthetic & if value comes more than the above rangeas the image is classify as natural image.Small different values are shown for natural & synthetic image by edge map. In natural image higher spikes are found as that of synthetic image. These two features are combined and the result of classification system is boosted & we achieved 87% of accuracy.

Energy Level

For energy level evaluation we start converting the given image into gray scale. Rangfilt function is used for analysis of texture which returns the array of image, where each output pixel contains the range value (maximum value − minimum value) of the 3-by-3 neighborhood around the corresponding pixel in the input image . The size of input image and output image are same and have any dimension. First using DWT total energy is calculated, then the image precision is double and Single-level discrete 2-D wavelet transform is calculated. Which performs a single-level 2-D wavelet decomposition with respect to particular wavelet. The approximation coefficients matrix and details coefficients matrices (horizontal, vertical, diagonal) are obtained by a wavelet decomposition of the input matrix of image by DWT2. Only a single set of DWT derived features is considered, which is a vector containing energies of wavelet coefficients calculated in subbands at successive scales[14]& [15].Harr wavelet is calculated for whole image to compute the wavelet features and image is transform into 4 subband image at its scale.

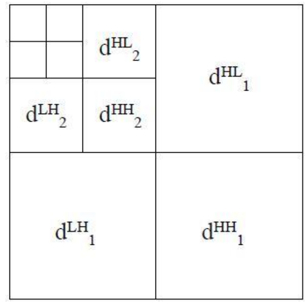


Fig 3 Subband Image

For DWT calculation at the next scale for the given image only Subband image *aLL* is used, the maximum of 8 scales can be calculated. If output subbands have dimensions of at least 8 by 8 points then only Harr wavelet is calculated. Energy (3) of *dLH*, *dHL* and *dHH* is calculated at any considered sale in marked ROIs in next step. In order to correspond to subband image dimensions ROIs are reduced in successive scales. If ROI at this scale contains at least 4 points then only in a given scale the energy is calculated. The vector of features containing energies of wavelet coefficients calculated in subbands at successive scales is the final output of this procedure. The three energy levels of various natural & synthetic image is calculated and is given by e1,e2 and e3.

The captured images from digital camera are natural images chosen for analysis and the founded energy levels for natural image are e1=54.36, e2=108.71,
& e3 = 217.43. As one of the following categories comes under the Synthetic image: Logos, Maps, Chart, Drawing, & Windows Application Screen shoot. The energy belong to each categories is shown below in table.

Table: Energy level

Energy	Logo	Maps	Drawing	Win App Screen Shot
E1	10.33	22.11	23.26	22.89
E2	20.65	44.22	45.14	45.78
E3	91.57	88.45	90.02	91.57

We can conclude from the above analysis as if energy level is higher the image is classified as natural otherwise image is classified as synthetic image.

Threshold

The OTSU method is used for the calculation of Threshold of image.The gray level image intensity can be expressed in L gray level [1, 2, ……..L]. The number of point with Gray level at I is

denoted by x_i and the entire number of point can be expressed $X = x_1 + x_2 + \cdots + x_L$

The occurrence distribution of probability is given by gray level image histogram as given below

$$p(i) = \frac{x_i}{X}, \quad x_i \geq 0, \quad \sum_{i=1}^{L} x_i = 1$$

The image pixel are divided into two parts C_0 and C_1 i.e Foreground and background by a threshold t. Where C_0 Represent pixels with levels [t + 1, …….L]. The probabilities of occurrence of this class and average can be expressed as

$$\omega_0 = \omega(t) = \sum_{i=1}^{t} p(i).$$

$$\omega_1 = 1 - \omega(t) = \sum_{i=t+1}^{L} p(i).$$

$$\mu_0 = \sum_{i=1}^{t} \frac{i \cdot p(i)}{\omega_0} = \frac{1}{\omega(t)} \sum_{i=1}^{t} i \cdot p(i).$$

$$\mu_1 = \sum_{i=t+1}^{L} \frac{i \cdot p(i)}{\omega_1} = \frac{1}{1-\omega(t)} \sum_{i=t+1}^{L} i \cdot p(i).$$

The Total mean can be given as

$$\mu_T = \sum_{i=1}^{L} i \cdot p(i)$$

$$\mu_T = \omega_0 \mu_0 + \omega_1 \mu_1$$

ω_0 ω_1

μ_0, μ_1 μ_T

σ_B^2 C_0 C_1

Also we can find that

Where and denote probabilities of foreground and background parts. Beside and refer to the mean in gray level of the foreground of the gray image, the background of gray image. And the entire gray level image.

The between-class variance of the two classes & variance is given by [16]

σ_B^2

$$t^* = \arg\max \sigma_B^2$$

C_k

C_k

μ_T

m_T

μ_T

μ_0 μ_1 m_0 m_1

C_0 C_1

σ_B^2 C_0 C_1

$$\sigma_B^2 = \omega_0 (m_0 - m_T)^2 + \omega_1 (m_1 - m_T)^2$$

t^* σ_B^2

$$t^* = \arg\max \sigma_B^2$$

$$\sigma_B^2 = \omega_0(\mu_0 - \mu_T)^2 + \omega_1(\mu_1 - \mu_T)^2$$

The separate degree of the class , in discrimination analysis is given by

If we maximised to chose the optimal threshold t. then we have

If the distribution of class (K = o, or 1) is skew or heavy-tailed then Props-function is used. We know that a very robust estimate mean value is getting when compared with average gray level. We find that the mid value replacement of the average may obtained optimal threshold that is very accurate to the presence of heavy-tailed distribution for compare with this threshold chosen by OTSU method [16]

Replacement of the total mean with the total medium level of all the point in the entire gray level image Similarly to the whole image value the mean value can be replace by medium gray and for foreground part & background part respectively.

The between-class variance of the two classes & Can be rewritten as.

KNN Classifier

The (***k*-NN** for short) or ***k*-Nearest Neighbors algorithm** method used for classification and regression is a non-parametric. In the feature space *k* closest training examples are there in input in both cases. Whether *k*-NN is used for classification or regression the output depends on that:

In *k-NN classification,* A class membership is the output. By a majority vote of its neighbors an object is selected, and being assigned to the most common class among its *k* nearest neighbors (*k*-small positive integer). The object is simply assigned to the class of the single nearest neighbor if *k*=1.

In *k-NN regression,* the property value for the object is the output in *k-NN regression.* This value is the average of the values of its *k* nearest neighbors.

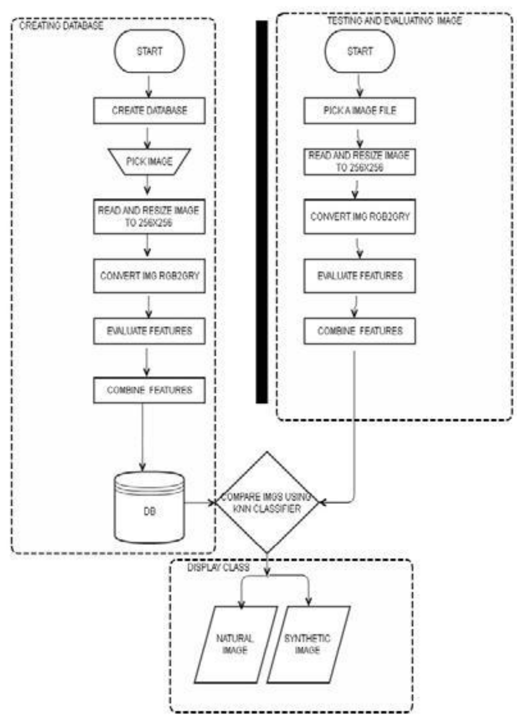
And the threshold is chosen by maximizing

From OTSU method the calculated threshold value shows good performance in image classification. The threshold of 500 synthetic image and 400 natural image was calculated. If the value is between 0.0001 to 0.0002 image is classified as synthetic image & if the value is between 0.0005 to 0.0006 the image is classified as natural image. The error rate shown by the features is of 37%.

V. CLASSIFICATION SYSTEM

This paper has different accuracy level for every feature. The accuracy rate shown by the color map is 88% for natural and 87% for synthetic image. Low level of accuracy is shown by Edge map than color map. The overall result of edge map & color is also calculated which gives 87% of accuracy for natural & synthetic image. From image the three energy level are calculated and combine together to evaluate the class of image which shows 80% accuracy for synthetic image & 75% for natural. From OTSU method the optimal threshold is calculated which gives 37% error rate.By using a single feature it is very difficult to increase the accuracy by 1 or 2 percent.Hence in classification system to increase the accuracy an algorithm is designed which extract all the required features from images & combine together to produce optimum result. The flow and activity diagram of design algorithm is given below:

Instance-based learning, or lazy learning is a type of K-NN classifier, where the function is only approximated locally and all computation is deferred until classification. The time required to evaluate the image is also reduced by using K-NN classifier.



Firg.4 Flow Diagram

Step

Database Creation

1. The database loading.
2. Selecting an image file.
3. Reading of image.
4. The image should be resize to 256*256.
5. rgb2gray image conversion.
6. Evaluation of edge map, Extended histogram, Energy level , & threshold.
7. Feature combining.
8. Loading into the database.

Image Testing

1. Image file picking.
2. Reading of image.
3. The image should resize to 256*256.
4. rgb2gray image conversion.
5. Evaluation of edge map, Extended histogram, Energy level , & threshold.
6. Feature combining.
7. Comparing the database.
8. Using KNN classifier checking which is the best matching.
9. Shows class of output "**Synthetic or Natural**" .

VI. Conclusion

The accuracy rate shown by color map is 88% percent for natural image & 87 percent for synthetic image.The low level of accuracy is shown by Edge map than color map. From color map & edge map calculation combined result is calculated and found the accuracy of 87% for synthetic & natural image. From image the three energy levels are calculated and also combined together to find the class of image which gives accuracy of 80% for synthetic image 75% for natural.Using OTSU method the optimal threshold is calculated and the error rate found is 37 percent. The overall average accuracy is 78% if this feature is used individually. Using K-NN Classifier the accuracy can be increased to 90% by taking all the features together in the algorithm and finding the best match using it and significant amount of computational time is reduced.

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