Image Retrieval Using DCT/KWT and D4/KWT in Distributed System

Assi. Amna H. Al Saffar
Assi. Dawser T. Naman
Baghdad University
College of Education Ibn Al-Haitham
Computer Science Department

Abstract

This paper presents a proposed method for (CBIR) from using Discrete Cosine Transform with Kekre Wavelet Transform (DCT/KWT), and Daubechies Wavelet Transform with Kekre Wavelet Transform (D4/KWT) to extract features for Distributed Database system where clients/server as a Star topology, client send the query image and server (which has the database) make all the work and then send the retrieval images to the client.

A comparison between these two approaches: first DCT compare with DCT/KWT and second D4 compare with D4/KWT are made. The work experimented over the image database of 200 images of 4 categories and the performance of image retrieval with respect to two similarity measures namely Euclidian distance (ED) and sum of absolute difference (AD) and compared with the overall average of precision and recall.

Keywords: CBIR, DCT, D4, Kekre Wavelet Transform (KWT), Star Distributed Database

1. Introduction

Content-Based Image Retrieval (CBIR) is defined as a process that searches and retrieves images from a large database on the basis of automatically-derived features such as color, texture and shape.

All the solutions, in general, perform the retrieval process in two steps. The first step is the 'feature extraction' step, which identifies unique signatures, termed as feature vector, for every image based on its pixel values. The feature vector has the characteristics that describe the contents of an image. Visual features such as color, texture and shape are more commonly used in this step. The classification step matches the features extracted from a query image with the features of the database images and groups' images according to their similarity. Out of the two steps, the extraction of features is considered most critical because the particular features made available for discrimination directly influence the efficacy of the classification task [1].

For feature extraction in (CBIR) there are mainly two approaches feature extraction in spatial domain and feature extraction in transform domain. The feature extraction in spatial domain includes the (CBIR) techniques based on histograms, BTC, VQ. The transform domain methods are widely used in image compression, as they give high energy compaction in transformed image. So it is obvious to use images in transformed domain for feature extraction in (CBIR). But taking transform of image is time consuming and also needs all images of database to be of same size to get similar feature vectors [2].

2. Related Work

This section gives a brief overview of related works where it is useful to review some image retrieval methods.

Kekre et al.[3] discribes Sectorization of Haar Wavelet transformed images and Kekre’s Wavelet Transformed images to extract features for image retrieval. Transformed images have been sectored into 4,8,12 and 16 sectors. The retrieval rate checked with crossover of average precision and recall. The performance of image retrieval with respect to two similarity measures namely Euclidian distance (ED) and sum of absolute difference (AD) are measured.

In this paper Kekre et al.[4] presents a comparison of performance of Wavelet Pyramid based image retrieval techniques using Walsh, Haar and newly introduced Kekre wavelet transforms. Here content based image retrieval (CBIR) is done using the image feature set extracted from Wavelets applied on the image at various levels of decomposition.

Hossein et al.[5] presents an approach for an image indexing technique that extracts features directly from DCT domain. Feature vector is extracted in DCT domain. Then, feature vectors of all blocks of image using a kmeans algorithm is clustered into groups. Then select some clusters that have largest members after clustering. The centroids of the selected clusters are taken as image feature vectors and indexed into the database.

Burkhardt et al.[6] describes their submission for a new kind of feature for color image retrieval based on DCT-domain vector quantization (VQ) index histograms (DCTVQIH) . For each color image in the database, 12 histograms (four for each color component) are calculated from 12 DCT-VQ index sequences, respectively. The retrieval simulation results show that, compared with the traditional spatial-domain color-histogram-based features, the proposed features can largely improve the recall and precision performance.

3. Feature Matching

Finding good similarity measures between images based on some feature set is a challenging task. On the one hand, the ultimate goal is to define similarity functions that match with human perception, but how humans judge the similarity between images is a topic of ongoing research. Many current

(CBIR) systems use the Euclidean distance on the extracted feature set as a similarity measure.

The Direct Euclidian Distance between image P and query image Q can be given as equation 1, where Vpi and Vqi are the feature vectors of image P and Query image Q respectively with size 'n' [7,8].

$$ED = \frac{1}{2}\sum_{i=1}^{n}(Vpi - Vqi)^2 \quad \text{…………(1)}$$

Another similarity measure is sum-of-Absolute Differences (AD) equations given below define (AD)

$$SAD = (f_q, f_t) = \sum_{i=0}^{n-1}(f_q[i] - f_t[i]) \quad \text{…………..(2)}$$

Where f_q, f_t represent query feature vector and database feature vectors and n is the number of features in each vector [9].

4. Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one dimensional DCT in the other dimension. The definition of the two-dimensional DCT for an input image A and output image B is

$$B_{pq=}a_p a_q \sum\sum A_{mn} COS\frac{\pi(2m+1)p}{2M} COS\frac{\pi(2n+1)q}{2N} \quad \begin{matrix} 0 \le p \le M-1 \\ 0 \le q \le N-1 \end{matrix} \quad \text{…….(3)}$$

$$a_p = \begin{cases} 1/\sqrt{M} & p = 0 \\ \sqrt{2/M} & 1 \le p \le M-1 \end{cases} \quad \text{…….(4)}$$

$$a_q = \begin{cases} 1/\sqrt{N} & q = 0 \\ \sqrt{2/N} & 1 \le q \le N-1 \end{cases} \quad \text{……..(5)}$$

Where M and N are the row and column size of A, respectively [10]. If you apply the DCT to real data, the result is also real. The DCT tends to concentrate information, making it useful for image compression applications and also helping in minimizing feature vector size in CBIR[11].

5. The Daubechies D4 Wavelet Transform

The Daubechies wavelet transform is named after its inventor the mathematician Ingrid Daubechies. The Daubechies D4 transform has four wavelet and scaling function coefficients. The scaling function coefficients are:

$$h_0 = \frac{1+\sqrt{3}}{4\sqrt{2}}, \quad h_1 = \frac{3+\sqrt{3}}{4\sqrt{2}}, \quad h_2 = \frac{3-\sqrt{3}}{4\sqrt{2}}, \quad h_3 = \frac{1-\sqrt{3}}{4\sqrt{2}}$$

Each step of the wavelet transform applies the scaling function to the data input. If the original data set has N values, the scaling function will be applied in the wavelet transform step to calculate N/2 smoothed values. In the ordered wavelet transform the smoothed values are stored the lower half of the N element input vector[12].

The wavelet function coefficient values are:

$g_0 = h_3$, $g_1 = -h_2$, $g_2 = h_1$, $g_3 = -h_0$

Each step of the wavelet transform applies the wavelet function to the input data. If the original data set has N values, the wavelet function will be applied to calculate N/2 differences (reflecting change in the data). In the ordered wavelet transform the wavelet values are stored in the upper half of the N element input vector [12].

In the case of the forward transform, with a finite data set (as opposed to the mathematician's imaginary infinite data set), *i* will be incremented until it is equal to N-2. In the last iteration the inner product will be calculated from calculated from s[N-2], s[N-1], s[N] and s[N+1]. Since s[N] and s[N+1] don't exist (they are beyond the end of the array), this presents a problem. This is shown in the transform matrix below [12].

Daubechies D4 forward transform matrix for an 8 element signal.

$$\begin{matrix} h_0 & h_1 & h_2 & h_3 & 0 & 0 & 0 & 0 & & \\ g_0 & g_1 & g_2 & g_3 & 0 & 0 & 0 & 0 & & \\ 0 & 0 & h_0 & h_1 & h_2 & h_3 & 0 & 0 & & \\ 0 & 0 & g_0 & g_1 & g_2 & g_3 & 0 & 0 & & \\ 0 & 0 & 0 & 0 & h_0 & h_1 & h_2 & h_3 & & \\ 0 & 0 & 0 & 0 & g_0 & g_1 & g_2 & g_3 & & \\ 0 & 0 & 0 & 0 & 0 & 0 & h_0 & h_1 & h_2 & h_3 \\ 0 & 0 & 0 & 0 & 0 & 0 & g_0 & g_1 & g_2 & g_3 \end{matrix} \bullet \begin{bmatrix} s_0 \\ s_1 \\ s_2 \\ s_3 \\ s_4 \\ s_5 \\ s_6 \\ s_7 \end{bmatrix}$$

6. Kekre's Wavelet Transform

Kekre's Wavelet transform is derived from Kekre's transform. From NxN Kekre's transform matrix, we can generate Kekre's Wavelet transform matrices of size (2N)x(2N), (3N)x(3N),……, (N2)x(N2). For example, from 5x5.Kekre's transform matrix, we can generate Kekre's Wavelet transform matrices of size 10x10, 15x15, 20x20 and 25x25. In general MxM Kekre's Wavelet transform matrix can be generated from NxN Kekre's transform matrix, such that M = N * P where P is any integer between 2 and N that is, $2 \le P \le N$. Kekre's Wavelet Transform matrix satisfies [K][K]T = [D] Where D is the diagonal matrix this property and hence it is orthogonal.

The diagonal matrix value of Kekre's transform matrix of size NxN can be computed as:

$$D(x,y) = \begin{cases} 2 & \text{, if } x=y=N \\ N & \text{, if } x=y=1 \\ 0 & \text{, if } x \neq y \\ D(x+1,y+1)+2(N-x+1) & \text{, if } x=y=p \text{ and } p \neq 1 \text{ or } N \end{cases} \quad \ldots(6)$$

Kekre's Wavelet transform on 2D matrix f is given by: [3,13]

$[F]=[KW][f]\ [KW]^T$ ……..……(7)

7. The proposed method

In this section we propose an Algorithm for CBIR using DCT/KWT and D4/KWT, Figure (1) shows this procedure in flow chart.

7.1 Proposed Algorithm for DCT/KWT

1. Client sends the query image to server.
2. Server receives the query image and resizes the query image (NxN) for example (128x128).
3. Find R, G and B color layers of the resized image Apply DCT algorithm on each layer, and then save the results.
4. Drive the Kekre's Wavelet Transform [KWT] form Kekre Transform and then find $[KWT]^T$.
5. Generate the feature of the query image by the equation (7) and save the result.
6. Match the result with database image features to retrieve the matching images, using one of the similarity measures (ED) or (AD).
7. Server sends the matching images to the client.

7.2 Proposed Algorithm for D4/KWT

1. Client sends the query image to server.
2. Server receives the query image and resizes the query image (NxN) for example (128x128).
3. Find R, G and B color layers of the resized image Apply D4 algorithm on each layer, and then save the results.
4. Drive the Kekre's Wavelet Transform [KWT] form Kekre Transform and then find $[KWT]^T$.
5. Generate the feature of the query image by the equation (7) and save the result.
6. Match the result with database image features to retrieve the matching images, using one of the similarity measures (ED) or (AD).
7. Server sends the matching images to the client.

8. Experimental Results

The CBIR techniques are tested on the image database [14] taken 200 variable size images spread across 4 categories of Buses, Dinosaurs, Rose and Elephants. The categories and the distribution of the images are shown in table (1). The database is exists in distributed system where clients/ server as a star topology. In star topology the server is a central computer that is form the main and other computers which are form the clients. The star topology is the most widely implemented network design in use today. Because all devices connect to a centralized hub, but if the hub fails, any device connected to it will not be able to access the network. Figure (2) shows client server star topology.

Starting by generating features vector for all images in the database, then a 5 randomly chosen query images of each categories are produced to search the database to experimental the result for each methods. To compare the techniques and to check their performance two different similarity measures namely AD and ED are considered. Average precision and recall are used for performance study of these approaches.

The precision-recall refers equations are [10]:

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total Numbers of images retrieved}} \quad \dots (8)$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of Number of relevant images in database}} \quad \dots (9)$$

The DCT/KWT, DCT and D4/KWT, D4 with the consideration of two similarity measures sum of absolute difference (AD) and Euclidean distance(ED) has been shown in Figure(3) and Figure(4). The average value of each method has been plotted as horizontal lines to compare the individual class performances .It is seen that DCT/KWT performs better than DCT but D4 alone gives better performance than D4/KWT. And the use of Euclidian distance (ED) gives better retrieval than the sum of absolute difference (AD) for allmost images classes. The 4 categories retriev difference performances for example the Buses give the less retrival and the flowers has the maximum retrieval. Table(2) and Figure (5) show the overall average performances of the four methode DCT, DCT/KWT, D4, D4/KWT.

9. Conclusion

The work experimented on 200 image database of 4 different categories discusses the performance of comparison DCT with kekre's wavelet transform and D4 with Kekre wavelet transform for color images for image retrieval. The performance of the proposed method is checked with similarity measuring approaches namely Euclidian distance and sum of absolute difference. It has been observed that KWT improve performance of DCT approach but D4/KWT is not better than D4 transform as far as overall average precision and recall. In this proposed method the Euclidean distance (ED) is recommended as similarity measure due to its better retrieval rate performance for all 4 categories.

Also any client in distributed system can retrieve the images from the database to find the best result this gives a flexibility although the distance between computers, fast, and best results because of a central information.

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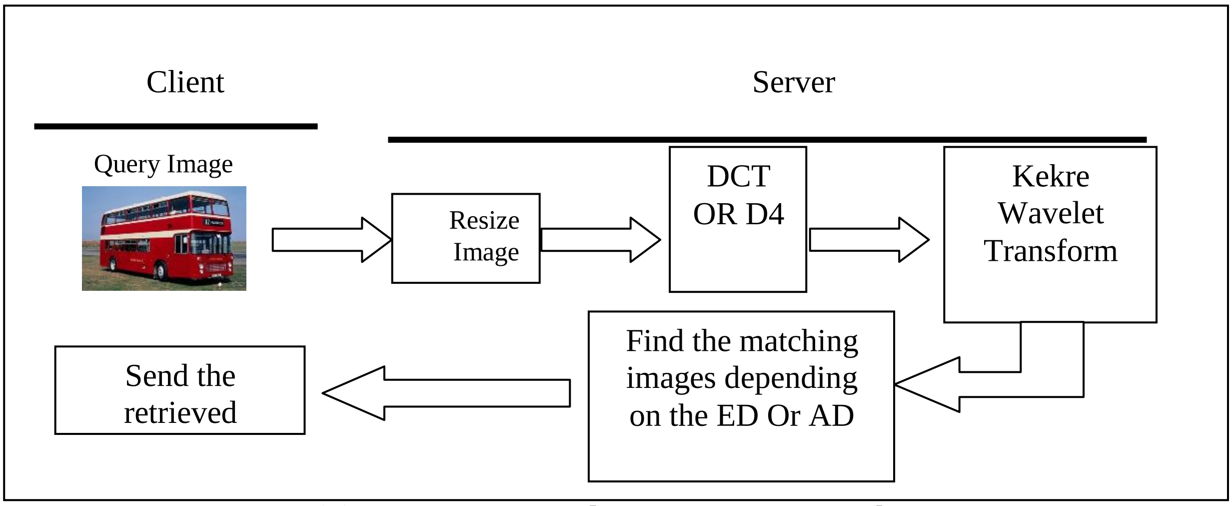


Figure (1) DCT/KWT and D4/KWT approach

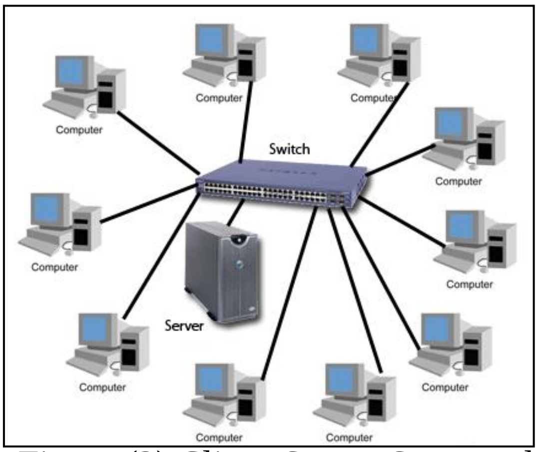
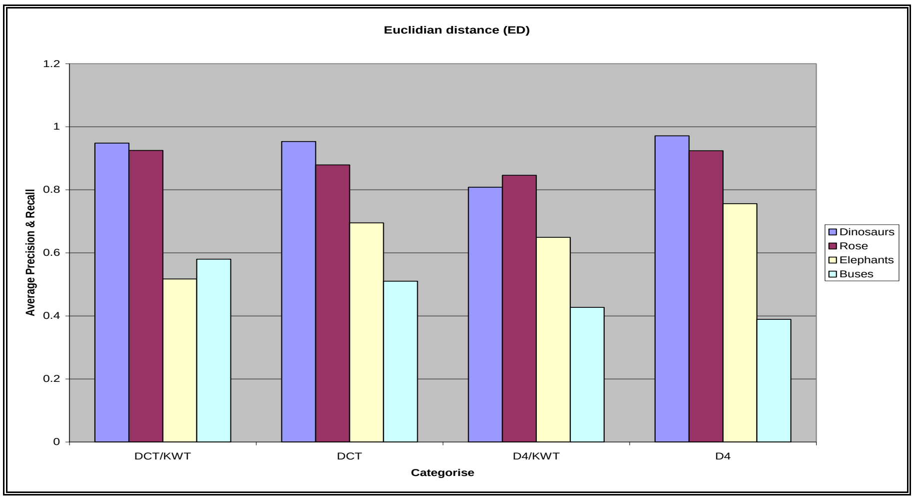


Figure (2) Client-Server Star topology



D4/KWT, Figure (3) Average Precision and Recall performance DCT, DCT/KWT,
D4. Euclidian Distance (ED) as similarity measures.

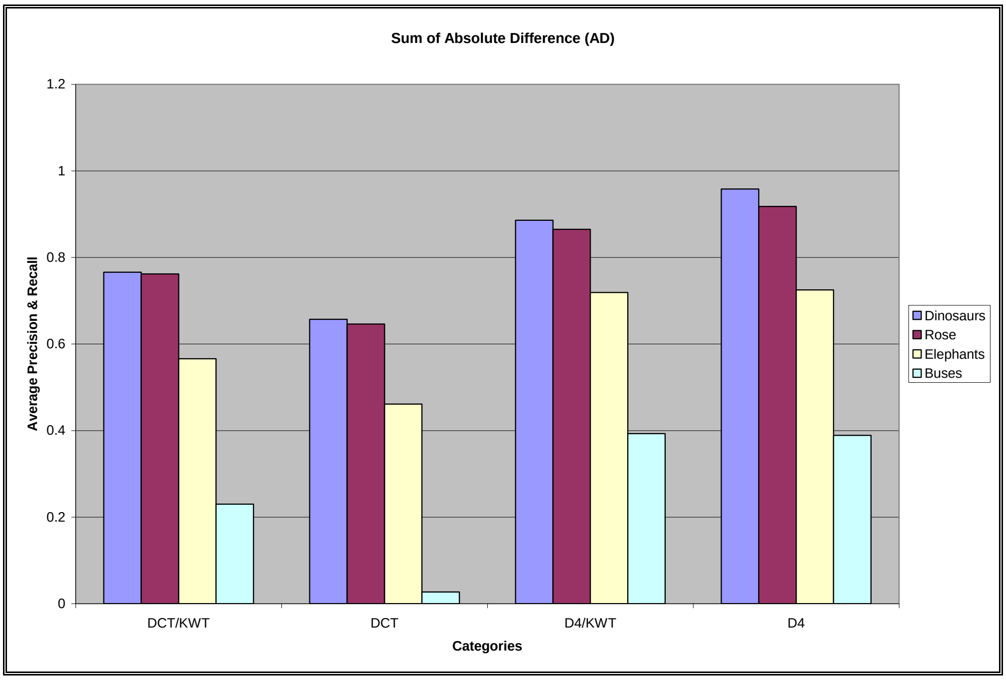


Figure (4) Average Precision and Recall performance DCT/KWT, DCT, D4/KWT, D4 Absolute Difference (AD) as similarity measures

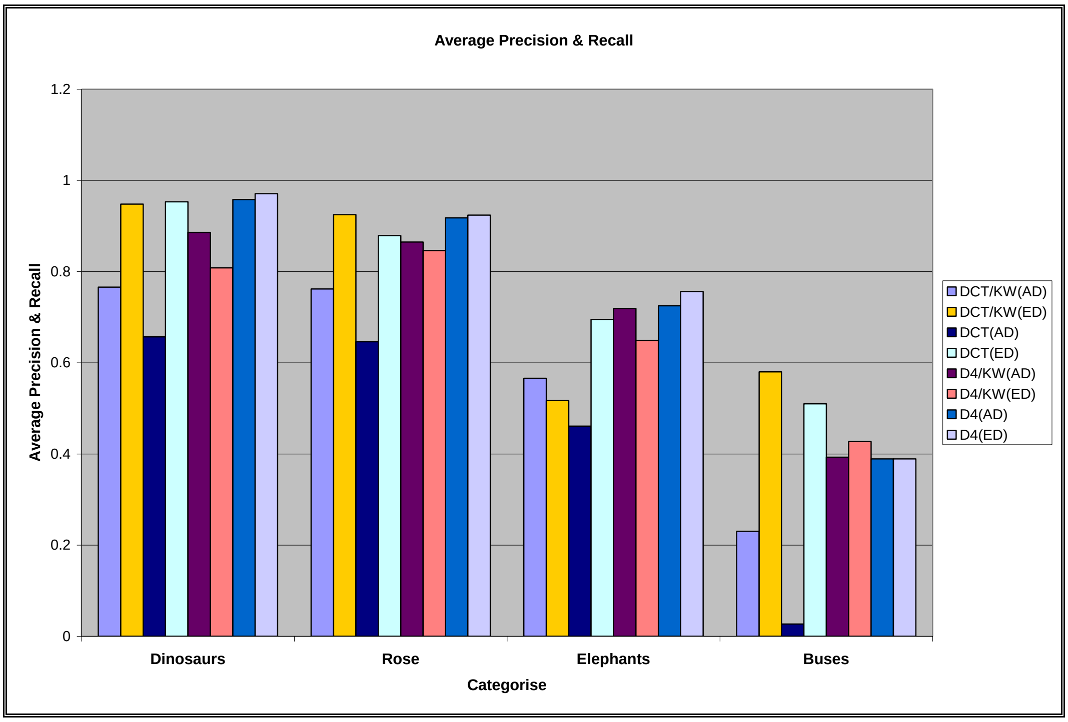


Figure (5) the over all performance of the 4 methods DCT, DCT/KWT, D4, D4/KWT Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

Table (1) show the Database Categories and Examples

Categories	Elephants	Rose	Dinosaurs	Buses
Example				
No. of Image	50	50	50	50
No. of example	5	5	5	5

Table (2) the over all performance of the 4 methods DCT, DCT/KWT, D4, D4/KWT. Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

Categories / Methods	DCT		DCT/KWT		D4		D4/KWT	
	AD	ED	AD	ED	AD	ED	AD	ED
Dinosaurs	0.657	0.953	0.766	0.948	0.958	0.971	0.886	0.808
Rose	0.646	0.897	0.762	0.925	0.918	0.924	0.865	0.846
Elephants	0.461	0.695	0.566	0.517	0.725	0.756	0.719	0.649
Buses	0.027	0.510	0.230	0.580	0.389	0.440	0.393	0.427

إسترجاع الصورة باستخدام DCT/KWT و D4/KWT في نظام التوزيع

الخلاصة

يقدم هذا البحث طريقة مقترحة لإسترجاع الصورة إعتمادا على المحتوى (CBIR) وذلك باستخدام (DCT/KWT) و (D4/KWT) لاستخراج خصائص الصور لنظام قاعدة بيانات موزع حيث يكون فيه العملاء/الخادم مرتبين كنجمة طوبولوجية ،فيقوم العميل بارسال صورة مبهمة الى الخادم (والذي يحتوي على قاعدة البيانات) ويقوم بعمل اللازم ومن ثم يرسل الصور المسترجعة الى العميل.

ستتم المقارنة بين هاتين الطريقتين: حيث سنقوم اولاً بمقارنة (DCT) مع (DCT/KWT) وثانياً مقارنة (D4) مع (D4/KWT) . وسنقوم باختبارالعمل على صور قاعدة البيانات 200 صورة لاربعة اصناف من الصور ومن ثم قياس اداء الصور المسترجعة والأخذ بمقياسي التشابه وهما مقياس المسافة الاقليدسية (ED) ومجموع الاختلاف المطلق (AD) و مقارنته مع المعدل العام للدقة و الاعادة.