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Cloud based CBIR SaaS Model using Hybrid Wavelet Type I & Type II based Texture Feature Extraction

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ABSTRACT
Content Based Image Retrieval (CBIR) is a technique used for efficient retrieval of relevant images from large databases based on features extracted from the image. Image Feature extraction is a method used to extract feature vectors of an image based on color, shape, texture etc. This paper proposes a system that can be used for retrieving images related to query image. Kekre's Hybrid Wavelet Type I & Type II are used for feature extraction. Hybrid Wavelet transforms are generated using orthogonal transforms such as Discrete Cosine transform (DCT), Walsh transform, Haar transform, Hartley transform, Kekre transform in any combination. The feature vectors of the database images are stored and then are compared to the feature vectors of the query image. The image information is sorted in decreasing order of similarity. This paper aims at implementing a CBIR system on cloud due to which services of CBIR will be dynamically made available resulting in increase in applications processing speed, scalability, flexibility and availability. Similarity measures like precision and recall are used for performance evaluation.

Keywords
Content Based Image Retrieval (CBIR), Hybrid Wavelet, Cloud Computing, Web Role, Worker Role, Blob storage.

1. INTRODUCTION
The age of computers has brought tremendous increase in the all types of data, it contains audio, video and text. With the increase in size of data, its indexing has become a challenge. In this paper the image data type is in focus. Indexing and retrieval of images requires improved methods for sorting, browsing, and searching through increasing image databases. Image databases are used by several professionals including doctors probing for similar clinical cases, editors looking for illustration images and almost everyone needs to organize their personal photos [1].

Content Based Image Retrieval (CBIR) is a technique which uses visual contents of image such as color, shape, texture, etc. to search user required image from large image database according to user's requests in the form of a query [2]. In the conventional search engines without the ability to examine image content, searches have to rely on metadata such as keywords or captions, which are difficult or costly to produce.

In traditional image databases, images are text-annotated and image retrieval is centered on keyword searching. Some of the disadvantages of this approach are: 1. Since there are no fixed set of words that describes the image content, Keyword based image retrieval is not appropriate; 2. keyword annotation is very general. Manual annotation can be avoided by using an alternative approach known as content-based image retrieval.

Content-Based Image Retrieval (CBIR) systems are search engines for huge image databases, which index images according to their visual content. In content-based image retrieval framework, the visual features of the images in the database are extracted and described by multi-dimensional feature vectors. The feature vectors of the images in the database form a feature database. A query image is given as input to the retrieval system. The system then changes these query image into its internal representation of feature vectors. The similarities distances between the feature vectors of the query image and those of the images in the database are then calculated and retrieval is performed with the aid of an indexing scheme [3]. The indexing scheme provides a competent way to search for the image database.

An important task solved by CBIR systems is that a user submits a query image or series of images and the system is required to retrieve all relevant images from the database as similar as possible. Another task is a support for browsing through large image databases, where the images are supposed to be grouped or organized in accordance with similar properties [1]. High retrieval efficiency and less computational complexity are the important characteristics of CBIR systems.

Cloud computing is defined as a type of computing that depend on sharing computing resources rather than having local servers or personal devices for management of applications. Cloud computing is a system for empowering ubiquitous, convenient, on-demand network access to shared & configurable computing resources that can be swiftly provisioned and freed with marginal management effort or service provider interface [4]. Some of the significant characteristics of cloud computing are:

- On-demand self-service
- A broad network access
- Resource pooling
- Rapid elasticity
- Measured service

With cloud computing, the developer eliminates those headaches because they are not managing hardware and software, that's the responsibility of an experienced vendor like salesforce.com, AWS, Azure, etc.

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1.1 Applications of CBIR

Detailed applications for CBIR technology can be found in [5]. Some of them are listed below:

- **Web Searching**: A large number of digital images are accessed by the Internet users. CBIR systems can help the users to effectively find what they are looking for.
- **Medical diagnosis:** A large number of medical images have been stored by hospitals. Thus, CBIR systems can be used to aid diagnosis by identifying similar past cases.
- **Journalism and advertising:** Articles, photographs, videos of the newspapers, journals or televisions are queried by using CBIR systems
- **Military:** Databases of all images in military applications; such as remotely sensed data, weapons, aircrafts, automatic target recognition, etc.
- **Intellectual property:** Most of the companies have their own trademark image. Whenever a new trademark image is to be registered, it must be compared with existing marks to eliminate duplications.
- **Crime prevention:** After a serious crime, law enforcement agencies search their archives for visual evidence. Such archives include photographs, fingerprints, shoeprints, and etc. of the past occasions. Thus, a CBIR system may help those agencies in finding related evidence.

2. WINDOWS AZURE TECHNOLOGIES

Azure is Microsoft's cloud based platform, a growing collection of integrated services such as compute, storage, data, networking and app that help developer move faster, do more and save money.

2.1 Cloud Services

When creating an application and run it in Azure, the code and configuration together are called an Azure Cloud service. Cloud Services is a Platform-as-a-Service (PaaS) model. Cloud service technology is designed to support applications that are reliable, scalable and cheap to operate. A cloud service consists of one or more web roles and/or worker roles, each with its own application files and configuration.

"Web Role" virtual machines are Windows Servers with IIS installed, whereas "Worker Role" virtual machines are Windows Servers without IIS installed. Web roles provide a dedicated Internet Information Services (IIS) web server that can be used for hosting the web front-end of the cloud service. Application code hosted within worker roles can run tasks in the background that are asynchronous, long-running, or perpetual [6].

With Cloud Services [6], the developer don't create virtual machines. Instead, the developer provides a config file that tells Azure how many of web role and worker role instances the developer needs, and the platform creates them. The developer still have to choose what size those VMs should be, the options are the same as with Azure VMs, but it don't explicitly create them. If the application needs to handle a greater load, the developer can ask for more VMs, and Azure will create those instances. If the load decreases, the developer can shut those instances down.

2.2 Azure Storage Services

Cloud computing enables new scenarios for applications requiring reliable, scalable and highly available storage for their data. Azure Storage is highly scalable, so the developer can store and process terabytes of data required by financial analysis, business and media applications. Even the developer can store smaller amounts of data needed for a small business web site.

As Azure Storage is elastic, the developer can design applications for a large global customers, and scale those applications whenever needed, both in terms of the amount of data stored and the number of requests that have come from it. The developer pays only for what is used/stored. [7]. Azure offers three types of storage services such as: Blob, Table and Queue.

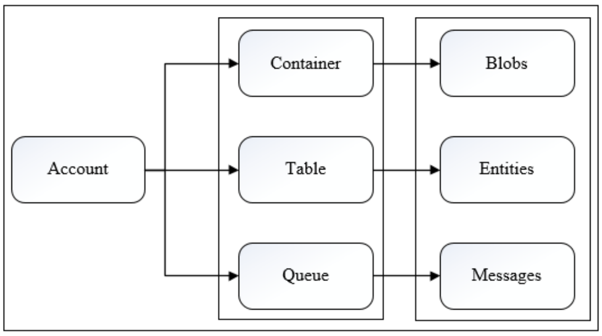

Fig 1: Windows Azure Storage Services

2.2.1 Blob storage

Azure Blob Storage [7] [8] is a service for storing large amounts of unstructured data. The developer can use Blob storage to store content as listed below:

- Documents
- Photos, videos, music, and blogs
- Backups of files, computers, databases, and devices
- Images and text for web applications
- Configuration data for cloud applications
- Logs and other large datasets

There are two types of blobs: block blobs and page blob. A "bock blob" can store up to 200 GB of data and is enhanced for streaming workloads. While a "page blob" supports up to 1 TB of data and is meant for random access. Each object is stored in a Container and can also have properties associated with it. The properties can be used to store any meta-data information relevant to the object persisted.

2.2.2 Table storage

Table storage [7] provides a highly scalable storage, so that the application can automatically scale to meet user demand. Table storage is Microsoft's NoSQL key/attribute storage, it owns a schema less design, making it differ from traditional relational databases.

In the table storage, a unit of data is persisted as an Entity. Each entity is defined as a set of attributes that constitute the properties of the entity. There is no limit on how many entities can be stored in one table but typically billions of entities can be stored in one table.

2.2.3 Queue storage

Queue Storage [7] provides reliable storage and delivery of messages in an application. A queue's prime function is to enable communication between Web and Worker Role instances. Queues are accessible using REST interfaces. A storage account can contain any number of queues. A queue can contain any number of messages, up to the capacity limit of the storage account. Individual messages may be up to 64 KB in size.

3. HYBRID WAVELETS

Wavelets are mathematical tools that can be used to extract information from many different kinds of data, including images [9] [10]. Sets of wavelets are generally needed to analyze data fully. A set of "complementary" wavelets will reconstruct data without gaps or overlap so that the deconstruction process is mathematically reversible and is with nominal loss. The wavelets are results of the thought process of many people starting with Haar's work in the early 20th century [11].

The orthogonal transforms are used for analysis of global properties of the data into frequency domain. For studying the local properties of the signal, the concept of wavelet transform is presented, where the mother wavelet function gives the global properties of the input signal and wavelet basis functions which are compressed versions of mother wavelet are used to study the local properties of the signal [12]. In wavelets of some orthogonal transforms the global characteristics of the data are hauled out better and some orthogonal transforms might give the local characteristics in better way. The concept of hybrid wavelet transform comes in to picture in view of combining the traits of two different orthogonal transform wavelets to exploit the strengths of both the transform wavelets [13][14].

The hybrid wavelet transforms are generated using four orthogonal transforms alias Discrete Cosine transform (DCT), Discrete Hartley transform (DHT), Discrete Walsh transform (DWT) and Discrete Kekre transform (DKT). In this paper different combinations of wavelets transform are used for the multi resolution analysis of the images and their performances are compared.

3.1 Hybrid Wavelet Type I

In Hybrid Wavelets Type I the image is divided into LL, LH, and HL, HH components in the first level. Hybrid Wavelet I has non-standard components size. The size of the LL component is decided by the Low Frequency component of the Wavelet Matrix. In case of the Hybrid Wavelets the Low frequency components is first M rows of the M X P size matrix (first 64 Rows in case of 256 X 256 (64X4) Size Matrix). In case of other wavelets this is exactly half the size of the matrix.

3.2 Hybrid Wavelet Type II

The Hybrid Wavelet Type I have limitation of reduced size of LL component. Hence combined Decomposition Based Multi-resolution Analysis is used. To overcome this problem Hybrid Wavelets Type II were proposed. Here the only change is that, while generating the Low Frequency Component the multiplication is repeated N Times, hence the LL component has the size of MXN.

4. IMPLEMENTATION

Content based image retrieval is a technique concerned with the retrieval of images similar to the query image, from an image repository. The CBIR system is an application build on the windows Azure platform. In this application the request is made in the form of the query image. The query image is checked for its size and then it is normalized. Image Normalization takes place where image of size m*n is reduced to size 256*256 in order to extract the feature vectors of the image on the basis of texture using image extraction technique. This technique is implemented by a web service deployed on a web role on the cloud using Hybrid Wavelet Type I and Type II. The extracted feature vectors of the query image will be compared with the extracted features of the image residing in the image repository. For similarity evaluation among the database image and the query image, the Euclidean distance method is used. By means of a suitable threshold, images that are semantically nearer are retrieved from the database and displayed in the form of image output.

4.1 Similarity Measurement

In the CBIR field, there are a number of distance measures used for similarity computation, such as the Minkowski metric, Hausdorff distance, K-L divergence, Earth Mover's distance (EMD), and Integrated Region Matching. The well-known Euclidean distance (L2 distance) and Manhattan distance (L1 distance) are special cases of Minkowski metric.

In this research, Euclidean distance is used for similarity comparison. The weighted Euclidean distance between two vectors x and y, can be computed by:

$$DL2\,(x,y) = \sqrt{\sum_{j} w_j\,(x_j - y_j)2} \qquad (1)$$

Where, w_j is the weight of the j-th component, and x_j and y_j are components of x and y respectively.

4.2 Performance Evaluation

The performance of retrieval of the system can be measured in terms of its precision and recall [15]. Precision is defined as the number of retrieved relevant images divided by the total number of retrieved images. Recall is defined as the number of retrieved relevant images divided by the total number of existing relevant images. Precision and recall have an inverse relationship. Image retrieval results are usually reported by precision-recall curves.

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}} \qquad (2)$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images}} \qquad (3)$$

4.3 Enrollment Operation

This part is focused on the image enrollment on Azure cloud. Enrollment operation consists uploading the image in the blob storage in the cloud using a web role. It also consists of background processing of feature extraction done by the worker role on the uploaded image. The techniques used for extraction the feature vectors are Hybrid Wavelet Type I and Type II. After feature extraction, feature vectors of the image are stored in the blob storage.

The Enrollment operation consists of the following steps shown in fig (2):

1) User will upload the image to web role.
2) Web role stores the image in the blob storage.

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3) After storing the image, the web role posts a work item to a queue to have the Feature vector calculated for the uploaded image.
4) Worker role fetches the work item from the queue.
5) Worker role connects to the blob storage for retrieval of image.
6) Worker Role retrieves the image from blob storage, and process it to create a feature vector of the image.
7) And store the calculated feature vector in blob storage.

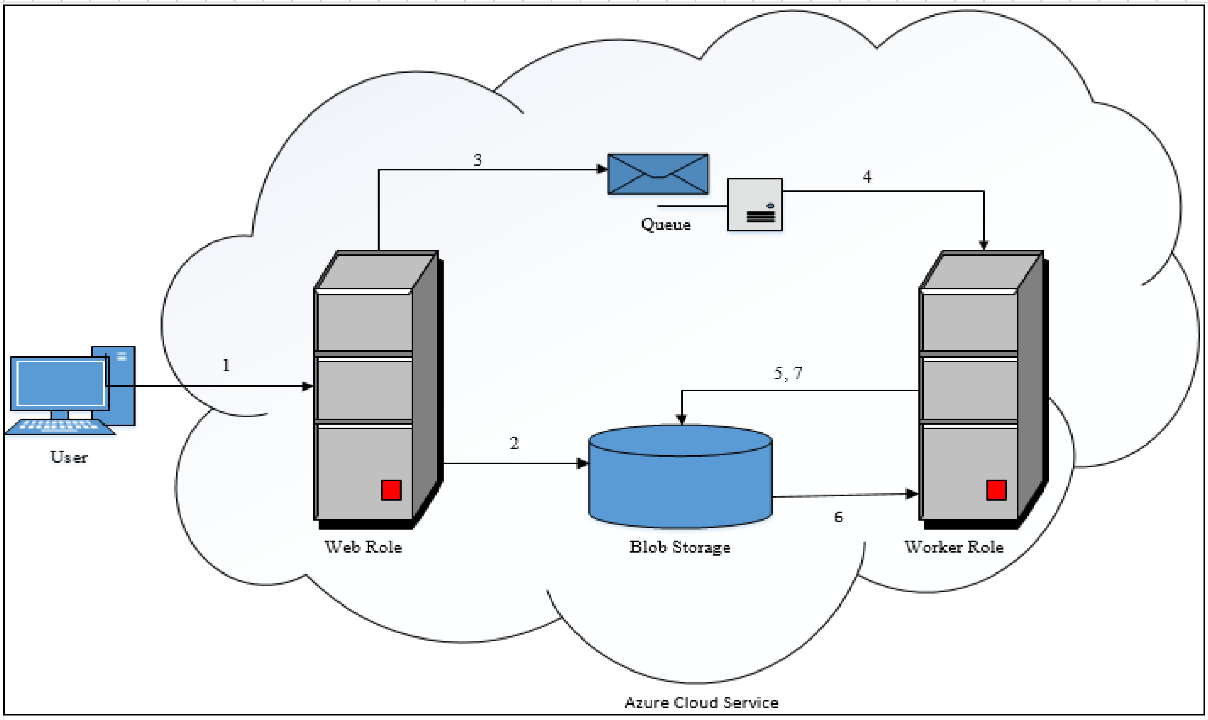

Fig 2: Enrollment Operation

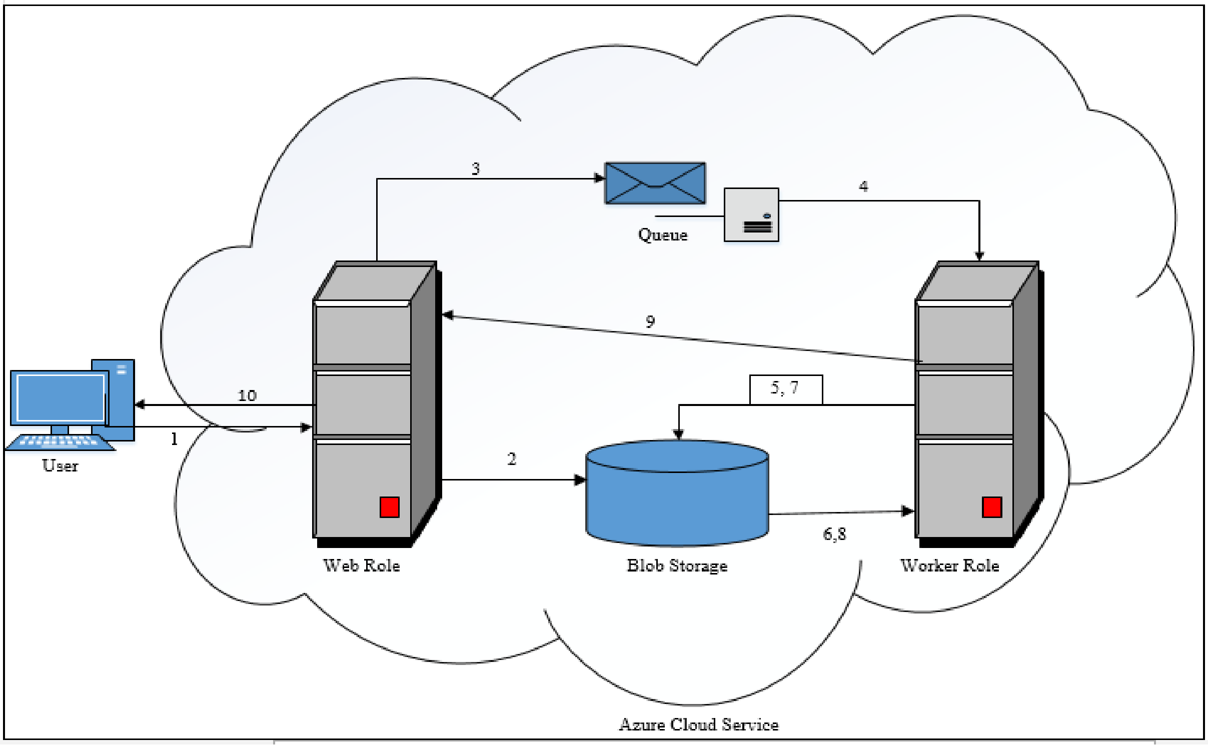

Fig 3: Searching Operation

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4.4 Searching Operation

Searching operation consist of verification and retrieval of relevant images from the database. This is done by computing the feature vector of the query image and comparing this calculated feature vector with the feature vectors stored in the blob storage. If the calculated feature vector matches with the feature vector in the blob storage than it's a valid image or else it's an invalid image.

The Searching operation consists of the following steps shown in fig (3):

1) The image to be searched will be first uploaded to the web role.
2) Web role stores the image in the blob storage.
3) After storing the image, the web role posts a work item to a queue to have the Feature vector calculated for the uploaded image.
4) Worker role fetches the work item from the queue.
5) Worker role connects to the blob storage for retrieval of image.
6) Worker role retrieves the image from blob storage, and process it to create a Feature Vector of the image.
7) Checks for match between the calculated feature vector and the feature vector stored in the blob storage.
8) Sends the relevant images to the worker role.
9) Worker role update the status of whether the image is valid or invalid and send it to the web role.
10) Web role will give back the retrieved images onto the user screen.

5. RESULTS

The image database consists of 1000 images, randomly taken from web. The images in the image database are classified into ten classes based on the objects present in them such as animals, bicycles, buildings, cars, doors, flowers, chimneys, leaves, trees and windows. The feature vector extraction for a query image is shown in Fig (4). The common evaluation measures used in CBIR systems are precision and recall. So, from the image database of 1000 images, we have calculated the precision and recall crossover for varied image queries. The Precision-Recall Crossover and the Processing time for different transform combinations of the query image is given in Table 1. The Precision-Recall Crossover for Hybrid Wavelets Type I Haar-Hartley Combination was at 52%, for Hybrid Wavelets Type II, Hartley-Haar combination gave maximum of 31% crossover.

5.1 Performance

Since, the proposed architecture is implemented on the cloud platform, there is increase in the speed of computation. Azure provides a set of worker roles which performs parallel computations thus decreasing the overall processing speed. A VM with 8 Cores, 16 GB RAM (Extra Large VM) has almost one tenth of processing time as compared to normal desktop processing.

5.2 Scalability

Scalability is achieved in two ways: Computing Scalability and Data Storage Scalability. When requirement arises, the worker role instances can be dynamically scaled out, thus achieving computing scalability. Blob storage is scalable by nature. By making the use of BLOBs for storing the images, data storage scalability is achieved.

Fig 4: Feature Vector Extraction using Hybrid Wavelet Type I and type II

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Table 1. Performance of the CBIR System using Euclidean Distance

		Hybrid Wavelet Type I				Hybrid Wavelet Type II			
Image Category	**Image name**	**Precision Recall Crossover**	**Transform Combination**	**Processing time (ms)**	**Cloud Processing time (ms)**	**Precision Recall Crossover**	**Transform Combination**	**Processing time (ms)**	**Cloud Processing time (ms)**
Animals	a (13)	0.42	DCT Haar	1347	135	0.20	DCT Haar	1614	147
		0.49	DCT Hartley	1330	133	0.23	DCT Hartley	1576	158
		0.39	DCT Walsh	1352	150	0.26	DCT Walsh	1087	99
		0.51	Haar DCT	28188	3524	0.23	Haar DCT	1095	100
		0.52	Haar Hartley	64762	5887	0.15	Haar Hartley	1167	146
		0.40	Haar Walsh	65895	6590	0.18	Haar Walsh	1134	126
		0.46	Hartley DCT	68970	7663	0.25	Hartley DCT	1184	118
		0.47	Hartley Haar	68006	6182	0.31	Hartley Haar	1179	118
		0.47	Hartley Walsh	68338	6834	0.31	Hartley Walsh	1190	119
		0.50	Walsh DCT	86386	7853	0.2	Walsh DCT	1182	131
		0.42	Walsh Haar	66270	6627	0.29	Walsh Haar	1237	137
		0.50	Walsh Hartley	64578	8072	0.27	Walsh Hartley	1247	125
Flowers	f (13)	0.19	DCT Haar	1130	113	0.09	DCT Haar	1601	178
		0.13	DCT Hartley	1136	114	0.10	DCT Hartley	1675	209
		0.19	DCT Walsh	1097	137	0.10	DCT Walsh	1721	157
		0.11	Haar DCT	1167	130	0.09	Haar DCT	1678	168
		0.10	Haar Hartley	1133	142	0.09	Haar Hartley	1681	168
		0.12	Haar Walsh	1192	119	0.08	Haar Walsh	1700	170
		0.17	Hartley DCT	1141	143		Hartley DCT	1762	1307
		0.21	Hartley Haar	1192	132	0.14	Hartley Haar	1650	165
		0.24	Hartley Walsh	1214	111	0.12	Hartley Walsh	1698	179
		0.17	Walsh DCT	1235	112	0.11	Walsh DCT	1631	163
		0.14	Walsh Haar	1234	137	0.09	Walsh Haar	1741	193
		0.12	Walsh Hartley	1226	123	0.12	Walsh Hartley	1665	208
	f (45)	0.23	DCT Haar	1238	124	0.17	DCT Haar	1738	174
		0.17	DCT Hartley	1285	161	0.11	DCT Hartley	1803	164
		0.20	DCT Walsh	1309	131	0.17	DCT Walsh	1851	185
		0.22	Haar DCT	1265	141	0.15	Haar DCT	1758	176
		0.16	Haar Hartley	1318	120	0.14	Haar Hartley	2149	195
		0.18	Haar Walsh	1326	133	0.13	Haar Walsh	1828	203
		0.18	Hartley DCT	1386	139	0.14	Hartley DCT	1893	172
		0.17	Hartley Haar	1350	135	0.16	Hartley Haar	1894	172
		0.15	Hartley Walsh	1421	158	0.18	Hartley Walsh	1883	188
		0.19	Walsh DCT	1440	144	0.12	Walsh DCT	1820	165
		0.27	Walsh Haar	1389	139	0.11	Walsh Haar	1791	179
		0.17	Walsh Hartley	1429	179	0.09	Walsh Hartley	2029	203

6. CONCLUSION

In this paper public cloud based CBIR Software as a Service (SaaS) architecture is discussed in detail and successfully implemented on Microsoft Azure cloud which aims to devise a highly scalable, pluggable and faster Content based image retrieval system. This architecture gives 90% improvement in execution speed as compared to existing implementation. Hybrid wavelets Type I and II are used for feature vector generation. The proposed cloud based approach is having better accessibility, scalability and reduction in processing time. Hybrid Wavelet Type I have given 52% crossover for precision and recall. In the Content based image retrieval based on Public cloud, the image and the image data storage is on the cloud. This model is a low cost and flexible implementation, but as the data is stored on a public cloud, it has risk involved. The hybrid cloud based Content based image retrieval is a more secure model, where the data is stored on private cloud and the image retrieval service is running on a public cloud. This model is secure and flexible, but complexity is high and has a high implementation.

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