# Cloud Computing for Providing Electronic Service for Skin Health

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***Abstract*—This paper proposes a new software for separation of skin lesion based on cloud computing. The objective of this system is to provide electronic services for initial dermatologic detections based on electronic function principles accessible at all times, all spaces, while being accurate, fast and low cost applicable by observing the security and confidentiality principles. The conducted assessments regarding the accuracy of the system's detections, applicability and user satisfaction indicate success with 89% in detection accuracy and 89% user satisfaction with respect to the systems usability, accessibility, easiness, response time and detection accuracy. The response time of the server in operation in the (3 G) mobile phones is 5.45 seconds which is acceptable and appropriate as far as medical diagnosis is concerned.**

***Index Terms*—skin lesion, medical diagnosis, cloud computing, content-based image retrieval**

## I. Introduction

The wide spread of skin lesion in the recent decades and its negative effect on the individuals' appearance and emotion caused by it and the growing number of patients infected with skin impairment has promoted low cost, accurate services and accessible systems for initial detections with no need to visit the skin specialists. Skin lesions in general, are divided in the following six common groups: Actinic Keratosis (AK), Basal Cell Carcinoma (BCC), Squamous Cell Carcinoma (SCC), Melanocytic Nevus (MN), Seborrheic Keratosis and Melanoma (ML). Accurate detection of skin lesion must be conducted by the dermatologists since most of the skin lesions have common features: Melanoma and Clark skin lesion are very similar, while the Melanoma is a malignant cancer and fatal and the Clark is benignant caner.

The attempt is made here to design and implement a service accessible to the experts in this field, MDs and the public who do not have expert knowledge on skin. Here no marginal specific hardware or software is needed. With the least of efforts, the digital images are taken with no need of hardware/software platforms everywhere, at any time with the highest accuracy, speed and certainty with the lowest cost. This study provides a new application in cloud computing based on Microsoft Windows Azure providing electronic services for skin health (Tele dermatology).

## II. Skin Health Care Software System Architecture

The server software is ranked in the 'Software as a service' of the cloud computing [1]. The users (experts of the field), by becoming members of this electronic service will benefit. As observed in Fig. 1 the software service consists of two beginning and end sections.

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### A. The Beginning Section

This is where the end user has collaborated with. This section is designed and implemented by Microsoft Silverlight 4 technology. One of the features of this is its being independent of operating system and browser through which the operating intermediate can be implemented on any acting interface(the acting systems are: Apple's IOS, Android, Windows Phone, Windows 8 and Linux). The section is assigned to receive the image. The user determines the image taken from the lesion mole and request detections through this Graphic User Interface (GUI). Prior to data dispatch to the server, all encrypted and detailed data is stored on the user's equipment (mobile phone, etc.) for further use. The connection of the beginning section (GUI) and the end section (the server) is made through Access Control Service (ACS) of Windows Azure based on Secure Socket Layer (SSL) through Windows Communication Foundation (WCF). Through the (ACS) the user can connect to other identity verifying servers like Google, Facebook, Yahoo, and Windows Live. This service increases the capability, use and ease in connection to the service and receiving services in addition to providing high customer satisfaction. Data transfer between these two sections through WCF, is designed and implemented. This section provides a weigh equilibrium between the end points (user and cloud computing) as well as providing safe data transfer along the path by encrypting the data through asymmetric encryption algorithm, AES 512. Most of the end users are worried about data disclosure in the communicating channel in different manners, especially through electronic sniffing of the information, but this process removes that worry.

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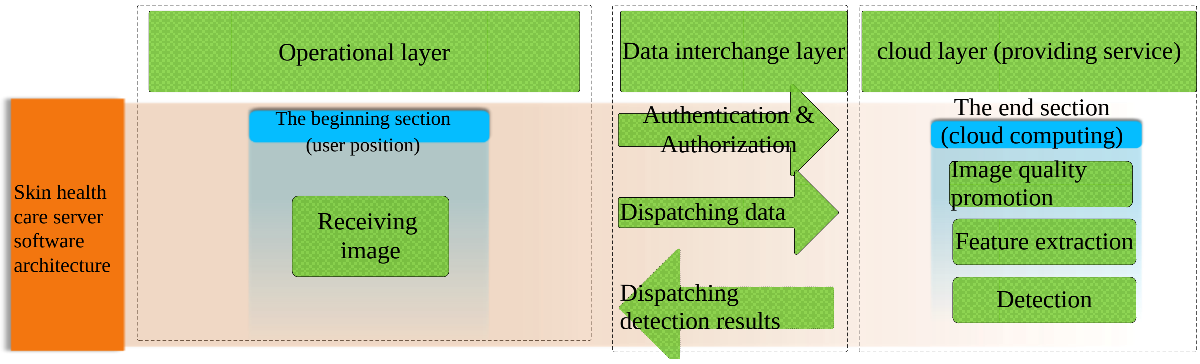



Figure 1. Skin healthcare software system architecture

The intelligent skin lesion segmentation process in the detection phase includes the image quality enhancement, segmenting the skin lesion and extracting the features. In the recent years some limited studies are conducted in this field. Alexandra *et al.* [2] suggested the tele Dermatoscopy through cellular phone as an effective and low cost method for rapid detection of skin cancer. Adopting this method, in addition to the limitations of using mobile i-phone, needs about 1.500$ for providing the marginal mobile Dermoscopic hardware. The authors in [3] and [4] introduced "skin scan" software, a portable library for (ML) based on the IPhone Operating System (IOS). This system, by manipulating the tissue features makes the classification where the accuracy in detecting (ML) against benignant lesions reaches 81%. The process time is 5 seconds on IPhone 4. Implementation of the first installable version on mobile phone provided in [5] and the open-CV library is used for desired image processing. In that work, the emphasis is on the pigmentation and form features where the KNN classifier is used. This applicable program is implementable on Android with 66.7 % accuracy in detection. Celebi et al [6] developed a system for skin lesion image recovery based on form. The results obtained from analyzing 184 images indicate that there exists a statistical significance between computer assessment and human perception. Rahman *et al.* [7] introduced an image retrieval system based on Content Base Image Retrieval (CBIR) for Dermoscopic images. Their system's evaluation illustrated on the accuracy diagram indicates that this system is accurate in assessing the lesions with a 60% average. Dorileo *et al.* [8] recommended a CBIR for the skin lesion. They used the features based on histogram and co-occurrence matrices for similar image retrieval. 50% accuracy is obtained by analyzing 215 images. Ballerini *et al.* [9] examined five types of lesions from 533 images and introduced a CBIR system through evolutionary feature's synthesis with an accuracy percentage ranging from 67 to 82%. Despite the above mentioned experiments many business oriented are introduced to be accessible through mobile I-Phones based on IOS and Android. Among From the applicable programs based on Android the 'ABCDE's of Melanoma', 'Doctor Mole' and 'Spot Mole' can be pointed out. In parallel based on Apple interface system such as 'Melanoma Visual Risk Calculator', the 'Mole Checker' and 'skin cancer' could be listed.

Both the groups of these programs concentrate on the extraction of asymmetry of features according to ABCD or ABCDE regulations with the following common restriction.

1. Implementation restriction on the software platform
2. Hardware platform restriction due to performing processes on the user equipment Detection accuracy at maximum 81%
3. Lack of extracting maximum effecting features in the detection process according to ABCD or its modified regulations with a focus on specific features due to the restriction of processing power, etc.
4. Lack of using the patient's clinical data in order to achieve maximum accuracy and precision
5. Disregarding the effecting factors during image taking like unbalanced lighting
6. Lack of access to some of these systems due to the economic sanctions and high software cost

## *B. The End Section*

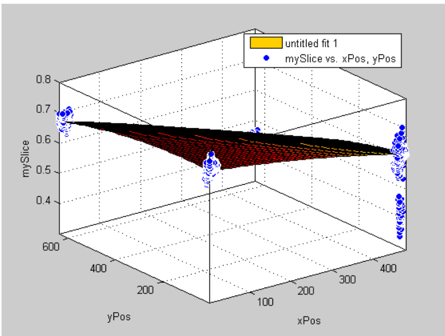
This section is executed on the cloud and is responsible for the processing task. The core of serving software is designed and implemented based on Microsoft ASP.Net technology and Internet Information Service (IIS). All the data accompanied with the images are saved in encrypted manner through asymmetric algorithm (AES) with a 1024 key length in the SQL Azure data bank. This makes the uncertainty regarding the stored data security on the cloud computing away and the user's peace of mind to communicate with the system. This software, at the end section has four major functions:

### *1) Image quality enhancement*

In most of the captured digital images due to non-adjustment of the camera outlet, the existence of light sources as shadows and non-professional photo-taking are evident. If a system should become a common tool among many, it should have the least of deficiencies. This stage is the most important in segmentation and extracting accurate features. In this project the approximation of shadow pattern approach based on the least square's error with the average color pixels of healthy skin around the lesion mole is adopted. After approximating the pattern the shadow is eliminated from the main picture with the least of effects on the picture (Fig. 2).

(a)

(b)




(c)

Figure 2. (a) Main picture, (b) Picture after light adjustment, (c) The light modification function

At this stage noise and hair elimination takes place through a 5x5 intermediate filter.

*2) Segmentation the lesion mole*

Here, in order to extract the asymmetry features according to ABCDTP regulation and its modified versions through the findings are of importance.

Extracting the asymmetry features according to ABCDTP regulation and its modified versions is very important. In this study, a random walker algorithm by [11] is applied.

*3) Extracting the features*

In this system extracting the features takes place based on a modified ABCDTP through the authors of [11]. This rule is expanded due to an advanced digital camera function which evaluates: Asymmetry, irregularity of the border, Color variation, Diameter, Texture and Profile. According to this rule the lesions which are asymmetric, deformed in Boundary, have color shade variety dark to light, have a diameter bigger than 6 mm, condensed and have the potential features of blooding, change of shape in about 90 days, becoming harder and itchy are mostly the cancerous ones. By adopting ABCDTP, 430 effective features are extracted from the lesion surface.

*4) Detection*

For this purpose the CBIR and KNN are adopted to distinguish and detect the skin lesion from 6 groups under study. In this study features vector obtained from feature selection step with the picture feature available in the data bank are compared through the distance criterion described by Equ.1, below and afterwards the K images are retrieved similar to that of the entrance image, where the K is 7, selected on experimental basis; indicating that the subject sample is subject to the majority.

$$d(I1, I2) = \left(\sum_{i=1}^{p} (f_{1,i} - f_{2,i})^2\right)^{\frac{1}{2}} \quad (1)$$

where, d is the distance and I1 and I2 are the subject images described through feature vector of 430 dimensions. Based on the retrieved images sticker content which identifies the lesion type another sticker is added to the image under study. The majority of the K images are retrieved from the identified group of lesions.

After making the detections, the data are stored in a encrypted state and the result is transmitted to the user through SMS or e-mail by the server. This increases the system's utility capability and the user satisfaction. The reason here is that it could happen that during data processing by the system the user-system connection may be cut.

## III. Resutls

We evaluated our proposed system by three parameters: accuracy, service applicability (process time) and user satisfaction. For experimental results we used two following statistical populations:

### *A. Digital Images and Data Available in Credible Scientific Sources*

A total of 580 images collected from credible internet sources [12] and [13] are involved in this study. Each one of the images is evaluate by two skin experts. The images that share the same evaluation made by the experts and that of the source are selected and the ones with doubt are eliminated from the data bank.

TABLE I. The Types and the Count of Skin Lesions Applied in This Study

| Count | Type of lesion |
|---|---|
| 40 | Actinic Keratosis(AK) |
| 125 | Basal Cell Carcinoma(BCC) |
| 85 | Melanocytic Nevus/MOLE(ML) |
| 101 | Squamous Cell Carcinoma(SCC) |
| 94 | Seborrheic Keratosis(SK) |
| 135 | Melanoma(ML) |

*B. A Number of 35 Samples are Collected during 2010 and 2013 in the City of Esfahan.*

To access the CBIR, the P&R graph is usually applied. Since the objective of this system is to detect the type of lesion and for medical detection the sensibility and accuracy criterion are usually applied, the assessment here is based on the same criterion.

**Sensibility:** The accuracy level in detecting a type of lesion (accurate fitting of the lesion in its right group)

$$\text{Sensitivity} = \frac{Tp_i}{Tp_i + Fp_i} \quad (2)$$

where, $T_{pi}$ is the count of true detection in the lesion($Tp_i$ {AK,BCC,ML,SCC,SK,MN})

And $F_{pi}$ is the count of the false detection in the lesion ($Fpi \in$ {AK,BCC,ML,SCC,SK,MN})

**Accuracy:** The percentage of correct detection of all types of skin lesion (correct grouping of the skin lesion fitting in each one of the groups)

$$\text{Accuracy} = \frac{\sum_{i=1}^{5} Tpi}{\sum_{i=1}^{5} Tpi + Fpi} \quad (3)$$

TABLE II. ASSESSING THE DETECTION SYSTEM ACCURACY ON 580 LESION SAMPLE [12] AND [13]

| Sensitivity | Accuracy | |
|---|---|---|
| 91% | 89% | KNN K=7 |

TABLE III. ASSESSING THE DETECTION SYSTEM ACCURACY ON 35 LESION SAMPLE COLLECTED IN THE CITY OF ESFAHAN

| Sensitivity | Accuracy | |
|---|---|---|
| 97% | 98% | KNN K=7 |

The increase in both the criteria, the second statistical population is due to observance of image taking principles: vertical exposure, no flash light and adjusted distance to prevent blurriness.

In order to evaluate the process time necessary in this service, types of user connection based on the two common access procedures, the (3G) and (Wi-Fi) are considered here. Since the resolution of different cameras or devices differ, here the most common (521 × 437) and (640 × 960) resolutions are applied. The processing and storage sources are unlimited in Cloud computing, but here the 1 and 8 virtual processes are selected with 4GB Ram and 1Gb storage on the SQL azure.

$T_{Total}$: Time necessary in image processing and transmitting the necessary data to cloud computing and retrieval of detected results per second.

$T_{Enhancement}$: Time necessary for quality enhancement

$T_{Segmentation}$: Time necessary for image parceling

$T_{Feature\ Extension}$: Time necessary to extract features from the image

$T_{Detection}$: Time necessary for detection

$T_{send/receive}$: Transmission and receiving time through counting, twice the time of transmission from user to cloud computing (See the results in Table IV)

TABLE IV. ASSESSING THE PROCESS TIME NECESSARY FOR THE SERVER

| Type of network | Image dimensions (Pixel) | Processor count | $T_T$ Second | $T_E$ Second | $T_S$ Second | $T_F$ Second | $T_D$ Second | $T_{SR}$ Second |
|---|---|---|---|---|---|---|---|---|
| 3G | 521×437 | 1 | 11.3 | 6.3 | 2.1 | 1.2 | 1.4 | 0.3 |
| | 521×437 | 8 | 5.45 | 2.6 | 1.2 | 0.25 | 1.1 | 0.3 |
| | 640×960 | 1 | 13.22 | 8 | 2.3 | 1.22 | 1.4 | 0.3 |
| | 640×960 | 8 | 6.25 | 3 | 1.6 | 0.25 | 1.1 | 0.3 |
| Wi-Fi | 521×437 | 1 | 11.23 | 6.3 | 2.1 | 1.2 | 1.4 | 0.23 |
| | 521×437 | 8 | 5.38 | 2.6 | 1.2 | 0.25 | 1.1 | 0.23 |
| | 640×960 | 1 | 13.15 | 8 | 2.3 | 1.22 | 1.4 | 0.23 |
| | 640×960 | 8 | 6.18 | 3 | 1.6 | 0.25 | 1.1 | 0.23 |

According to Table IV, using the process sources increases the response speed. In a single state processor the minimum time is 11. 23 and the maximum is 13. 22 seconds and in an 8 state processor the minimum time is 5.38 and the maximum is 6. 25 seconds.

By comparing the obtained results from both the processors it is found that high efficiency of cloud computing in relation to other procedures (the software approaches based on mobile phone, in specific) is high with respect to achieving accuracy and detection. In this respect this issue is of major concern; therefore, most of the studies due to the processing restrictions have been able to extract less than 100 features.

To evaluate user satisfaction level, 35 samples are selected from the 25 users of the three groups of dermatologists (4), MDs (6) and non-experts (15) at hospitals and clinics of the city of Esfahan during 2010-13.

All obtained samples are evaluated by 4 experts and the results are compared to what is obtained from the server. The results of the server in these cases where the specialists were doubtful about were properly detected. A questionnaire of 30 questions in four aspects of: ease in using the GUI, accessibility (time, space and cost), detection speed, detection result is used in addition to statistical analysis made by applying SPSS software to measure user satisfaction which is 89%. The dissatisfaction among the experts in dermatology is that, this system cannot replace the actual dermatologist. After this issue was discussed they justified the service in a sense that for the initial detection it could be a good assistance to the specialist and this fact eased the discomfort of the specialists to a certain degree.

## IV. CONCLUSION

This system in addition to performing separation on 6 common skin lesions revealed 89% accuracy, 91% sensitivity and 89% user satisfaction. The process time of this cloud computing system is accepted in being about 5.45 seconds and using 3G networks. This system, as far as medical diagnosis is concerned, in comparison to the detrimental procedures which are costly due to sampling the results of which are given in many weeks is considered as an acceptable system.

The most important distinguishing points of this server with other systems and procedures are:

1. Server Type: It detects 6 types of common skin lesion: AK, BCC,SCC,MN, SK, and MC, while other systems run studies only on one type of skin lesion
2. The Server Architecture: In order to pass through the processing restrictions of mobile phone sets, tablets, computers, this server is designed based on cloud computing while the other systems have installation and implementation restrictions and due to low powered equipment do not consider the important factors for detection. Using cloud computing and modern technologies for achieving objectives providing electronic services, in this case for skin health is effective.
3. The User Interface Technology: Not having restrictions in implementing the GUI on operating system and browser. This feature of the (GUI) is one of the major indicators and due to its low capacity (less than 500 Kbit) it is applicable on low powered equipment.
4. The Utility Cost: Unlike other introduced software, the user pays per-use, while in other systems the user pays per software cost. This issue is important with respect to the business objectives when selecting a system.
5. Efficiency obtained in this study was much higher than in other studies, due to the image quality improvement process, image segmentation and feature extraction is accurate.
6. The Necessary Apparatus: No marginal apparatus are needed here like Macro lens, mobile Dermoscope, etc. Here, a 5 Mega pixel camera is enough.

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