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Analyzing Predicaments of Using Cellular Phone Cameras for Optimizing Mobile Tele-Dermatology

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ABSTRACT

Patients with skin diseases are not treated in casualties, however, it requires physical meeting between patient and doctor for better diagnosis and cure procedures. Mobile Tele-dermatology (MTD) was developed to overcome the challenges of accessing the consultant and getting treatment at a distance, mainly targeting the underserved areas. It is notable even today that, established MTD infrastructure requires equipment and expertise both, at the patient's site. For a population of 7Billion (67% of which is mobile subscribers) 35% population is effected of skin diseases. The optimism in MTD is about sending patient's lesion images to the remote site for diagnostic and getting treated by expert dermatologists. Hence, this research focuses the challenges in achieving the optimized concordance rate for accurate diagnosis of lesion images taken by patients themselves (or called as selfies), with the most common gadget, i.e., mobile phone cameras. The lesion data for this research is directly collected from rural and urban areas using different cameras of varying parameters (i.e., resolutions, distances and light-conditions). This helps to get the level of randomness required in carrying out research. Lots of interesting facts in the diagnostic process are observed and discussed during the pilot demonstration of MTD. Later, by assuming various data transmission bottlenecks and analyzing the rate of concordance between physical and image based diagnosis of the lesion, the statistics are compiled. The results of our MTD demonstration refute many established assumptions / research work in the field of MTD. In short, the work consists of i) compiling an innovative way of cataloguing the patients' selfies (image acquisition) and ii) presents comparative analysis between physical (on-site) as well as image-based (MTD) diagnosis.

KEYWORDS: Tele-dermatology, mobile dermatology, lesion, cellular phone cameras, patient's selfies.

1. INTRODUCTION

Developing countries of South and Central Asia are adopting Tele-Dermatology rapidly. The research from these countries includes study of opportunities about Mobile Tele-Dermatology too. The field is becoming a frontline cure for increased number of reported lesion and diseases in underserved areas of these countries and their African partners. Correct lesion diagnosis and skin treatment is a very challenging task, especially in remote areas. The shortage of dermatologist in rural region makes it difficult or almost impossible to attain skin-related issues [1] [2] [3]. Due to digital divide between metropolitan and rural areas, availability of a dermatologist is considered as mile-away obstructing the healthcare efforts. In underserved regions the patients don't get even proper first-aid services of dermatology. According to the cited report, the ratio of dermatologist to skin patients is 1:226,000, eventually making the first treatment dependent on travelling to any nearest city [3] [4]. Therefore, at times, healthcare centers lack dermatologists and this emphasis on initiating more dermatologic cure programs with sufficient resources to improve the true diagnostic of the lesion. All such factors necessitate effective implementation of Tele-dermatology [4] [5] [6]. The dermatology services can become accessible through Store-and-forward or Real-time Tele-Dermatology, by using the available communication link, as shown in figure 1 [7].

2. Motivation

Mobile Tele-Dermatology (MTD) is a reliable method of accessing expertise of dermatologists in digitally divide regions with limited access to the healthcare. High resolution images of the skin lesions are used in disease diagnostic process. Any reliable or pre-established communication medium helps in transferring these images to the destination or the dermatologist at some remote location. This is fact that the population of the World has exceeded 7 billion in 2012whereas 7 million are mobile subscribers [8] [9]. Hence, our research has been motivated to verify the feasibility of mobile Tele-Dermatology in the countryside deployment using cell phone cameras? If it is, then up to what ratio? This can be sought by obtaining diagnostic concordance between Mobile Tele-Dermatology and physical consultation of the same lesion. It also includes about finding standards to be followed while taking patient's images of the affected lesion by quantitative assessment of the role of Image Processing and Enhancement tools in successful image based diagnosis [10][11][12].

3. Related work

Mobile Tele-Dermatology offer services to patients with growing skin diseases. It is also helpful for following up the patients after first treatment that may be in need of systemic treatment. Mobile Tele-dermatology facilitates speedy

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transmission of affected lesion images via e-mail or specific web-application and several studies have confirmed a high 91%, concordance between physical and image based diagnosis [13][14][15]. Thus, Mobile Tele-Dermatology may be implemented as a tool to facilitate early detection and diagnosis of affected skin lesion as well as malignant skin tumors, to improve patient outcomes [16][17][18].Junior Dermatologists diagnose thirty patients having diverse skin diseases via physical consultation in Cairo, Egypt [19][20]. The images of the patients' lesion are analyzed later by the senior dermatologists using mobile Tele-Dermatology technique. The ClickDoc™ is used for lesion images taken at 5MP resolution of camera. Telederm Click™ tool is used to analyze those 30 cases via its WWW interface developed in Java. The under observation study acknowledges that diagnostic concordance is 70% despite of the controlled Mobile TD environment. The study reveals the practicability of MTD for mobile telephone cameras and special application does partially amplify the results [19][20].

3.1 Limitation of the work

The cellular phone with the camera of 5MP resolution is only used in this study. The photographers take the patient photo in a controlled environment, e.g., light, angle, and distance of the camera to the lesion. The application for using camera and analyze the lesion requires expertise. The error ratio cannot be measured as only single junior Dermatologist beside 2 expert Dermatologists present in the cited work [20]. There is not much work on categorizing the common skin diseases. For a set of thirty patients the achieved one-third success ratio does not qualify the implementation of MTD. The role of patient history or its accuracy is not identified in the results obtained in the study in question. Hence, the research [20] is not able to provide any rational logic for incorrect diagnosis.

4. Model of Mobile Tele-dermatology

The traditional model of MTD is in the figure 1. This model is capable to fulfill the need of patients and doctors with basic Tele-medicine's infrastructure intact.

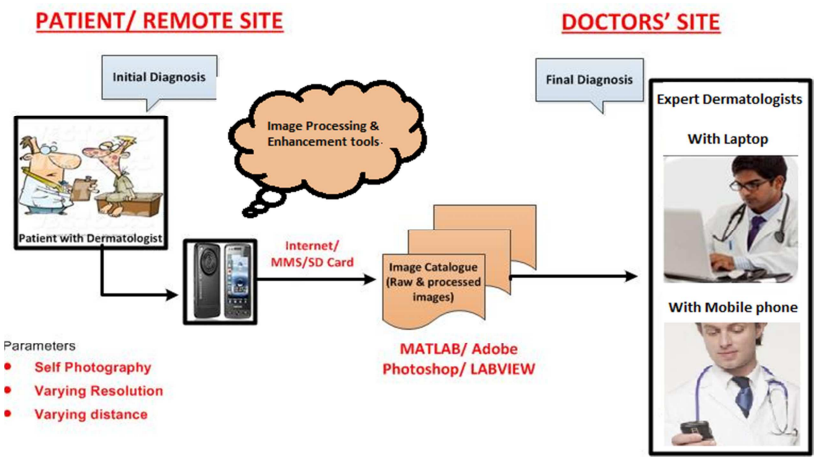


Fig. 1. The traditional model of Mobile Tele-dermatology

For the sake of idealism in MTD, the proposed model in this paper does not demand patient side infrastructure as 'ideal', for image acquisition. It takes following steps to achieve natural images as described in the given steps [21][22].Step-I: The captures images are sent through several methods via cell phone cameras. Different resolutions of cameras are available namely, 3MP, 5MP and 8MP. The methods of image transmission include WWW, MMS and Bluetooth. Criteria recommended for taking images includes; i) non-expert photography by patients themselves / people around; ii) different resolutions of cellular phone cameras; iii) different distance measures between the object (patient) and the camera. Step-II: The initial Diagnosis is based on the patient's onsite physical examination.Step-III: An image catalogue is also maintained based on actual and processed snaps as defined later in the figure 3.Step-IV: The dermatologist available onsite shall carry an image based diagnosis. The panel of dermatologists is asked for blind review based on the images.

4.1 The Deployed / Pilot Model

Our actual model of "Mobile Tele-Dermatology" consists of four different phases as shown in the figure 2. It depicts the way we conducted our research for Mobile Tele-Dermatology [23] [24]. Our deployed model of Tele-dermatology consists of four distinct phases. Each of these phases is mentioned here with respective details.Phase-1: We select three different sites for examining and data gathering of patients with skin related problems. The strategy helped us to collect data of variety of diseases. These three sites include Liaquat University of Medical and Health Sciences (city area), M/S Al-Shifa hospital (rural area) and a private clinic in medically advanced region.Phase-2: In this phase, with the consultation of senior dermatologist about the nature of lesion we selected sixty (60) patients for face-to-face consultation process. These consultations were carried out at three different sites, mentioned in the last phase. The scenario is shown in the figure. Dermatologists were given a Performa for patient evaluation with complete history. The age, name and disease

duration is part of the patient history too. Additionally, we collect information about the occupation, address for geographical consideration or inherit or seasonal diseases occurrences.

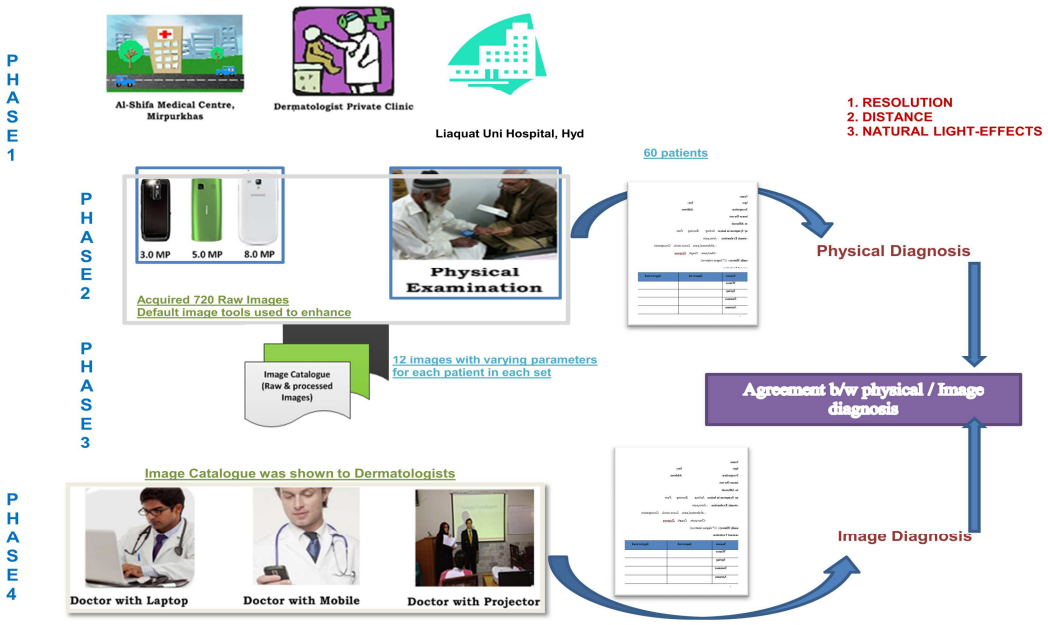


Fig. 2. The Ideal depiction of Mobile Tele-dermatology

After a physical examination, Images of affected lesions of the same patients have been taken in an uncontrolled environment to set some set of rules for mobile Tele-Dermatology, such as:i) a cellular phone camera resolution taken: 3, 5, 8MP; ii) distance between patient and image taken: 3/6 in focal length; iii) images taken by: Non-expert/ patient himself, and iv) images taken under natural light affect. Phase-3: This phase consists of formation of an image catalogue hierarchy. The idea is to obtain six (06) images for each patient, then process it using default image enhancement tool, i.e., MS Office Picture Manager. Use of any specific software for processing images obtained remotely, is beyond the scope of this research project as we are looking for all those procedures that are low-cost for MTD. Hence, after processing the total number of images for each patient there are twelve (12) images. Consequently, the total number of images for 60 patients is 12x60 equals to 720. This requires some chronological Image cataloguing as shown in the figure 3.

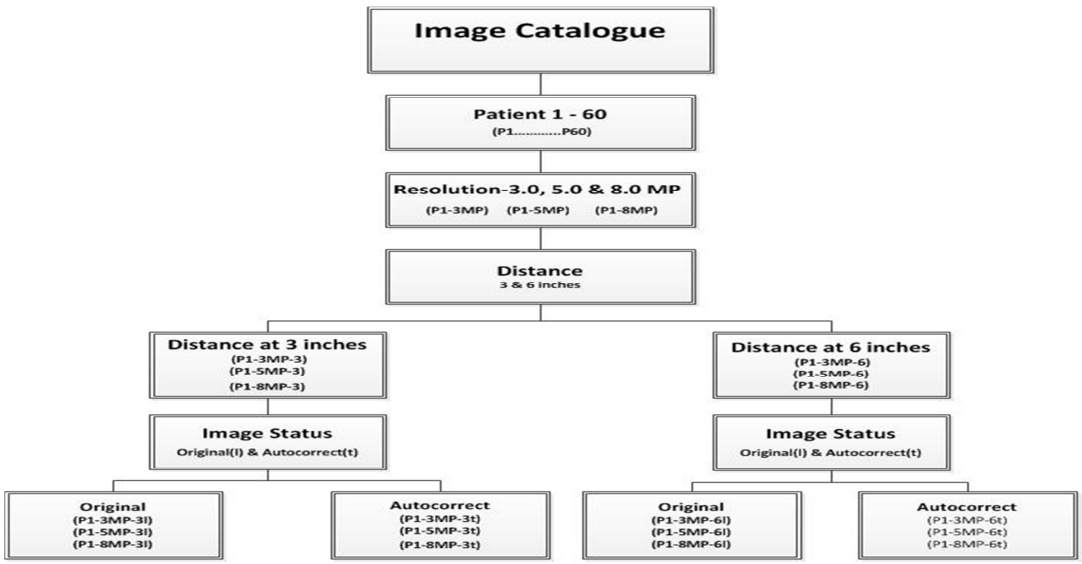


Fig. 3. The flowchart of measuring affectation of mobile cameras in MTD

Phase-4: After Image Cataloguing, patient images are diagnosed by the same Panel of Expert Dermatologists. Out of 720 images, 96 random images, as recommended by Experts, are shown to the Dermatologists using three different methods. These methods are Mobiles, Laptop and the multimedia projectors.

5. Analysis of Results

Physical Diagnosis: After the Initial Diagnosis, at three different locations of-sixty patients, by the on-site Dermatologists, the total numbers of various diseases obtained were Thirty Six (36). Total number of diseases obtained, have been categorize in diverse categories depending on their no: of occurrence as suggested by the senior Dermatologists, as shown in figure 4.

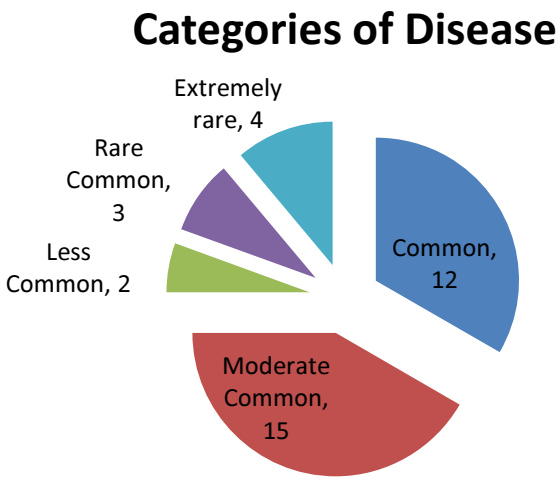


Fig. 4. Categories of diseases under observation

The last category is extremely rare and in most cases, these diseases are hard to identify through images, for this reason images of this category remain un-analyzed as suggested by the Panel of Dermatologists. Thus, the remaining four categories then analyzed through images. The total number of diseases that have been analyzed becomes 32.Image Only Diagnosis: In this sort of diagnosis we select random images for the dermatologists. The results submitted by the experts are compared with the physical results. The same is shown in figure 5.

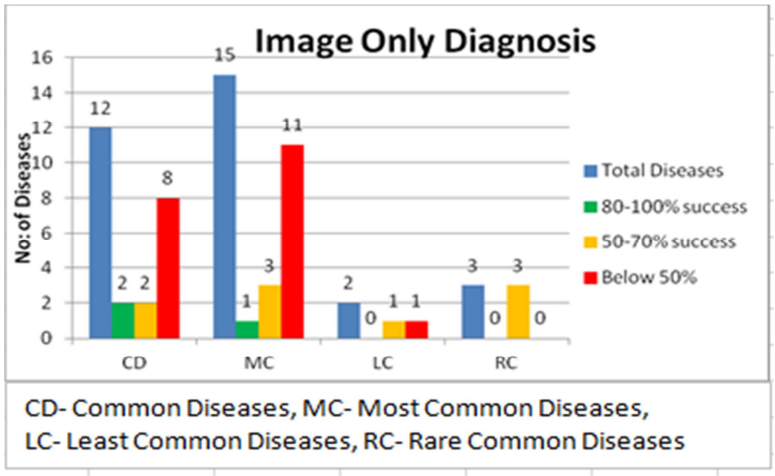


Fig. 5. Image only diagnosis by the panel of dermatologists

Image Diagnosis with History: The above mentioned images are shown to the Dermatologists but, this time it includes the history of patients. The history parameters consist of the gender, age, affected area and disease on-set. For each category of disease, random pictures are selected. The results have been improved in comparison to image only diagnosis as shown in figure 6.

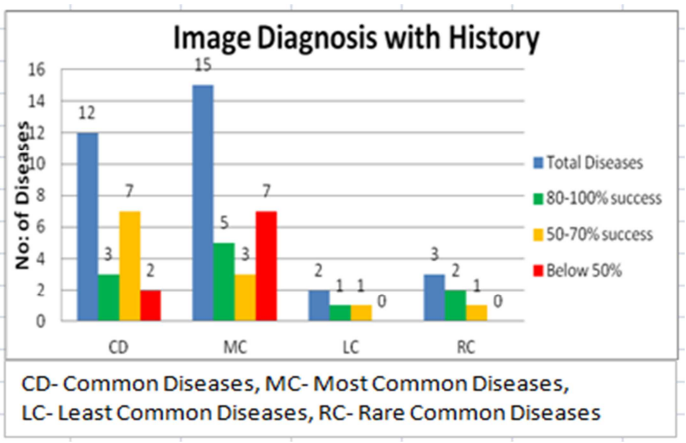
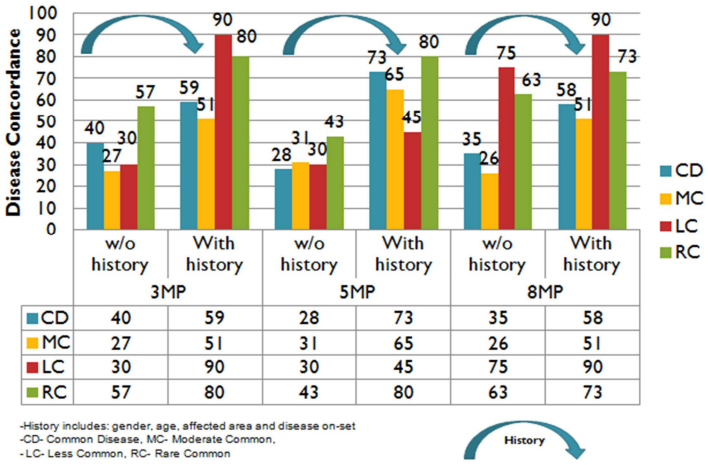


Fig. 6. Image only diagnosis by the panel of dermatologists

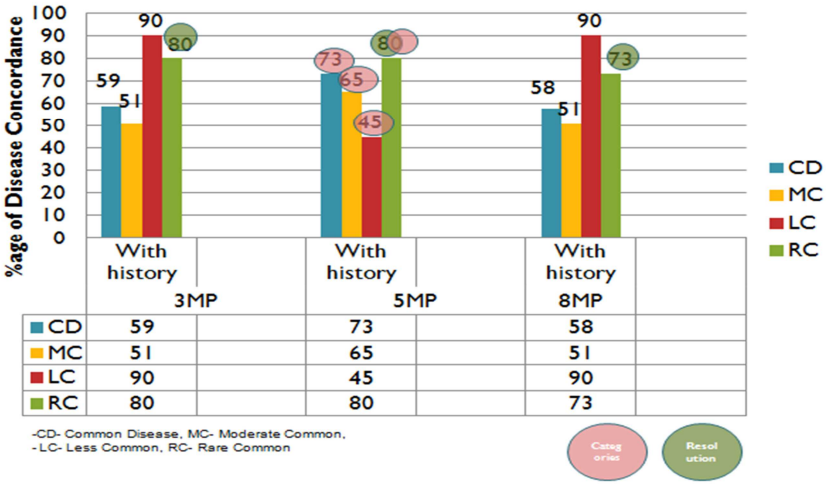
The final comparison gives us the results of *Image only diagnosis* with *Image diagnosis w/History* to achieve the final conclusion. The concordance rate between aforementioned diagnosis techniques is shown in figure 7.



	3MP w/o history	3MP With history	5MP w/o history	5MP With history	8MP w/o history	8MP With history
CD	40	59	28	73	35	58
MC	27	51	31	65	26	51
LC	30	90	30	45	75	90
RC	57	80	43	80	63	73

Fig. 7. The total concordance rate b/w both diagnoses

The figure defines a significant progress in image diagnosis which is based on the patient history. It proves that image with medical history is mandatory for an improved concordance rate. Graphical illustration in the figure 8 maintains that images including medical history have also difference based on the camera resolution and category of disease.



	3MP With history	5MP With history	8MP With history
CD	59	73	58
MC	51	65	51
LC	90	45	90
RC	80	80	73

Fig. 8. Total concordance rate with respect to disease categories and mobile resolutions

It is observed that out of 4 pre-defined disease categories of the scenario, the LC (Less Common Disease Category) has the highest concordance rate, i.e., 90 at 3 & 8 MP respectively, and RC (Rare Common Disease Category) has the highest concordance rate as 80 at 5MP, while remaining two categories i-e: CD (Common Disease Category) and MC (Moderate Common Disease Category) has the lower concordance rate in comparison to LC and RC. Hence, it is

concluded that disease diagnosis doesn't depend on the categories they belong to, but relies on its visual appearance in MTD. It is also found that Disease categories don't affect the image diagnosis. Also, based on patient selfies (image acquisition), there is no significant trend of improved concordance rate with respect to varying resolutions of cellular phone cameras. After profound analysis, with respect to mentioned image categories and resolution, we move towards the 'Distance' concordance rate between patient and camera, see figure 9.

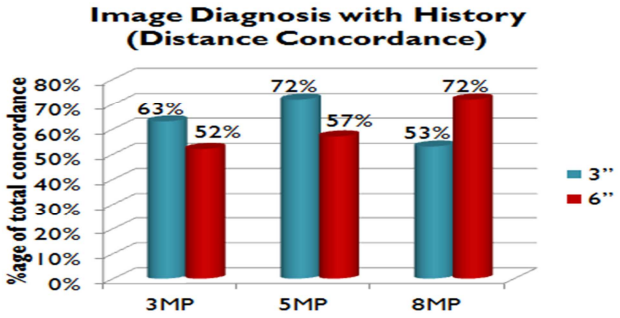


Fig. 9. Total concordance with respect to distance (camera and object of interest)

As shown in the figure, it was 3 and 6 inches which don't follow any concordance trend. Thus, it has been concluded that distance between patient and camera doesn't affect the diagnosis but the image must be taken at a distance that the affected skin lesion is completely visible. Now for 'Quality' of an Image i-e: original and auto-correct, results have been concluded next in the figure 10.

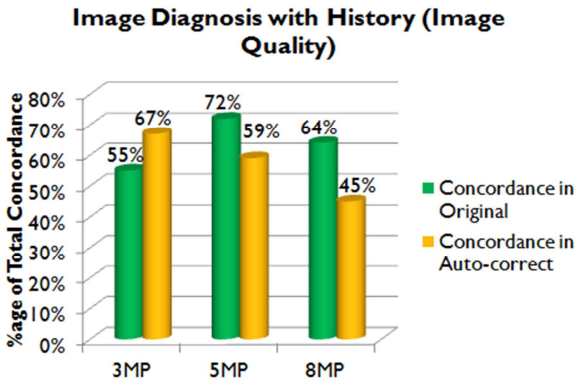


Fig. 10. Total concordance with respect to image quality

From the figure, it can be analyzed easily that at 3MP, concordance of the original image is lower than concordance of auto-corrected image, i-e: image enhancement has improved the result over here. But if we look at 5 & 8MP the original concordance rate is greater than auto-corrected concordance in comparison, thus, image enhancement has not given any significant improvement in these two resolutions specifically.

6. Conclusion

The statistics presented in this paper, helps to conclude that there is no optimized strategy, available for Mobile TD using cellular phone cameras. Instead of, our proposed and deployed model is a real test model for MTD Mobile Tele-dermatology. Based on the figures compiled, we conclude that mandatory elements of the patient's history, in addition to patients' selfies, include gender, age, a precise description of the effected region, and the disease on-set for correct diagnosis. It is also evident that categorization of diseases, on the basis of its occurrences, is not considerable in MTD. Also, default image-enhancement applications in cellular-phones with auto-correct features are truly unreliable. The parameters including the resolution of camera (tested for 3/5/8 MP) and distance from object (3 & 6 inches) don't have significant impact but, an error of 10% in the correct diagnosis. Hence, it is recommended that further research, in this direction, will be perform by developing / embedding different image-enhancement tools in cellular-phones for further improvement in diagnostic concordance. An optimized MTD can only be then sought. Our image catalogue is now made public to revise and extend the future study in various MTD projects.

7. Acknowledgement

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