APPLICABILITY OF MOBILE PHONES FOR TELE-DERMATOLOGY
A Pilot Study

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Abstract: Examination in dermatology is primarily based on visual inspection. Since this visual information can be stored and transmitted easily through digital images, tele-consultation and tele-diagnosis are predestined methods especially in the field of dermatology. Nowadays mobile phones represent the most important communication tool around the world. To study how the process of acquiring, transmitting and diagnosing images can be implemented by using cheap and widely available devices, such as mobile phones, we conducted several experiments at the Medical University of Vienna. Material and Methods: In a study patients were asked to take one or more photos of their dermatoses with the camera of a mobile phone. Images were transmitted electronically by using the MMS function of the phones. All participants were examined routinely at the outpatient department, establishing the gold standard diagnosis. Three different phone models were evaluated with regard to colour fidelity, illumination effects, and terms of resolution. Images for tests were produced at not standardized conditions. Results: In all three phones high resolution images are compressed. Resolution was skilled down to 640x480 while sending via MMS. Colour fidelity was different depending on the manufacturer. Colour fidelity increased proportional with increasing illumination.

1 INTRODUCTION

The use of telemedicine, especially tele-dermatology, can be of great advantage for patients and doctors. The following points show where tele-dermatology can be of use:

- Outlying territories with a low density of dermatologists
- Patients without access to a car or public transportation
- Patients who want to save time
- Patients who are in foreign countries and want to receive a diagnosis and therapy advice in their native language
- Patients who want to avoid or shy personal contact to doctors due to several reasons (e.g. religion, agitation, shame, etc.)
- Patients who want to obtain a fast (and reliable) second opinion

Some examples where tele-dermatology can be of use for doctors:

- Second opinion: with telemedicine it is possible to receive another specialized opinion without time delay
- Temporally optimized advanced training: images can be stored and used as instruction material for medical students and doctors

Further possibilities of tele-dermatology:

- Selection of patients - the urgency of cases can be judged, in order to achieve a faster and more efficient treatment (triage)

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- Optimal resource use through purposeful transfer: patients mustn't wait for investigation at a "mismatching" department. They are passed on to the appropriate specialists.
- Follow-up assistance: the patient can receive further assistance economically and fast (e.g. wound inspection)

The university clinic has the advantage of always being on the newest state of the art and science. This results in some disadvantages for the patient, e.g. long waiting times for an appointment at the outpatient's department. Particularly in dermatology there is the possibility of reducing these waiting periods to achieve a better time management. The patient can photograph his skin lesions at any location – either through a digital or mobile phone camera, and then forward the provided image by MMS or email to a dermatologist, who examines it.

Tele-dermatology has the potential to optimize time management. Costs can be reduced in comparison to the actual standard diagnostic way. Efficiency of the outpatient clinics could be increased with regard to economic considerations and patient friendliness.

Recently published studies showed that cell phones can be used in tele-dermatology. They are very useful devices to produce photos easily. But cell phones are not subject to medical device law. A standard for produced images does not exist. So it was necessary to test some cell phones and analyze the produced images.

The impulse of this research was a tele-dermatological pilot study at the Department of Dermatology, Division of General Dermatology. Photos were produced with cell phone cameras. The major question was: Can camera phones produce acceptable image quality for dermatology.

Before the study we analyzed three cell phones with regard to quantitative and quality criteria.

1.1 Previous Work

Herrmann et al. got throughout positive results in a study about tele-dermatological (TD) and face to face (FTF) consultation. In a comparison of diagnoses from 120 patients by tele-dermatologists, agreement was from 46.4% respectively 70,2% without additional information and 64,3% respectively 76,6% with additional information. This shows the absolute necessity of additional information. Dermatologists felt certain with their diagnoses in most cases. Sureness was evaluated with a visual analogical scale from 0 to 10. Cases difficult to assess with a tele-dermatologist were also difficult for standard diagnoses and were therefore identified with "doubtful diagnosis". Furthermore, image quality influenced the diagnosis. In 70% it was possible to make a diagnosis. (Herrmann, 2005)

In 2004 Tai Khoa Lam tried to create photos with two randomized mobile phones (Nokia 7650). These photos were sent between a medical specialist and an archivist. Photography was limited to the hand trauma, radiographs or both. At the beginning there was a discussion between the medical specialist and the archivist who created a management plan. After that, photos were sent via mobile phone and multimedia. Now there was another discussion and then the management plan had to be modified. Within the following two months 39 photos were sent. During the course of the study there were four cases in which the management plan had to be modified. (Lam TK, 2004)

Authors of „Telemedical Wound Care" devised a study in which leg ulcers were photographed. 61 feet were examined by three dermatologists. One of them made FTF consultation and the other two were responsible for mobile phones. They transmitted images via e-mail. The result of the study was that the image quality in 36 cases was "good" and in 12 cases "very good". 50 of the involved parties felt well and only one felt unwell. Three photos were of poor-quality. (Braun RP, 2005)

In a cooperation of the Medical University of Graz, Vienna and L'Aquila, diagnoses from camera phone images and face-to-face dermatology were compared. Two dermatologists examined these images from 58 patients. In 48 patients a diagnosis was provided. Six were immediately sent to a dermatologist and four patients were advised to come again a few days later.

During the following comparison of diagnoses in 41 cases, diagnosis was correct (full agreement). In 15 cases the diagnosis was wrong but still in the same category of diagnoses (relative agreement). In only three cases diagnosis was wrong (disagreement). (Jauk B, 2006)

The Medical University of Graz (Austria) ran a study researching the agreement between teledermatology based on images from a cell phone camera and face-to-face (FTF) dermatology. With a quantity of 58 subjects two tele-dermatologists (TD) analyzed the images produced. After checking, the concordance between tele-diagnosis and FTF diagnosis represented almost three-quarters (TD1: 71%, TD2: 76%). Nearly all diagnoses were in the same diagnostic category (TD1: 97%; TD2: 90%). (Ebner C, 2008).

2 MATERIAL AND METHODS

Image quality can be rated through different methods. In this paper two kinds of analysis are used. First an objective method with measurement methods and second the subjective view of the images.

2.1 Technical Methods

To acquire more information about colour fidelity, illumination and MMS altering, some tests were realized.

The tests involved three different cell phones. Device 1 (D1) and Device 2 (D2) include a 3.2 megapixels camera. Device 3 (D3) includes a 5 megapixels camera and a "Tessar-lens" by order of Carl Zeiss. These devices were selected randomly. Tests were produced at the same settings and conditions.

For photo analysis "Adobe Photoshop" was used which produced histograms and relevant data. Illumination was measured with "Minolta Auto Meter IV F". Scale unit is "exposure value" (ev) which designates a number of combinations of glare number (Relationship of the focal length f to the diameter D of the entrance pupil) and exposure time, which are equivalent to each other in photography and photometry.

The colour fidelity test involves photographing a single-coloured photo which was sent via mail. Tolerance was 70. By the size of this parameter one determines how large a colour area is in the selection and the number of partly selected pixels increased or reduced. (Selection range: 0-200)

Three series of tests were created at various illuminations (5.3ev, 7.7ev and 9.1ev). Every situation included 5 photos. The flash and the camera light were always deactivated.

Every picture was analyzed with regard to central pixel, mean pixel, standard deviation and colour range. First a colour range was selected, which includes the area with the most similar pixel. In this area there is a central pixel and a mean pixel with different standard deviations. All values are derived from RGB spectrum.

2.2 Clinical Study

In a tele-dermatological pilot study at Department of Dermatology, Division of General Dermatology, Medical University of Vienna, 915 photos were produced by 300 patients. Patients took photos of their own dermatoses. If the dermatose was unreachable, an assistant took the photo. Patients only received a short instruction in the usage of the mobile phone camera but they did not receive any information how to obtain the best photo. Images were created in a badly lit examination room without any daylight.

3 RESULTS

3.1 Technical Results

The first test refers to colour fidelity. The following three tables demonstrate the cumulative average results of five photos per device. The "central pixel" stands for the colour value which appears most in contrast, "mean value" describes the average brightness value. "Standard deviation" indicates how strongly the brightness values vary. "Relative value" is the amount of total pixel in percent. Central pixel of template was 173 in RGB spectrum.

Table 1: Results at 5.3ev in a badly lit room.

	central pixel	**mean value**	**standard deviation**	**relative value**
D1	150.80	151.35	23.74	94.44%
D2	83.20	90.80	22.17	99.03%
D3	140.80	139.52	13.97	73.69%

In Table 1 D1 and D3 nearly reached the original pixel value. But D3 only includes 73.69% of the mean value 139.52. D2 resulted in a mean pixel value of 90.80 in an area of 99.03%.

Table 2: Results at 7.7ev with lateral illumination.

	central pixel	**mean value**	**standard deviation**	**relative value**
D1	152.40	148.54	23.84	86.17%
D2	119.80	122.77	20.00	99.51%
D3	151.20	156.00	21.83	71.52%

With 7.7ev D1 and D3 reached a mean pixel value of 148.54 (D1) or rather 156.00 (D3). D2 also increased central pixel. It is about 122.77.

Table 3: Results at 9.1ev with vertical illumination.

	central pixel	**mean value**	**standard deviation**	**relative value**
D1	150.60	148.95	24.14	88.91%
D2	77.80	101.97	44.44	90.57%
D3	160.00	163.37	16.46	56.48%

At maximum illumination (9.1ev) D1 reached a mean value of about 148.95 (88.91% of image pixel) and D3 reached 163.37 (only 56.48% of image pixel). D2 reached a mean value of about 101.97.

Table 4: Average results at 5.3ev, 5.7ev and 9.1ev.

	central pixel	**mean value**	**standard deviation**	**relative value**
D1	151,27	149,61	23,91	89,84%
D2	93,60	105,18	28,87	96,37%
D3	150,67	152,96	17,42	67,23%

In an area of 67.23% D3 took photos with a mean standard deviation of 17.42. Mean pixel value was nearly the original value. In contrast 96.37% at D2 had mean pixel of about 105.18. The average standard was from 17.42 (D3) to 28.87 (D2).

Additional light sources can influence the brightness distribution. In some areas in which light reflect pixel, values are extremely falsified.

While sending MMS or email the original high resolution photo stored on mobile phones will not always remain unaffected. Usually, original images were altered by lossy compression algorithms. Images will be compressed, during sending via MMS to a size of 640x480.

The following histograms present the comparison between the original photo and compressed photo after sending via MMS.

Figure 1: Histogram of original photo.

Figure 2: Histogram of MMS-photo.

Comparing the original photo with the MMS photo, the histograms show that there is a minor difference.

This reveals that colour distribution is nearly the same. Mean pixel value changed from 185.63 to 183.89. After compression, central pixel value is 183 (before 185).

Image compression effects dimension and file size. The following table shows the dimension and file size of the images before and after sending via MMS.

Table 5: Dimensions and file size.

	dimensions		**file size**	
	original	**MMS**	**before**	**after**
D1	2048x1536	640x480	695 kb	13 kb
D2	2048x1536	640x480	748 kb	13 kb
D3	2592x1944	640x480	1852 kb	32 kb

3.2 Results of the Clinical Trial

Every phone produced about 22 blurred photos. In total this results in only 66 photos.

15 photos were overexposed and therefore waste. One of the three cell phones produced only one and the worst only 8 overexposed photos.

4 DISCUSSION

Test results indicated that a homogeneously bright illumination allows preventing errors and noise artefacts. Diffuse illumination is the best scenario for camera phone photos. Concentrated light creates the most defects. It produces extremely bright pixels in a wide area. Illumination had a considerably unfavourable effect on colour fidelity.

While sending MMS, the original high resolution photo stored on the mobile phone will not always remain unaffected. Usually, original images are altered by lossy compression algorithms.

The results of this pilot study show that the ability to acquire close-up images and optimum illumination are very important to obtain photos that are of sufficient quality for tele-diagnosis.

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