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Exploring the Impact of Imaging Resolution and Sharpness on Dermatological Diagnostics Using eSFR Measurements

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***Abstract*—High-resolution, small-form-factor image sensors enable the integration of mobile device cameras, which are increasingly being used for photographic documentation in many fields, including medicine. With the interface and handheld dermatoscopy, the smartphone camera forms an alternative tool to professional dermatoscopic systems for performing teledermatology and teledermoscopy. For the accurate diagnosis of skin diseases, image quality is essential, with sharpness and resolution being essential criteria. This paper focusses on measuring the sharpness and resolution of cameras used for image acquisition in dermatology using the spatial frequency response (SFR) method, which is based on standardised test charts featuring characteristic slanted contrast edges, known as edge SFR (eSFR) charts. The images were captured with mirrorless and DSLR cameras, smartphones, and a professional dermatoscopy video camera under typical dermatological conditions with digital cameras, mobile phones, and professional video dermatoscopes. Captured images were analysed, and the modulation transfer function (MTF) was defined to evaluate the performance of different camera optical systems applied for dermatological imaging. The results provide insight into the strengths and limitations of the various imaging devices and highlight their effectiveness in meeting the requirements of dermatological practice.**

***Index Terms*—eSFR; Image resolution; Image sharpeness; Digital camera.**

I. INTRODUCTION

Digital cameras have entirely supplanted analogue cameras, becoming essential in our everyday lives. Recent technological advances in the past decade have facilitated the capture of high-quality images using compact image sensors. The integration of sophisticated cameras into mobile devices has profoundly altered our lifestyle. Smartphones have revolutionised photography by enabling users to capture high-quality images effortlessly. The ease of downloading, sharing, and editing photos on mobile devices enhances their convenience, making smartphone cameras more user-friendly and accessible than traditional professional digital cameras. The proliferation of smartphone cameras has significantly affected numerous professional sectors, particularly medical diagnostics [1]. For example, in dermatology, the diagnosis of skin diseases often depends on the visual differentiation of skin lesions. Usually, its monitoring is required for a shorter or longer period [2]. Consequently, the capture of images of skin and pigmented lesions proves essential for effective diagnosis, management, research, and educational purposes [3]. A significant challenge in dermatology lies in differentiating pigmented skin lesions, especially when distinguishing benign lesions from melanoma, the most aggressive type of skin cancer [4]. The timely identification of melanoma is vital to improve patient survival rates. The accuracy of diagnosis is improved by dermoscopy. This non-invasive technique employs magnifying lenses and an integrated light source to reveal subcutaneous structures not discernible to the naked eye. Professional systems, such as digital dermatoscopes used for skin examinations, typically include high-resolution digital and HD video cameras with optical magnification capabilities ranging from 20x to 140x. These systems display images on a computer screen, allowing the capture, storage, and analysis required for an accurate diagnosis [5].

Despite the widespread use of digital dermatoscopes in dermatology clinics for the detection of melanoma, their adoption in smaller clinics and general practices has been slow. This delay is primarily attributed to the high costs and concerns about practicality [6]. Smaller dermatology clinics frequently employ a fundamental digital dermatoscope for examinations. This device typically comprises a digital camera, a coupling interface that links the camera to a handheld dermatoscope, and the essential software required for operation [7]. The handheld dermatoscope improves the visibility of skin structures with a magnification of 10 times. Its integrated LED illumination allows examinations under both polarised and nonpolarised light, improving diagnostic accuracy [8]. Research shows that the image quality of commercial cameras can present challenges that are crucial for accurate diagnoses. Dermatologists notice discrepancies in image quality when using various combinations of devices

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to capture images [9]. Consumer camera manufacturers frequently utilise image processing algorithms that can significantly alter reality. Adjustments in contrast, colour, and excessive sharpening can undermine visual clarity, reducing the effectiveness of melanoma screening, prolonging diagnostic processes, and potentially leading to incorrect clinical decisions [10].

Various standards and methodologies are used to evaluate the quality of digital cameras, encompassing a wide spectrum of measurements such as resolution, sharpness, contrast, colour accuracy, noise, impact of the programme, and other critical factors [11]. In dermatological image capture, it is crucial to ensure colour accuracy, sharpness, and resolution, as these factors significantly influence the assessment of quality of a digital camera [12]. The perception of sharpness in digital photography can be subjective, influenced by various technical and perceptual elements [13]. Therefore, it is crucial to utilise objective methods to evaluate the sharpness of the image. ISO 12233:2017 outlines procedures to measure sharpness and resolution [14].

Assessing the resolution and contrast of digital cameras on smartphones and standalone devices is crucial to evaluating the performance of optical systems, image sensors, and associated software. Over the years, various methodologies have been developed to measure these parameters accurately. Fischer and Holm [15] explored the spatial frequency response measurements of electronic still-picture cameras, offering essential information about the early methodologies used in this field. Okano's research [16] delves deeper into the analysis of the modulation transfer function (MTF) and its measurement techniques for digital still cameras, emphasising the critical role of MTF in assessing image quality. A significant advancement in the standardisation of these measurements was achieved with the introduction of ISO 12233. This standard delineates methodologies for evaluating resolution and spatial frequency responses in digital cameras. Parulski, Wueller, Burns, and Yoshida [17] provided a comprehensive overview of the development and progression of this standard, highlighting its significance in standardising measurement techniques throughout the industry. The most recent version, ISO 12233:2023, continues to serve as a critical reference for professionals aiming to ensure consistency and accuracy in image quality assessments [18]. Furthermore, Asnani, Presti, Amato, and Montrucchio [13] introduced the MTF Calculator, a mobile application designed to measure the modulation transfer function of smartphone cameras by employing the ISO 12233 slanted edge method, demonstrating the adaptability of these standards to modern mobile devices.

In a previous work in [19], we presented the e-Derma system, a new wireless system for dermatoscopy that overcomes the limitations of existing systems by providing high-quality images and eliminating motion restrictions through wireless image transmission. We subjectively and objectively assessed the acuity of several digital dermatoscopes using USAF test targets for objective testing. In our next study in [20], we performed a thorough evaluation of image quality parameters across various digital capture devices, identifying problems such as colour inaccuracies and oversharpening. We have proposed a two-step camera calibration procedure to improve the accuracy of clinical and dermoscopic images. The results showed that software sharpening had a significant impact on the sharpness of dermoscopic images.

This study builds on those results by looking more closely at how to measure image sharpness and resolution using the spatial frequency response (SFR) method. Previous tests on mobile device cameras have demonstrated that image oversharpening can pose a challenge for diagnosing dermatoscopic images. We want to explore whether advanced sensor technologies built into the latest cameras and AI techniques can solve the issue of excessive focus. The goal is to see how sharpening the software to different degrees affects the results. This approach allows for a more accurate assessment of the performance of imaging devices in dermatological diagnostics and offers valuable information about their suitability for the accurate diagnosis of skin diseases.

We introduce the application of the edge-based eSFR methodology for evaluating the sharpness and resolution of digital and mobile phone cameras through MTF analysis. We outline the theoretical foundations of the eSFR method, detailing the procedures for conducting precise measurements that assess the sharpness and resolution of images captured by digital cameras using standardised test targets. In addition, we critically analyse the relevance and applicability of these methods in specialised fields, such as the use of medical document cameras in dermatology. To address the specific requirements of dermatological applications, we propose a customised measurement procedure that integrates a camera system with a handheld dermatoscope and a test macro target, thereby ensuring accurate and reliable image quality assessments. The research provides an objective assessment of the sharpness and resolution of digital cameras commonly used in dermatological practice for close-up, full-body, and dermoscopic photography [21]. The remainder of the paper is structured as follows. Section II outlines the materials and methods employed, Section III presents the measured results, Section IV examines the significance of the findings, and the conclusions are detailed in Section V.

II. MATERIALS AND METHODS

A. Materials and Equipment

ISO 12233 outlines standardised measurement methods using specific test targets and comprehensive performance instructions. A variety of commercial and open-source software tools are available for data analysis, including Imatest [22], Image Engineering [23], and Quick MTF [24], among others. Various types of target patterns have been employed in previous studies to calculate the MTF. Among these, the slanted edge target is favoured for its simplicity and reliability. A standardised high-quality test target from suppliers such as Edmund Optics, Imatest, Applied Image, and Image Engineering can effectively assess the sharpness of dermatological imaging in both close-up and full-body photography. The test target, depicted in Fig. 1, was sourced from Imatest [25] and printed on high-quality matte photo paper using a large-format printer, measuring 90 cm by 135 cm.

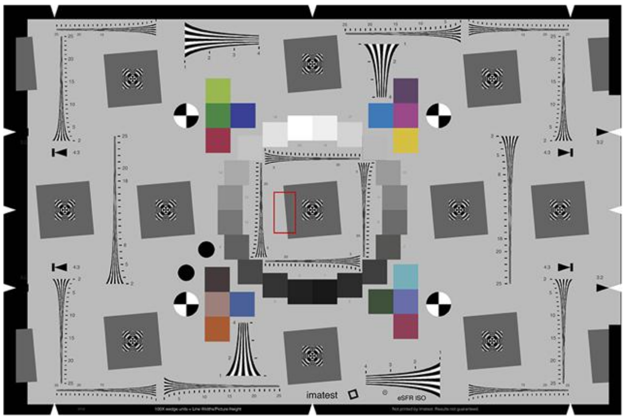

Fig. 1. The eSFR ISO test target enables measuring different qualitative camera metrics, such as chromatic aberration, white balance, dynamic range, colour deviation, exposure uniformity and accuracy, noise levels, sharpness, and image resolution [7]. We assessed the sharpness in the middle region of the target, utilising the designated ROI in the red square.

Figure 1 illustrates a target specifically designed to evaluate various qualitative camera metrics. This target allows for the assessment of sharpness across 57 distinct regions of interest (ROIs), with particular emphasis on the highlighted ROI located in the central area of the image. The position of the camera is adjusted using a movable test lead (see Fig. 2), which considers the dimensions of the camera sensor and the focal length of the lens, ensuring that the entire target is effectively captured within the image frame. A camera mounting head is securely attached to a measuring bar that features a sliding guide. This design ensures the repeatability of the measurement process by allowing precise adjustments to the depth and height of the camera.

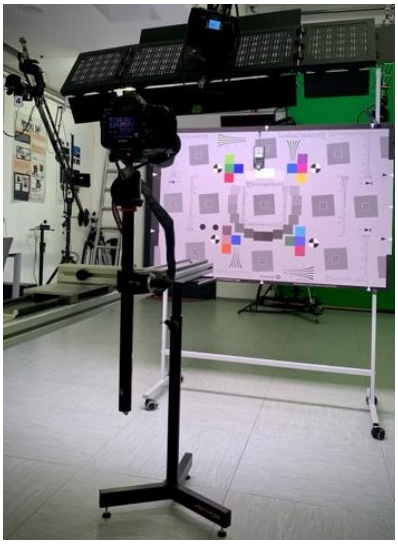

Fig. 2. Measurement field with uniformly illuminated eSFR test target to ensure repeatability of measurements.

A calibrated LED light was used to illuminate the test field of the target, ensuring consistent brightness with an intensity of 800 lux at a colour temperature of 5500 K. The light source was activated 20 minutes prior to the test, and a Gossen Digisky light meter was used to assess the uniformity of the illumination on the target. The auto-trigger feature effectively mitigates vibrations that could result in blurred images. Additionally, the sliding mounting system of the camera allows for precise adjustments in the distance between the target and the camera, ensuring that the target fully covers the sensor's surface without any background interference.

The sharpness of the dermoscopic image, obtained in dermatoscopy mode, was evaluated using a macro test target. This chart featured a thin layer of silver coating applied to a glass plate, which created a perfectly straight slanted edge, as illustrated in Fig. 3. Dermlite DL4 (DermLite, 3Gen, Inc. in San Juan Capistrano, CA, USA), a handheld dermatoscope device, was connected to the camera via a magnetic interface. The device emitted polarised light that illuminated the macro target. The photographic equipment used for capturing the test images, commonly found in dermatological practices, includes a mirrorless Canon 7R (Canon Inc., Tokyo, Japan) and Sony A7RII (Sony Group Corporation, Japan) cameras, a Canon 5D DSLR camera, a Fotofinder Medicam 1000s (FotoFinder Systems GmbH, Bad Birnbach, Germany) video camera, as well as smartphones such as the iPhone Xs, iPhone 13, iPhone 15 (Apple Inc. Cupertino, CA, USA), and Samsung Galaxy S24 (Samsung Electronics Co., Ltd., Seoul, South Korea).

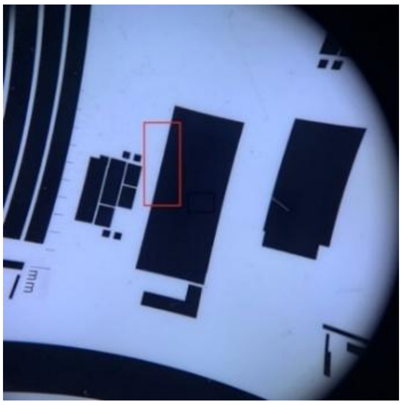

Fig. 3. The macro test target is specifically designed to assess sharpness, optimised for use with the camera in dermatoscopy mode. It features a dedicated section that enhances the evaluation of sharpness in this context.

B. Spatial Frequency Response Method

Initially, the resolution of optical systems was subjectively evaluated using standardised graphics, such as the 1951 USAF test target. However, this method is now considered less accurate. Currently, a variety of methods and corresponding test targets are used. The ISO 12233 standard evaluates sharpness using the spatial frequency response (SFR) method, which depends on standardised test charts that display characteristic slanted contrast edges, referred to as eSFR charts.

The SFR of a digital imaging system describes its ability to accurately reproduce specific spatial frequencies. An SFR of 100 % indicates that the reproduction of the spatial frequency line pairs in the image has the same modulation as the original subject. Ideally, the SFR would be 100 % for all spatial frequencies that the system can reproduce, extending up to the Nyquist frequency. This frequency represents the theoretical maximum determined by the image sensor sampling frequency.

Similarly, the MTF is defined to assess the performance of optical systems. While SFR can be determined using various methods, the MTF is calculated using harmonic spatial frequencies and discrete Fourier transformation. Figure 4 illustrates the six steps involved in calculating the slanted edge SFR method.

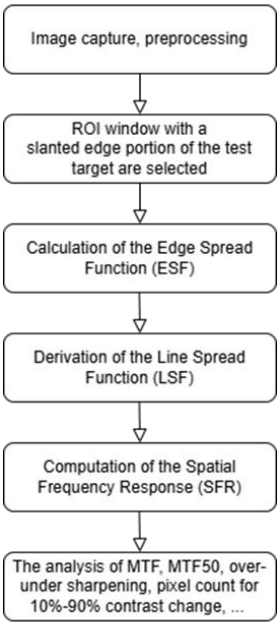

Fig. 4. The slanted edge SFR method is calculated in six steps.

The initial step involves capturing an image of the test chart with the imaging system being evaluated, while ensuring optimal lighting and focus. Proper preprocessing of the image is essential to achieve accurate and consistent results. Typically, we carry out several preprocessing steps, including illumination correction, white balance adjustment, distortion correction, and noise reduction. The second step involves identifying the region of interest (ROI) within a specific area of the test chart, particularly along the edge of a square that is tilted at an angle of five degrees.

The transition spread occurs in the direction perpendicular to the slanted edge. The slope of the edge in the vertical direction is estimated using linear or polynomial regression and the least squares method. This approach enables the mapping of pixel intensity values of the slanted edge onto the horizontal axis of a graph, which is also perpendicular to the slanted edge.

The next step after edge detection is to determine the oversampled edge spread function (ESF), which is a high-resolution representation of the transition between light and dark regions in an imaging system. It is achieved by sampling at a rate that considerably exceeds the Nyquist rate.

Higher sampling rates yield greater detail on edge transitions, resulting in more accurate MTF measurements.

According to system theory, the ESF reflects the system's response to a step function. The first derivative of the ESF produces the line spread function (LSF), which represents the system response to an input of an impulse. The LSF can be determined through discrete approximations of the derivative, including techniques like the finite difference method. Additionally, the modulation transfer function (MTF) is derived using the discrete Fourier transform (DFT) after applying a Hamming window to the data.

A crucial metric in MTF analysis is MTF50, which indicates the spatial frequency at which the system's contrast response decreases to 50 % of its low-frequency value. This threshold serves as a benchmark for perceived sharpness and is closely linked to the system's capacity to resolve fine details. On the contrary, the MTF50P metric identifies the spatial frequency at which the MTF drops to 50 % of its peak value. MTF50P offers a more reliable assessment of system performance, particularly in images that have undergone significant sharpening, as it accounts for artificial enhancements that can inflate MTF50 values.

III. RESULTS

For the analysis, images were captured in two different manners: first, the Imatest target was photographed for close-up and total body photography, and second, a macro test target was photographed for the analysis of the dermatoscopic images. Measurements were made using a software application developed with Matlab's Image Processing Toolbox. We analysed the images obtained from all available cameras through two different approaches. First, we evaluated the images using the Imatest chart, with the results summarised in Table I. Next, we assessed the images captured by both the camera and the handheld dermatoscope device on the macro test target, with these findings presented in Table II.

TABLE I. SHARPNESS RESULTS FOR CAMERAS AND IMATEST TARGET.

Device	Image Height (pixels)	Image Width (pixels)	MTF50 (LW/PH)	S (%)	10 %–90 %
Canon 5DIII	3840	5760	2418	7.7	1.4
Canon EOS 7R	4640	6960	3151	21.9	1.1
Sony A7RII	5304	7952	3338	-7.8	1.4
iPhone XS	3024	4032	2630	69.1	0.7
iPhone 13	3024	4032	2716	46	0.7
iPhone 15	3024	4032	3290	44.9	0.7
Samsung S24	4284	5712	2683	34.6	1.0

TABLE II. SHARPNESS RESULTS FOR CAMERAS AND MACRO TEST TARGET.

Device	Image Height (pixels)	Image Width (pixels)	MTF50 (LW/PH)	S (%)	10 %–90 %
Canon 5D	3840	5760	2518	-16.1	8.7
Canon EOS 7R	4640	6960	2147	-31.2	8.2
Sony A7RII	5304	7952	707	-39.4	24.8
Medicam 1000s (Fotofinder)	1080	1920	491	-29	6.4
iPhone XS	3024	3024	1392	-27.8	7.1
iPhone 13	3024	4032	1601	-13.6	2.3
iPhone 15	3024	4032	1369	-33.5	6.8
Samsung S24	4284	5712	3535	-1.6	5.8

Figure 5 illustrates the ESF diagram derived from an image captured with the Imatest chart using the iPhone 13 camera, together with the corresponding MTF characteristics. The diagram indicates that the iPhone 13 camera requires 0.7 pixels to traverse a bevelled contrast edge (from 10 % to 90 %), demonstrating a sharper transition compared to the Canon R7, which requires 1.1 pixels for the same edge transition, as shown in the ESF diagram in Fig. 6. However, the plot of the MTF function indicates that the Canon R7 achieves higher contrast retention, with an MTF50 of 3151 LW/PH, compared to the iPhone 13's MTF50 of 2716 LW/PH. This disparity can be attributed to the larger image sensor area of the Canon R7 and the higher resolution, which improves its contrast performance.

Additionally, the impact of software sharpening during the conversion to the JPG format is clearly illustrated in the MTF diagrams. This is evident in Table I, where the MTF50P value is considerably lower than the MTF50. Additionally, this effect is further highlighted in the MTF curve, which shows a percentage of the maximum value compared to the MTF at a spatial frequency of zero.

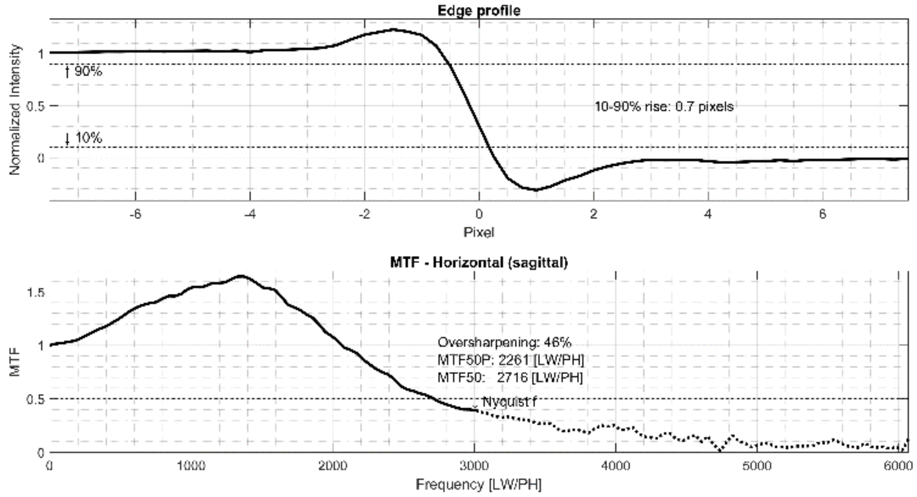

Fig. 5. The results of the sharpness measurement, illustrated by the edge spread function (ESF) diagram and the associated modulation transfer function (MTF) characteristics, were derived from an image taken with the Imatest target using the iPhone 13 camera.

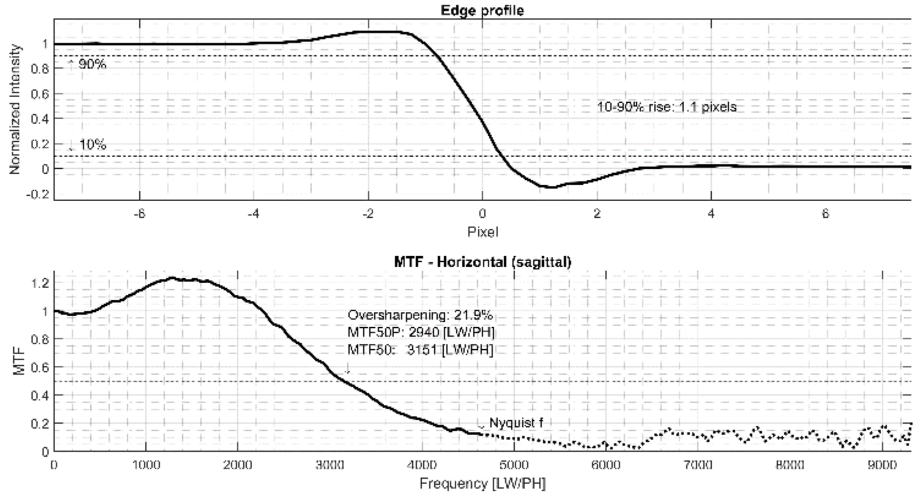

Fig. 6. Sharpness results for the Canon R7.

Excessive sharpness is recorded at 21.9 %, suggesting that considerable post-processing has been used to improve sharpness. The MTF curve illustrates the system's ability to maintain contrast across various spatial frequencies, measured in line widths per picture height (LW/PH). The MTF50 for the iPhone 13 is 2716 LW/PH, which is lower than the Canon R7 3151 LW/PH, indicating a slightly reduced capacity for detail provision. Additionally, the MTF50P is 2261 LW/PH, reflecting an extra 46 % sharpening, which is significantly higher than that of the Canon R7. The pronounced peak, accompanied by a swift decline, suggests an assertive approach to post-processing aimed at enhancing sharpness perception, potentially compromising the natural quality of the image. Both systems achieve Nyquist limits without notable aliasing, reflecting good overall system design for both devices. The analysis indicates that the Canon R7 strikes a superior balance between optical sharpness and post-processing. It exhibits a more gradual decline in MTF and demonstrates less noticeable oversharpening, making it particularly well-suited for achieving detailed and natural renderings. The iPhone 13, although equipped with a smaller sensor and enhanced sharpening, delivers sharper edge transitions and satisfactory MTF results. It is optimised for a consumer-friendly “sharp” image aesthetic, although at the expense of natural rendering.

The dermoscopy images used in this study were obtained using a DermLite 4 DL handheld dermoscope, which was connected to the lens of a smartphone or a digital camera. To assess image sharpness, a macro test plate was employed that features a thin silver coating pattern, characterised by a perfectly straight edge and a corresponding 5 ° bevel.

Each component of the system - namely the camera lens, sensor, electronics, and optics of the hand-held dermoscope - possesses its own individual MTF value. The overall MTF of the system was assessed, reflecting the cumulative MTF values of all components. Figure 7 illustrates a diagram of the ESF obtained using a Samsung S24 camera connected to a DermLite 4 DL handheld dermoscope.

The edge profile demonstrates the transition from dark to light intensity along an edge. A rise time of 5.8 pixels, measured from 10 % to 90 %, indicates relatively short transitions, which are indicative of good edge sharpness and the ability to render fine details. The MTF50 value is recorded at 3535 LW/PH, indicating that 50 % of the maximum contrast is maintained at this spatial frequency. This result highlights exceptional detail resolution, although there is a gradual decline in contrast at higher spatial frequencies, without any sudden drops or distortions.

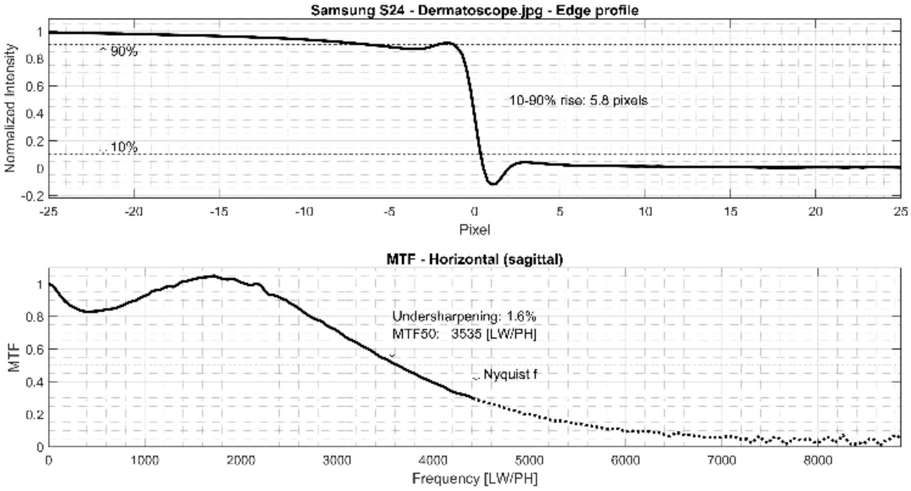

Fig. 7. Sharpness results for the Samsung S24 camera, when used in conjunction with the DermLite 4 DL dermoscope, demonstrate notable clarity and precision.

The Nyquist limit, which defines the theoretical maximum resolution of the sensor, is clearly evident. Additionally, the system exhibits a negligible undersharpening of -1.6 %, leading to a realistic image representation. The findings suggest that the Samsung S24 is an outstanding device, particularly in terms of sharpness and detail retention. The collaboration between the camera and dermoscope demonstrates a seamless performance, marked by minimal sharpening artifacts and exceptional resolution. This combination is especially advantageous for applications that involve dermoscopic imaging.

For comparison, the results presented in Fig. 8 were obtained by integrating a dermatoscope with the full-frame mirrorless camera, Sony A7RII. The MTF curve indicates a notable loss of sharpness, as demonstrated by the MTF50 decreasing to 707 LW/PH. Furthermore, the edge rise distance (10 %–90 %) was recorded at 24.8 pixels, and an undersharpening value of 39.4 was determined. These findings lead us to conclude that the combination of the selected lens and the full-frame sensor camera is less effective in capturing dermatoscopic images when used with the dermatoscope’s magnifying glass.

Table I summarises the consolidated results for sharpness and device resolution from a selection of seven cameras captured with the Imatest target. The first column identifies the camera names, while the second and third columns provide details on the pixel count of the sensors. The fourth column displays the calculated line pairs per sensor height at a 50 % contrast ratio. The fifth column indicates the sharpening value, and the sixth column outlines the pixel count required to transition from a 10 % to a 90 % contrast edge. The data indicate that the Sony A7RII boasts the highest image resolution at 5304×7952 pixels, surpassing the Canon EOS 7R and Samsung Galaxy S24. Additionally, the Sony camera achieves the highest measured sharpness at MTF50, recording 3338 LW/PH, closely followed by the Canon EOS 7R at 3151 LW/PH.

On the other hand, the Canon 5DIII reaches 2418 LW/PH at MTF50. All cameras used 35 mm lenses with an aperture set to f8. Notably, the Canon EOS 7R, equipped with a built-in crop sensor, demonstrates a greater degree of added sharpening compared to its full-frame counterparts. Although the iPhone 15 records a high resolution of 3290 LW/PH, it is important to note that significant post-processing sharpening is evident in mobile device cameras. Excessive sharpening can pose serious challenges for accurate dermatological image analysis.

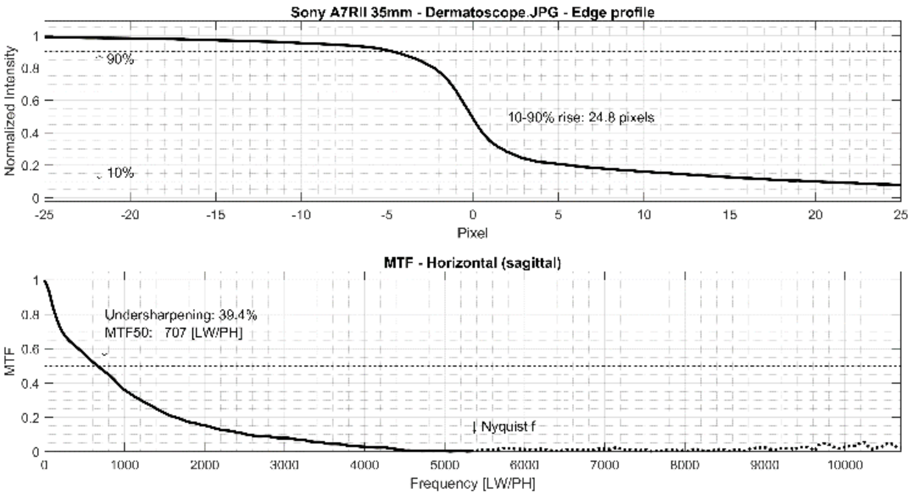

Fig. 8. Sharpness results for the Sony A7RII camera, equipped with a 35 mm lens and the DermLite 4 DL dermoscope.

Table II displays the measured results for camera sharpness and resolution, specifically for images captured through the magnifying lens of a handheld dermatoscope aimed at a macro test target. The first column lists the camera models, while the second and third columns provide details on the pixel counts of their sensors. The fourth column presents the calculated line pairs per sensor height at a 50 % contrast ratio. The fifth column indicates the sharpening value, and the sixth column specifies the number of pixels required to transition from a 10 % to a 90 % contrast edge.

Professional DSLR and mirrorless cameras boast significantly higher pixel resolutions than smartphones and medical cameras like the Medicam 1000s, with the Sony A7RII providing the largest image dimensions. However, despite its high resolution, the Sony A7RII has a surprisingly low MTF50 value of 707 LW/PH, suggesting poor sharpness. This discrepancy may point to potential issues, such as optical limitations or focus inaccuracies. On the contrary, the Samsung Galaxy S24 stands out with the highest MTF50 value of 3535 LW/PH, indicating superior sharpness compared to all other devices.

Among smartphones, the iPhone 13 offers better sharpness (1601 LW/PH) compared to the iPhone XS (1392 LW/PH) and iPhone 15 (1369 LW/PH), the latter showing a slight decrease in sharpness. In terms of undersharpening/oversharpening, most devices exhibit negative values, indicating a tendency toward undersharpening.

The Sony A7RII exhibits the highest degree of undersharpening (-39.4 %), while Samsung Galaxy S24 is nearly neutral (-1.6 %), indicating minimal sharpening adjustments. In particular, the iPhone 13 demonstrates less undersharpening (-13.6 %) compared to other iPhone models, suggesting more aggressive sharpening during post-processing. Given that all Apple models share sensors with the same resolution, the differences in image quality are probably attributed to the optical properties of the integrated lenses and variations in image processing techniques.

IV. DISCUSSION

Sharpness analysis of images captured with the iPhone 13 and Canon R7 reveals that the iPhone 13 achieves sharper edge transitions (0.7 pixels) compared to the Canon R7 (1.1 pixels). However, the Canon R7 maintains a higher contrast level at a spatial frequency of 3151 LW/PH, indicating superior optical sharpness and less reliance on aggressive post-processing. In comparison, the iPhone 13 has an MTF50 value of 2716 LW/PH, suggesting that the Canon R7 provides a better balance between optical sharpness and post-processing, making it more suitable for rendering natural details.

In dermatoscopic image analysis, the Samsung S24 combined with the DermLite 4 DL dermatoscope demonstrated exceptional sharpness and detail retention, achieving a MTF50 value of 3535 LW/PH. This result highlights its ability to capture high-resolution details with minimal sharpening artifacts, making it highly suitable for dermatoscopic applications. Conversely, the Sony A7RII paired with the DermLite 4 DL dermatoscope exhibited significant sharpness loss, with an MTF50 value of 707 LW/PH, indicating less effective performance in capturing dermatoscopic images.

Optical factors such as lens quality, aperture size, and light scattering play a crucial role in determining sharpness and contrast in captured images. Image processing, on the other hand, uses advanced algorithms to reduce noise, improve colour accuracy, and fine-tune sharpness. Additionally, artificial intelligence significantly improves final image quality by dynamically compensating for hardware limitations and optimising various aspects of image rendering.

In smartphones, achieving the optimal balance between sharpening and the rise distance is vital. Computational processing is key, as it integrates multiple techniques to deliver clarity and sharpness, even in challenging imaging conditions. This seamless integration of hardware and software highlights the sophistication of modern mobile photography systems. The Samsung S24 exemplifies this synergy, demonstrating exceptional overall performance. Its capabilities suggest that it could rival entry-level professional cameras for nonspecialised imaging tasks, showcasing the rapid advancements in smartphone photography.

The resolution of a professional video dermatoscope camera, widely used in dermatology clinics for live and follow-up examinations, is optimised to provide sharp and satisfactory image quality on a HD screen. However, when the image is magnified, it quickly reaches a threshold where critical details are no longer discernible. To overcome this limitation, professional dermatoscopes are equipped with optical magnification systems that allow zoom levels of up to 140x, ensuring enhanced detail visibility for accurate diagnosis.

In contrast, a handheld dermatoscope paired with a photo camera typically offers a fixed optical magnification of 10x. In this setup, high resolution and superior sharpness are essential to enable further digital magnification without significant degradation in image quality. However, the additional sharpening applied by the camera system can pose a challenge, as it can distort image details and hinder the precise assessment of medical conditions.

Images can also be saved in RAW format without any processing, preserving all the image data. However, because of the large file sizes, RAW files are often replaced by compressed JPEG files for storage. In telemedicine, where quick and efficient image transfer is crucial, the bulky RAW format is not practical. Furthermore, RAW files are not automatically optimised for display on various device screens because each device uses its own proprietary format. Opening and processing RAW files also require specialised software and plugins, adding to their complexity. In contrast, JPEG files are universally compatible, standardised, and can be easily displayed on most systems without additional adjustments or tools, making them more practical for everyday use.

Since camera manufacturers do not disclose the specifics of their image processing algorithms, which play a significant role in sharpness reproduction, image quality can vary between captures. Establishing standards in medical imaging is essential not only to ensure consistent quality in regulatory assessments, but also to foster innovation [26]. Despite the substantial volume of images generated in dermatology, this does not necessarily translate into superior image quality or compliance with the Digital Imaging and Communications in Medicine (DICOM) standard [27]. Although DICOM is widely adopted in medical imaging fields such as radiology, cardiology, and radiation therapy, its application in dermatology remains limited. However, there is growing recognition of the benefits of implementing DICOM in dermatological imaging, particularly in ensuring superior image quality, spatial resolution, and sharpness [26]. Currently, no equivalent standardised format has been established for dermatology [27], which presents significant challenges in achieving consistent image quality and interoperability across devices and platforms in dermatological imaging.

V. CONCLUSIONS

High-resolution, small-form-factor image sensors have made it possible to integrate mobile device cameras into medical applications, including dermatology. The combination of smartphones and handheld dermatoscopes provides a viable alternative to professional dermatoscopic systems, especially for teledermatology and teledermoscopy. In this study, we focus on evaluating the sharpness and resolution of cameras used in dermatological imaging, employing the SFR method. This method uses standardised edge SFR test charts to measure image quality.

The analysis of images captured with various devices revealed notable differences in performance. The iPhone 13 demonstrated sharper edge transitions, while the Canon EOS R7 offered superior optical sharpness and well-balanced post-processing, making it more suitable for preserving natural details. In dermatoscopic imaging, the Samsung Galaxy S24 paired with the DermLite 4 DL dermatoscope exhibited exceptional sharpness and detail retention. In contrast, the Sony A7RII showed significant sharpness loss, highlighting the variability in device effectiveness for specialised imaging tasks.

The results highlight the critical role of image quality, specifically sharpness and resolution, in the accurate diagnosis of skin diseases. By proposing metrics using MTF for different camera-optical systems, we have provided a systematic evaluation of their suitability for dermatological applications. The findings emphasise the need for standardised methods and tools, such as DICOM compliance, to ensure consistent image quality. This would enable automatic and accurate reproduction of results, which is essential for reliable clinical assessments.

In conclusion, this study outlines the strengths and limitations of various imaging devices in dermatological practice and offers practical guidance for selecting the appropriate equipment. Future research should build on these findings by examining a wider range of devices and investigating the impact of settings and capture methods, with the aim of further improving the quality and reliability of dermatological imaging.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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