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Article

Proof of Concept for Low-Cost Thermographic Assessment of Skin Lesions

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Abstract: Currently, for obtaining thermographic images there is a wide variety of portable thermographic cameras for mobile phones. Thus, by connecting a thermographic camera of this type to a smartphone, it is possible to obtain thermographic images of reasonable quality in a simple, quick, and painless way. Its transport and handling are quite easy, which allows its use by anyone and anywhere. Furthermore, the cost of these cameras is reduced, thus making their use even more accessible. In the present work, it was intended to develop an application to automatically segment and evaluate the skin lesions from thermographic images obtained through the smartphone. The detection of the injured region (by the percentage of area) and obtaining its characteristics, such as minimum, average, and maximum temperature were implemented to monitor the lesion. The results obtained are promising and reinforce the interest in using this application in health centers or by medical and nursing teams, for the care, prevention, and monitoring of skin lesions in conjunction with other diagnostic methods.

Keywords: image processing; thermography; skin lesions; temperature; infrared

1. Introduction

Currently, for obtaining thermographic images there is a wide variety of portable thermographic cameras for mobile phones. Thus, by connecting a thermographic camera of this type to a smartphone, it is possible to obtain thermographic images of reasonable quality in a simple, quick, and painless way. Its transport and handling are quite easy, which makes it possible to use it by anyone and anywhere. Furthermore, the cost of these cameras is reduced, thus making their use even more accessible.

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Skin lesions are currently followed by health professionals through visual inspection, subject to human errors (different observers) and lack of monitoring (information in different periods of time). In this paper, an image processing application will be presented to automatically segment and evaluate the evolution of skin lesions. The application can be used by health centers or by medical and nursing teams, for the care, prevention and monitoring of skin lesions. It is able to detect and monitor injuries, often not so easily detected with the naked eye. Also, in conjunction with other diagnostic methods, it can become quite useful. The application allows you to insert one or several skin images acquired with the aid of the low-cost thermographic camera and instantly analyze the injured region and its characteristics, such as average temperature and percentage of the injured region.

2. State of art

Thermography has been used for over 50 years, the first research in medicine, more particularly in the area of infection detection, involved the diagnosis of breast cancer and melanoma. Followed by studies of inflammatory arthritis, musculoskeletal injuries, fibromyalgia, regional pain syndrome, wound healing after surgical procedure and the evaluation of microcirculation in vascular diseases [1]. In the analysis of thermographic images of squamous cell carcinomas and melanomas [2] to find indicators of the presence of a tumor or in the detection and characterization of the severity of spondylarthritis (inflammatory diseases involving spinal ligaments and tendons) [3], thermography also plays an important role. In skin burns, thermography is effective in predicting healing or the need for amputation [4]. Not only for its sensitivity to determine the depth of an injured area, but also to visualize in real time the body temperature of the site and predict the progression of the injury in the first days [5].

In surgical treatments such as in the case of hidradenitis suppurativa (inflammatory skin disease), thermography optimizes the surgical mapping showing the margins of the lesion, making it possible to remove damaged tissues with greater precision [6]. In the early diagnosis and control of diabetic foot disease [7], thermography makes it possible to identify patients who require specific and rigorous care. More recently, this technique has been widely publicized and recognized through its use in airports for the detection of influenza viruses and recent pandemics, namely SARSCoV-2 [8]. Thermography, being a low-cost, harmless and easily implemented technique, can be useful to complement the diagnosis of sinusitis, however it should not be considered as a stand-alone diagnostic technique, but in conjunction with other clinical exams [9].

In general, thermography is a non-invasive diagnostic technique that detects and measures temperature through thermal radiation. The heat rays of a body are recorded with the help of a thermographic camera, measured and displayed as a visible image. After image processing, each measurement point is assigned a certain color according to the temperature value [10]. Warm regions of the body are represented with white or red colors, indicating greater blood circulation and therefore the possibility of the existence of inflammatory

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processes, while cold regions are represented with blue or black colors, indicating places with affected blood flow or in tissue necrosis situation [11]. In Figure 1, two examples of a thermographic image can be seen.

The growing interest in thermography, the recognition of its importance and the limited information available on skin thermal maps led to the development of this study as an aid in evaluation and diagnosis.

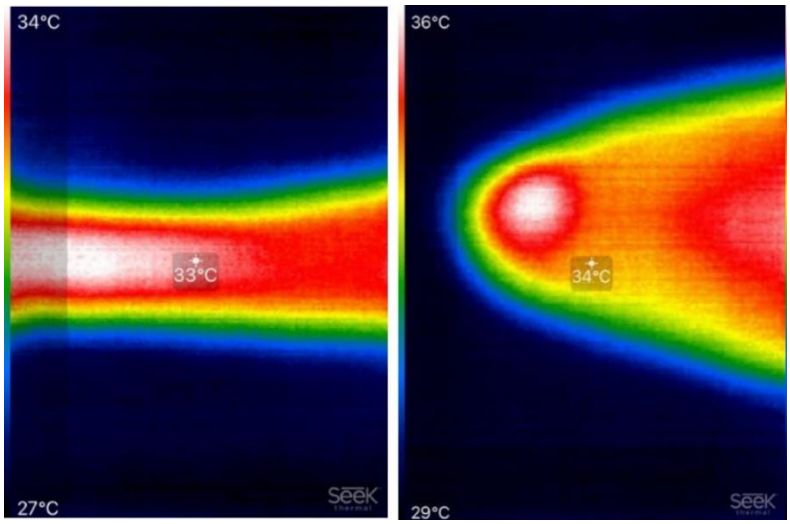


Figure 1. Thermographic images examples.

3. Skin injuries and inflammation

Intact skin is an anatomical barrier, which prevents the entry of harmful substances, maintains vital chemicals and nutrients in the body, and provides protection from the harmful effects of ultraviolet radiation. The resident flora of the skin is of low virulence, stable and rarely causes disease [12]. The skin has three layers: the epidermis; the dermis and the hypodermis, also called the fat layer. Blood vessels in the dermis nourish the skin and help regulate body temperature. Heat causes blood vessels to dilate, and large amounts of blood circulate close to the surface of the skin, releasing heat. Cold, on the other hand, causes the vessels to narrow and conserve body heat. In humans, the temperature in the dermis, considered normal for healthy adults, comprises values close to 37ºC. Values below 35ºC (hypothermia) or above 38ºC (hyperthermia) can cause health problems and should be monitored and avoided [13]. Whenever a skin lesion (skin) occurs, the inflammatory process is triggered in the vascularized tissues. The characteristic signs and symptoms of the inflammatory process are flushing (redness), heat, edema (swelling), pain and loss of functionality in the affected region.

4. Methodology

The main objective of this work is the development of a simple, portable and low-cost system for the detection, control and monitoring of skin inflammation. The system will consist of a smartphone, a thermographic camera, and an automatic application accessible to

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any health professional or patient. The automatic application was developed in Matlab [14] to acquire the ROI heat map (Region Of Interest) and diagnose the infection in question. Figure 2 shows the flowchart of the developed application.

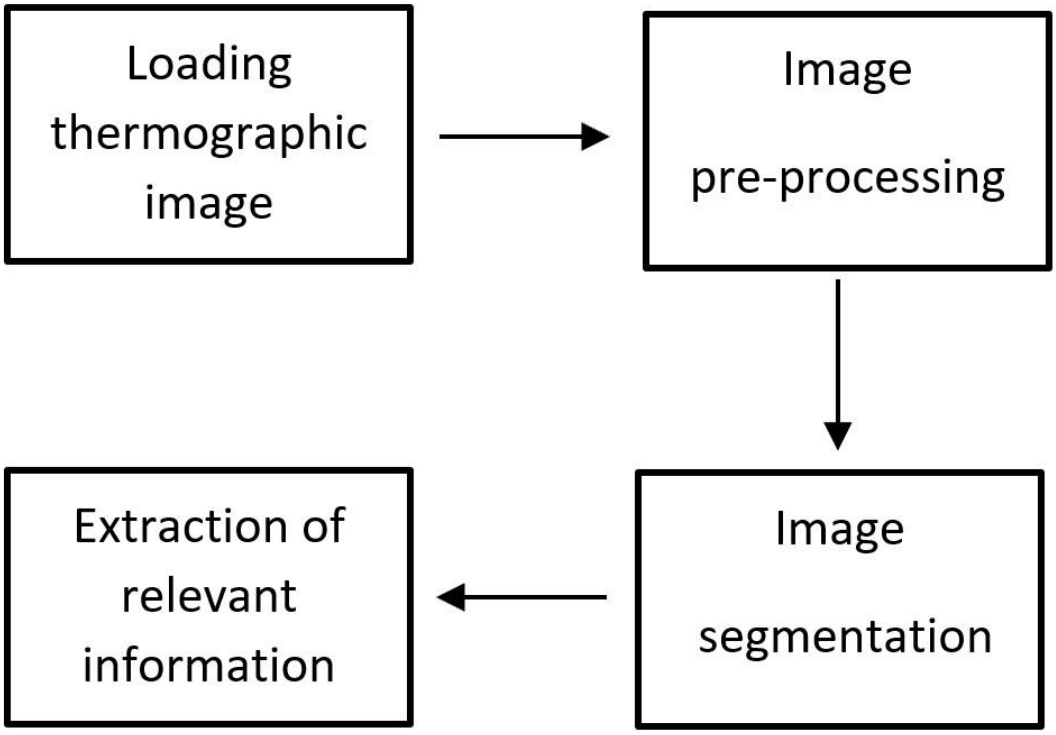


Figure 2. Flowchart of the developed application.

The original thermographic image is read by the application, and the pre-processing of the image is started to highlight the features of interest in the image. Contrast enhancement, noise reduction, isolating regions and lighting correction techniques are applied during this step. Then, a widely used technique of thresholding of intensity (thresholding) is applied.

Here, a global threshold was applied based on the analysis made to thermographic images and knowledge of normal human skin temperature. After this step, the image is segmented, that is, the desired regions of the image are collected. At this point it is already possible to collect all the relevant information from the image and interpret the data. As a final result, the information is displayed.

4.1. Loading the thermographic image

After loading the thermographic image in the application, the color bar is automatically separated (Figure 3).

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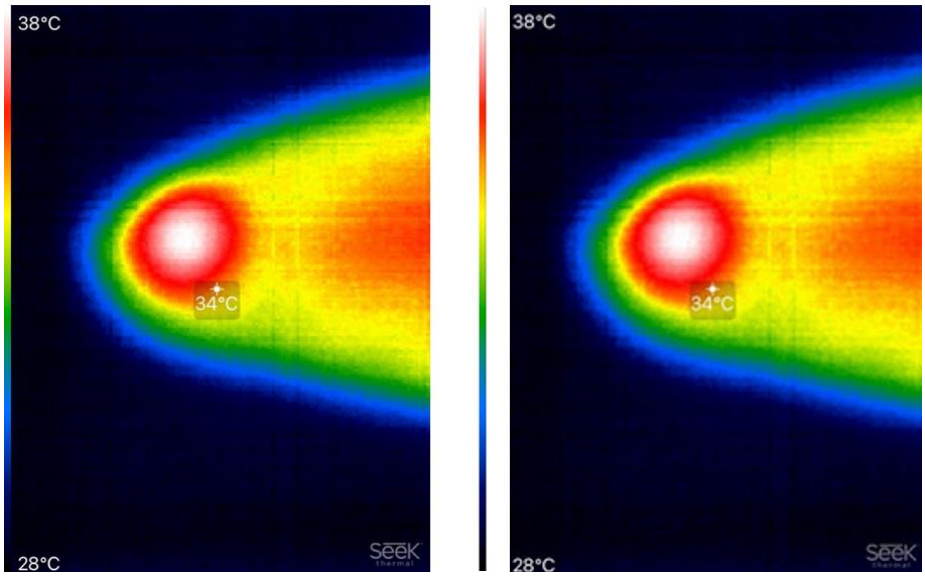


Figure 3. Original thermographic image (left) and automatic color bar separation (right).

4.2. Image Pre-processing

In pre-processing, thermographic images are converted to indexed images in order to extract the temperature associated with each image pixel. In this way, the intensity value of each pixel is replaced by the respective temperature value, according to the temperature bar from the original image. Figure 4 shows the indexed image obtained from the thermographic image of Figure 3. Thus, the pixel at position P= [x, y] = [382, 171] corresponds to 340 intensity maps (left).

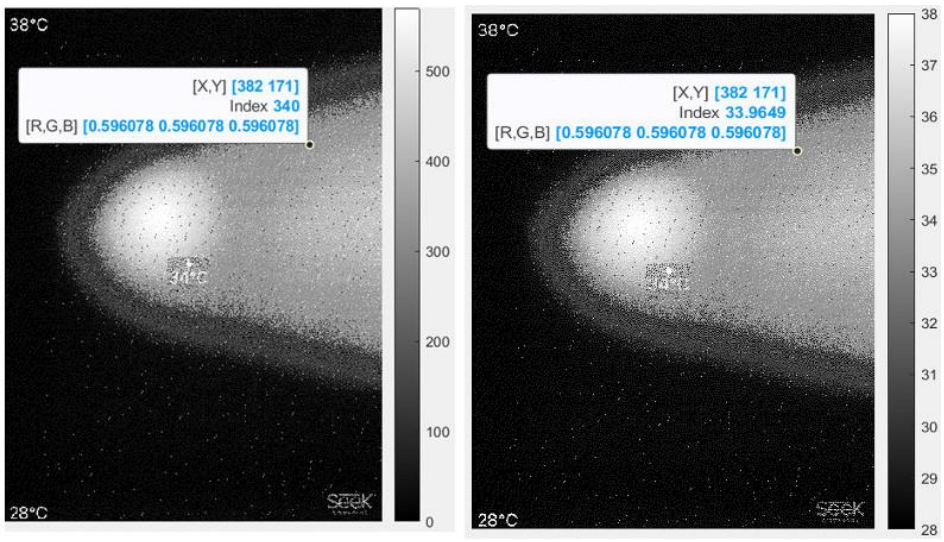


Figure 4. Indexed thermal image with intensity map (left) and indexed thermal image with temperature map (right).

To improve the indexed thermal image (Figure 4) some techniques were applied, such as contrast enhancement, noise reduction and light correction, as can be seen in Figure 5.

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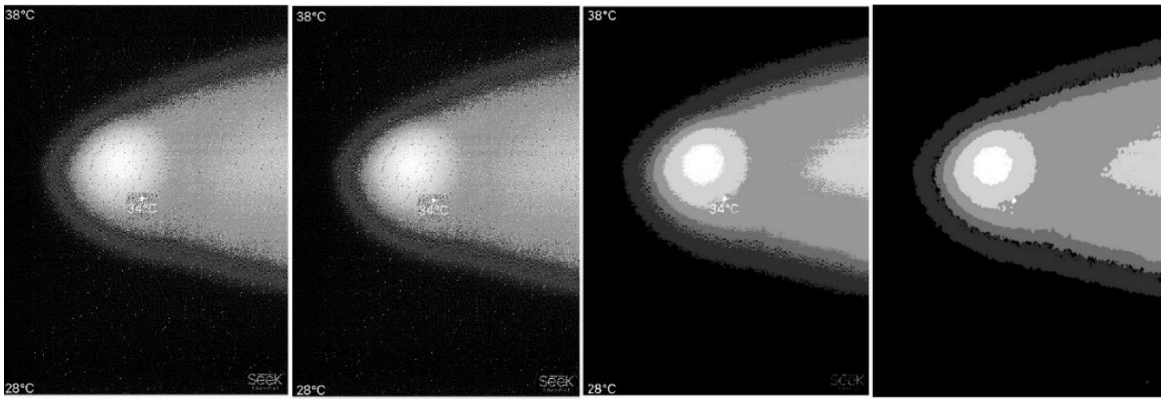


Figure 5. Original indexed thermal image (left), contrast enhancement, noise reduction and light correction techniques (right).

Now, the final indexed image is converted into an indexed thermal image, matching the intensity values with the temperature values. To establish this relationship, it was necessary to extract the minimum and maximum temperature values from the original image (presented in the lower and upper left corners of the indexed image) using character recognition. In the example shown in Figure 3 (left), the minimum temperature is 28ºC and the maximum is 38ºC. In this case, the pixel at position P with the intensity of 340 will be 33.96ºC (= 28 + (38-28) × 340 = 33.96ºC) (Figure 3 (right)). The histogram of this image (Figure 6) shows that 55% of the skin region has a temperature of 28ºC (below the normal skin temperature) and 15% has temperatures ≥ 36ºC (10% with temperatures of approximately 36ºC and less than 5% with temperatures of 38ºC). That is, the skin infection is about 5% of the total region.

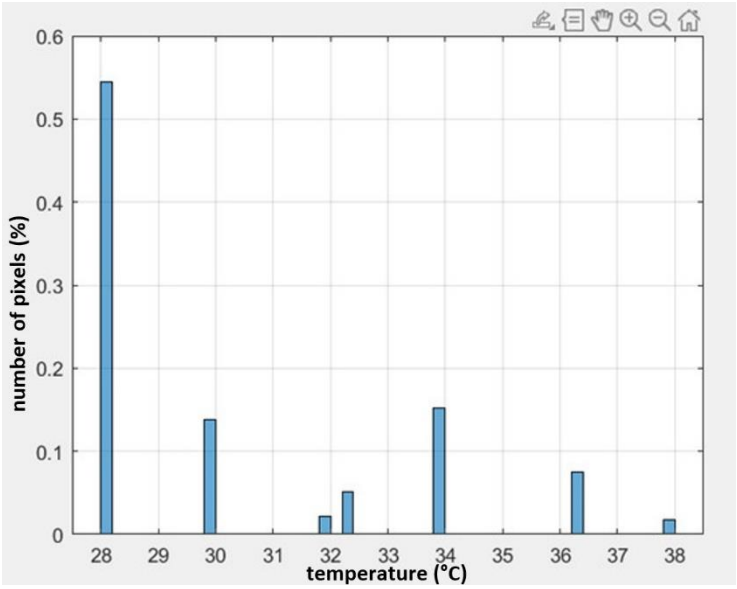


Figure 6. Normalized histogram of the indexed thermal image

4.3. Image segmentation

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Segmentation of the indexed image was performed by thresholding. It was decided to target only regions with temperatures above 35ºC, since the dermis temperature is approximately 37ºC. Thus, the regions where the pixels have temperatures above 35ºC are selected. In the example shown in Figure 7 on the left, the region where the temperature is above 35ºC was identified (center) and then segmented (right). This detected region is then divided into two sub-regions (see Figure 7 right): R1 (in red) has temperatures higher than 35ºC and lower than 36.5ºC and R2 (in white) has temperatures higher than 36.5ºC (value defined as the reference temperature, based on in the thermographic images obtained).

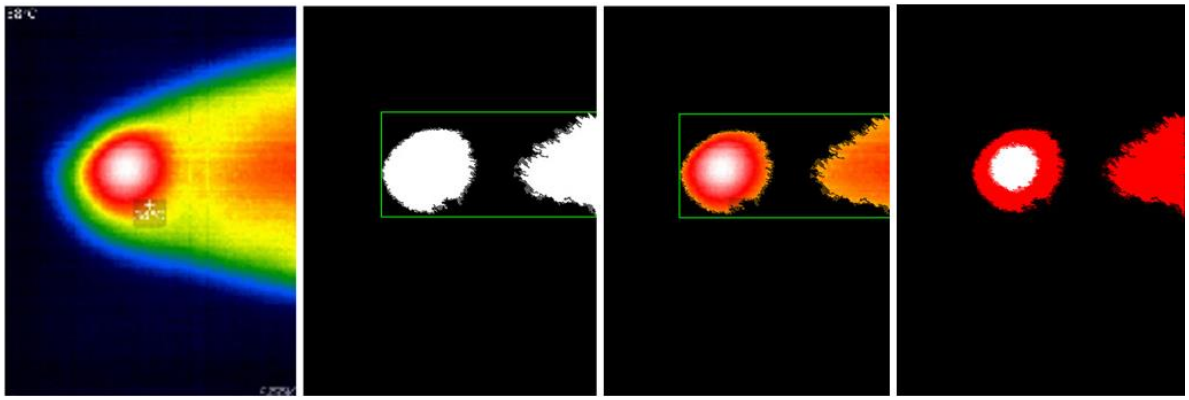


Figure 7. Original thermographic image (left), identified region, segmented image and definition of the regions R_1 in red and R_2 in white (right).

4.3. Extraction of relevant information

The following characteristics of the segmented region (lesion) were extracted: minimum, maximum, and average temperature in the lesion (in ºC); area of region R1 and R2 (in pixels); percentage of area for region R1 (area of R1/total area) and for region R2 (area of R2/total area). In the case of the thermographic image in Figure 7, the characteristics obtained for the segmented lesion are: maximum temperature of 38ºC, minimum temperature of 28ºC, average temperature of 36.33ºC, percentage of R1 of 4.808% and the percentage of R2 of 1.429%. Which confirms the 5% of skin infection in relation to the total region.

5. Results of simulations and discussion

In order to test the developed application, tests were carried out on thermographic images of different parts of the body. Some protocols were followed by the environment and the way the images were acquired. The place where the images were acquired was kept at constant ambient temperature, free from drafts. To acquire the images, 5 procedures were followed (Figure 8): (1) Keep the body at rest for at least 5 minutes; (2) Put a black cloth as a background; (3) Keep the camera 0.6m from the study area; (4) Place the camera perpendicular to the body; (5) Take the photograph of the body at rest.

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Figure 8. The procedures to acquire the images.

To simulate the skin infection, a metal was heated and applied to different parts of the body, and the thermographic image was captured through a Seek-thermal portable thermographic camera for the mobile. To simulate their evolution, the metal was heated to different temperatures (well below the "burn threshold" so there is no risk of burns) and the area of application on the skin was also changed. Figure 9 shows the metal that was used to heat the skin (left) and a thermographic image of the same (right).

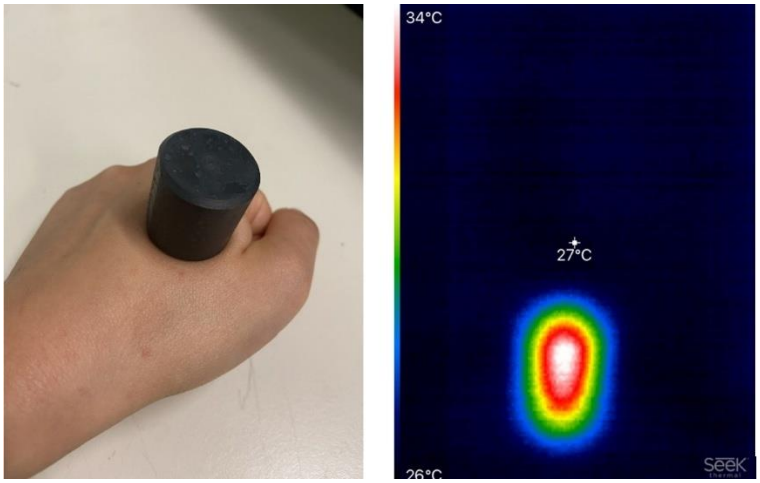


Figure 9. Hot metal (left) and corresponding thermal image (right).

In the first simulation, 4 thermographic images were obtained from a region of the arm (Figure 10) identified by the black circumference in the left image after heating the region for 4 times, simulating the development of the lesion over 4 weeks. The evolution of infection growth was gradual over the weeks, but more evident from the 3rd week to the 4th week. The week 1 image obtained does not have thermal characteristics through which it is possible to identify any of the R1 or R2 lesion areas. The weeks 2 and 3 images already show a sufficient temperature rise to identify the R1 region (1.95%, 1.63% and 7.04%) and only week 4 (0%, 0% and 1.48%) image has a sufficient temperature rise to identify an area of R2. The evolution of the minimum temperature was 28ºC, 27ºC and 28ºC, the average of 34.3ºC, 35.3ºC and 35.1ºC and the maximum of 35.0ºC, 36.0ºC and 37ºC from week 2 to week 4.

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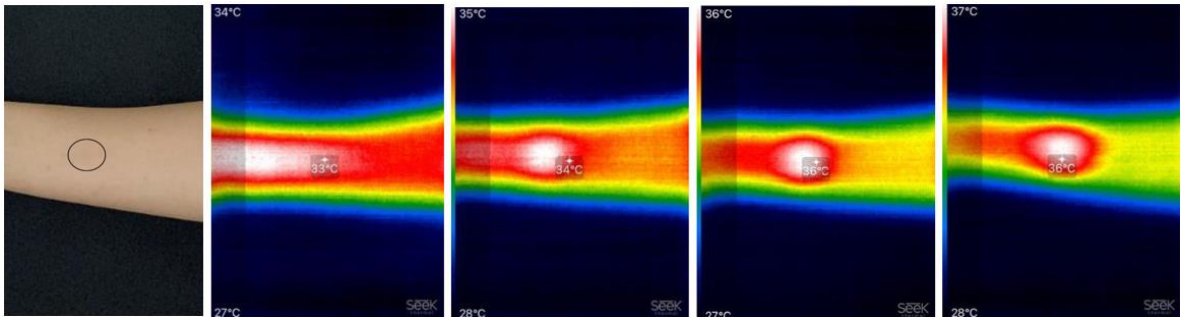


Figure 10. Arm injury (left) and simulation of infection for 4 weeks (right).

A second simulation in the leg area was performed by heating this region following the previously defined protocols. In Figure 11 on the left, the image of the region and the two images on the right are the thermographic images obtained after heating the region for two steps simulating two weeks. The values of the percentage of injured areas (1.8%), minimum (27ºC), average (36.56ºC) and maximum (37ºC) temperature for the two weeks are the same. In this case, the percentage of injured areas is significant, but the temperature does not show a significant increase in relation to normal skin temperature. It can also be concluded that the injury remained during the two weeks, since there are no differences in the results.

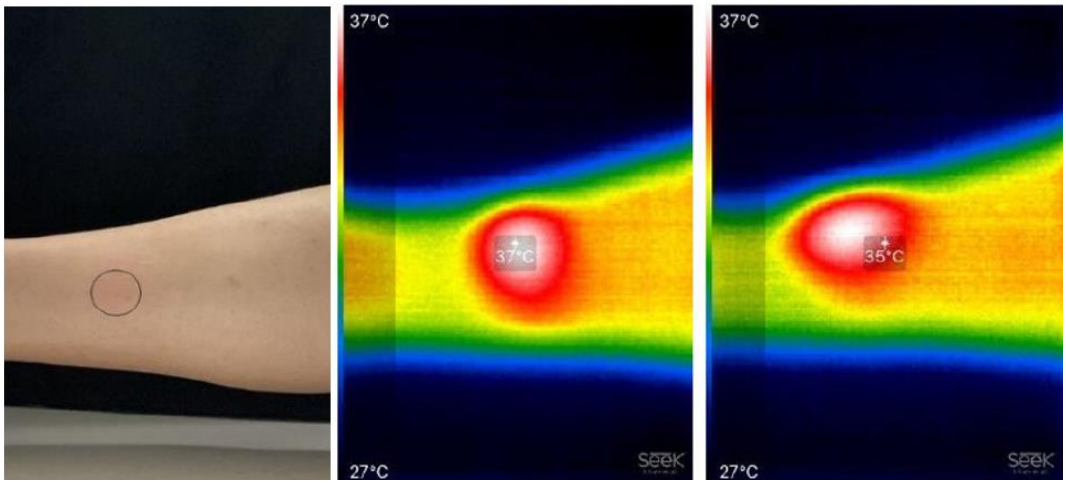


Figure 11. Leg injury (left) and simulation of infection for 2 weeks (right).

A third simulation for two weeks was performed by heating the palm of the hand (Figure 12). The lesion area increases slightly from the first image to the second (about 0.04%), the minimum temperature increased by 2.04ºC (from 27ºC to 29.04ºC), the average temperature increased by about 1ºC (from 36.48ºC 37.40ºC to 37.40ºC) and at a maximum temperature of 1ºC (from 37ºC to 38ºC). In this case the skin infection evolved.

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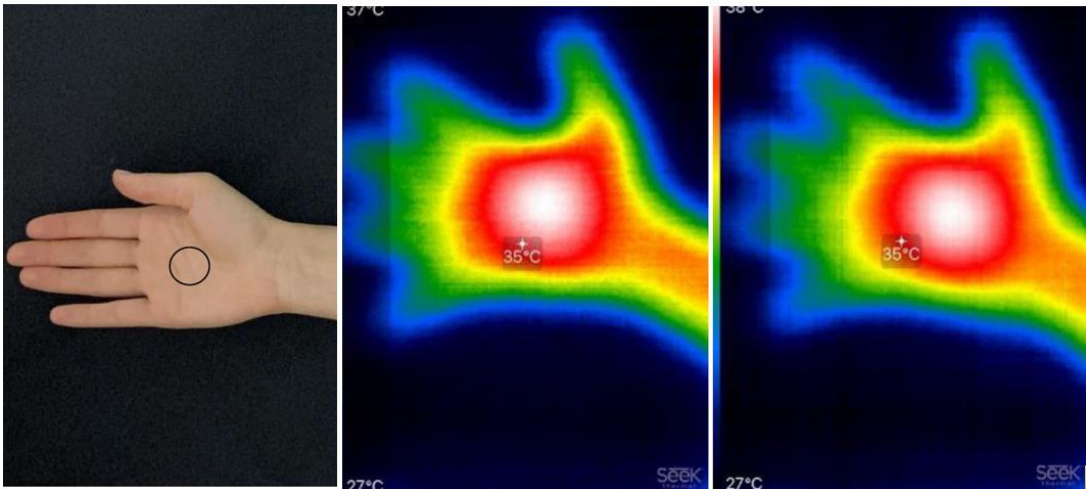


Figure 12. hand (left) and simulation of infection for 2 weeks (right).

Another last simulation was performed on the elbow over 4 weeks as shown in Figure 13. The lesion area increases slightly from week 2 to week 4 (week 2 - 1.43%, week 3 - 1.45% and week 4 - 1.5%). The minimum temperature is maintained over the weeks, the average and maximum temperatures increase from the second to the third week by 0.94ºC (37.48-36.54=0.94ºC) and 1ºC (38-37=1ºC) respectively, remaining from the third to the fourth week. It is concluded that the lesion progresses in terms of the affected area over the weeks, but the temperature, although it has increased from the second to the third week, seems to be stabilizing, since in the fourth week there was no increase in maximum and average temperatures.

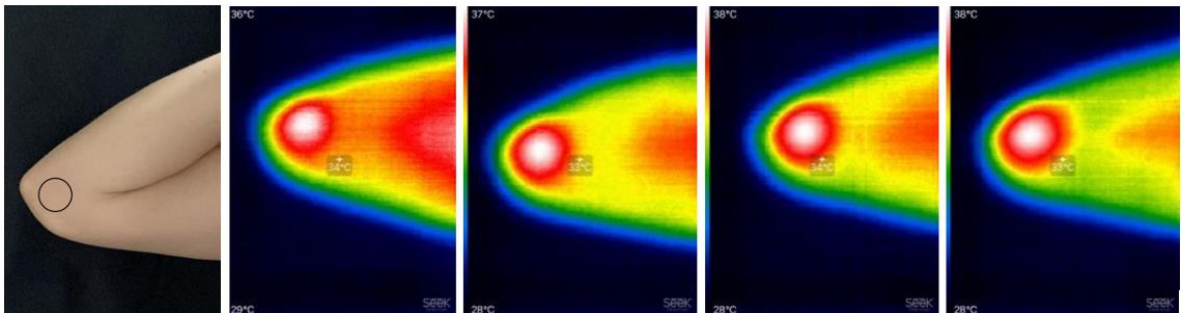


Figure 13. Elbow (left) and simulation of infection for 4 weeks (right).

Finally, in the simulation of the lesion in the thumb region, 3 images were captured (Figure 14). The lesion area decreases over the 3 weeks (week 1 - 12.36%, week 2 - 9.27% and week 3 - 3.88%). The minimum temperature increases slightly over the weeks (28ºC, 29ºC and 30.64ºC), the average and maximum temperature decrease from week 1 to week 2 (36.91ºC to 36.40ºC and 39ºC to 37ºC respectively) and increases from the second for the third week (36.40ºC to 37.47ºC and 37ºC to 38ºC respectively). In this simulation, the lesion area decreases, identifying a region in recovery, but the inflammation temperature has some unexpected variations, requiring an analysis with a greater number of weeks.

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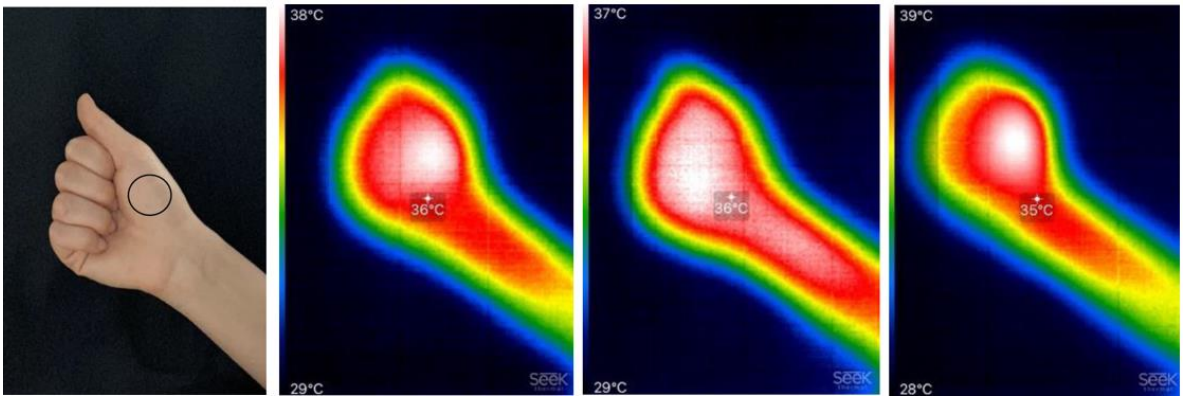


Figure 14. Thumb finger (left) and simulation of infection for 3 weeks (right).

6. Conclusions

An image processing application was developed in Matlab to automatically monitor skin lesions using thermographic images obtained by a low-cost camera attached to a mobile phone. Simulations of skin lesions were performed on various parts of the body and thermographic images were obtained according to a protocol developed for the acquisition of thermographic images. In this protocol, factors such as the distance from the camera to the object to be photographed, the characteristics of the surrounding environment, the way in which the thermographic image must be acquired, among others, were defined. The simulations were obtained by heating a part of the body with a metallic object and consequently increasing the skin temperature.

Several tests were performed using the acquired thermographic images. The algorithm recognizes the region affected by the temperature increase, the area of this region and its minimum, maximum and average temperatures. The objective of the work was achieved, despite the limited number of volunteers and tests performed. The results are promising and showed that it is possible to automatically monitor any skin lesion. However, other numerical measures such as dispersion measures should also be studied. The most relevant contribution of this work comes from the fact that there are no published works that allow the monitoring of skin lesions through portable and low-cost devices. In addition, the positive results obtained in the cases studied show the potential of this tool as a diagnostic aid. This reinforces the great interest of its use in health centers or by medical and nursing teams, for the care, prevention, and monitoring of skin lesions in conjunction with other diagnostic methods.

Conflicts of Interest: “The authors declare no conflict of interest"

References

[1] Chojnowski, M. Infrared thermal imaging in connective tissue diseases. *Reumatologia* 2017, *55*, pp. 38-43. doi: https://doi.org/10.5114/reum.2017.66686

© 2025 ITMA. All rights reserved.

[2] Benjumea, E.; Morales, Y.; Torres C.; Vilardy, J. Characterization of thermographic images of skin cancer. *Journal of Physics: Conference Series* 2018, 1221. doi: 10.1088/1742-6596/1221/1/012076

[3] Khorobchuk, N.R. Aplicação da termografia para deteção e caracterização da severidade das espondiloartrites. Master's degree in biomedical engineering, Nova University of Lisbon, Portugal, December 2016. http://hdl.handle.net/10362/23017

[4] Burmeister, D.M.; Cerna, C.; Becerra, S.C.; Sloan, M.; Wilmink, G.; Christy, R.J. Noninvasive techniques for the determination of burn severity in real time, *J. Burn Care Res* 2017. 38(1): e180-e191. doi: https://doi.org/10.1097/BCR.0000000000000338

[5] Simmons, J.D.; Kahn, S.A.; Vickers, A.L.; Crockett, E.S.; Whitehead, J.D.; Krecker, A.K.; Lee, Y.L.; Miller, A.N.; Patterson, S.B.; Richards, W.O.; Wagner Jr, W.W. Early Assessment of burn depth with far infrared time-lapse thermography, *J. Am. Coll. Surg* 2018. 226(4): pp. 687-693. doi: https://doi.org/10.1016/j.jamcollsurg.2017.12.051

[6] Polidori, G.; Renard, Y.; Lorimier, S.; Pron, H.; Derruau S.; Taiar, R. Medical Infrared Thermography assistance in the surgical treatment of axillary Hidradenitis Suppurativa: A case report, *Int. J.* Surg. Case Rep 2017. 34: pp. 56-59. doi: https://doi.org/10.1016/j.ijscr.2017.03.015

[7] Mancilla, R.B.; Daul, C.; Gutierrez Martínez, J., Hernández, A.V.; Wolf, D.; Salas, L.L. Detection of Sore-risk Regions on the Foot Sole with Digital Image Processing and Passive Thermography in Diabetic Patients, 17th International Conference on Electrical Engineering, Computing Science and Automatic Control (CCE). Mexico City, Mexico, 2020, pp. 11-13, doi: https://doi.org/10.1109/CCE50788.2020.9299144

[8] JAV Câmeras termográficas estão ajudando no combate à Covid-19. Grupo JAV, 2022. Available online: https://www.jav.com.br/case/como-cameras-termograficas-estao-ajudando-no-combate-a-disseminacao-da-covid-19/ (accessed on 10 July 2025).

[9] Kalaiarasi R.; Vijayakumar, C.; Archana, R.; Venkataramanan, R.; Chidambaram, R.; Shrinuvasan, S.; Prabhu, R. Role of Thermography in the Diagnosis of Chronic Sinusitis. Cureus. 2018 Mar 10;10(3): e2298. doi: https://doi.org/10.7759/cureus.2298

[10] Alpes Automação: O essencial que você precisa saber sobre termografia. Alpes Automação, 2022. Available online: https://www.alpesautomacao.com.br/blog/essencial-termografia/ (accessed on 10 July 2025).

[11] Silva, J.F. Estudo do mapeamento térmico das mãos para o auxílio ao diagnóstico da LER. Universidade Federal De Campina Grande Centro De Ciências E Tecnologia. Programa De Pós-Graduação Em Engenharia Mecânica 2017-11-28

[12] Leça A.; Carvalho, L. Infecções da Pele e Tecidos Moles [Relatório]. Secção de Infecciologia Pediátrica, 2022. Available online: https://www.spp.pt/UserFiles/file/Protocolos_SPP/Infeccoes_da_Pele_e_Tecidos_Moles.pdf (accessed on 10 July 2025).

[13] Benedetti, J. Manual MSD. Estrutura e função da pele, Harvard Medical School, 2022. Available online: https://www.msdmanuals.com/pt/casa/dist%C3%BArbios-da-pele/biologia-da-pele/estrutura-e-fun%C3%A7%C3%A3o-da-pele (accessed on 10 July 2025).

[14] MATLAB, version 7.10.0 (R2010a). Natick, Massachusetts: The MathWorks In

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