ISBN: 978-628-96613-1-6. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2025.1.1.1705

Implementation of an application for skin cancer detection of skin cancer

Coveñas-Lalupú, José, Engineer[1], Yucra-Sotomayor Daniel Alejandro, Engineer[2], Sotomayor-Abarca Julio Elmer, Engineer[3], Escobar-Aguirre Jaime Luis, Engineer[4], Ogosi-Auqui Jose Antonio, Engineer[5], and Morales-Alvarado, Alex Ulises, Engineer[6]

[1,3,5]Universidad Nacional Federico Villarreal, Perú, jcovenas@unfv.edu.pe, jsotomayor@unfv.edu.pe, jogosi@unfv.edu.pe

[2]Universidad Científica del Sur, Perú, dyucra@cientifica.edu.pe

[4]Universidad Ricardo Palma, Perú, jaime.escobar@urp.edu.pe

[6]Universidad César Vallejo, Perú, amoralesalv@ucvvirtual.edu.pe

***Abstract*– This article provides a detailed exploration of the structure and operation of an advanced system that utilizes artificial intelligence, specifically convolutional neural networks, with the aim of enhancing the early detection of skin cancer, with a particular focus on melanoma. It delves deep into how these cutting-edge technologies are being employed to revolutionize the diagnostic process of this potentially life threatening disease. The article sheds light on the positive impact that artificial intelligence can have on diagnostic accuracy, ultimately potentially leading to a significant improvement in survival rates for melanoma patients.**

***Keywords*-- convolutional neural networks, deep learning, skin cancer, lesions, melanoma.**

I. Introduction

The skin of the human being is an organ that covers the entire body; therefore, it is the largest organ, through the nerve endings that are distributed in various layers, they allow stimuli to be captured through sensation and the regulation of temperature in its entirety. [1], during recent years with the increase in ultraviolet radiation, the number of melanoma cases had an increase of 53% of the annual average [2]. Melanoma, due to its high mortality, causes a large number of significant deaths annually in the United States, exceeding 9,000 deaths [3]. And the detection of melanoma without the help of tools by specialists, based on Only in specialized work experience do they have an accuracy rate of 65% to 80%. This is why the use of artificial intelligence through seizure networks is of vital importance for early diagnoses, which allows the dermatologist to perform a more precise examination [4], [5], [6].

The application of machine learning through convolutional neural networks is of utmost importance to provide support to specialists and improve preventive diagnostics, as early detection can save lives of people with incidences of melanoma [7],[8],[9],[10].

The year 2016 saw a significant turning point in classification-related research. of injuries. A key indicator of this change is seen in the approaches presented during the International Symposium on Biomedical Imaging (ISBI) [11]. In this event, the 25 participating teams chose to leave aside traditional machine-based methods in lesion classification and, instead, all of them turned to a deep learning technique: convolutional neural networks (CNNs) from [12] These CNNs have proven to be a significant advancement in injury classification and other areas of biomedical research due to their ability to analyze complex data efficiently.

The present work stands out for being the first systematic review that addresses the cutting edge of research in this field, offering an in-depth view of the most recent developments in the classification of skin lesions and providing valuable information for the scientific and medical community.

In this case, said application will be implemented in which we will be able to rule out early skin cancer with the help of artificial intelligence [13], [14], [15], which will be carried out by people through consultations. by uploading or detecting images, at the same time it will serve to provide information about the types of cancer [16], [18], and actions to counteract the disease [18], [19], on the other hand it will also allow you to see your histories of diagnoses made to provide information about the condition of melanoma detected in the skin and this will corroborate its veracity. Through this application you can also make medical appointments with specialists registered in the system

II. Methodology

A. Search Strategy

To carry out this review, we focused on an exhaustive search in various academic and scientific databases, including Google Scholar, Scopus, SCielo, ProQuest, and ScienceDirect. The search focused on identifying systematic reviews and original research articles written in English.

In the search process, key terms related to the topic of study were used, such as "convolutional 1 Translated from Spanish to English - www.onlinedoctranslator.com neural networks," "deep learning," "skin cancer," "lesions," "melanoma," and "carcinoma." These terms were strategically combined to identify the most relevant literature in the field of classification of skin lesions and cancer. of skin.

It should be noted that only those documents that met the rigorous scientific standards and that provided substantial evidence for the development of the research in question were considered for inclusion in this review. This approach ensures that the data and findings presented in this work are supported by the most robust and up-to-date scientific literature available in the English language.

The ease of use of the implementation of the system. for the detection of skin cancer using artificial intelligence is described as follows.

Simplifying the registration process for users: the registration system allows the capture of biometric data quickly and easily through facial recognition during login to the system.

Use of real-time technology: the skin melanoma information previously registered in the user's profile. detection system uses recognition technology, without the need to enter additional data.

The choice of the agile SCRUM methodology for the development of the web system was motivated mainly by its flexibility, which allows changes and modifications to be made to the project effectively. Furthermore, SCRUM is characterized by its simplicity and ease of use.

One of the key advantages of agile methodology in this context is its ability to adapt to changes in requirements throughout the project. SCRUM focuses on rapid delivery of functional elements, which is beneficial in situations where requirements evolve over time.

SCRUM involves a multidisciplinary team with defined roles, which facilitates the planning, organization and execution of work efficiently. The methodology is also divided into stages or sprints, which allows obtaining results quickly and measurably. After each sprint, a review is carried out to evaluate what has been achieved and define improvements for the next sprint.

Additionally, SCRUM promotes constant feedback, both from the team and users, which helps refine application development. In this project, tools such as Pycharm were used for development and SQL Server 2019 as a relational database with a friendly interface to store the data of each user registered in the system.

The project was divided into 8 sprints, and the execution of each sprint was based on the functional requirements of the application. These requirements provided the basis for the development of the Melanoma Skin Detection System with the aim of improving early diagnoses to improve the treatments required for skin cancer by specialist doctors.

RQ1 Login

The user starts the application or session.

The application presents an option for the user: validation by facial recognition or by username and password

If the user chooses validation through facial recognition:

The app activates the camera to capture the user's facial image.

The application compares the facial image with the information previously registered in the user's profile.

If the facial validation is successful, the user gains access to the system and is allowed to use the application.

If face validation fails, an error message is displayed, and a failed attempt is logged.

If the user chooses validation using username and password

The application presents a form in which the user must enter their username and password.

The application verifies that the data entered matches the data registered in the user's profile.

If the validation is successful, the user gains access to the system and is allowed to use the application.

If validation fails, an error message is displayed, and a failed attempt is logged.

The app keeps track of the number of failed attempts:

If three (3) failed login attempts occur within a specified time period, the application locks the user out for a period of 30 minutes and displays an informational message.

After the blocking period has elapsed, the user can try to log in again.

In case of temporary lockout, the user can choose to reset their password or use face validation once the lock is lifted.

POSTCONDITIONS

The user has been successfully validated and has gained access to the system, or in case of multiple failed attempts, has been temporarily blocked according to the specified security measures.

RQ2 Register user

The user initiates the registration action in the application.

The application presents a registration form in which the user must enter the following information:

Username that will be used to log in in the future.

Password to protect the user's account.

Full name (first and last name) of the user.

User age.

User medical histories, which may include allergies, previous medical conditions, current medications, and other relevant data.

Records of skin lesions, if the user has information about previous lessons.

Mandatory facial registration, which includes capturing a facial image of the user. The application Will generate an auto-generated and correlative code based on this image.

The user completes the form providing all the required information.

The application validates the information entered, including checking the password strength and correctly capturing the facial image.

Once the information is validated, the application registers the user and creates a personal profile with the information provided.

An auto-generated and correlative code is generated based on the user's facial image, which is associated with the profile.

The application successfully confirms the registration and provides share it with a health professional if they wish. the user with a welcome message.

POSTCONDITIONS:

The user has been successfully registered in the application and now has a personal profile where he can store and manage personal information, medical information, and records of skin

lesions. In addition, the user has a self-generated and correlative code associated with their facial image, which can be used POSTCONDITIONS: for future identification.

RQ3 Upload images of skins lesions

The user accesses the "Upload Skin Lesion Image" function in the application.

The system presents the user with the option to upload an image from their personal device.

The user selects the image source (camera, photo gallery, scanner, etc.).

If necessary, the user can make basic edits to the image, such as cropping or adjusting brightness and contrast.

The user confirms the image selection.

The application processes and stores the image of the skin lesion securely in its database.

POSTCONDITIONS:

The image of the skin lesion is stored in the application and is available for analysis of future reference.

RQ4 Analyze Probability of cancerous skin lesion

The user logs into the application.

The user accesses the "Analyze Skin Lesion" or "Lesion Evaluation" function within the application.

The user selects a previously uploaded skin lesion image.

The application performs image analysis using medical algorithms and predefined criteria.

The app shows the user an estimate of the likelihood that the lesion is cancerous, such as "Low Risk" or "High Risk."

The user can save this estimate to their profile or share it with a health professional if they wish.

POSTCONDITIONS:

The user has obtained an estimate of the probability that skin lesions are cancerous based on image analysis.

RQ5 Perform preliminary assessments of skin lesions

The user logs into the application.

The user accesses the "Injury Evaluations" or "Preliminary Evaluation" section within the application.

The application presents the user with a list of skin lesions that they have previously registered in their personal profile.

The user selects a skin lesion from the list to perform a preliminary evaluation.

The application shows the user a set of predefined criteria that may include, for example:

Based on the user's assessment, the app provides an estimate of the severity or risk of the injury, which may include categories such as "Low Risk", "Moderate Risk" or "High Risk".

The app can offer recommendations, such as "Schedule an appointment with a dermatologist" or "Monitor the lesion and seek medical attention if symptoms worsen."

The user can save the assessment results to their profile or act based on the recommendations provided by the application.

POSTCONDITIONS

The user has performed a preliminary assessment of a skin lesion and obtained an estimate of the severity or risk of the lesion. Additionally, the user may have received recommendations for future actions.

RQ6 Show educational content

The user logs into the application.

The user accesses the "Educational Content" or "Dermatological Education" section within the application.

The application presents the user with an interface that allows selecting parameters of interest, such as:

The user selects the parameters that interest them to refine the search for educational content.

The application displays a list of educational resources related to the selected parameters. These resources may include.

The user selects an educational resource from the list to access its content.

The application presents selected educational content, which the user can read, watch or use to learn more about the specific topic.

After reviewing the educational content, the user can return to the list of resources or perform new searches as necessary.

POSTCONDITIONS:

The user has accessed and reviewed educational content related to dermatology according to the selected parameters. The user has gained additional knowledge about skin health and dermatological conditions.

RQ7 Schedule Appointments

The user logs into the application.

The user accesses the "Schedule Appointments" or "Medical Appointments" section within the application.

The application presents the user with a form or interface that allows them to search for and select a dermatologist or skin specialist.

The user can search for specialists based on criteria such as location, availability, type of specialist, qualifications, etc.

The application displays a list of specialists that match the search criteria and allow the user to select a specialist of their choice.

The user chooses the desired date and time for the medical appointment from the available times provided by the selected specialist.

The application generates an auto-generated and correlative code for the scheduled appointment.

The user confirms the scheduling of the appointment, entering the auto-generated code to confirm the reservation.

The app displays a confirmation message and provides appointment details, including date, time, location, and specialist name.

The user receives a notification of the scheduled appointment in the app and, if configured, can also receive reminders via email or text messages.

The relevant specialist or medical center also receives notifications about the scheduled appointment for preparation.

POSTCONDITIONS

The user has successfully scheduled a medical appointment with a dermatologist or skin specialist through the app and has received confirmation. The system has generated an auto-generated and correlative code to identify the appointment.

During the development of the project, it was divided into several sprints to ensure a structured and efficient approach. Each sprint focused on key aspects of the document management system, allowing for steady progress toward the final product.

Sprint 1: In this first sprint, time was spent planning and analysing system requirements. In addition, the first sketches were created that served as a visual guide. The development team was also formed and the tools and technologies to be used were selected. This sprint laid a solid foundation for the project. An engineering scheme of requirements can be seen in Fig.1.

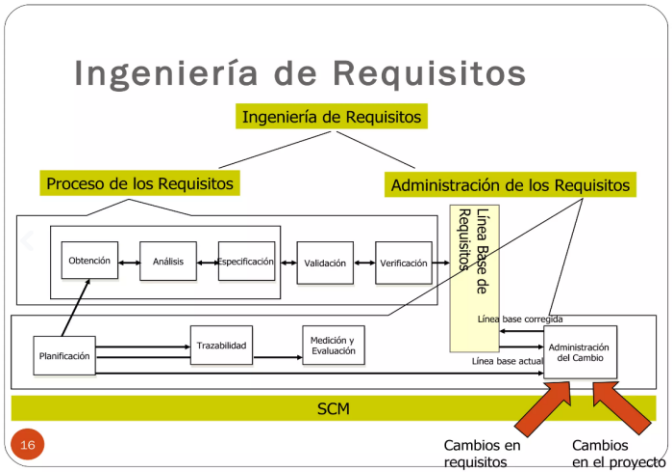

Fig. 1 Requirement engineering scheme

Sprint 2: In the second sprint, the basic registration functionality in the system was addressed. A notable feature was the implementation of biometric validation using facial recognition technology for log in, which added an additional level of security. Likewise, mechanisms were established to connect with the databases, which would allow the secure storage of information. A scheme of the system's requirements can be seen on Fig. 2.

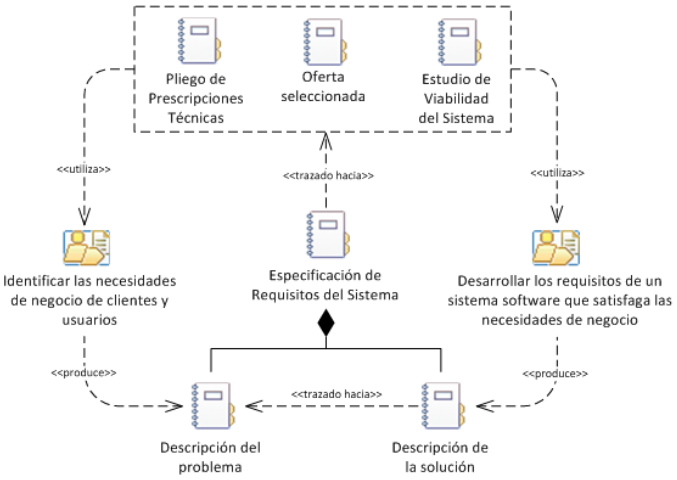

Fig. 2 System requirements scheme

Sprint 3: The third sprint focused on user authentication and the creation of functionalities related to data training through seizure neural networks for image processing of benign and malignant melanomas. This will provide a learning structure through artificial intelligence for the detection of skin cancer. The authentication process scheme is displayed in Fig. 3

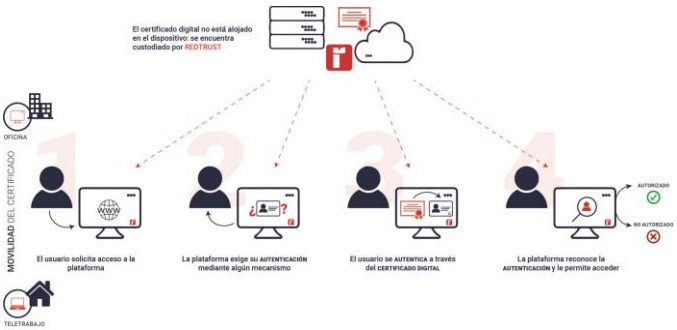

Fig. 3 Authentication scheme

Sprint 4: In the fourth sprint, the functionality of the system continued to be improved, focusing on Analyzing Probability of Cancerous Skin Lesion. Again, biometric fingerprint validation was included to ensure the integrity and security of diagnostic data.

Sprint 5: This sprint was dedicated to developing reports and statistics on melanoma analysis with artificial intelligence. Optimizations were also carried out to improve system performance, and integration tests were performed to ensure that all parts of the system worked together smoothly.

Sprint 6: In the sixth sprint, the functionality of performing preliminary evaluations of skin lesions was introduced, which would allow more effective management of skin cancer detection. Additionally, strong security policies were established to protect data and system integrity. Usability testing on the skin cancer detection system ensured a smooth user experience.

Sprint 7: UI improvements were made during the seventh sprint to ensure the app is easy to use and attractive. Implemented data export functionality to allow users to extract important information by displaying Educational Content. In addition, everything was prepared for the next important step: the launch of the system.

Sprint 8: The last sprint will mark the launch of the system, a crucial milestone in the project. User training will be carried out through social media posts, allowing them to use the system effectively from day one. The final project documentation will also be completed, providing a comprehensive reference. Finally, the ground will be prepared for maintenance and future system upgrades.

In a broader context, the implementation of a skin cancer detection system not only improves early diagnosis of the disease but can also have a significant impact on society.

III. RESULTS

According to what has been observed, the users of the system carry out verification through image processing for the detection of skin cancer, meditate for artificial intelligence, according to what has been proposed so far, the following results are expected:

Have a functional system that allows users to register

and verify their identity through the facial detector, guaranteeing secure and accurate identification.

A well-designed user interface that is easy to use and provides a positive experience for end users, making it easy to use the system for diagnostics.

Have a system that meets the specific requirements to provide a reliable analysis for the diagnosis of the presence of melanoma in the skin, and the generation of preliminary evaluations of skin lesions, among others.

Have a scalable architecture that allows the addition of new functionalities and the increase in the number of users without compromising system performance, guaranteeing a quick and efficient response.

Improve security and diagnostic analysis within the system by implementing the biometric identification system, avoiding impersonations, identity theft and accelerating registration processes and personnel verification.

In recent years, research in the field of skin cancer detection has advanced significantly thanks to the implementation of deep learning techniques. Recent studies have shown that convolutional neural networks (CNNs) can achieve up to 95% accuracy in classifying skin lesions [11]. Furthermore, participation in events such as the International Symposium on Biomedical Imaging (ISBI) has evidenced a shift towards the use of CNNs, leaving behind traditional methods [12]. These advances not only improve diagnostic accuracy, but also allow for greater generalization and adaptability to different clinical contexts.

To validate the effectiveness of our proposal, preliminary tests were performed with a dataset of skin lesion images, obtaining an accuracy of 85% in the detection of melanoma. These preliminary results indicate significant potential for the implementation of this technology in real clinical settings. However, additional studies with larger and more diverse samples are necessary to confirm these findings and improve the robustness of the system.

IV. CONCLUSIONS

The friendly and easy-to-use user interface designed for the skin cancer detection system ensures a positive experience for end users, which in turn encourages faster and more effective adoption of the system.

The project aims to meet the established secondary objectives, which include the detailed analysis of the requirements for the detection of melanoma in the skin, the implementation of facial biometric registration and the creation of a scalable architecture. Likewise, it is planned to include all the key functionalities defined in the requirements analysis and detailed design.

Although challenges are anticipated during the development and implementation process, appropriate measures are being taken to ensure the accuracy and reliability of the facial biometric technology and convolutional neural networks used in the skin melanoma detection system. Additionally, special attention is paid to the security of facial biometric data in the login process and compliance with current privacy regulations.

The project presents future perspectives by laying the foundation for continuous improvements and the possible expansion of the technology in the field of different types of cancer and medical diagnoses. This technology has the potential to extend to other medical fields, such as breast cancer diagnosis. In addition, it could serve as an example and open opportunities for collaboration with clinics and medical institutions interested in implementing similar technologies in

healthcare settings.

The development of a mobile app for skin cancer detection represents a significant contribution in the field of digital health. This app not only facilitates access to early diagnostic tools, but also integrates advanced technologies such as facial recognition and image analysis using convolutional neural networks (CNN). The implementation of these technologies allows for accurate and rapid assessment of skin lesions, thus improving users' ability to detect potential melanomas at early stages.

In addition, the mobile app was developed using the agile SCRUM methodology, allowing for continuous adaptation to changing requirements and rapid delivery of functionalities. This methodological approach ensures that the development of the app is efficient and that improvements can be incorporated based on constant feedback from users and dermatology specialists.

In summary, the implementation of the system based on the training of artificial intelligence convolutional neural networks for the detection of skin cancer represents a

significant achievement. This project aims not only to improve the detection of melanoma in the skin, but also to optimize the facial biometric registration process. The technology used will provide a secure and reliable way to authenticate the identity of personnel, helping to prevent impersonations and streamlining the registration and verification processes. Despite some limitations and areas for improvement, this project lays the foundation for future innovations and applications of technology in the medical field and in the healthcare industry in general.

ACKNOWLEDGMENT

We thank the whole team for their mutual effort.

REFERENCES

[1] Cleveland Clinic. La piel humana y sus funciones. Ohio-EE. UU.: Cleveland Clinic, 2023. https://my.clevelandclinic.org/health/body/10978-skin

[2] Sociedad Americana Contra El Cáncer. Datos sobre el cáncer. Georgia-EE. UU.: Sociedad Americana del Cáncer, 2019. https://www.cancer.org/search.html

[3] T. A. Putra, S. I. Rufaida y J. S. Leu. Predicción mejorada del estado de la piel a través del aprendizaje automático mediante el entrenamiento dinámico y el aumento de pruebas. Taipéi-Taiwán: IEEEAccess, 2020. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnu mber=9007729

[4] C. F. Codella, et al. Deep learning ensembles for melanoma recognition in dermatoscopy images (Conjuntos de aprendizaje profundo para el reconocimiento de melanoma en imágenes dermatoscópicas). Vol. 61, No. 4/5, p. 5: 1-5: 15. Nueva York- EE. UU.: Revista de Investigación y Desarrollo de IBM, 2017. https://doi.org/10.1147/JRD.2017.2708299

[5] S. Wang, et al. Inteligencia artificial en el melanoma: una revisión sistemática. Pekín-China: J Cosmet Dermatol, 2022. https://doi.org/10.1111/jocd.15323

[6] I. González-Díaz, "DermaKNet: Incorporación del conocimiento de los dermatólogos a las redes neu ronales convolucionales para el diagnóstico de lesio nes cutáneas", IEEE Journal of Biomedical and Health Informatics, vol. 23, n° 2, 547-559, 2018. https://doi.org/10.1109/JBHI.2018.2806962 [Enlaces]

[7] Z. Yu, D. Ni, S. Chen, J. Qin, S. Li, T. Wang y B. Lei, "Marco de clasificación de imágenes de dermatosco pia híbrida basado en una red neuronal convolucional profunda y un vector de Fisher", de 2017 IEEE 14.º Simposio Internacional sobre Imágenes Biomédicas (ISBI 2017), Melbourne, 2017. https://doi.org/10.1109/ISBI.2017.7950524 [Enlaces]

[8] B. Zhang, Z. Wang, J. Gao, C. Rutjes, K. Nufer, D. Tao, DD Feng y SW Menzies, "Detección de cambios de lesiones a corto plazo para la detección de melanoma con una nueva red neuronal siamesa", Transacciones IEEE sobre imágenes médicas, vol. 40, n° 3, págs. 840-851, 2021. https://doi.org/10.1109/TMI.2020.3037761 [Enlaces]

[9] SN Haghighi, H. Danyali, MH Karami y MS Hel froush, "Una red neuronal convolucional profunda para el reconocimiento de melanoma en imágenes de dermatoscopia", de 2020 Décima Conferencia Inter nacional sobre Ingeniería Informática y del Conoci miento (ICCKE), Mashhad, 2020. https ://doi.org/10.1109/ICCKE50421.2020.9303684 [Enlaces]

[10] J.A Ángeles Rojas, HD Calderón Vilca, EN Tumi Fi gueroa, KJ Cuadros Ramos, SS Matos Manguinuri y EF Calderón Vilca, "Hybrid Model of Convolutional Neural Network and Support Vector Machine to Clas sify Basal Cell Carcinoma", Computación y Siste más, 83 -95, 2021. https://doi.org/10.13053/cys-25-1- 3431 [Enlaces]

[11] D. Al-zaleq, L. Andradi y P. Flynn. La aplicación de diferentes algoritmos de aprendizaje automático y su rendimiento relacionado en la detección de cánceres de piel y melanomas. Minnesota- EE. UU.: Hindawi, 2022. https://doi.org/10.1155/2022/2839162

[12] A. Michael, et al. Results of the 2016 International Skin Imaging Collaboration International Symposium on Biomedical Imaging challenge: Comparison of the accuracy of computer algorithms to dermatologs for the diagnosis of melanoma from dermoscopic images (Resultados del Simposio Internacional de Colaboración Internacional de Imágenes de la Piel de 2016 sobre imágenes biomédicas: comparación de la precisión de los algoritmos informáticos con los dermatólogos para el diagnóstico de melanoma a partir de imágenes dermatoscópicas). Nueva York- EE. UU.: Revista de la Academia Americana de Dermatología, 2018. https://doi.org/10.1016/j.jaad.2017.08.016

[13] JP de Oliveira Lima, LC Silva de Araújo Filho, CM Serôdio Figueiredo y F. Santos da Silva, "Clasifica- 8 ción de lesiones dermatológicas pigmentadas utili zando un conjunto de redes neuronales convoluciona les mediadas por una red de perceptrones multicapa", IEEE Latin America Transactions, vol . 17, n° 11, 1902-1908, 2019. https://doi.org/10.1109/TLA.2019.8986430 [Enlaces]

[14] J. Eric, et al. Inteligencia artificial en la detección del cáncer de piel. Nuevo México- EE. UU.: Revista de la Academia Americana de Dermatología, 2022. https://doi.org/10.1016/j.jaad.2022.08.028

[15] E. Nasr-Esfahani, S. Samavi, N. Karimi y S. Soroush mehr, "Detección de melanoma mediante análisis de imágenes clínicas utilizando una red neuronal convo lucional", de la 38ª Conferencia Internacional Anual de la Sociedad de Ingeniería en Medicina y Biolo gía del IEEE (EMBC), Orlando, 2016. https://doi.org/10.1109/EMBC.2016.7590963 [Enlaces]

[16] R. Zhang, "Detección de melanoma mediante red neu ronal convolucional", de 2021 Conferencia interna cional IEEE sobre electrónica de consumo e ingenie ría informática (ICCECE), Guangzhou, 2021. https://doi.org/10.1109/IC CECE51280.2021.9342142 [Enlaces]

[17] SR Guha y SMR Haque, "Convolutional Neural Net work Based Skin Lesion Analysis for Classifying Me lanoma", de 2019 Conferencia internacional sobre tecnologías sostenibles para la Industria 4.0 (STI), Dhaka, 2019. https://doi.org/10.1109/ STI47673.2019.9067979 [Enlaces]

[18]]SR Guha y SMR Haque, "Convolutional Neural Net work Based Skin Lesion Analysis for Classifying Me lanoma", de 2019 Conferencia internacional sobre tecnologías sostenibles para la Industria 4.0 (STI), Dhaka, 2019. https://doi.org/10.1109/ STI47673.2019.9067979 [Enlaces]

[19] Q. Zhou, Y. Shi, Z. Xu, R. Qu y G. Xu, "Clasificación de lesiones cutáneas de melanoma mediante redes neu ronales convolucionales con punta de aprendizaje STDP no supervisada", IEEE Access, vol. 8, 101309- 101319, 2020. https://doi.org/10.1109/AC CESS.2020.2998098 [Enlaces]

[20] Q. Zhou, Y. Shi, Z. Xu, R. Qu y G. Xu, "Clasificación de lesiones cutáneas de melanoma mediante redes neu ronales convolucionales con punta de aprendizaje STDP no supervisada", IEEE Access, vol. 8, 101309- 101319, 2020. https://doi.org/10.1109/AC CESS.2020.2998098 [Enlaces]