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Development of Artificial Intelligence Applications for Identifying Physiological Changes in the Skin: A Multidisciplinary Project in the Health and Information Technology Fields

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Abstract. This article presents an innovative project conducted by a multidisciplinary team composed of students and professors from the fields of health and information technology. The project's objective was to develop artificial intelligence applications focused on the identification of physiological changes in the skin, aiming to improve the early detection of dermatological conditions and provide a more efficient and accurate approach to skincare. The team combined specialized knowledge in dermatology, medicine, computer science, and engineering to create a technological solution capable of analyzing skin images and physiological data. Using advanced artificial intelligence techniques such as machine learning and image processing, algorithms were developed to identify patterns and specific characteristics associated with common dermatological conditions, such as skin aging, melanoma, acne, and psoriasis. The application development process involved fundamental steps, including the collection and preparation of clinical and image data, the definition of analysis parameters, algorithm training using reference datasets, and validation of the results obtained. Collaboration among the multidisciplinary team was essential to ensure the proper integration of medical and technological knowledge, as well as to fine-tune and optimize the algorithms throughout the project. The results achieved so far are promising. The developed applications demonstrated a high accuracy rate in detecting physiological skin changes, surpassing human identification capabilities in some cases. Furthermore, they proved to be efficient in analyzing large datasets, enabling rapid and accurate screening. The artificial intelligence applications developed in this project have the potential to contribute to dermatological clinical practice, offering an additional tool for users, physicians, and other healthcare professionals in the early detection and monitoring of skin conditions. They also assist in reducing diagnostic errors, improving healthcare efficiency, and guiding more appropriate and personalized treatments.

Keywords. *Artificial intelligence, Machine learning, Skin, Early detection, Dermatological conditions.*

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Introduction.

The skin is part of the integumentary system and is responsible for protecting the body from the external environment, covering the entire body's surface. Additionally, it is considered the largest organ in our body, accounting for approximately 16% of body weight (GUIRRO & GUIRRO, 2010). Throughout its extent, it exhibits structural variations, characterizing it as a complex organ composed of various tissues, cells, and specialized structures.

Cutaneous aging is a natural physiological alteration; however, as the outermost tissue, the skin has the ability to "reveal" an individual's age due to the presence of signs that emerge throughout life stages, such as wrinkles, sagging, spots, among others. Some skin characteristics such as softness, hydration, and elasticity, observed at higher levels in younger individuals, are modified and/or replaced by the presence of wrinkles, whitening of hair, and skin thinning commonly observed in older individuals. Additionally, the skin can also reveal the individual's nutritional status since vitamin deficiencies and other nutrients can alter the skin's appearance, as well as hair and nails (RENNÓ, 2022; VIEIRA, 2010).

For each type of alteration observed in the skin, specific attention is required for correct decision-making. Thus, conducting a thorough anamnesis with the aid of computer vision technologies could contribute to success in the treatment of different skin conditions.

The skin is composed of three layers: epidermis, dermis, and subcutaneous tissue (JUNQUEIRA; CARNEIRO, 2004). The most common and easily visible and diagnosable alterations are present in the epidermis, such as acromia, discromia, acanthosis nigricans, melasmas, freckles, rosacea, couperose, acne, lesions, ulcers, scars, xanthelasmas, bruises, hematomas, contusions, edema, seroma, lymphedema, mycoses, dermatitis, psoriasis, wrinkles, sagging, stretch marks, fibroedema geloid, among others. These and other dysfunctions can also favor alterations in elasticity, hydration, and skin color, as well as skin rashes (AZULAY et al., 2011; BAUMANN, 2008; CAMPANA, 2010; BAGATIN, 2009; KEDE; SABATOVICH, 2009).

The correct use of cosmetic products tailored to the physiological needs of different skin types is crucial to maintaining it in balance and conducive to performing or even restoring essential functions. Therefore, in situations where biochemical alterations are evident, the indication of specific active ingredients, delivered in a suitable material for the respective consumer, will assist in restoring skin homeostasis. Among the solutions to rectify this scenario are training for the detection of small signs and the integration of technology for the early diagnosis of non-uniform scenarios (CORREA, 2014). In this regard, knowledge of dysfunction and the potential benefits of cosmetic formulation, along with the computational technology to be used, contributes to providing positive results to formulation users (MATIELLO, 2019).

It is important to emphasize that skin alterations and associated diseases represent a serious global health problem, affecting millions of people worldwide. In Brazil, there are two additional complicating factors: a lack of early diagnosis and high variability in skin characterization (AVCI et al., 2013).

Therefore, the general objective of this study was to develop artificial intelligence applications for identifying physiological skin changes, with the purpose of improving early detection, promoting awareness and education about skincare, validating the effectiveness of the applications, and contributing to the advancement of the field of cosmetology and aesthetics.

Materials and Methods.

The methodology employed is related to the implementation of the technological solution requested by Vitaderm Company and has been divided into three stages. Throughout the 2023.1 academic semester, undergraduate students from the University São Judas in the fields of health (pharmacy, biomedicine, nursing) and information technology (IT), along with master's students in Aging Sciences, participated in the project as part of their curriculum units (CU) or Dual-degree Master's program with the company.

In the first stage of the project, following the definition of objectives, seven multidisciplinary teams were formed, and based on individual demands, a literature review was conducted on the characteristics of Brazilian skin, including physiological alterations and major associated pathologies. User needs and demands for cosmetic and aesthetic products were also taken into consideration, and all searches were carried out in the following databases: Scopus, Pubmed, ScienceDirect.

From the literature review conducted by the health students, a scientific document was compiled to consolidate the gathered information, aiming to assist the IT students in developing prototypes utilizing artificial intelligence (AI) to enhance treatment outcomes, improve process efficiency, and provide a personalized experience for users of cosmetic and aesthetic products from Vitaderm.

Building upon the identified needs in each of the topics and the literature review, the second stage of the project commenced, during which IT students developed technological solutions aligned with the project's objectives, including communication between scheduled medical/palliative/preventive/educational care and the user.

Lastly, in the final phase of the project, computer vision algorithms were developed to collect visual user data through photos, subsequently proposing a user skincare routine through the integration of AI trained for this purpose. Furthermore, in this last stage, a book chapter and/or scientific article is being drafted to present the catalog of skincare regimens and potential assessments of common skin alterations in the Brazilian population.

Results and Discussion.

The present study aimed to explore the convergence of the healthcare field with information technology in the creation of innovative programs in the cosmetology and aesthetics domain, in accordance with the needs identified by Vitaderm Company. Employing a multidisciplinary approach and the application of technological solutions, the objective was to enhance treatment outcomes, improve process efficiency, and provide a personalized experience for users.

Throughout the development of this work, a comprehensive methodology was adopted, which included defining objectives in collaboration with Vitaderm Company, followed by the formation of a multidisciplinary team. Initially, research was conducted to guide technology students in developing technological solutions for the healthcare domain. Thus, students discussed within their multidisciplinary groups the possibilities of implementing solutions to the presented problem.

The methodology proposed by Santos et al. (2023) for the development of solutions integrating computer vision with machine learning was employed in the development of the prototypes. All analyses and discussions regarding the impacts and implications of this tool for the cosmetology and aesthetics field will be briefly presented below, as well as the main results achieved during the project's development.

Testing, validation, as well as implementation and user training, will be addressed in future stages.

1. **Melasma.**

Melasma is a tissue alteration characterized by dark and irregular patches on the skin, primarily appearing on the face due to increased melanin production. Hormonal factors, excessive sun exposure, and genetic predisposition are likely to trigger the intensity of this pigmentation. Although it is not considered a health problem, it is an aesthetically undesirable condition as it affects the self-esteem of those affected (PEREZ, 2013; CAMPANA 2010; BAUMAN, 2008).

In this subgroup, the project's objective was to construct a computational solution (Figure 1) to receive an image from the user and assist them in detecting potential facial spots, possibly identified as Melasma. In this delivery, students employed artificial intelligence (AI) to distinguish between Melasma and other skin blemishes, identify possible disease progression or regression, recommend cosmetic products, and suggest medical treatment.

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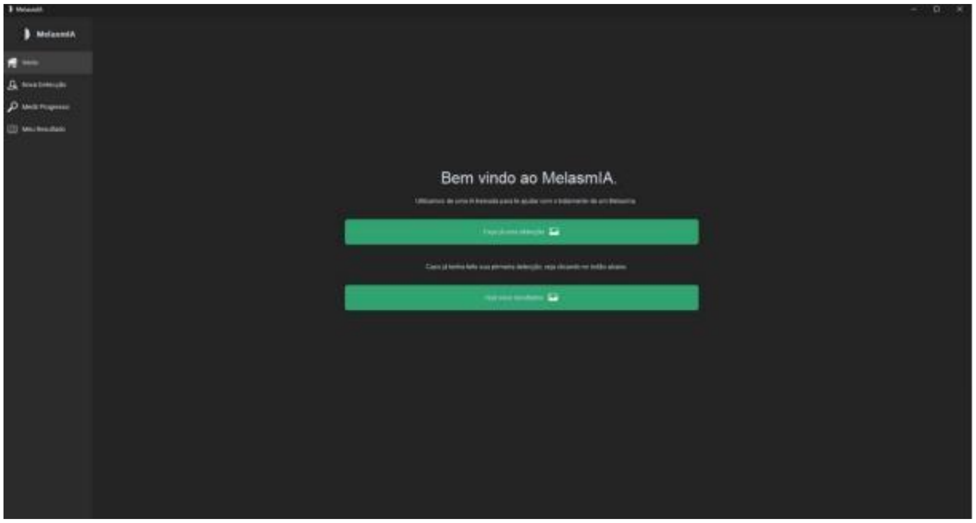

Figure 1: MelasmAI app created by students to recognize Melasma on human faces.

In this delivery, students employed computer graphics techniques and image preprocessing (Figure 2) to detect potential blemishes or imperfections on the skin from a photograph. By doing so, utilizing AI and machine learning, the software provides information about the blemish and distinguishes Melasma from other types of cutaneous tissue imperfections.

Figure 2: Excerpt from the explanatory video using the MelasmAI application.

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The software code is responsible for locating spots in the photo that the user submits to the software, automatically circling these spots, and sending the circumscribed area to the AI. In this manner, it enters the DataSet that will be responsible for providing all the necessary material for the AI to learn to differentiate between what constitutes Melasma and what are spots of another origin or cause. The purpose was to identify and differentiate, through comparison, the material submitted by the user and the material from the DataSet, ultimately delivering an appropriate response to the user at the end of the analysis.

Through the use of this software, it became evident that the user can obtain a more secure initial guidance with the assistance of AI. The use of this tool enables closer engagement with the aesthetic concerns for which the user seeks treatment in beauty clinics, thus contributing to the resolution of this issue.

2. Psoriasis.

Psoriasis is a chronic skin condition characterized by the presence of red and scaly lesions on the skin, which can be accompanied by itching, pain, and discomfort. These lesions result from an autoimmune process in which the immune system attacks the skin's own cells, accelerating the cellular turnover process. Early diagnosis is crucial as it enables the initiation of appropriate treatment as soon as possible (CAMPANA, 2010; CORREA, 2010).

In this subgroup, the project's objective was to construct a computational solution to receive an image from the user and assist in the detection of suspected tissue lesions identified as Psoriasis, as currently, confirming the diagnosis requires a local biopsy. In this delivery, students utilized AI to identify the lesion and recommend Vitaderm products to enhance the quality of life of these patients.

To achieve the expected outcome, the developed software (Figure 3) allows the user to input an image of the affected area.

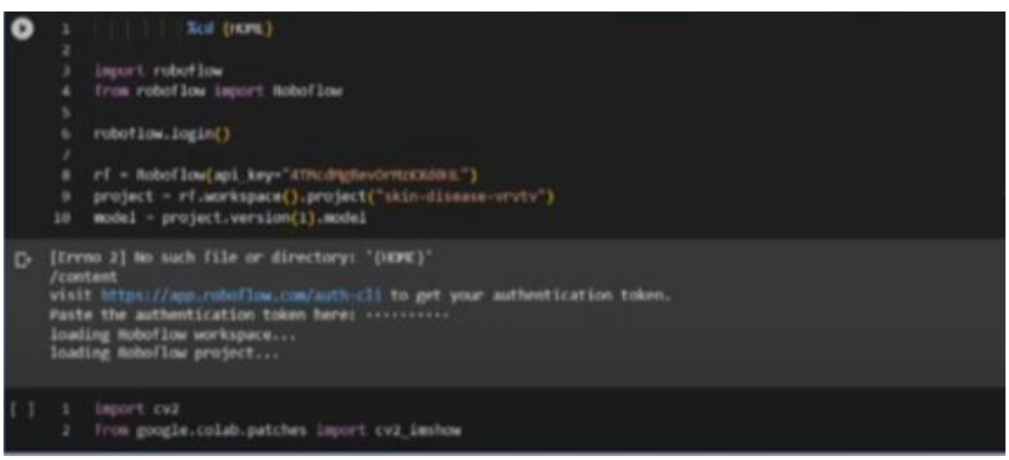

Figure 3: Development of software to identify psoriasis based on databases available in code libraries.

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After the addition of the image, a series of processing steps are performed, including the application of specific filters to locate the lesion. Following this step, a dedicated AI algorithm, previously trained, conducts the diagnosis based on the image (Figure 4). Furthermore, it recommends necessary and suitable measures to the user in an accessible, efficient, practical, and precise manner when compared to the current investigative process.

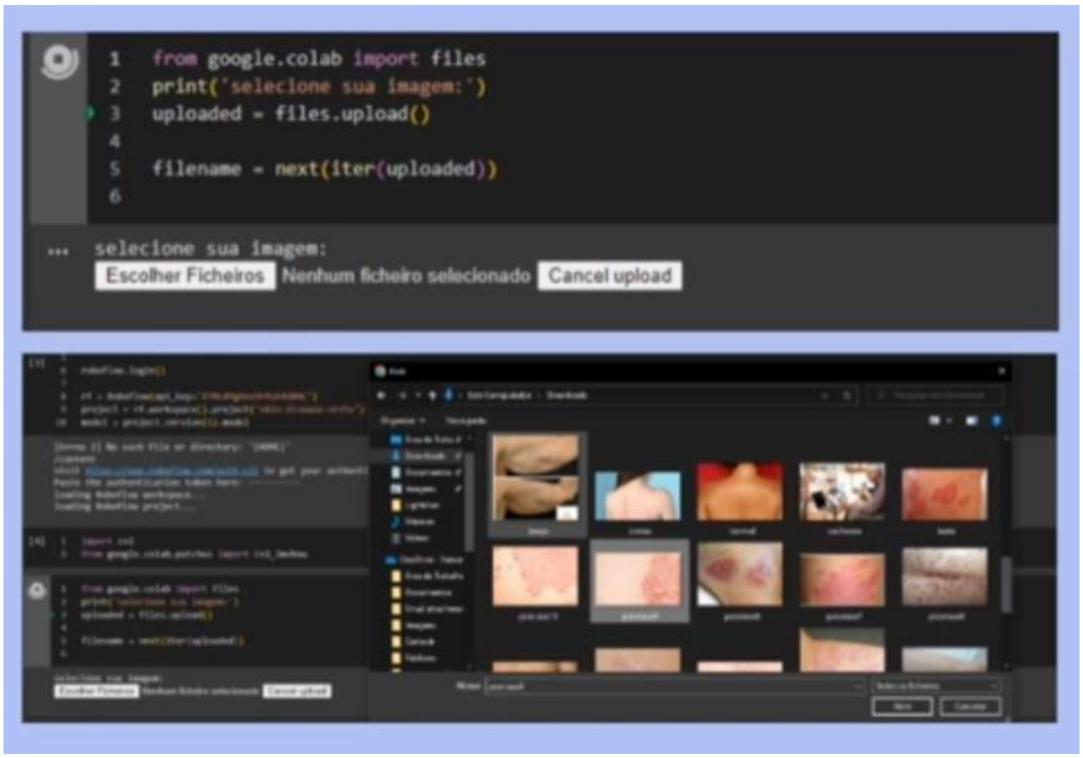

Figure 4: Evaluation of system performance using sample images from patients with psoriasis and images from individuals without the condition.

In the event that the lesion is not identified as psoriasis, the system presents the user with the original image without any highlighting, accompanied by the information that psoriasis was not detected in the region. This response provides the user with an indication that the analyzed area does not exhibit signs consistent with psoriasis. Following preliminary implementation tests of the image analysis recognition system to assess performance, conducted using image samples from patients with psoriasis and images of individuals without the condition, promising results were obtained, demonstrating the effectiveness and applicability of this innovative approach.

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3. Skin oiliness.

The skin is composed of the epidermis, dermis, and hypodermis layers. The epidermis, the outermost layer, is responsible for continuous cell renewal, providing a protective barrier against bacteria, pollutants, and excessive water loss. The second layer, situated beneath the epidermis, contains collagen and elastin fibers that impart elasticity and support to the skin. The third layer is the deepest, comprising adipose tissue that acts as thermal insulation and an energy reservoir (BAGATIN, 2009; CORREA, 2014).

Skin exhibits individual characteristics associated with skin type (normal, dry, oily, combination) as well as variations in color and texture. Moreover, it is subject to various factors that can impact its health and appearance, such as sun exposure, aging, pollution, stress, and lifestyle habits (JUNQUEIRA, 2004; KEDE, 2009; BAGATIN, 2009).

In the cosmetic field, oily skin is the target of different care and treatment approaches to maintain hydration, elasticity, smoothness, and uniformity. Skin becomes oily when sebaceous glands produce excess sebum, and the causes can vary based on genetics, environmental factors, hormonal production, stress, diet, the use of inappropriate cosmetic products, among other factors. The prevention and/or treatment of oily skin involve the use of gentle and specific cleansing products that are non-comedogenic (BAUMANN, 2008; MATIELLO, 2019; AZULAY, 2011).

In this subgroup, the project's objective was to develop an innovative application aimed at analyzing and monitoring skin oiliness using AI, in addition to providing users with a precise tool to assess oiliness levels and understand cosmetic and aesthetic needs and other specific care based on the information provided by the application. Through personalized and effective recommendations, the aim is also to simplify the user's life in terms of caring for oily skin in an accessible manner, helping them achieve balanced and healthy skin efficiently with the Vitaderm product line.

The approach combines image processing and AI. Deep learning algorithms were used to analyze user-provided data, image processing, and skin feature detection. These steps allowed for the generation of detailed images and the provision of information about the users' skin condition.

Figure 5 presents the intuitive and user-friendly interface of the SKIN VIS application's initial screen and the form screen, where the user must fill in the required information as instructed.

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Figure 5: Skin Vis app home and form screen.

After users submit the form, the data undergoes an advanced image processing stage, where feature detection techniques are applied (Figure 6).

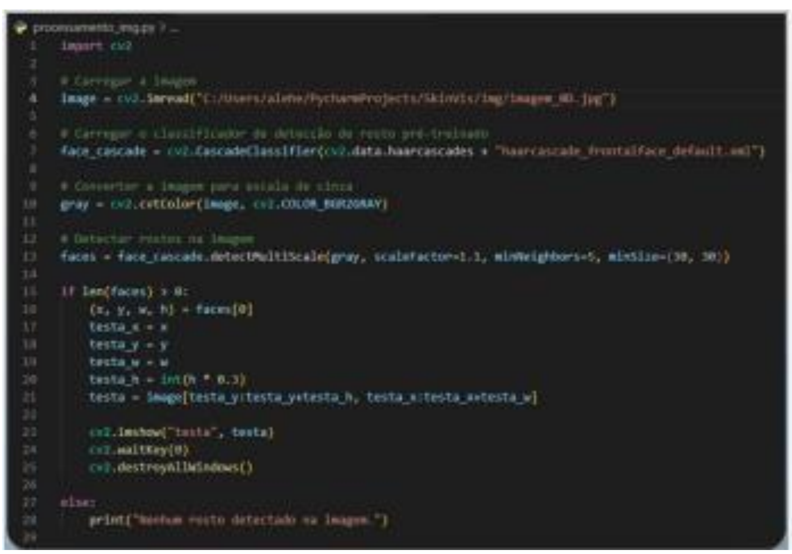

Figure 6: Skin Vis application user data analysis and processing screen.

Following the information processing, AI is activated using advanced algorithms to interpret the processed data and generate the analysis of the registered users' skin (Figure 7). This Following the information processing, AI is activated using advanced algorithms to interpret the processed data and generate the analysis of the registered users' skin (Figure 7). This analysis takes into consideration factors such as skin oiliness, texture, and other relevant characteristics.

GENERO	COR_PELE	MAQUIAGEM	FILTRO_SOLAR	DIETA_0	DIETA_1	DIETA_2
0	1	0	1	1	1	0
1	0	2	1	1	1	1
0	1	0	0	1	1	1
1	0	2	2	1	1	0
0	2	0	0	1	1	1
0	0	0	1	0	0	1
0	0	0	0	1	1	1
0	2	0	0	1	1	1

Figure 7: AI action step in analyzing images and other relevant responses provided by users while filling out the form via the application.

The results obtained by AI are compiled into a comprehensive and personalized report for each of the users. This document provides information about the skin's condition and offers specific care recommendations. As a result, users can better understand their skincare needs and adopt a healthier skincare routine.

4. Vitiligo.

Vitiligo is a skin disorder characterized by the progressive loss of pigmentation, resulting in irregular white patches on the skin, caused by the destruction or absence of melanocytes. This condition can affect any area of the body, including the face, hands, feet, arms, legs, and genital area. The extent and pattern of the patches can vary widely from person to person, with some having only small localized patches, while others may have large areas of depigmentation. The exact cause of vitiligo is not fully understood, although some studies suggest it may have an autoimmune origin (CORREA, 2014; JUNQUEIRA, 2004; GUIRRO, 2010).

In this subgroup, also based on AI, the project involves the development of an application named Skin Spot in the Python language, which uses a dataset available on Kaggle to train an image recognition model for vitiligo. This application will be implemented as a REST API, allowing interaction with other systems and providing accurate responses regarding the presence of the disease in the provided images. The goal was to use advanced machine learning algorithms and neural networks to analyze images of skin lesions, comparing them with a vast database of vitiligo cases at different stages.

By providing an intuitive and user-friendly interface, the application allows users to take photographs of affected areas of the skin and submit them for analysis. The AI then examines the images and, based on specific features such as the presence of irregular white patches, determines

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whether there are indications of vitiligo in its early stages. Additionally, the application can also provide additional information about the condition, such as possible causes, risk factors, and available treatment options.

Initially, research was conducted on Kaggle to select a suitable dataset for training the model. Next, the dataset was prepared by preprocessing the images to ensure compatibility with the machine learning model. With the dataset prepared, the next step was to train an image recognition model using machine learning algorithms. After the model was trained, the Python application was built as a REST API. Libraries were used to create endpoints that received images and submitted them to the trained model. The API processes the images, applies the model, and returns a response indicating the presence or absence of vitiligo, as well as the reliability of the detection (Figure 8).

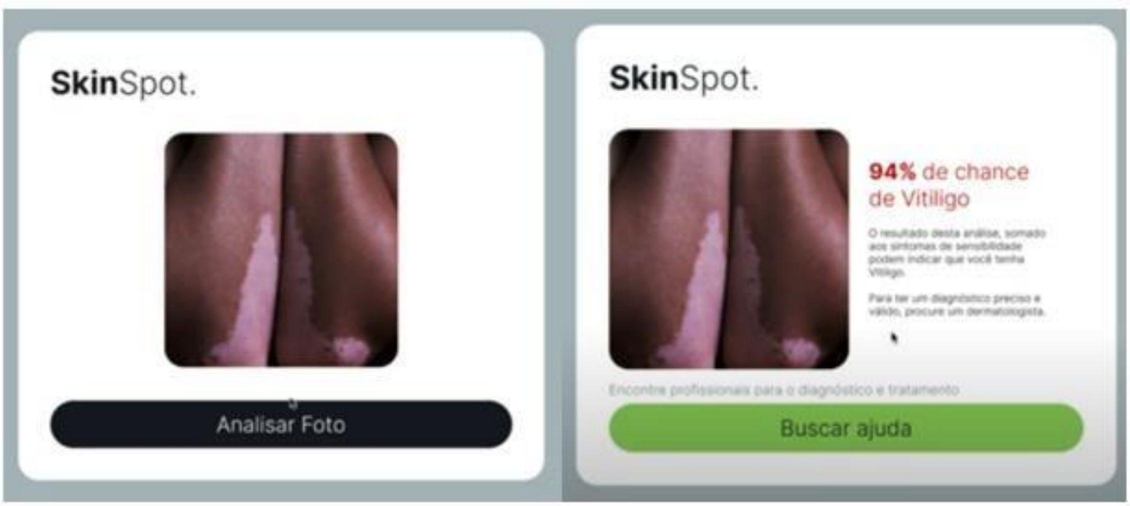

Figure 8: Step of the Skin Spot application with the tab for sending the image and the response with the confidence level of the image analysis.

The project resulted in a functional application, where the proposed model achieved a satisfactory level of accuracy in classifying vitiligo images. Accuracy rates and results were evaluated and demonstrated good recognition capabilities.

In the future, the application can learn from new data and improve its detection capability, becoming even more accurate and reliable. This can be especially useful for individuals who want to monitor their skin at home, allowing for early detection of new affected areas and assisting in communication with healthcare professionals. Combining advanced technology with medical knowledge, this solution can provide valuable support and empower users in their pursuit of skin health.

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5. Acnes and wrinkles.

There are different skin types, and understanding one's own skin is often the first factor to be considered when deciding to start a skincare routine. However, when it comes to skincare products, it is essential to consider the current state of the skin and what can be done to help restore its natural balance efficiently, gently, and safely (HASSUN, 2000; BAGATIN, 2009; VIEIRA, 2010).

Upon analyzing facial skin, it is evident that it requires special care due to noticeable changes that occur over time, such as the appearance of acne during adolescence or even in adulthood, and the emergence of wrinkles and expression lines with age (JUNQUEIRA, 2004; KEDE, 2004; RENNÓ, 2022).

In this subgroup, the project's objective was to develop an algorithm capable of detecting some of these skin conditions, such as the presence of acne, characterized by skin inflammation, and skin aging, characterized by the appearance of wrinkles and expression lines. In addition to identifying skin issues, the algorithm, based on what is detected, can provide personalized recommendations for specific Vitaderm skincare products.

Initially, information was collected to search for the dataset because this is an essential part of the success of an artificial intelligence project. This large dataset allows for the training and validation of the model to be created. In artificial intelligence projects, a large amount of data is required, gathered in a set called a database. This item is extremely useful for teaching an algorithm, as with this data, the algorithm becomes capable of identifying patterns, establishing relationships, and making decisions autonomously. Without training, AI algorithms are incapable of taking any action. Therefore, the better the data training, the better the model will perform. As the team did not find an available dataset, it was created by the team members, using 276 images available on the internet, with 240 for training and 36 reserved for testing (Figure 9). The number of images used was determined considering the previously established classes as 0 for acne, 1 for forehead wrinkles, and 2 for eye area wrinkles.

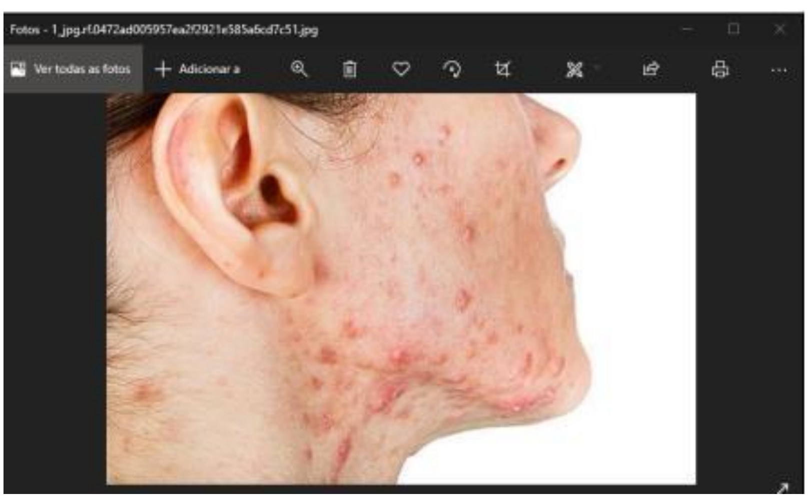

Figure 9: Example of an image from the internet used to create the DataSet in this work.

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To implement the algorithm, Google Colaboratory, a free cloud service hosted by Google, was used. For the execution of artificial intelligence that would receive training, YOLO was chosen, which is a single-pass object detection method that uses a convolutional neural network as a feature extractor. Unlike other object detection algorithms, such as R-CNN or Faster R-CNN, it only needs to look at the image once to send it to the neural network. YOLO works with the COCO database and already classifies 80 different object classes. However, to create a detector with objects not cataloged in this database, it was necessary to use the created database. In order to detect acne and wrinkles, changes had to be made to the YOLO neural network to retrain it with the created dataset while reusing the already trained neural network of YOLO for standard objects with the COCO database, in other words, performing a transfer of learning between the old neural network and the new one.

Image preprocessing was performed by the neural network itself, which resized the images for internal training and set the use of three color channels as the standard. The training process of the neural network and its learning occur over epochs. During each epoch, the process of updating weights towards the ideal and error minimization is repeated each time.

To obtain an algorithm with good performance, it is necessary to analyze the average accuracy achieved by the algorithm with test images. Every 1000 trained epochs, the AI itself backs up the performance. After performing the necessary training, and analyzing the results, a trained model is obtained that has learned characteristics about the declared data.

After adjustments, the application was challenged to detect images where the algorithm, as a response, provided a personalized recommendation for skincare products. Each skincare routine suggestion was based on VitaDerm brand products, and all proposed items are forwarded along with purchase links on the respective company's website. If the algorithm detects signs of acne, as in Figure 10, the user will receive a message with links to cosmetic product lines.

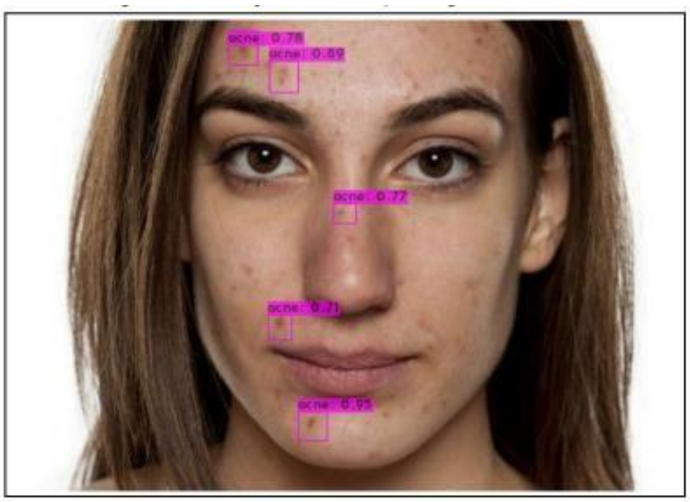

Figure 10: Detection of acnes by the created algorithm.

Taking into account the results achieved in this project, it became possible to verify the importance of artificial intelligence in the beauty market, considering the current demands of cosmetics customers who seek innovative, personalized, and precise solutions for their needs. It is important to emphasize that the quantity of data used in the implementation of artificial intelligence is of paramount importance in the performance of the detections performed because the more information AI receives, the better its performance.

6. Types of Skin and Specific Care.

DermAnalizer is a desktop application developed by the group that utilized artificial intelligence (AI) to identify skin types and generate information for users to perform appropriate care. The application was developed for desktop use using the C# and Python languages with AI trained from a dataset of images containing various skin types. Its purpose is to allow users to upload an image to the app in the first stage of analysis (Figure 11).

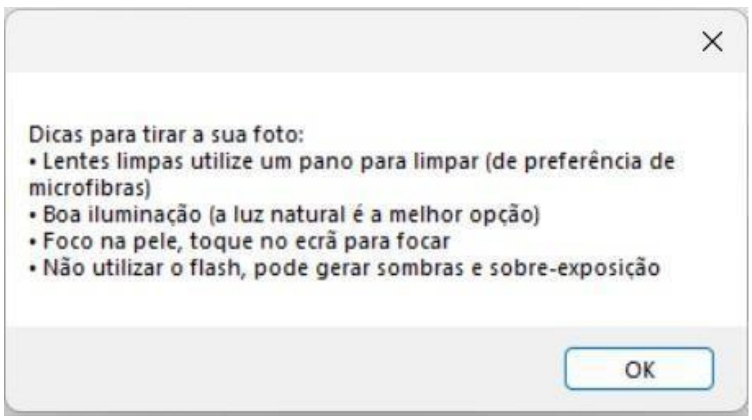

Figure 11: DermAnalizer application screen with instructions for the user to attach the photo.

Upon uploading an image of their skin (Figure 12), the user will need to wait for a few seconds for the analysis to be performed using AI.

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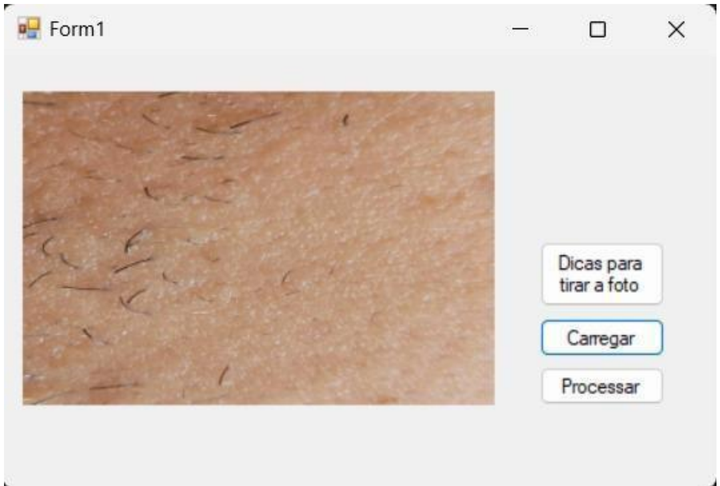

Figure 12: DermAnalizer application screen with the respective photo uploaded by the user.

After the analysis and image recognition by the app, the user can identify their skin type and receive recommendations for skincare (Figure 13).

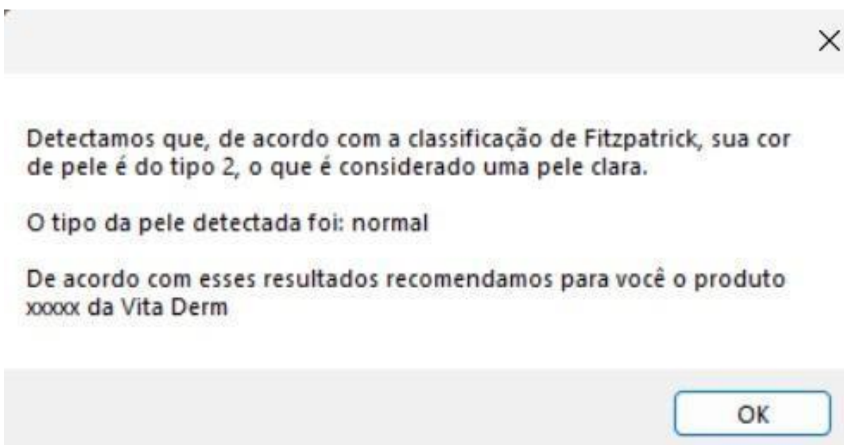

Figure 13: DermAnalizer application screen with the response generated from reading the image.

The skin analysis application holds significant importance for users in the field of cosmetology and aesthetics. It plays a fundamental role in providing valuable information about the skin's condition, enabling users to better understand their needs and make informed decisions regarding suitable treatments and care.

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7. Skin Cancer.

Skin cancer is a condition in which skin cells become abnormal and multiply uncontrollably, forming malignant tumors. There are several types of skin cancer, with the most common being basal cell carcinoma, squamous cell carcinoma, and melanoma. Melanoma, while less common, is the most aggressive type. It can develop from pre-existing pigmented moles or arise naturally without any apparent initial cause. Early detection of melanoma is crucial as it significantly increases the chances of a cure and allows for less invasive treatments (GUIRRO, 2010; PEREZ, 2013; CAMPANA, 2010).

In this group, the project's objective was to develop an image analysis algorithm focused on skin cancer identification to assist dermatology and aesthetics professionals in the early detection and diagnosis of this condition. The software utilizes artificial intelligence (AI) for image processing and analysis through computer vision methods. The CNN method with the Keras library was employed.

The filters served as a visual aid to human observers, enhancing the ability to discern differences, particularly for melanoma skin cancer, which benefits the most from AI applications. Regular self-skin examination is essential for identifying any suspicious changes. Warning signs include spots, non-healing wounds, changes in color, growth of existing moles, the appearance of new moles, itching, bleeding, or pain.

Overall, this project focused on studying fair skin, as it is more susceptible to the effects of solar radiation. It was found that visual aids provided by the filters were highly beneficial to professionals in this field. Among various filter tests, binarization, contour, and negative contrast were found to be the most viable (Figure 14).

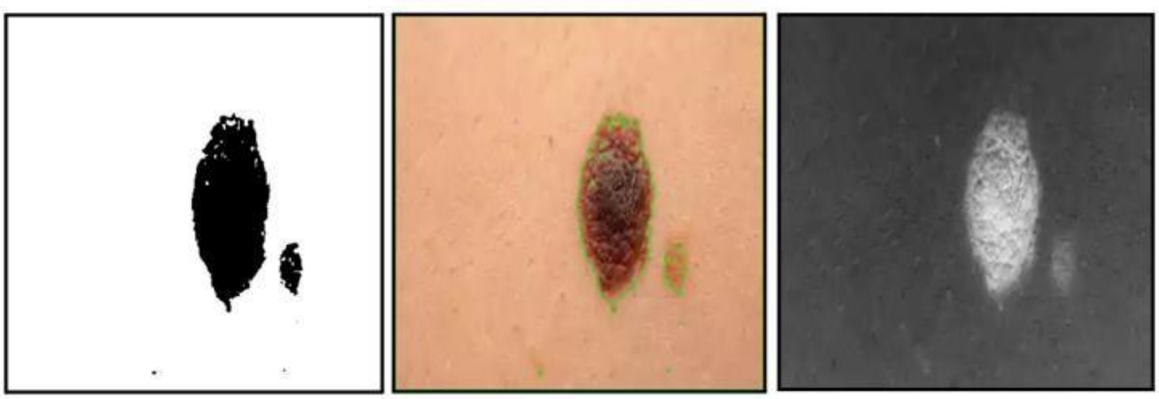

Figure 14: Filters related to binarization, contour and negative contrast of the studied area..

Regarding AI, the ISIC database was used, which provided a large number of images. The AI training with 6 epochs achieved an accuracy of 82%.

It was observed that there were significant difficulties in identifying skin cancer in black skin during tests, with less relevant results. Therefore, it was not included in this study because the group believes that skin cancer occurs at a very low frequency in black skin.

The use of an application for melanoma detection brings important benefits, such as early detection, easy access, awareness, regular monitoring, user-friendliness, artificial intelligence support, and complementarity to medical care. This technology plays a crucial role in promoting skin health and combating skin cancer.

Conclusion.

The results obtained demonstrate the promising potential of integrating students from the healthcare field with those from information technology in addressing demands within the cosmetology and esthetics domain. These findings reveal significant advancements in how the utilization of aesthetic and cosmetic products is carried out and perceived by patients. Such discoveries contribute to the continuous enhancement of services offered, as well as the development of more effective and personalized approaches. This innovative approach represents progress in early detection and skin health monitoring, thereby contributing to improvements in dermatological care and patient well-being.

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