

Treball Final de Màster

Estudi: Màster en Ciència de Dades

Títol: Plataforma per Classificar Melanomes

Document: Memòria

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Departament: ARQUITECTURA I TECNOLOGIA DE COMPUTADORS

Àrea: ARQUITECTURA I TECNOLOGIA DE COMPUTADORS

Convocatòria (mes/any): Setembre 2023

MASTER'S THESIS

A Platform for Classifying Melanoma

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September 2023

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Introduction

Skin cancer, including melanoma, is a significant global public health concern. Melanoma presents a considerable challenge due to its high mortality rate and the critical importance of early detection for successful treatment. Cancer begins when healthy cells undergo changes that cause them to grow and divide uncontrollably, forming tumors. These tumors can be classified as either cancerous (malignant) or non-cancerous (benign).

In recent times, there has been a growing focus on automating tasks in the medical field through Computer-Aided Diagnosis (CAD)¹. Some studies have demonstrated that these systems can achieve results similar to those of professionals. However, the integration of CAD into the medical system remains a significant challenge.

Firstly, certain methods are constructed based on theoretical models of melanoma appearance, which may restrict their applicability to specific morphologies and fail to capture the wide range of variations seen in real-world scenarios. Secondly, the artificial intelligence (AI) systems utilized in these classifiers are trained to address singular and narrow tasks. Unlike human dermatologists, these systems lack the ability to consider holistic patient information when formulating a final diagnosis, reflecting the concept of weak AI [Marr 2021]. Lastly, numerous methods have been trained and evaluated using high-quality image frames, which may result in instability when applied under real-time conditions where image quality is often compromised.

Overcoming these constraints and creating melanoma cancer classifiers that encompass an extended array of morphologies, integrate comprehensive patient information, and exhibit resilience in real-world situations are essential steps in the development of automated tools that can provide assistance to healthcare professionals.

¹CAD refers to the use of computer algorithms and technologies to assist healthcare professionals in the process of medical diagnosis.

0.1 Objectives

The main objective of this thesis is to create a health care infrastructure, focused on melanoma detection using deep learning methods to train a system capable of detecting melanoma on dermoscopy images to test the ability of computer-assisted image analysis. To this end, the gradual achievements that must be accomplished are:

- Gaining a comprehensive understanding of the theory behind deep learning and its practical applications.
- Explore and study the optimal approach for utilizing the distribution of dermoscopy images from the dataset during the training process.
- Propose and train deep learning models with different techniques based on transfer-learning, exploiting images of the melanoma ISIC² Challenge [ISIC 2019].
- Developing a CAD infrastructure. The CAD infrastructure, should contain the already trained models with a simple web UI³ an API⁴ and finally a mechanism using Docker to create the images of the services making it ease to deploy in any based Linux System.

0.2 Development Process

The project methodology employed in this endeavor follows a continuous process that builds upon previous approaches. Additionally, the project incorporates the concept of utilizing idle time effectively. For instance, during the training of models, there are periods of idle time, which we exploited by concurrently working on other tasks related to developing the entire infrastructure. This approach allows for maximizing productivity throughout the project (see Figure 1).

²International Skin Imaging Collaboration. An international effort to improve melanoma diagnosis.

³User Interface. Is the point of human-computer interaction and communication in a device.

⁴Application Programming Interface. Is a set of protocols, routines, tools, and definitions that allow different software applications to communicate with each other

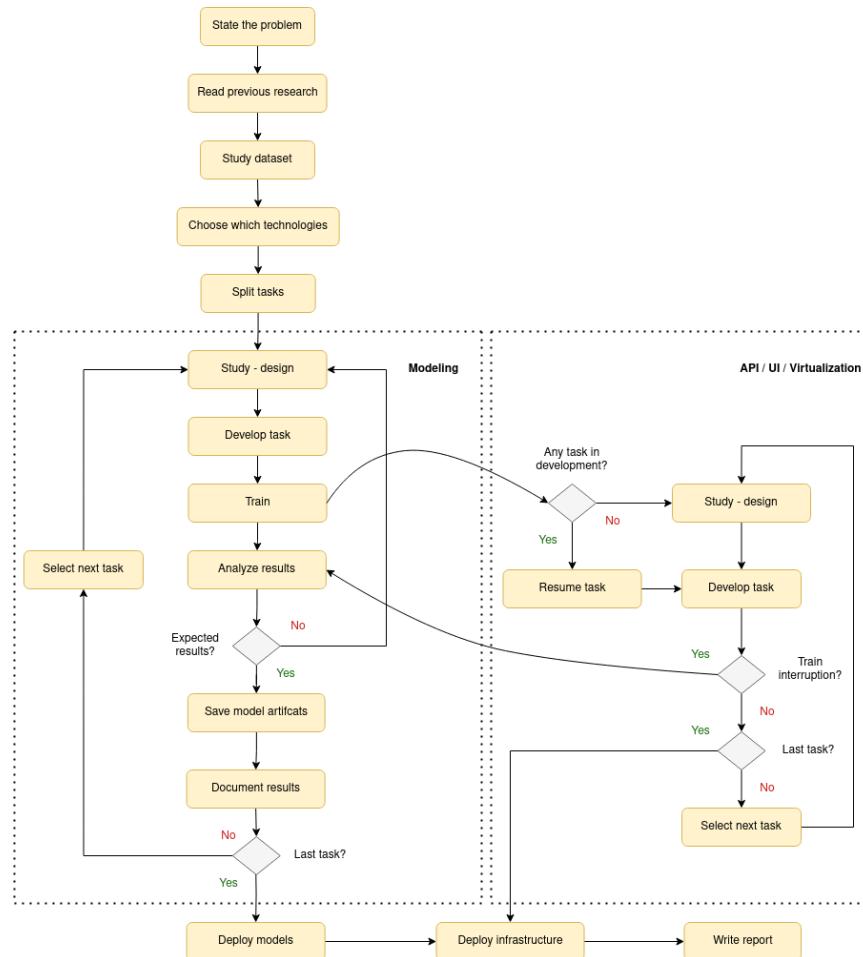


Figure 1: Activity Diagram Describing the Methodology.

The process used to train, validate, test, and implement the models is illustrated in Figure 2. This sequence consists of several stages elaborated below.

The first stage involves cleaning and splitting the initial dataset into smaller datasets. This step ensures that the data is organized and ready for further processing.

The second stage focuses on training and validating the models using the training and validation datasets. During this stage, the system reads images and applies data augmentation techniques to train images and Test Time Augmentation (TTA) to validation images. These techniques enhance the model's performance by introducing variations in the data and improving its generalization ability.

The third stage involves analyzing the training results obtained from different training approaches. In this section, we evaluate and analyze the model's performance by comparing the predicted results against the test dataset. This step helps us understand how well the models are learning and performing on unseen data.

The last stage revolves around exposing the trained models through an API's container image. This container image allows for easy deployment and integration of the models into other systems or applications, providing a convenient way to utilize the trained models for various tasks.

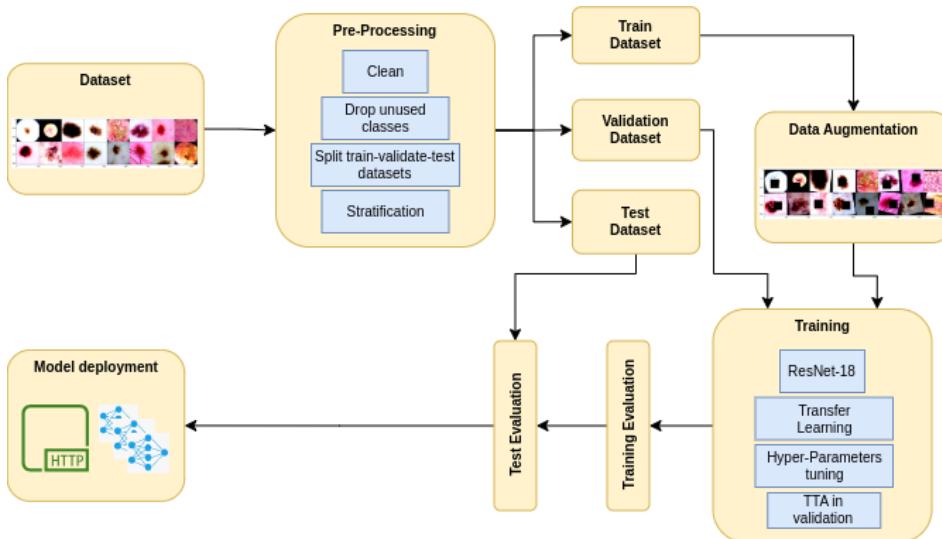


Figure 2: CAD Infrastructure Pipeline.

0.3 Results

The training phase ended with the development of eight models using an imbalanced dataset comprising eight classes. Various learning policies and Artificial Intelligence (AI) techniques were tested during the experimentation process. These models were divided into two categories: one without any additional regularization and another with additional regularization techniques such as data augmentation and the inclusion of dropout layers.

Model	Test AUC	Model	Test AUC
M0	0.892	M4	0.858
M1 *	0.892	M5 *	0.843
M2 *	0.885	M6 *	0.848
M3 •	0.886	M7 •	0.849
Mean	88.875%	Mean	84.950%
SD	0.377%	SD	0.625%

Table 1: *Models Metrics in Test Dataset.*

The initial group of models, lacking extra regularization, displayed impressive performance on the test set, boasting a mean AUC metric of 88.875% with a minor standard deviation of $\pm 0.377\%$. However, this group exhibited signs of overfitting during training, as evidenced by their performance on the validation set. In contrast, the second group of models, which underwent training with additional regularization techniques, achieved lower results compared to the first group. Nonetheless, these models did not suffer from overfitting, indicating potential for improved results with extended training epochs. The second group of models attained an average AUC of 84.950% with a standard deviation of $\pm 0.625\%$. The increase in standard deviation in the second group is attributed to the impact of using more training epochs, rendering the behavior of the schedulers more noticeable.

Concurrently, while in the model training phase, we seized the opportunity to build the CAD infrastructure required to support the project. For the API, we embraced a flexible approach utilizing soft configurations, allowing for the specification of settings through file-based parameters. This approach offers both adaptability and simplified management. Furthermore, we meticulously crafted an intuitive and UI to facilitate seamless interaction between healthcare professionals and the accessible models (refer to Figures 4 to 9).

Moreover, we have included a script to initiate the infrastructure, leveraging Docker images, which can be executed on any Linux operating system. This script ensures the efficient startup of the infrastructure components, enhancing the ease of deployment and operation.

Melanoma Classifier API Service 0.1.0 OAS 3.1

[openapi.json](#)



Figure 3: API Service End-Points.



Figure 4: Main Interactive Buttons of the UI Service.

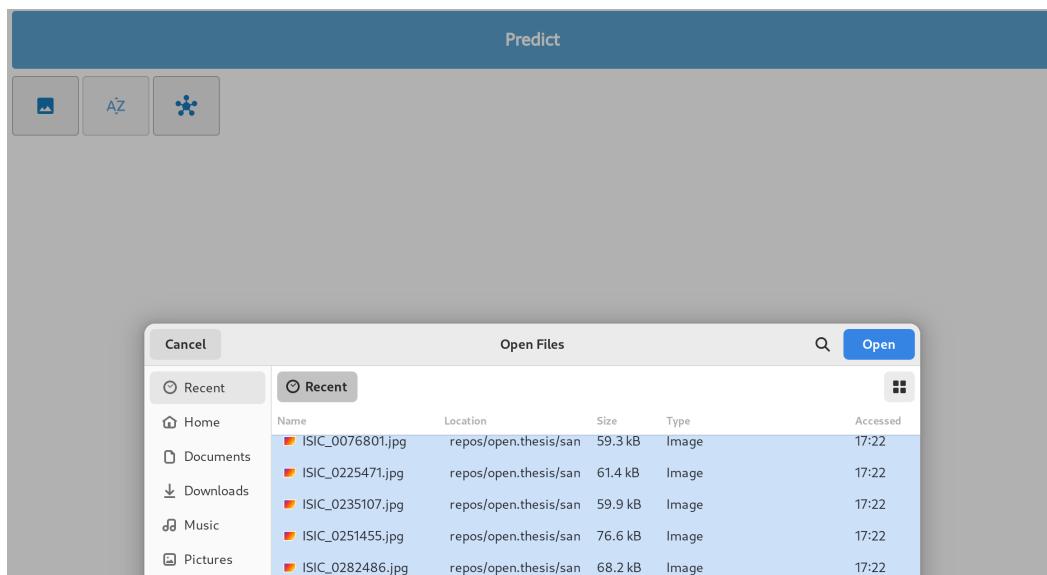


Figure 5: Loading Dermoscopy Images from Device.

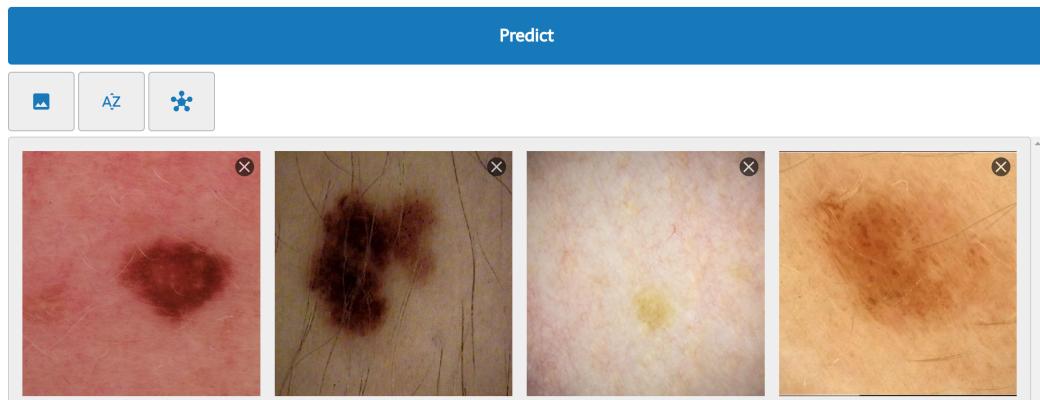


Figure 6: Dermoscopy Images Loaded in the UI.



Figure 7: Selecting Exposed Models by the API.

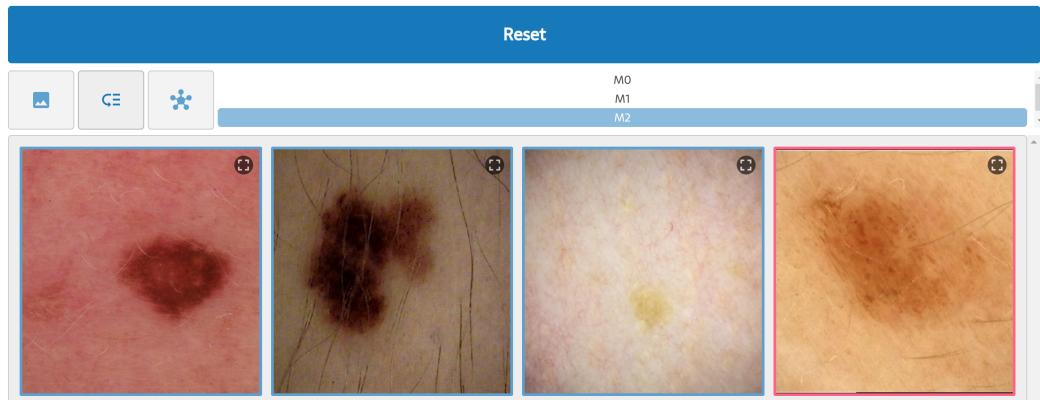


Figure 8: UI State After Prediction Response.

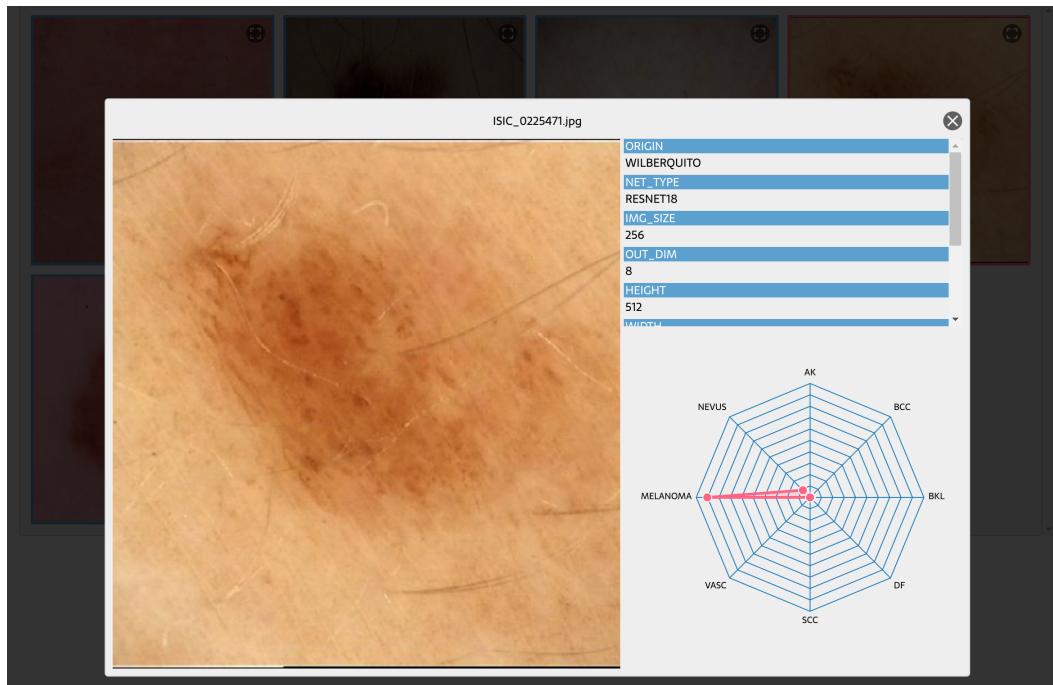


Figure 9: *Extra Prediction Information.*

Bibliography

[ISIC 2019] ISIC. *ISIC Challenge*, 2019. Available at <https://challenge.isic-archive.com/>. (Cited on page 2.)

[Marr 2021] B. Marr. *What is Weak AI*, 2021. Available at <https://bernardmarr.com/what-is-weak-narrow-ai-here-are-8-practical-examples>. (Cited on page 1.)