1. Introduction

Melanoma is the most common and most dangerous type of skin cancer. However, it can be treated effectively if detected early. Dermoscopy is one of the main non-invasive imaging techniques for diagnosing skin lesions. Computer-aided diagnosis is usually based on dermoscopy image processing.

We can distinguish three stages in the standard analysis of dermoscopic images:

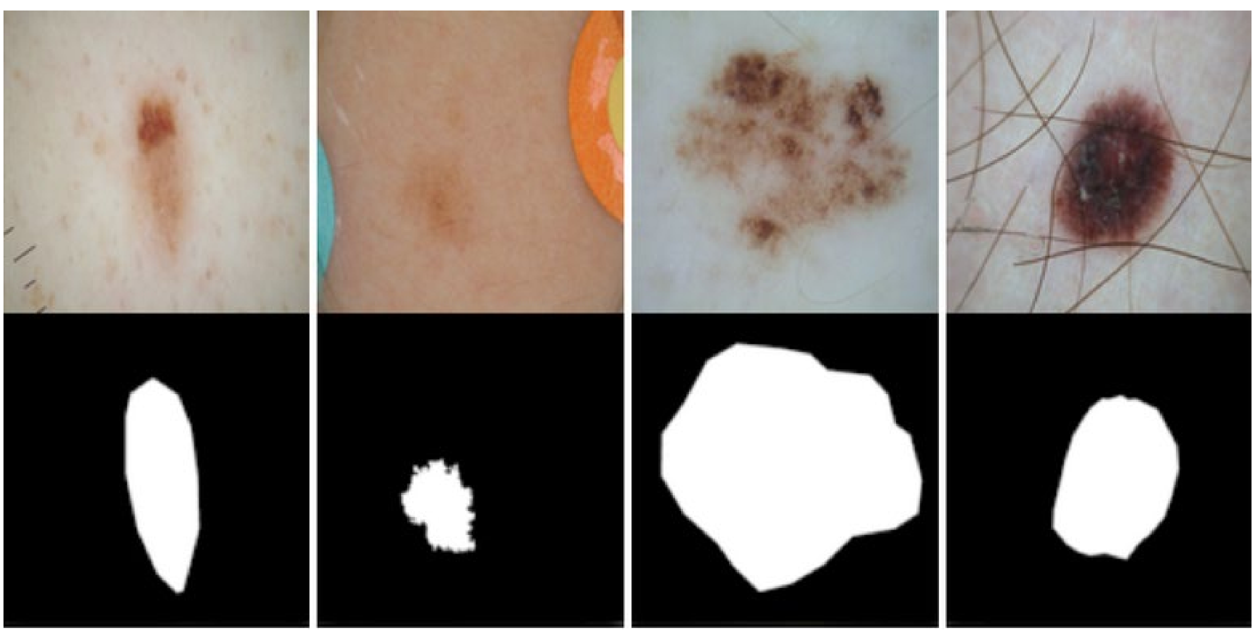
1. Segmentation of the lesion
2. Extraction and selection of characteristics
3. Classification of the lesion

1.1. Objective of the Lab exercise

This lab exercise will focus on the first step: image segmentation. This stage is of utmost importance, since the precision achieved when differentiating between the region of the lesion and that of the skin will determine the correct functioning of the subsequent stages.

Image segmentation involves the classification of all pixels in the image either as part of the lesion or as part of the surrounding healthy skin.

Below there are some examples of segmentation masks for skin lesions:



2. Project description

The basic block diagram of the automatic image segmentation system is as follows:

1. Preprocessing: to reduce the impact of external artifacts to the lesion (hairs, vignetting, etc.)

2. Segmentation: use of an automatic segmentation algorithm to separate the lesion region from the normal skin areas, generating a binary mask.

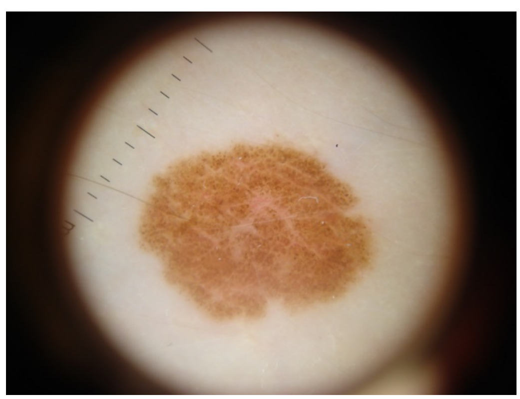
3. Post-processing: to achieve a more precise segmentation, the binary mask resulting from the segmentation can be post-processed (soft edges, elimination of holes within the regions of the lesion, etc.)

2.1. Preprocessing

Dermoscopic images often contain external artifacts, such as ink marks or traces of fluid used for dermoscopic observation, as well as intrinsic skin characteristics, such as skin lines, blood vessels, hair or changes in skin texture.

The easiest way to mitigate these artifacts is to smooth the image using a low-pass Gaussian filter or a median filter.

- Some images show a vignette that can affect segmentation performance (see figure below). In our case, we have previously removed this type of images. In a real scenario, we would need to remove vignettes by creating a bounding box containing only the lesion and skin areas.



- Filtering: due to the presence of artifacts, a Gaussian smoothing operation is a common option, but you need to pay attention to the tradeoff between the blurring of undesirable features and the preservation of the edges. Median filter is another option.

2.2. Automatic segmentation

A wide variety of methods for automatic segmentation of skin lesions in dermoscopic images have been proposed. In class, we have studied the most basic approaches, namely:

1. Threshold-based segmentation: these algorithms determine one or more appropriate threshold values to separate the pixels of an image into two or more regions.

2. Cluster-based segmentation: these methods segment an image into two or more regions according to a set of predefined features (color, texture, location, etc.).

2.3. Post-processing

The result of the automatic segmentation stage is a binary mask that separates the area of the lesion from the healthy skin region.

In order to determine the region of the lesion, it is advisable to postprocess the result of the segmentation method, applying one or more morphological operations: erosion, dilation, opening, closing, hole filling, etc.

3. Evaluation

The metric used for the evaluation of the proposed segmentation system will be the Jaccard Index (JI). It measures the degree of similarity between two regions, in this case two segmentation masks:

- the ground-truth (GT) mask, determined by medical experts
- the mask predicted by our automatic system.

The formulation of the JI is as follows:

$$JI(A, B) = |A \cap B| \,/\, |A\ U\ B|$$

i.e., the cardinality of the intersection of both sets divided by the cardinality of their union. Given a segmentation system, A would represent the GT segmentation mask and B the predicted mask (or vice versa).

JI takes values between 0 and 1. The closer to 1, the better the segmentation.

4. Database

- The database provided for the lab consists of 75 images of size 768x1024, in JPEG format, taken from the ISIC file:

  https://www.isic-archive.com/#!/topWithHeader/wideContentTop/main

- The images are divided into two sets:
  - A training set, consisting of 50 images, for which GT masks are provided, in PNG format. Therefore, this set can be used to evaluate the performance of the system during its development.
    The masks are coded as 8-bit PNG images and a single channel where each pixel can take either the value 0 or 255:
    - 0 represents the background of the image.
    - 255 represents the region of the lesion.

- A test set, consisting of 25 images, for performance evaluation (additionally, your work will be assessed in an alternative test set – do not overfit you solution to the test set provided)

5. Basic project and extra work

All the students will tackle at least a basic version of the project. Once this basic version has been addressed, there are several options for extra (optional) work.

5.1. Basic project

For the basic project:

- No post-processing is required
- Your goal: exploring preprocessing and clustering-based (k-means) segmentation options to improve you results

5.2. Extra work (optional: up to +0.5 extra points in continuous evaluation)

- Implement a morphology-based post-processing stage
- Use other algorithms: Mean shift, SLIC, etc.
- Design an automatic procedure to show the 5 images for which your system attains the worst results.

6. Implementation and submission

The implementation code must implement the different stages of the system: pre-processing, automatic segmentation and (optionally) post-processing. All the software has to be properly documented.

The headers of the provided functions cannot be modified, as they will be used for the evaluation of the work.

6.1. Project submission

For the evaluation of the project, you must submit:

1. The software implemented according to the Python scripts provided, properly structured and commented. If you have used some source of external software, you have to include it in your submission (and properly describe it in the project report).
2. A brief project report (2 pages maximum, excluding the cover; 3 pages if you do extra work) including the following information:
   - Brief introduction (one paragraph; it is just a formality)
   - Pre-processing: brief motivation and description of the techniques used
   - Description of the proposed segmentation methods
   - Post-processing: techniques used and their justification
   - Evaluation and discussion of results
   - References

The report must be brief but precise in terms of the description of the procedure used. The student must provide all relevant information about the system and the experimental protocol (with the exception of the description of the known methods or algorithms – those than can be found in papers an books), so that a reader of the report could reproduce the experiments. In other words, you only need to describe what you have done without describing the underlying concepts and algorithms. For example: you do not have to describe *k-means*, but you need to describe how you decide which cluster represents the skin lesion.

Deadline for submission through “Aula Global” (Python code and report): Sunday, Oct. 17th, 2021.

6.2. Evaluation

The evaluation of the lab is structured as follows:

- 80%: technical content of the report.
- 20%: results and quality of the code.

6.2.1. Original contributions

All the original contributions will be valued positively.

6.2.2. Evaluation of the technical content

The instructor will evaluate the design of the segmentation system. Failed approaches will also be considered as long as they are properly motivated and described.