An Open Internet Platform to Distributed Image Processing applied to Dermoscopy.

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Abstract

Proprietary systems for dermoscopy images analysis are available to improve the diagnosis and follow-up of the pigmented skin lesions. Their performance seems comparable with that of a human expert. Progress in computer-aided classification of melanocytic lesions depends notably on judicious choices of the algorithms dedicated to the extraction of signs from the dermoscopy images and of the method which combines these signs to classify the lesions.

To allow the researcher's community to benefit from their large set of elementary algorithms already available for dermoscopy, we set up a system accessible through the Internet which:

- *allows the engineers to register their algorithms while preserving their secrecy: their programs run on their own server;*
- *lets a user to define its own sequence of image analysis and to apply it to its images: the system automatically calls the appropriate remote programs;*
- *makes possible and stimulates the synergy of worldwide researchers in order to validate algorithms of images analysis best suited to achieve the correct diagnosis and to track the malignant melanoma;*
- *makes these techniques available to the greatest number of users through the Web and thus to support a mass screening;*
- *reduces the maintenance of the system to the minimum: it requires users only an Internet browser and engineers to follow a simple widespread standardised interface for distributed programs.*

Various problems should be addressed:

- *the lack of standardisation of images acquisition: algorithms based on relative colours are best suited to this system;*
- *the copyrights on images and algorithms;*
- *charging the use of remote computer resources.*

This system allows for an international collaborative work in the fight against the malignant melanoma by offering a conceptual and technical platform of teledermoscopy. It is intended to support synergy between the engineers and the users implied in the diagnosis and teaching of dermoscopy.

Keywords:

Malignant melanoma ; dermoscopy ; image processing ; international collaborative network.

1. Introduction

Dermoscopy is a non-invasive technique of skin surface microscopy that allows the *in vivo* study of the superficial layers of the skin. Semiology has been defined and is now well recognized to improve the diagnosis of pigmented skin lesion, especially the malignant melanoma [1]. This is of importance because that skin cancer can be cured without complications when diagnosed at an early stage of its development but effective treatments are lacking at the spreading stage. Because the rate of accurate diagnoses made by experts is about 75 to 90 % (true positives), many research groups are currently focusing their efforts on the analysis and numerical processing of dermoscopy images with the aim to improve the performance of the early diagnosis of malignant melanoma. Some computer-aided diagnosis systems are already available to help the physician in the different processing steps, from the lesion detection inside an image to the classification into the various types of lesions (figure 1).

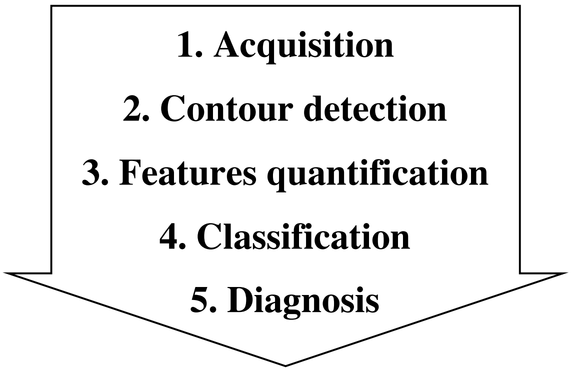

Figure 1. Sequence scheme for the image analysis of pigmented skin lesion

The quantification of diagnostic features (e.g. symmetry, textures) is an essential and difficult step and numerous different algorithms (operations) are available or under development. Their validation are based on a limited number of test cases and have been obtained through subjective evaluation. Validation issue has been discussed elsewhere [2]. It is therefore very difficult to know what is the exact contribution of every diagnostic feature to the final diagnosis. The classification scheme is the combination of several quantified features whose relevancy has been established by physicians or by comparison to a set of images with histology-proven diagnosis.

2. Objectives

Progress in computer-aided classification of pigmented skin lesions actually depends on the choices of the algorithms for extracting features. Because many research groups have developed a few or more valuable algorithms, we are willing to offer the research community a platform to stimulate an international collaborative work. The system should support the sharing of a large knowledge specifically dedicated to dermosopy image processing in order to enhance the diagnosis accuracy of the malignant melanoma.

The architecture of this system, its state of development and some issues we met in the deployment are presented in this article

3. Definitions and stating the problem

An *imaging operation* can be summarized in the following steps :

1. Obtain the *source image*: in our context the acquisition phase is made with a skin surface microscope;
2. Define the *imaging graph* of the operation: this involve the definition of *operators* and parent-child relationship between sources and sinks;
3. Evaluate the graph using the appropriate execution model;
4. Process the result by saving it or displaying it.

An *operator* has zero or more image sources and other parameters that define the operation. Two or more operators may be string together so that the first operator becomes an image source to the next operator. By linking one operator to another, we create an imaging graph. In its simplest form, the *imaging graph* is a chain of operators with one or more image sources at one end and an image result at the other end. The graph is a directed acyclic graph, where each operator is a node in the graph and images form the edges. An imaging graph is highly recursive so that an operation can be defined by a graph of other operations or by involving only one operator.

When considering the current situation of the research in dermoscopy image processing, we found that many groups have developed specific operators for the segmentation of the lesion (contour detection), for the symmetry quantification based on colour, shape or texture, and for the texture identification [3-15]. Beeing developed in one research setting, these operators specifically dedicated to dermoscopy image processing are often used and tested in a very limited timespace, the one of a study or a student thesis. Moreover, the lack of a wide availability of operators puts a brake on building a more complex operations which combines selected operators from various research teams. Also, research teams usually want to keep the industrial secrecy of their operators.

In order to address all these questions, we design and implement a platform to allow any researcher worldwide to register his/her imaging operators while preserving its secrecy. Then, a user can define his/her own graph of image analysis (e.g. a macro operation) and can apply it to his/her images in order to validate the best suited algorithms to achieve the correct classification of the pigmented skin lesion.

4. Scenario

The research community involved in dermoscopy represents the users of the system. The following steps explain the use of the system :

1. The researcher registers once its *Processing Units* (PU). The latter runs the software to execute an operation (or operator) for contour detection, features extraction like symmetry or texture quantification, or for the classification of the images. A PU runs on the remote server defined by its owner which ensures the industrial secrecy of the software.
2. The user defines an imaging graph from source image to results. The defined operation or macro of image processing can be stored by the system for later use.
3. Users can upload their images into an *image database* with clinical data and histopathological diagnosis. This database is the reference base for testing the algorithms and the classification of the lesions.
4. Users can submit images throught the web, either by common browsing or by email, and choose one macro to apply to. Then, our system automatically calls the sequence of requested operators on the appropriate remote servers, stores the results and returns it back to the user.

Because we want an easy access to this facility, we choose to run the system on the Internet with standard tools like a Web browser or an email facility.

5. Architecture of the system

The general architecture of the system comprises the following main modules: the Processing Units Directory, the Image Processing Operations Manager, the Processing Units Manager and Operators Dispatcher, the User Manager, the reference images database and the operation results database (figure 2). The system is build on a classic three-tier architecture with intrinsic clustering support to allow for maintainability and scalablility.

The ***Processing Units Directory*** **(PUD)** is responsible for registering the available processing units, including the operators they can process, the address in the network and the protocol to be used to communicate with.

The *Image Processing Operations Manager* (IPOM) is responsible for storing the graphs (sequences) of image analysis from source image to results, i.e. the macros or operations defined by user for image processing. Each node of the graph is an operation (or operator) named in a processing unit. The IPOM and PUD collaborate for the mapping between the operator defined in a macro and the processing unit which should executed remotely.

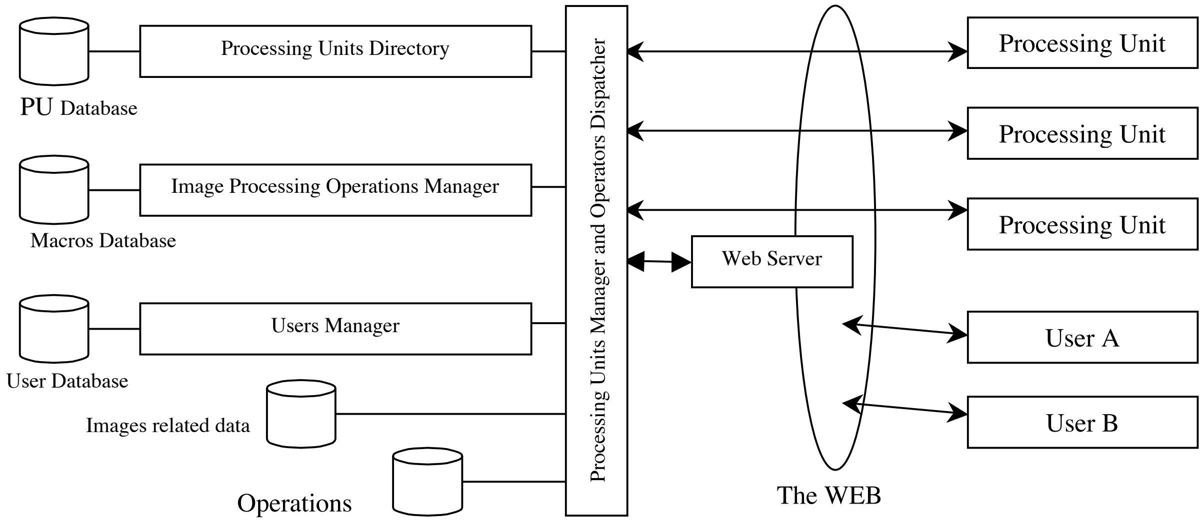

Figure 2: The system architecture shows the main modules of the system.

The ***Processing Units Manager and Operators Dispatcher*** **(PUMOD)** coordinates the other modules, manages a cache of results (operation results database), sends appropriate data like images to the remote processing units and receives the results. It also formats output results for user as html pages or emails.

The ***Users Manager*** is a standard access control to check for user rights. It is also securing the data transmission between the registered processing unit and the PUMOD.

A ***Processing Unit*** is an external module running on the remote server of the participating researcher. A processing unit can be implemented by any research group so we did not make any assumption on the hardware and operating system used. We currently defined two ways to communicate : the first one using raw TCP packets and a simple definition of content for the data stream, and the second one using Java Advanced Imaging API (JAI, see http://www.sun.com/products/java-media/jai/ which is very flexible and powerfull but much more resources consumming.

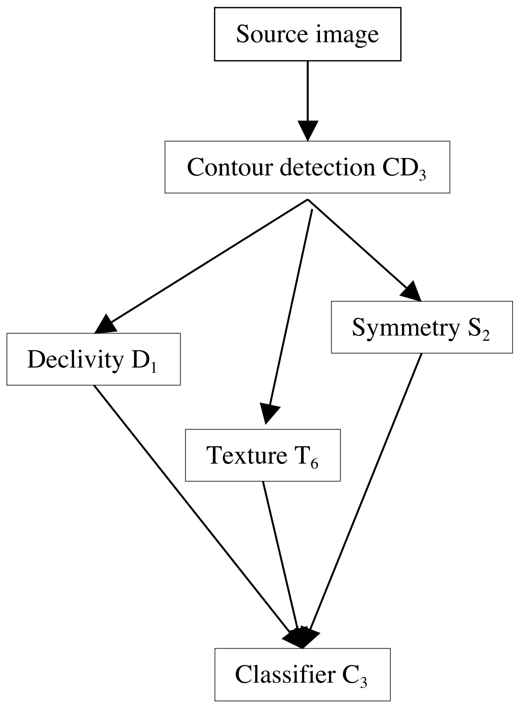

Figure 3.Imaging graph sample (an operation).

6. Example

Figure 3 illustrates an operation (macro) a user request to activate. He/she submits the source image. Then, the PUMOD finds the next operator to execute in the imaging graph which is the coutour detection CD_3: our system searches in the Processing Unit Directory for the appropriate remote server hosting the Processing

Unit for this operator. The server receives the original image, processes the image, and returns the results to our system.

Then, the system finds the next operation in the graph to be the symmetry calculation S_2 which maps to a remote processing unit. The system sends the previous result as the data source for processing S_2 and gets the result of the processing. And then, our system proceeds the same for the texture operation T_6 and the declivity D_1.

Finally, our system invoques the remote server registered to execute the classification process C_3 on the results obtained by the three others processing units. The results are then available and can be presented to the user on a web page.

7. Current implementation

Most of the system has been implemented in Java and WebObjects™ (http://www.webobjects.com) and is currently running in a beta test stage. Two servers have been effectively registrered as Processing Units. The current implementation of the IPOM does not allow for macros to be defined in an user-friendly graphical interface. Macros are recorded as xml files. An Applet will allow users to easily draw imaging graphs in the future.

8. Issues and Conclusion

The presented system is an open platform for a cooperative research in the fight against the malignant melanoma. It allows the engineers to publish competing algorithms to extract features from dermoscopy images. It should also help researchers to combine the many possible and specific methods of measurement in order to build classifiers for the pigmented skin lesions.

The software for an operator is running on only one computer which is the server of the developer. Therefore the upgrade is kept easy and the secrecy of the software is warrantied at the discretion of the developer.

Users are required to have a web browser and they only have to connect to one url/address, which simplifies the maintenance process and avoids operating system incompatibilities.

Because there are no standard for image acquisition in dermoscopy, operations based on relative colours will be best suited to this system.

Other issues are under consideration, like the copyrights for images as well as the use of algorithms and the charging for computer resources.

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