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Web-based platform for the automatic analysis and visualization of vascular diagnostic markers in ophthalmological images *

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Abstract

Currently, more than 400 million people are visually impaired due to different diseases. To diagnose many of these diseases, it is often fundamental to perform an exhaustive analysis of the retinal vasculature. Notwithstanding, such an analysis is rarely done in clinical practice, since it is arduous. This motivated the proposal of automatic methods. Some of these methods provide valuable results. However, their use is limited, as there are no graphical tools in which to integrate them. In this work, we propose a new web-based tool for the analysis of medical images using automatic methods. The tool already includes methods for analyzing the retinal vasculature. Also, it allows to dynamically add any method that complies with the API. All data is securely stored in the cloud for ubiquitous access. All these features, together with an intuitive interface, make the tool an effective solution for implementing automatic methods in daily clinical practice.

Keywords: web application · deep learning · medical imaging · ophthalmology

1 Introduction

Today, it is estimated that more than two billion people are visually impaired [1]. In many cases (around 20%), the impairment is caused by systemic or ocular diseases (e.g. diabetes and glaucoma, respectively). To diagnose these diseases, a thorough analysis of the retinal vasculature becomes essential. For this purpose, retinography images (color images of the eye

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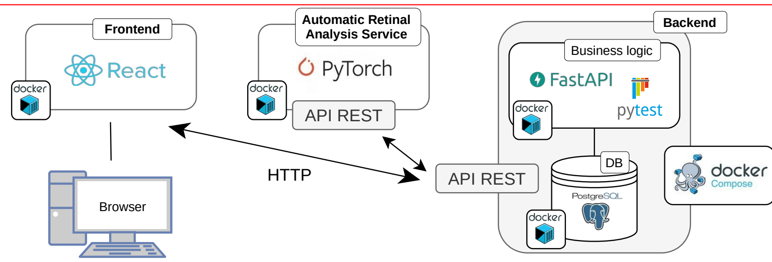

Figure 1: Microservices architecture of the proposed platform and the technologies employed for its implementation.

fundus) are often used, as retinography is the most widespread retinal imaging modality. Among other tasks, a thorough analysis of the retinal vasculature in retinography requires segmenting the blood vessels and classifying them into arteries and veins (A/V), as well as segmenting or localizing the optic disc (OD), the entry point for the major blood vessels that supply the retina. In addition, it is also common, based on the segmentation, to obtain representative measurements of the vasculature, such as the arteriolar-to-venular diameter ratio (AVR). All these tasks are useful for the diagnosis of several diseases. However, they are highly laborious and challenging, as well as partially subjective. These issues limit their application in clinical practice. To avoid these problems, several works have proposed automatic methods that are capable of performing these tasks [2, 3, 4]. Some of these works provide highly satisfactory results. In some cases, very close to those of clinical experts. However, the application of these methods in clinical practice is highly limited, since there are no suitable graphical tools in which to integrate them. This prevents the automatic methods from being used by the clinical staff.

In this work, we propose a novel, extensible web-based tool for the analysis of medical images. The platform is oriented to specialists, to facilitate them the use of automatic methods in their daily clinical practice. The proposed tool already includes, among its services, several methods for the analysis of ophthalmological images. Specifically, it has automatic methods for segmenting retinal A/V and OD as well as computing the AVR in retinography images.

2 Analysis platform

Figure 1 depicts the architecture of the proposed tool and the technologies employed for its implementation. As can be seen in the figure, the platform has a microservices architecture with multiple services: Frontend, Backend and Automatic Retinal Analysis Service (ARAS). All services communicate with each other using RESTful APIs, and are containerized using Docker. For the Frontend and the ARAS, only one container is used. Differently, for the Backend, two containers are used: one for the business logic of the Backend and another one for the database (DB). The diagram only depicts the automatic analysis service (AAS) providing the automatic methods for the analysis of the retinal structures since, for the moment, it is the only available AAS. However, the tool allows any number of AASs to be dynamically added, as long as they comply with the specified API. Additionally, separating backend and frontend allows other frontends to be implemented (for example, an Android application) keeping the same backend.

Frontend. Frontend was implemented following Google's material design principles using the JavaScript library React. The interface was primarily designed for desktop.

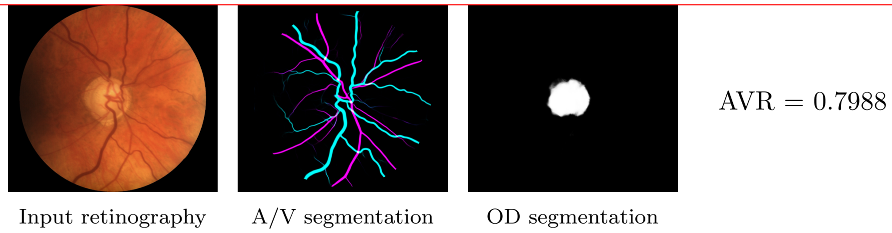

Figure 2: Results of the AAS for a given retinography.

ARAS. ARAS implements state-of-the-art methods for the segmentation of A/V [3] and OD [4], as well as for the calculation of the AVR [2]. All these methods are based on deep learning, and more specifically, on fully convolutional neural networks. Figure 2 depicts an example of the outputs provided by ARAS for a given retinography.

Backend. Both the analysis results and the retinography images can be analyzed within the application using an analysis panel. This panel enables the visualization of all the information related to the image at the same time. Also, it allows the user to create text annotations about the image being analyzed. All the analysis outputs (images, annotations, etc.) are stored in a relational DB. Data security is ensured by the application, which implements the standard OAuth 2.0 authorization framework. Beyond the analysis panel, the application includes different displays for the management of images. Also, for administrator users, it includes displays for the management of users and analysis services. Using these displays, admin users can add, delete and/or modify images, users and services. With the proposed implementation, an administrator user can add any type of service that complies with the API without making any changes to the source code. In particular, the API comprises the following methods:

- `POST` `/{analysis_method}`: analyze image using `{analysis_method}`. The method can return either an image or a JSON string.
- `GET` `/help/{analysis_method}`: get help about the `{analysis_method}`. Mainly what kind of image the method expects and what information it returns.

All the features of the platform, along with its flexibility and its intuitive interface, make it an effective solution for the implementation of automatic methods for the analysis of medical images in the daily clinical practice.

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