Vázquez-Ingelmo, A., García-Holgado, A., García-Peñalvo, F. J., Pérez-Sánchez, P., Sánchez-Puente, A., Vicente-Palacios, V., Dorado-Díaz, P. I., & Sánchez, P. L. (2024). D-AI-COM: A DICOM Reception Node to Automate the Application of Artificial Intelligence Scripts to Medical Imaging Data. In A. Rocha, H. Adeli, G. Dzemyda, F. Moreira, & V. Colla (Eds.), Information Systems and Technologies. WorldCIST 2023 (Vol. 3, pp. 199–206). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-45648-0_20

D-AI-COM: A DICOM Reception Node to Automate the Application of Artificial Intelligence Scripts to Medical Imaging Data

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Abstract. Artificial Intelligence (AI) has proven to be useful in several fields. The medical domain is one of the fields that benefits from the application of AI methods to automate and ease complex tasks including disease detection, segmentation, assessment of organ functions, etc. However, applying these kinds of methods to the variety of data formats involved in health contexts is not trivial. It is necessary to provide technologies that enable non-expert users to benefit from AI applications. This work presents a platform that acts as a DICOM reception node with the goal of automating the application of AI algorithms to medical imaging data. This platform is set to ease the process applying AI to their DICOM images by making the whole process transparent and straightforward for users without AI-related or programming skills.

Keywords: Information System · Medical Imaging Management · Artificial Intelligence · Health Platform · DICOM

1 Introduction

Over the years, artificial intelligence (AI) algorithms have grown in popularity and expanded their use. The ability to apply them to different problems and contexts provides broad support in data-intensive scenarios. One of the domains in which these scenarios are commonplace is the medical domain, where data is constantly being generated.

In this sense, AI algorithms are becoming increasingly important when analyzing medical data to reach insights and find hidden patterns [1]. However, another additional difficulty within field is the variety of potential data formats: electronic health records, clinical trials, or even images.

The analysis of medical imaging can support several tasks, such as disease detection, segmentation, assessment of organ functions, etc. [2]. Introducing AI algorithms in these tasks can increase the benefits derived from medical imaging analysis by automating complex activities with similar performance compared to human skills [3].

But although the benefits of applying AI to medical images is unquestionable, it is important to provide usable and transparent technologies that make the use of these methodologies accessible to non-expert users.

In this work, we present the first version of a platform (D-AI-COM) focused on applying AI algorithms to DICOM (Digital Imaging and Communication In Medicine) [4] images. This platform has two main objectives:

1. To provide an independent and configurable service to apply AI algorithms to DICOM images on demand
2. To support the integration of custom algorithms by fostering the flexibility of the platform's components

The rest of this paper is organized as follows. Section 2 describes previous works on assisted application of AI to medical images. Section 3 outlines the proposed architecture and interface of D-AI-COM. Finally, Sect. 4 discusses the proposal as well as the conclusions reached during the development of the architecture.

2 Background

This platform has been proposed in the context of the Cardiology Department of the University Hospital of Salamanca. In this context, two platforms have been previously developed to support the application of AI in the medical domain.

The first one, the CARTIER-IA platform [5, 6], was designed to support the unification of structured medical data and imaging data. This platform allowed users to upload their datasets and images and match them through DICOM identifiers, such as the patient's, study's, etc.

The CARTIER-IA platform also provided a DICOM viewer and editor, which enabled users to perform segmentations without leaving the platform, as well as apply pre-uploaded artificial intelligence algorithms to their data (Fig. 1).

On the other hand, the other platform, KoopaML, focused on the application of machine learning algorithms to medical data through visual means [7–9]. This platform has the goal of facilitating the application of these kinds of algorithms to novice users (Fig. 2).

The D-AI-COM platform aims at continuing to enhance the technological ecosystem by providing a transparent node that does not require any explicit user action to carry out the application of AI algorithms to medical imaging. As will be detailed in subsequent sections, the node will transparently apply the algorithms whenever it receives a new image through the DICOM protocol.

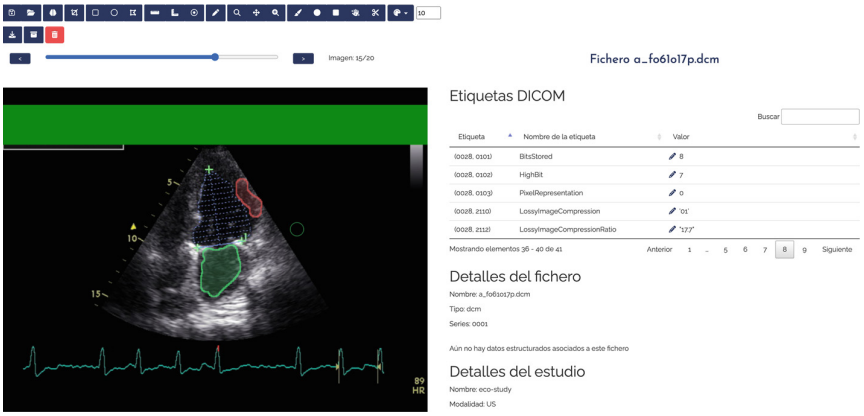

Fig. 1. The CARTIER-IA platform DICOM viewer and editor.

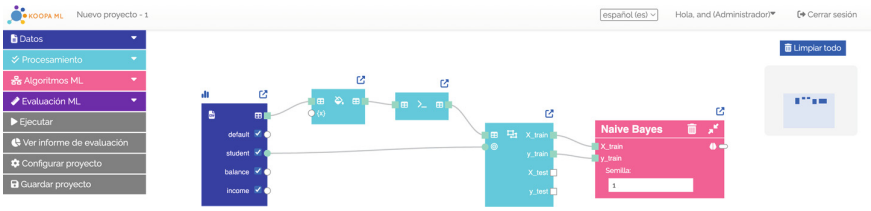

Fig. 2. The KoopaML platform workspace.

3 Proposal

This section details the proposed architecture and first version of the graphical interface for the D-AI-COM platform. The whole platform has been designed to focus on the flexibility and independence of the different modules.

3.1 Architecture

As introduced above, the platform must comply with different requirements specific to the context AI and medical images. This kind of scenario has a set of implications, among them:

1. Services must be continuously listening for incoming DICOM images
2. The application of AI algorithms is time- and resource-consuming, so they should be executed in the background and on-demand

In this sense, we designed the architecture outlined in Fig. 3. The platform consists of two separated but communicated services: a DICOM storage SCP (Service Class Provider) and a Django web application. The DICOM SCP is set to receive incoming images through the DICOM protocol, specifically it will listen for C-STORE commands.

To send an image to D-AI-COM, users need to configure the platform as a PACS (Picture Archiving and Communication System) by using the required parameters (IP address, port, and AE (Application Entity) title (Fig. 3).

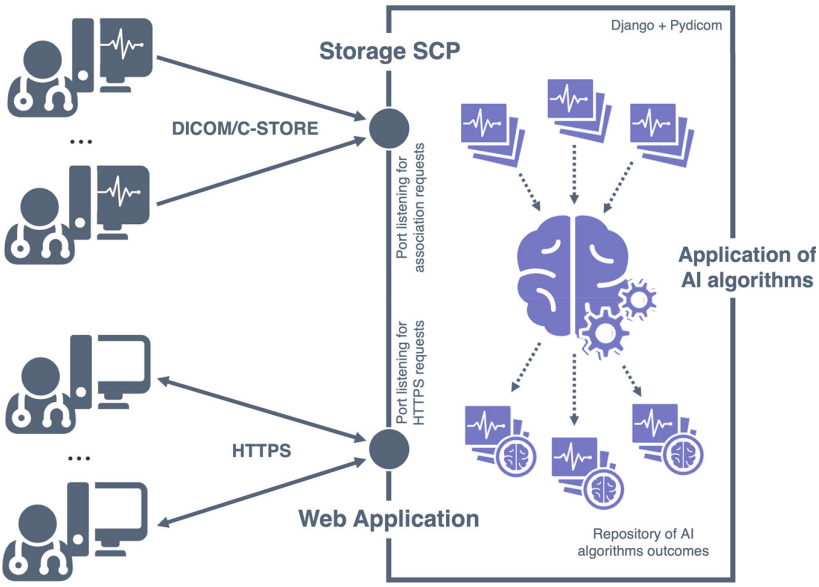

Fig. 3. Outline of the node's architecture. This node relies on two ports, one listening for incoming DICOM C-STORE requests, and the other listening for HTTPS requests for web application.

The workflow of the functionality is described in Fig. 4. The DICOM storage service is constantly listening for new associations. Whenever a new image is sent, it is analyzed to see if there are any issues regarding the DICOM protocol, and if it has been properly sent, it is stored in the node's filesystem.

The communication between the storage service and the web application is carried out through the relational Postgres database. Once the received image has been persistently stored, the SCP finishes the process by creating a new row in the database containing all the metadata (file name, patient ID, study ID, series ID, modality) and a reference to the path of the DICOM file.

Meanwhile, the Django web application is configured to monitor any new additions to the database, so when a new file has been received and stored through the SCP, a signal is triggered and processed by the web application, automatizing the whole process.

When the algorithms have been applied, a new image is generated with the results, which is also stored both in the filesystem and in the database (referencing the original DICOM file as a foreign key).

In this sense, the newly added file is inspected to see if any AI algorithm integrated in the platform supports its DICOM modality, and if it is the case, retrieves the scripts and executes them as a background process.

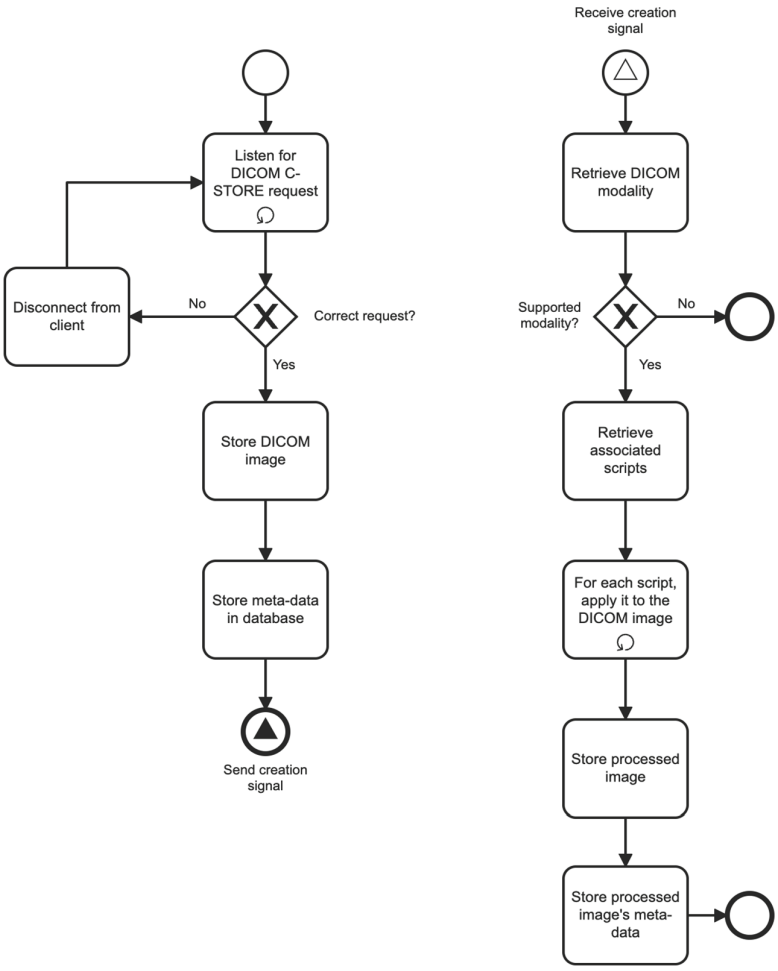

Fig. 4. Business process model of the workflow followed to receive and process incoming DICOM images. On the left, is the workflow for the DICOM storage SCP, and on the right, is the workflow of the web application.

3.2 Graphical Interface

A graphical interface has also been developed to ease the navigation and to provide access to the AI algorithms' outcomes. While the architecture provides the support to act like a PACS and to apply AI algorithms automatically, the interface focuses on making the processed DICOM images accessible and available for any user at the institution where the D-AI-COM node is deployed.

The first version of the interface enables users to navigate the received and processed DICOM images (Fig. 5). Users can add images to a favorite list to retrieve them faster.

In addition, the user interface allows privileged users to upload new AI algorithms, so the set of available algorithms can be modified without changing the codebase. To

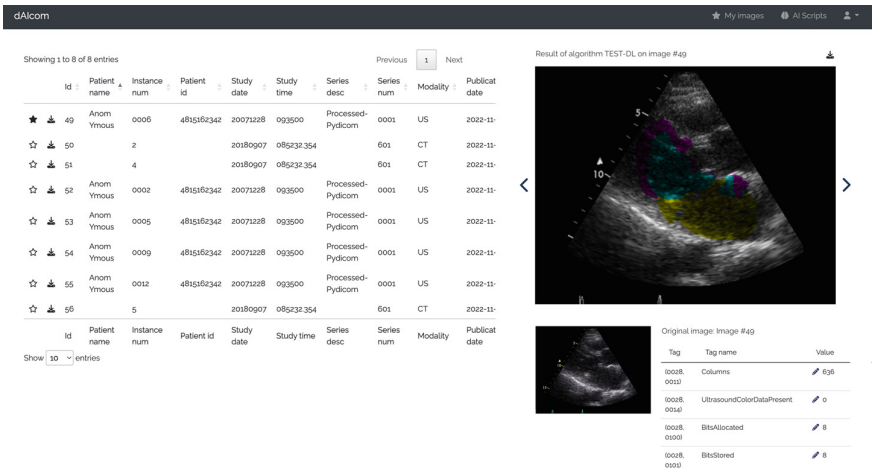

Fig. 5. First version of the graphical interface to navigate the results of the AI algorithms.

upload a new algorithm, it is necessary to provide some crucial data: the modality or modalities to which it can be applied, the model, and the python script that executes the model. Once the algorithm has been uploaded and validated, it is stored persistently in the database to be retrieved and executed when new images arrive.

4 Discussion and Conclusions

This work details a new platform for the automated application of AI algorithms to medical images. The approach taken to accomplish the development of the platform relies on a workflow with two main services:

1. The reception of DICOM images through an SCP
2. The application of AI algorithms to incoming images

This workflow has different benefits. First, the independence of the two services. The SCP does not depend on the web application and vice versa. In this case, these two services rely on the same database; the SCP is in charge of updating it with the received DICOM images and the web application monitors new additions to execute the corresponding algorithms on the fly. However, both services could work with their own databases as independent services.

Second, the workflows described in Fig. 4 are easily automatable, so the different events (such as receiving a new image or adding a new row to the database) can be traced and converted in signals that trigger subsequent actions. This method unburdens the web platform with time-consuming tasks, as they are executing in the background.

In this sense, the user does not need to perform any further action than sending the images to the D-AI-COM node through their imaging tools and accessing the web platform to get the results of the AI algorithms.

In addition, the possibility of adding new algorithms through the interface also increases the flexibility of the platform, as the scripts are not hard coded in the infrastructure and can act as interchangeable components.

The functionality of the node has been tested with real DICOM images, obtaining promising results. Relying on this node can make the process of applying AI methods more transparent and easier to lay users, as they only need to send the DICOM images through their own imaging management applications and consult or download the results through the interface.

Future research lines will involve the improvement of the graphical interface, as it is at its first stage of development and the user experience is crucial to enable users to understand the results. In addition, the D-AI-COM node will be integrated and tested in a real-world scenario to continue enhancing its features.

Acknowledgments. This research was partially funded by the Ministry of Science and Innovation through the AVisSA project grant number (PID2020-118345RB-I00). This work was also supported by national (PI14/00695, PIE14/00066, PI17/00145, DTS19/00098, PI19/00658, PI19/00656 Institute of Health Carlos III, Spanish Ministry of Economy and Competitiveness and co-funded by ERDF/ESF, "Investing in your future") and community (GRS 2033/A/19, GRS 2030/A/19, GRS 2031/A/19, GRS 2032/A/19, SACYL, Junta Castilla y León) competitive grants.

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