Building a mass online annotation tool for dental radiographic imagery

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Abstract

In medical images analysis in general and for dental radiographic imagery more specifically, deep learning algorithms, in particular convolutional neural networks, are increasingly applied for detecting pathologies. However, creating an sufficiently large data set of labeled radiographic imagery for training deep neural networks is resource- and time-consuming. In order to build a large and reliably database of annotated dental radiographic imagery we are building a mass online annotation tool (Mono) for dental panoramic x-ray images. The tool is designed to allow evaluating the annotator's proficiency against clinical records, majority vote schemes and model predictions in real time.

1 Introduction

Cognitive AI driven decision assistance systems have an increasing role in medical practice and deep learning algorithms have become a methodology of choice for analyzing medical images [1]. Convolutional neural networks (CNNs) have been successfully applied to detect cancer in mammographies [2] and diabetic retinopathy in eye examinations [3]. In dental healthcare, CNNs have been applied for x-ray image segmentation [4]. More recently Srivastava et al. [5] used deep CNNs to detect and classify dental caries based on radiographic imagery. We applied deep convolutional neural networks on dental radiographic imagery in order to detect periodontal bone loss (PBL), primary and secondary caries and root canal filling and endodontic (peri-apical) lesions on panoramic dental x-ray scans collected from 2010 to 2017. To do so, a data set of 2,001 images each focusing on one particular tooth was constructed. Seven experts assessed these images to annotate them for the described morbidities. In order to scale up the annotation process we are building an online annotation tool for dental radiographic imagery. The goal of this tool is to allow both a convenient online annotation experience for the annotator and just-in-time quality control.

2 Mass online annotation tool for radiographic imagery

The application flow of the tool consists of (Fig. 1):

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- Image preprocessing – panoramic x-ray images are segmented to extract single teeth while generating metadata, e.g. type (incisor, canine, molar) and position of each particular tooth in the dentition
- Annotator management – a subsystem to hold personal profiles and annotation history of users
- Annotation system – a single page user interface for image annotation
- Rating system – a subsystem to collect information for the annotators labeling quality

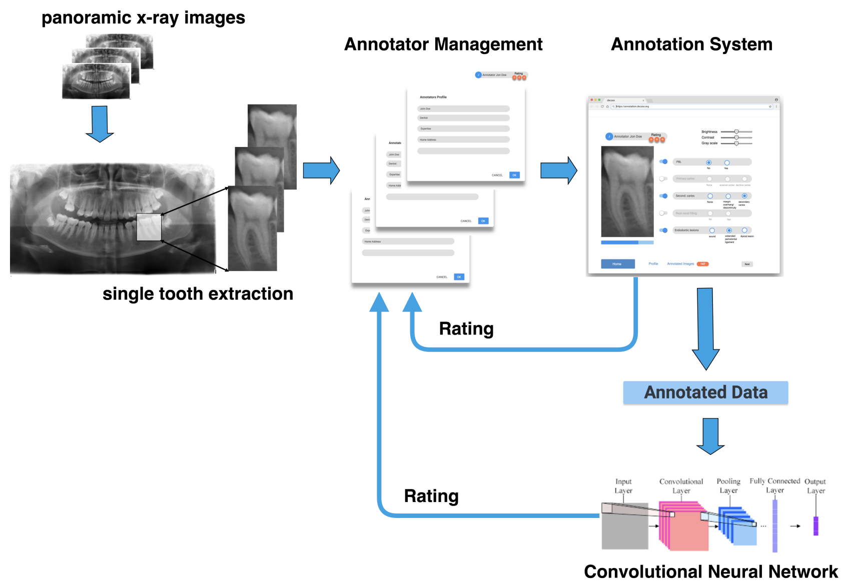

Figure 1: **M**ass **o**nline an**no**tation tool for radiographic imagery (Mono) application flow.

2.1 Image preprocessing

The input for the image preprocessing system is a set of panoramic dental x-ray scans. We use a neural network for image segmentation to extract each single tooth within the panoramic scan that will be available for labeling by annotators.

2.2 Annotator management

Annotators are invited dental experts. Self-registration is used to build a profile database, which stores personal and professional data:

- Expertise: The annotators classify themselves in which areas they are experts in. The system adjusts to the annotator's expertise according to their performance.
- Rating: The system collects quality indicators and evaluates the annotators classification proficiency.
- Image tracker: Images already processed by an annotator are tracked.

2.3 Annotation system

The annotation system consists of a single-page website that is based on a user optimized UX design. It shows the image of the tooth itself and possible labels. The annotator can modify intensity, hue and contrast of the image to improve the display. With respect to the annotator's field of expertise selected morbidities and appropriate options are shown to the annotator. The system is built as a RESTful Web Service backed by a multi-tier application. Security is achieved by design by separation of data storage, application and frontend. Encryption is applied to all transport and data layers. Authorization and authentication rules apply and are managed by state of the art administration, directory and monitoring services. Infrastructure is divided into separate zones that secure data from business logic and production frontend to increase security. Static user data as well as transaction data is stored in a SQL database. Images are kept in an encrypted file system.

2.4 Rating system

The rating system implements several techniques to account for an annotator's proficiency on labeling x-ray images.

The rating is based on:

- Ground truth: For a subset of images, clinically obtained ground truth data is available. Hence, we compare annotators labels with clinical records.
- Model predictions: While more annotated data becomes available the outcome of a CNN is evaluated against the human annotation.
- Interrater agreement: Each image is presented to many annotators. Hence, we leverage different majority vote schemes to assess interrater agreement.
- Intrarater agreement: In order to rate the intrarater agreement selected images are presented several times to one particular annotator.

3 Conclusion

We are building a mass online annotation tool for dental panoramic x-ray images. The tool allows incorporating dental experts from all over the world to build up an annotated image data set for radiographic dental pathologies. The system offers a convenient image annotation workflow and concurrently allows evaluating the annotator's proficiency against clinical records, majority vote schemes and model predictions.

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