Deep learning segmentation of dental radiographs for pulp pulp effraction predictionaction pulpaire

I Scientific Context

Among the world's pathologies, untreated caries on permanent teeth is the most widespread, affecting 2.3 billion people in 2017, i.e. 34% of the population [1]. Radiographic detection of deep carious lesions presents little risk of false positives (good sensitivity and specificity) [2]. However, there is considerable variability between evaluators when reading the same radiograph, particularly when estimating pulpal proximity [3]. Minimally invasive treatment of a deep carious lesion is a single session treatment, with the restorative material applied in the same session in place of cleaned cavity of carious lesion. In case of pulpal exposure, the pulpal structure adjacent to the carious lesion is affected, and the treatment of the deep carious lesion becomes more invasive: in addition to the carious lesion treatment, the pulp structure adjacent to the carious lesion is also cleansed in a treatment called or endodontic treatment ("devitalization"), depending on where pulp treatment ends.

Figure 1: Left: schematic representation of a deep carious lesion. Right: X-ray of the same carious lesion.

Previous work by the supervising team has shown that trying to predict the risk of pulp from radiographic images is not conclusive.

Consequently, a segmentation step, automatically detecting healthy and decayed areas, becomes an indispensable first step to aid advanced analysis of these X-rays.

II Objectives of the internship

The aim of this internship is to contribute to the development of a predictive tool for estimating the risk of pulpal exposure from a preoperative radiograph, so as to be able to implement a care procedure that is as minimally invasive, predictable and reproducible as possible.

Deep learning is the state-of-the-art method for obtaining high-quality segmentations[4], but requires a lot of training data. In this course, we will use a private database segmented by an expert containing, on the one hand, bounding boxes detecting the position of teeth on 500 radiographs, and the segmentation of these same 500 bounding boxes containing deep carious lesions. A first neural network, using YOLOv8[5], has already been to detect each tooth individually, and accurately detects the presence or absence of carious lesion in the bounding box. The network will be retested on other bases to confirm its generalizability (database of

deep carious lesions from the Projet Hospitalier de Recherche Clinique DECAT (Deep Caries Treatment) registered on Clinical.Trials.Gov NCT 04607395.

Developments will be carried out in Python, using the PyTorch library for deep learning, possibly using the MONAI[6] framework.

The work involves several stages:

- Get to grips with the medical context
- Training and evaluating the existing YOLO network
- Training and evaluating a neural network for dental segmentations
- Use these networks to predict the risk of pulpal effraction.

III Required skills

- Good Python programming skills (Pytorch, NumPy, SciPy)
- Knowledge of deep learning
- Interest in medical imaging in general, and dental radiography in particular

IV Informations

- Duration of internship: 4 to 6 months
- Location: Créatis laboratory and Faculty of Dentistry, Lyon
- Supervisors : Marie-Agnès Gasqui, Fabien Millioz, Matthieu Perard
- Send CV, covering letter and latest transcript to ma.gasqui@gmail.com, fabien.millioz@univ-lyon1.fr, matthieu.perard@univ-rennes.fr

References

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