engineering proceedings

MDPI

Proceeding Paper

Clinical Applications of the Algorithm "Pipeline Advanced Contrast Enhancement (Pace)" in Dental Radiology †

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† Presented at the 3rd International Electronic Conference on Applied Sciences, 1–15 December 2022; Available online: https://asec2022.sciforum.net/.

Abstract: The Panoramic radiography is the result of a radiological technique that allows the reproduction of the dental arches and the support structures of a unique image. The clinical utility of panoramic radiography allows the overall assessment as well as the detection of structural abnormalities and/or possibly relates to pathological lesions. The disadvantage of this technique is related to the lower quality of the images compared to endoral radiographs and TC scans but especially to the attempt to represent a three-dimensional, curved anatomic region on a two-dimensional plane. This inevitably leads to geometric distortions of shape, enlargements and overlaps that adversely affect the detection of any pathological entities. However, the most important advantage is the possibility of reducing patient exposure to ionizing rays. The aim of digital radiology is to improve the characteristics of radiological machinery (through increasingly innovative and sophisticated data processing software and hardware) in order to obtain high-quality images while reducing dosimetry and to reduce "disturbing elements" in radiological images. To overcome the limitations of the panoramic technique and to improve the quality of radiological images, and thus the effectiveness of diagnosis, image optimization software can be used. In this regard, a tool called Pipeline for Advanced Contrast Enhancement (PACE) is being developed: This is an algorithm that allows image quality to be improved by optimizing contrast and reducing brightness inhomogeneity, resulting in increased definition, making details more evident. The purpose of the proposed investigation is to evaluate if the application of the PACE algorithm in dental radiology could be an advantage because of the possibility of enhancing the quality of radiological images to make details of anatomical structures and related pathological lesions more obvious.

Keywords: post-processing; contrast; brightness; quality; detail; definition; image enhancement software; OPT images; endoral radiographs; CT scans; new lesions; PACE

Citation: Cervino, G.; Cicciu, M.; Fiorillo, L.; Finocchio, G. Clinical Applications of the Algorithm "Pipeline Advanced Contrast Enhancement (Pace)" in Dental Radiology. *Eng. Proc.* **2023**, *31*, 10. https://doi.org/10.3390/ASEC2022-13759

Academic Editor: Gianrico Spagnuolo

Published: 1 December 2022

1. Introduction

The panoramic radiography is the result of a radiological technique that allows the reproduction of the dental arches and the support structures of a unique image. The clinical utility of panoramic radiography allows the overall assessment as well as the detection of structural abnormalities and/or possibly relates to pathological lesions. The disadvantage of this technique is related to the lower quality of the images compared to endoral radiographs and TC scans but especially to the attempt to represent a three-dimensional, curved anatomic region on a two-dimensional plane. This inevitably leads to geometric distortions of shape, enlargements and overlaps that adversely affect the detection of any pathological entities. However, the most important advantage is the possibility of reducing patient exposure to ionizing rays [1].

The aim of digital radiology is to improve the characteristics of radiological machinery (through increasingly innovative and sophisticated data processing software and hardware) in order to obtain high-quality images while reducing dosimetry and to reduce "disturbing elements" in radiological images [2]. To overcome the limitations of the panoramic technique and to improve the quality of radiological images, and thus the effectiveness of diagnosis, image optimization software can be used. In this regard, a tool called Pipeline for Advanced Contrast Enhancement (PACE) is being developed: This is an algorithm that allows image quality to be improved by optimizing contrast and reducing brightness inhomogeneity, resulting in increased definition, making details more evident.

In the publication "Pipeline for Advanced Contrast Enhancement (PACE) of Chest X-ray in Evaluating COVID-19 Patients by Combining Bidimensional Empirical Mode Decomposition and Contrast Limited Adaptive Histogram Equalization (CLAHE)" (by Giulio Siracusano, Aurelio La Corte, Michele Gaeta, Giuseppe Cicero, Massimo Chiappini and Giovanni Finocchio), the application of this algorithm in CXR images belonging to patients with COVID-19 was evaluated. These patients were admitted to Policlinico G. Martino Hospital in Messina in early 2020 and had lung lesions.

This study showed that the application of PACE on CXR images succeeds in enhancing them, achieving important results from a clinical point of view. Specifically, comparison of 79 CXR images with the same images reprocessed by PACE (thus enhanced CXR images—ECXRs) showed that the lesions in the enhanced images showed greater definition, but the most important result was that the number of lesions identified in the ECXR images was higher: New lesions were identified in 8 out of 79 cases, 3 of which, in the CXRs, showed no lesions. Such new lesions were also identified in TC scans, confirming the finding obtained from the enhanced images [3].

The purpose of the proposed investigation is to evaluate if the application of the PACE algorithm in dental radiology could be an advantage because of the possibility of enhancing the quality of radiological images to make details of anatomical structures and related pathological lesions more obvious [4].

The enhancement of these images, in fact, could allow the following advantage: simplifying the clinician detection of the anatomical structures and lesions. This would have two positive effects: a reduction in the time of radiological examination evaluation and a reduction in omission-type error (error related to non-identification of pathognomonic radiological signs). The increased prominence with which features appear may direct a distracted eye to observe the same features.

There is a possibility of identifying new lesions (lesions not identifiable in unenhanced images). The advantage of this is as follows: the possibility of making an early diagnosis of the presence of hard tissue abnormalities (and thus potential pathologic lesions in their early stages) and improving the prognosis of these patients, limiting the use of second-tier diagnostic tools. TC examination involves increased patient exposure to ionizing radiation.

2. Materials and Methods

To achieve the purpose of the proposed study, in the first step, unenhanced OPT radiological images will be collected and analyzed. In the second step, the PACE algorithm will be applied to the same radiological images. The third step includes the analysis of radiological images enhanced by PACE. In the final step, the results obtained will be compared.

The analysis will concern the identifying of the anatomical structures and potential pathological lesions.

Anatomical structures: mental foramen, mandibular canal, relationships between root apices and the mandibular canal, relationships between root apices and the floor of Higmoro's antrum, trabecular bone lamellae, cortical bone, the hard lamina and Underwood Sept. Pathological lesions: osteolytic lesions, periapical lesions, periodontal space enlargement, vertical and horizontal bone loss, peri-implant bone loss and carious lesions. The comparison of the obtained results is going to evaluate the differences between the

unenhanced images and the same ones to which the PACE algorithm has been applied, in terms of the possibility of detection of the elements mentioned above. It will be necessary to understand not only whether the enhanced images will be able to show new lesions (not detected in the images not processed by PACE) but also whether the elements present show equivalent features in both images or are more detailed and obvious. At least 150 OPT images will be analyzed in this study. Finding them will require the involvement of the odontostomatology departments of the Universities of Messina and Catania, as well as private dental centers that will join this study [5,6].

3. Results and Discussion

It is expected that the application of PACE in OPT radiological images will enable it to:

1. optimize the contrast and brightness of the images, improving their quality and definition;
2. bring more prominence to the elements contained in the images (the anatomical structures and pathological lesions);
3. simplify the identification of elements in radiological images;
4. perform more accurate evaluation of radiological images in less time;
5. reduce the omission-type error (error due to the failure to recognize pathognomonic radiological signs); and
6. to identify new lesions (not identifiable in unenhanced images).

These results are expected in most of the images to which PACE will be applied.

The possibility of identifying new lesions is to be evaluated on a large scale.

This study could also be extended to evaluating the application of PACE to endoral radiological and TC images.

4. Conclusions

Further future developments could include the possibility of performing quantitative evaluations of image enhancements from PACE for different areas of interest as well or the possibility of using the software as pre-processing for other applications for automatic detection of pathologies affecting bone tissue and dental elements.

Author Contributions: Visualization, L.F.; supervision, G.C. and M.C.; project administration, G.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Huda, W.; Abrahams, R.B. X-ray-based medical imaging and resolution. *Am. J. Roentgenol.* **2015**, *204*, W393–W397. [CrossRef] [PubMed]
2. Walz-Flannigan, A.; Magnuson, D.; Erickson, D.; Schueler, B. Artifacts in Digital Radiography. *Am. J. Roentgenol.* **2012**, *198*, 156–161. [CrossRef] [PubMed]
3. Al-Ameen, Z.; Sulong, G.; Rehman, A.; Al-Dhelaan, A.; Saba, T.; Al-Rodhaan, M. An innovative technique for contrast enhancement of computed tomography images using normalized gamma-corrected contrast-limited adaptive histogram equalization. *EURASIP J. Adv. Signal Process.* **2015**, *2015*, 32. [CrossRef]
4. Siracusano, G.; La Corte, A.; Gaeta, M.; Cicero, G.; Chiappini, M.; Finocchio, G. Pipeline for Advanced Contrast Enhancement (PACE) of Chest X-ray in Evaluating COVID-19 Patients by Combining Bidimensional Empirical Mode Decomposition and Contrast Limited Adaptive Histogram Equalization (CLAHE). *Sustainability* **2020**, *12*, 8573. [CrossRef]

5. Cao, A.M.Y.; Choy, J.P.; Mohanakrishnan, L.N.; Bain, R.F.; van Driel, M.L. Chest radiographs for acute lower respiratory tract infections. *Cochrane Database Syst. Rev.* **2013**, *12*. [CrossRef]
6. Gaeta, M.; Minutoli, F.; Mazziotti, S.; Visalli, C.; Vinci, S.; Gaeta, F.; Blandino, A. Diagnostic imaging in athletes with chronic lower leg pain. *Am. J. Roentgenol.* **2008**, *191*, 1412–1419. [CrossRef]