International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-6, April 2020

# Techniques of Image Processing on Dental Images and Identification of Challenges

**Shubhreet Kaur, Chetan Marwaha**

***Abstract:*** ***Digital image processing is a boon in medical image processing. Oral hygiene is considered as one of the main aspect of the health. So, it is important to determine the dental diseases and cure them. This leads to use of technologies that help in detecting the diseases. Dental imaging technologies have seen a rapid advancement over a century. The image capturing technologies have evolved from analog films to 2D imaging and recent 3D imaging technologies are now in vogue. Detection of dental diseases by using dental imaging techniques still possess some challenges, inappropriate use of techniques can lead to undesired results. In this paper we will look at various dental imaging technologies that are used for detection of dental diseases and the associated challenges.***

**Keywords** ***:digital imaging, radiography, image capturing techniques.***

## I. INTRODUCTION

The simplest method of detecting oral diseases is clinical examination. Although, the use of direct clinical examination is simple and well tested by design; the judgment in this case can lead to some potential bias [39]. Analog film was earlier used in dentistry, which has been replaced by digital image capturing techniques. Digital dental imaging can be used to overcome the restrictions in clinical assessment and also that of analog film. The use of radiography in image capturing has several advantages over analog film [4].

Dental radiographic analysis has a vital role in diagnosing, treating and in surgery of oral ailments. Radiographs are used to detect benign or malignant masses, bone cavities and loss and also to detect hidden structures. Dental radiographic procedures are obligatory in diagnosing and treating of dental caries, root canal and planning the treatment of orthodontic sufferer. Dental x-ray imaging can be classified into two groups extraoral and intraoral. Extraoral radiography is used to determine dental jaw and skull problems, using panoramic x-ray imaging and cephalometric projections. Whereas, intraoral radiography consist of bite wing x-rays to give away the details of lower and upper teeth in mouth, the occlusal x-ray imaging is done to record the placement and development of whole teeth arch in either lower or upper jaw and periapical x-ray imaging is used in monitoring the entire tooth [10]. Dental radiography mainly avoids the use of hazardous and toxic solutions that are used in film processing and also reduces the extent of exposure to the radiation. Faster image retrieval, display and storage are also the advantages of digital radiography in image capturing. This is effective in improving communication and dissemination of the information about image. Another advantage that is important is that it can create dynamic images by using various tools in image processing that can also modify contrast and brightness or reverse density pattern [4]. Manipulating the digital radiographs can improve the quality of the image. Image filters like sharpening, enhancing and smoothing filters can be used in dental image enhancement [3]. By using digital imaging other members in the dental team can be included in data collection, hygienists and nurses can be trained to capture digital images, it reduces the labor cost and logistical complexities [6]. Dental cysts and caries are commonly occurring dental pathologies encountered during dental practice. Radiographic examination is used in capturing images of the anomalies [1]. It is used to diagnose diseases affecting the teeth and supporting structures in the jaws, thereby improving treatment planning and overall patient health [4]. Near-infrared is a non-invasive, non-ionizing method used in identification and quantification of caries at any given stage.

Because of, the higher transparency of enamel to NIR, the optical property of the tooth displays low absorption of the stain and deep penetration into tooth [11]. NIR can detect caries at earlier stages due to their high sensitivity [12]. With advancement in technology the need of 3D imaging in dental imaging also arise.

Computed Tomography (CT) allows the dental conditions to be captured in 3D but the apparatus used for this is relatively expensive, large and also the exposure of patients to the radiation is relatively high. Cone Beam Computed Tomography (CBCT) was later developed for capturing 3D scans of maxilla-facial region. CBCT uses X-rays are used in form of large cones to capture images of head-surface area. It uses 2d planar-detector than that of linear-array detector as in case of normal CT [7]. A non-invasive diagnosis technique known as OpticalCoherence Tomography (OCT),provides cross-sectional imaging of biological structures on basis of differences in optical tissue properties.

**Revised Manuscript Received on April 30, 2020.**
***** Correspondence Author
**Shubhreet Kaur*** Dept. of Computer Engineering & Technology, Guru NanakDevUniversity,Amritsar,India.Email: shubhreetkaurbrar@gmail.com
**Chetan Marwaha** Dept. of Computer Engineering & Technology, Guru Nanak Dev University,Amritsar,India Email: chetan.cse@gndu.ac.in

Dental restorations, dental caries, dental implants are some of the application areas of OCD in dental imaging [8]. Multi-detector row CT (MDCT) is used for diagnosing odontogenic and non-odontogenic tumors and cysts, inflammation, metastatic lesions, maxillofacial trauma, fibro-osseous lesions, developmental abnormalities, and malignancy.

The images obtained using MDCT are of high resolution and in thinner sections of volume data, which leads to multiplanar reforming and near isotropic images over high acquisition. It is flexible and efficient in using contrast medium than simple CT [9].

Several, other techniques like flourosence can be used for quantitative analysis and visualization of both dental plaque and dental caries [12]. Techniques like megnatic resonance imaging and ultrasound in dentistry can also be used in dental image capturing.

## II. LITERATURE SURVEY

1. Veena Divya K.[1] presentedwork on dental anomalies detection by using two different algorithms. The paper was divided into two sections. The first section presented hybridized negative transformation technique for dental caries detection. The second section presented detection of cysts in dental images in accordance with dental caries.

2. K. Angelino [2] presentedwork on different dental imaging techniques and compared their clinical features. The techniques used were Cone beam computed tomography (CBCT), near-infrared transillumination and 2D radiograph imaging.

3. S. A. Ahmad [3] presented study on SOIE framework for identification of objective measurements on basis of dentist's subjective evaluation of abnormalities in the jaw area. The study was conducted in three phases: experimental design, image processing and subjective-objective evaluation. The study is restricted to three abnormalities such as wider periodontal ligament space (PDLs), loss of lamina dura(LD) and periapical radiolucency (PR) only.

4. Clark [4] presentedwork on unsharp masking (USM), an algorithm used for image sharpening to indicate its effect on image quality due to overshoot artifacts. Three digital sensors (1 photostimulable phosphor and 2 complementary metal-oxide-semiconductors) were exposed by using a digital dental quality assurance imaging phantom for evaluation of spatial resolution, dynamic range and contrast resolution. The 3 sensors were then again exposed without the phantom for determination of the degree of radiographic noise. Every single image was first sharpened and then highly sharpened. The overshoot was measured, and the comparison of the images was done using the Friedman 2-way ANOVA analysis.

5. Servais [5] presentedwork to evaluate fractal dimension and surface area of alveolar bone using cone beam computed tomography (CBCT) captured images of the patients with maxillary affected canines. Using the sample images, different comparisons were done using linear regression and paired t tests. Repeated measurements were also obtained randomly from about 20% of the sample.

6. Wang [10] presentedwork on a framework as established by IEEE International Symposium in Biomedical Imaging for evaluating dental radiographic analytic algorithms objectively. The challenges are Cephalometric X-ray and Caries Detection. With the set benchmark, 2 automatic methods for detecting bitewing radiographic caries and 7 seven automatic methods for analysing the cephalometric X-ray images were compared.

7. Liansheng [13] presented work on tooth segmentation and proposed a framework with Gaussian Filtering Regularized Level Set and Selective Binary technique that was improved by using unsupervised learning that is k-means++method and also using 3D information. For evaluating the proposed framework, experiments were performed on extensive and sufficient set of mandibular molar.

8. P. Pandey [14] This paper presents work on effective segmentation technique using combination of Level sets and Local Gaussian Distribution of fitting energy. Where intensities of the images are defined using combinations of level-set functions and Gaussian distribution for accurate segmentation in teeth contour. The work indicated that segmentation can achieve lesser iterations that makes it computationally fast and can perform in real time situations.

9. Zang [31] This paper presents work by applying a deep learning technique for detection and classification of teeth dental radiographs, and is essential for dental curing and also for postmortem identification. The teeth are detected from an input X-ray image and are distinguished from different position.Due to limited data availability a new method is proposed by using a label tree to give each tooth several labels and decompose the task, which can be used to deal with the lack of data availability. Then the cascade network structure is used to automatically identify 32 teeth position.It uses several convolutional neural network (CNN) as its base module.

10.Hegazy [40] This paper uses a Convolutional Neural Network (CNN) for detection of oral ailments. The main focus is on the role of neural network in maintenance of oral hygiene. The proposed machine learning model incorporates, learning and reasoning based on past experiences. This is method used for automatic detection of five oral ailments. The CNN familiarizes itself about the oral conditions and then easily evaluates them against disorders.

## III. DISCUSSION

1. X-ray or panoramic X-rays are preferred for initial teeth examination. X-rays should not be used for diseases with discernable symptoms. It should be still kept in mind that, there could be possible useful additional findings. Mandibular cortical erosion can be early detected by X-rays. But, X-rays can magnify and distort the 3-D anatomical structures to 2-D with overlapped tooth surfaces or any other important structures.

2. CT or MRI should be considered for maxillofacial fractures instead of CBCT because CBCT requires high soft-tissue contrasts. CBCT can be used in obtaining cephalometric views without distortion or magnification [38].
3. CT data is inadequate as compared to other soft tissue imaging techniques [35].
4. CBCT is an excellent alternative to CT for information regarding bone quantity and quality and also regarding the relationship between important anatomical structures. CBCT is also useful for TMJ analysis.
5. CBCT provides more appropriate diagnosis ofroot canal obturations, periapical lesions,root fractures. CBCT is also helpful in planning better endodontic surgery with precise portrayal of maxillary sinus anatomy such as the presence of septa. CBCT can be used in addition to X-rays for 3D findings.
6. CBCT as well as MDCT can be used for multiple odontogenic and non-odontogenic lesions encountered in radiological practice, including cysts or infections. CBCT allows accurate visualisation of pre-clinical necrotic bodies within osteonecrotic jawbone lesions and allowed accurate assessment of disease status [36, 38].
7. Recently, magnetic resonance imaging (MRI) in addition to CBCT has attracted a lot of attention due to its excellent tissue discrimination as well as the absence of X-ray exposure i.e., absence of ionizing radiation. MRI can be used to visualize periodontal tissues, teeth and morphology as well as vitality of dental pulp. It plays an important role in the field of regenerative medicine, particularly for dental pulp stem cells. Tissue visibility in MRI equal to or superior to that of CT and CBCT, but with a condition that is it requires significant resolution that can only be achieved by long scan time. As an essential to avoid useless root canal treatment follow-up MRI is often recommended because of occurrence of reperfusion [38].
8. Ultrasound(US) is highly accurate in detection of cystic lesions, benign tumors, malignant tumors, space infections and abscesses, and lymphadenopathies. US highly significant in planning or performing surgery[16].
9. The fluorescence systems fail to indicate the caries lesion depth in order to aid the clinicians in making a proper strategy decisions regarding treatment to be followed. Therefore, the data cannot be directly linked to intervention decisions [12]. No possibility of imaging the caries extension in relation to the pulp [23].

**Table-1. Discussion of Technologies.**

| TECHNIQUE | USES IN DENTISTRY | DEMERITS |
|---|---|---|
| X-RAY | 1. 1. Additional information regarding the bone contour around the tooth.<br>2. Evaluating internal anatomy and associated pathology.<br>3. For caries diagnosis: evaluation of occlusal caries that may be present in the deep grooves of occlusal surfaces.<br>4. Visualizing the bone supporting tissues, that include small details like bony trabecularisation, lamina dura and periodontal ligament space.<br>5. Measuring bone loss extent distance between the alveolar and crestusing cemento-enamel junction (CEJ).<br>6. Qualitative analysis of periodontal bone loss.<br>7. Evaluation of caries progression and periapical lesions [36]. | 1. Measurement accuracy is dependent on the geometrical projection as well as on presence of ir-regular hard to diagnose infra-bony defects.<br>2. Overlapping in nature; this often limits distinction between oral or buccal structures like the alveolar bony plates.<br>3. It is also prone to projection errors.<br>4. In craniocaudal direction, projection errors may lead to mis-interpretation of the actual alveolar bone height [36].<br>5. Noise in X-ray: Poisson Noise [26], Salt and Pepper Noise [27], Quantum noise [28] and Gaussian Noise [29]. |

| | | |
|---|---|---|
| CT | 1. Treatment of craniofacial deformities.<br>2. Evaluation of soft and hard tissues.<br>3. Diagnosing pathologies as well as contents of the boundaries.<br>4. Examining the temporomandibular joint (TMJ) structure.<br>5. TMJ fractures or ankylosis.<br>6. Examination of the maxillary sinus.<br>7. Orofacial fractures and trauma,<br>8. Evaluating differences in airway volumes after rapid palatal expansion.<br>9. Implant dentistry [35]. | 1. Expensive.<br>2. Skips lesions far away from the sections.<br>3. Foreign objects like prosthetics and restoration artifacts [35].<br>4. Noise: Electronic noise, Statistical noise, Random noise and Round-off errors [17]. |
| CBCT | 1. Temporomandibular joint.<br>2. Trauma and surgery can also be used for follow-up.<br>3. Maxillary sinus.<br>4. Pathology.<br>5. Orthodontics.<br>6. Periodontics.<br>7. Endodontics<br>8. Implants planning [7,35] | 1. Artifacts related to patients or beams and noise.<br>3. The risk of exposure to excess radiation.<br>4. The clinician must learn the new skill of properly manipulating a CBCT viewer in order to obtain the required diagnostic information.<br>5. Lower contrast resolution [7,18-19,37]. |
| OCT | 1. Dental caries.<br>2. Dental education.<br>3. Dental implants.<br>4. Dental prostheses/restorations.<br>5. Endodontics.<br>6. Periodontal disease.<br>7. Soft tissue pathoses [8]. | 1. Light scattering effects [20].<br>2. Noise is also an issue[21-22].<br>3. Principal issues are cost and lack of commercial availability [8]. |
| MDCT | 1. Developmental abnormalities<br>2. Fibro-osseous lesions<br>3. Inflammation<br>4. Leison extent<br>5. Malignancy<br>6. Maxillofacial trauma<br>7. Metastatic lesions<br>8. Odontogenic and non-odontogenic cysts and tumors<br>9. Soft tissue characterization [9]. | 1. Metallic artifacts: Presence of metallic objects such as prostheses, dental fillings, implants and orthodontic appliances can cause problems with MDCT. Metallic artifacts can be observed as streak or starburst an artifact that occurs when the projection data are unavailable because of incident beams getting blocked by metallic objects [24 -25]. |
| MRI | 1. Caries detection.<br>2. To image neuro-vascular bundle inside the mandibular canal.<br>3. Aveolar nerve identification.<br>4. Assessing pulp regeneration.<br>5. It can also be used for the depiction of neoplastic processes or inflammations.<br>6. Insertion of dental implants.<br>7. Characterization of pupal or periapical disease [15,34]. | 1. Dental material artifacts [30].<br>2. Projectile accidents.<br>3. Thermal heating.<br>4. Prostheses failure[32,38]. |

| | | |
|---|---|---|
| ULTRASOUND | 1. Caries lesions.<br>2. Tooth cracks or fractures.<br>3. Periodontal bony defects.<br>4. Maxillofacial fractures.<br>5. Muscle and soft tissue thickness.<br>6. Cracks in dentinoenamel junction.<br>7. Temporomandibular Disorders.<br>8. Diagnosis of periapical granuloma and cyst.<br>9. Identification of periapal lesions.<br>10. Implant Dentistry [16]. | 1. Optical illusion: error in the perception of the image.<br>2. Acoustic: error in the presentation of the image.<br>3. Anatomic: error in interpreting the image often known as pitfall.<br>4. Electrical noise is also one of the causes of errors in image interpretation [33]. |
| FLOURESCENCE AND NIR | 1.Faster and easier detection of dental caries.<br>2. Detection of oral cancer at the initial stage of formation.<br>3.In conservative surgical abscission of necrotic bones in diseases such as osteoradionecrosis (ORN),chronic osteomyelitis and medicationrelated osteonecrosis of the jaw (MRONJ) [12]. | 1. Fluorescence based systems areunable to distinguish between demineralised and stained surfaces.<br>2. Early caries as well as hypo-mineralization development are clinically present as white lesion spots but in fluorescence systems these are represented by dark spots and hence cannot be appropriately distinguished.<br>3. Presence of moisture on tooth surface can mask the contrast between sound and carious enamel; hence, rendering these devices incapable for monitoring unless the tooth surface is dry.<br>4. Presence of dental plaque can obscure lesion detection.<br>5. These systems cannot depict the depth of caries lesion and cannot distinguish between active and inactive lesions [12]. |

## IV. RESULTS

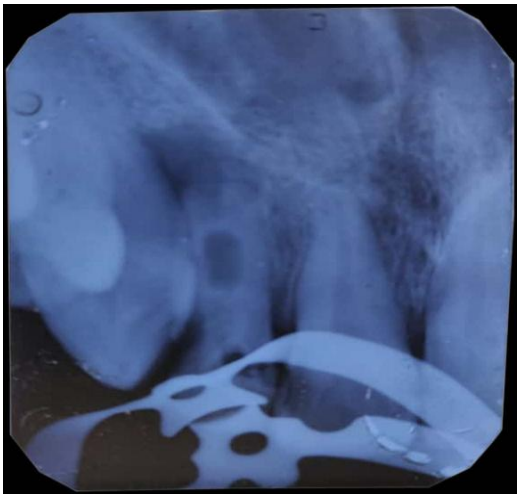
| Author | Year | Aim | Sample | Comments |
|---|---|---|---|---|
| Veena Divya K[1] | 2017 | Detection of dental caries.Feature extraction for images consisting of cysts along with that of dental caries. | 10 | The first algorithm i.e., Hybridized negative transformation gave positive results for 7 images. The second phase i.e., texture analysis was done using several texture parameters such as homogeneity, correlation, contrast, entropy and energy. Energy was found to be in range 7.3117 and 0.2645.Contrast and correlation in range 0.6179 and 0.92305 respectively. |
| K. Angelino [2] | 2017 | Comparison of different techniques used for diagnosis of dental diseases. | 13 | Near-infraredtransillumination imaging is suitable for early problem detection in teeth and can also be used as a preliminary assessment tool for guided radiographs administration. 2D and CBCT use harmful radiations and can be used after initial NIR scan is insignificant. |

| | | | | |
|---|---|---|---|---|
| S. A. Ahmad [3] | 2017 | Image interpretation of loss of lamina dura (LD), periapical radiolucency (PR), widen periodontal ligament space (PDLs) abnormalities. | 36 | The application of SOIE framework shows that the final output is produced as an abnormality matrix that can serve as a basis for cataloging the acceptable subjective interpretation images along with the objective values. The established framework is a method to utilize and has a potential in speeding up the process in exploration of the characteristic dental medical images. |
| Clark [4] | 2018 | Effect of USM on image quality and to indicate overshoot artifacts | 378 | Image quality can be improved byimage sharpening but can lead to increase in overshoot artifacts the can affect the diagnosis of diseases using radiographic images. |
| Servais [5] | 2018 | To evaluate fractal dimension and surface area of alveolar bone using cone beam computed tomography (CBCT) captured images of the patients with maxillary affected canines. | 49 | The resultant measurements showed that the maxillary bone area increased at the impacted side than that on the non-impacted side. |
| Wang [10] | 2016 | To present methods, datasets and results of the challenges and also presented the principles for further use in the defined benchmark. | 400 | The proposed method for X-ray dental images detection achieved significant improved performance on the challenging tasks. |
| Liansheng[13] | 2017 | To present a robust framework that Works with complicated datasets. | 280 | The results achieved in case of both dentine and enamel are good than that of pulp. The proposed method achieved relative low error to the ground truth and has high correlation. |
| P. Pandey [14] | 2017 | To present effective segmentation techniques for better diagnosis. | 40 | The proposed technique achieves the segmentation of the image by using only a few iterations. It can also help in root canal procedures as the geometric features of the teeth are also calculated. |
| Zang [31] | 2018 | To detect and classify dental periapical radiographs using deep learning. | 800 | The proposed approach achieved a good performance. It can be used for complex cases such filled tooth, tooth loss and also for decayed tooth . |
| Hegazy [40] | 2019 | Metal artifact reduction in dental CT. | 5 | The proposed method has better MAR performance than that of the conventional method and had reduced computation time. It should be noted that the proposed method used limited dataset. |

## V. CHALLENGES

1. Metal artifacts still remain a very important aspect and not all the techniques that are developed for metallic artifacts reduction are suitable, it has been found that some algorithms even further aggravate the artifacts.

(a)



(b)

**Fig.1. (a), (b) Images with metal artifacts.**

2. Patient related artifacts also tend in creation of unwanted artifacts.

3. The anatomical morphological structure of teeth and shapes of restoration also pose a significant challenge in the detection of dental diseases.

**Fig.2. Jaw Structure.**

4. Sometimes due to lack of information the dental disease assessment is entirely left to the clinical assessment, which can have potential bias.

## VI. CONCLUSION

Digital image processing has been in use for the detection of dental diseases for several years. The dental disease detection technologies have evolved over the span of time. The imaging technologies have several challenges that are needed to be considered. The image quality can be effected due to noise, patient artifacts or artifacts due to system used. In this paper, the main area of discussion was dental imaging technologies and various challenges related to them. There are still some techniques that need to be studied in detail. The radiation dosage used in some of these technologies should also be considered.

## REFERENCES

1. Veena Divya K., A. Jatti, R. Joshi and Deepu Krishna S., "Characterization of dental pathologies using digital panoramic X-ray images based on texture analysis," *2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Seogwipo, 2017, pp. 592-595.
2. K. Angelino, D. Edlund, G. Bhatia, S. Wu and P. Shah, "Near-Infrared Transillumination Guides Administration of Dental 2D Radiography and CBCT Imaging," *2017 IEEE 17th International Conference on Bioinformatics and Bioengineering (BIBE)*, Washington, DC, 2017, pp. 327-333.
3. S. A. Ahmad, M. N. Taib, N. E. A. Khalid and H. Taib, "Application of subjective objective image enhancement (SOIE) framework on dental images," *2017 IEEE 8th Control and System Graduate Research Colloquium (ICSGRC)*, Shah Alam, 2017, pp. 67-72.
4. Clark, Jefferson L., et al. "Effect of image sharpening on radiographic image quality." *The Journal of prosthetic dentistry* 120.6 (82018): 927-933.
5. Servais, Jerad A., et al. "Alternative cone-beam computed tomography method for the analysis of bone density around impacted maxillary canines." *American Journal of Orthodontics and Dentofacial Orthopedics* 154.3 (2018): 442-449.
6. Vandenberghe, Bart. "The digital patient–Imaging science in dentistry." *Journal of dentistry* 74 (2018): S21-S26.
7. Ibrahim Nasseh, Wisam Al-Rawi, Cone Beam Computed Tomography,Dental Clinics of North America, Volume 62, Issue 3, 2018, Pages 361-391.
8. Rujuta A. Katkar, Satyashankara Aditya Tadinada, Bennett T. Amaechi, Daniel Fried, Optical Coherence Tomography, Dental Clinics of North America, Volume 62, Issue 3, 2018,Pages 421-434.
9. Anita Gohel, Masafumi Oda, Amol S. Katkar, Osamu Sakai, Multidetector Row Computed Tomography in Maxillofacial Imaging, Dental Clinics of North America, Volume 62, Issue 3, 2018, Pages 453-465.
10. Wang, Ching-Wei, et al. "A benchmark for comparison of dental radiography analysis algorithms." *Medical image analysis* 31 (2016): 63-76.
11. R. R. Christina, R. Vanithamani and R. Dhivya, "Dental caries detection using NIR imaging technique," *International Conference on Recent Trends in Engineering, Science & Technology - (ICRTEST 2016)*, Hyderabad, 2016, pp. 1-4. doi: 10.1049/cp.2016.1486
12. Amaechi, Bennett T., Adepitan A. Owosho, and Daniel Fried. "Fluorescence and Near-Infrared Light Transillumination." *Dental Clinics* 62.3 (2018): 435-452.
13. Wang, Liansheng, et al. "A segmentation and classification scheme for single tooth in MicroCT images based on 3D level set and k-means++." *Computerized Medical Imaging and Graphics* 57 (2017): 19-28.
14. P. Pandey, A. Bhan, M. K. Dutta and C. M. Travieso, "Automatic Image Processing Based Dental Image Analysis Using Automatic Gaussian Fitting Energy and Level Sets," *2017 International Conference and Workshop on Bioinspired Intelligence (IWOBI)*, Funchal, 2017, pp. 1-5.
15. Husniye Demirturk Kocasarac, Hassem Geha, Laurence R. Gaalaas, Donald R. Nixdorf, MRI for Dental Applications, Dental Clinics of North America, Volume 62, Issue 3, 2018, Pages 467-480,
16. Husniye Demirturk Kocasarac, Christos Angelopoulos, Ultrasound in Dentistry: Toward a Future of Radiation-Free Imaging, Dental Clinics of North America, Volume 62, Issue 3, 2018, Pages 481-489,
17. Diwakar, Manoj, and Manoj Kumar. "A review on CT image noise and its denoising." *Biomedical Signal Processing and Control* 42 (2018): 73-88.
18. Nagarajappa, Anil Kumar, Neha Dwivedi, and Rana Tiwari. "Artifacts: The downturn of CBCT image." *Journal of International Society of Preventive & Community Dentistry* 5.6 (2015): 440.
19. Artefacts in CBCT: a reviewDentomaxillofac Radiolv.40(5); 2011 Jul

20. Tuchin, Valery V., ed. *Coherent-Domain Optical Methods: Biomedical Diagnostics, Environment and Material Science*. Springer Science & Business Media, 2004.
21. Leitgeb, R. A., and M. Wojtkowski. "Complex and coherence noise free Fourier domain optical coherence tomography." *Optical Coherence Tomography*. Springer, Berlin, Heidelberg, 2008. 177-207.
22. Aumann, Silke, et al. "Optical Coherence Tomography (OCT): Principle and Technical Realization." *High Resolution Imaging in Microscopy and Ophthalmology*. Springer, Cham, 2019. 59-85.
23. Langland, Olaf E., Robert P. Langlais, and John W. Preece. *Principles of dental imaging*. Lippincott Williams & Wilkins, 2002.
24. Meyer, Laura T., and Daniel T. Boll. "Novel technique for addressing streak artifact in gated dual-source MDCT angiography utilizing ECG-editing." *European radiology* 18.11 (2008): 2446-2448.
25. Chindasombatjaroen, J., Kakimoto, N., Murakami, S. et al. Oral Radiol (2011) 27: 114.
26. Kirti, Thakur, Kadam Jitendra, and Sapkal Ashok. "Poisson noise reduction from X-ray images by region classification and response median filtering." *Sādhanā* 42.6 (2017): 855-863.
27. Lu, Ching-Ta, et al. "Impulse noise denoising using confidence measure with non-sequential process order for X-ray bio-images." *Journal of Medical and Biological Engineering* 38.6 (2018): 905-916.
28. Toprak, Abdullah. "Quantum noise suppression in X-ray images using fuzzy 2-D Wiener filter." *Journal of medical systems* 31.5 (2007): 351-355.
29. Roy, Sudipta, et al. "International Journal of Advanced Research in Computer Science and Software Engineering." *International Journal* 3.6 (2013).
30. Shafiei, Farhad, et al. "Artifacts from dental casting alloys in magnetic resonance imaging." *Journal of dental research* 82.8 (2003): 602-606.
31. Zhang, Kailai, et al. "An effective teeth recognition method using label tree with cascade network structure." *Computerized Medical Imaging and Graphics* 68 (2018): 61-70.
32. Mathew, Chalakuzhiyl Abraham, and Maheshwaran Sudhakara Maller. "Interactions between magnetic resonance imaging and dental material." *Journal of pharmacy & bioallied sciences* 5.Suppl 1 (2013): S113.
33. Kremkau, Frederick W., and K. J. Taylor. "Artifacts in ultrasound imaging." *Journal of ultrasound in medicine* 5.4 (1986): 227-237.
34. Korn, P., et al. "MRI and dental implantology: Two which do not exclude each other." *Biomaterials* 53 (2015): 634-645.
35. Karatas, Orhan Hakki, and Ebubekir Toy. "Three-dimensional imaging techniques: A literature review." *European journal of dentistry* 8.01 (2014): 132-140.
36. Vandenberghe, Bart, Reinhilde Jacobs, and Hilde Bosmans. "Modern dental imaging: a review of the current technology and clinical applications in dental practice." *European radiology* 20.11 (2010): 2637-2655.
37. Zandona, Andrea Ferreira. *Detection and Assessment of Dental Caries: A Clinical Guide*. Springer Nature.
38. Ariji, Yoshiko, et al. "Magnetic resonance imaging in endodontics: a literature review." *Oral radiology* 34.1 (2018): 10-16.
39. Hogan, Richard, et al. "Further opportunities for digital imaging in dental epidemiology." *Journal of dentistry* 74 (2018): S2-S9.
40. Hegazy, Mohamed AA, et al. "U-net based metal segmentation on projection domain for metal artifact reduction in dental CT." *Biomedical engineering letters* 9.3 (2019): 375-385.


## AUTHORS PROFILE

**Shubhreet Kaur** is pursuing Master's of Technology in Computer Science & Engineering from Guru Nanak Dev University, Amritsar, Punjab. She has received her Bachelor's of Technology degree from Giani Zail Singh Campus College of Engineering and Technology, Bathinda, Punjab. Her research interests are Digital Image Processing and Deep Learning.

**Chetan Marwaha** is working as a System Manager in Department of Computer Science & Technology at Guru Nanak Dev University, Amritsar, Punjab. He has a post graduation degree in Master of Computer Applications in Computer Science from Guru Nanak Dev University, Amritsar. He has published more than 10 research papers in UGC Approved Journals. His main research area focuses on Digital Image Processing, Image Segmentation, Web App. Development.