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Review Article

Capturing Precision: The Role of Photogrammetry in Modern Dentistry

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ABSTRACT:
Photogrammetry, a non-invasive imaging technique, has become indispensable in modern dentistry.This technique utilizes photographs to create accurate 3D models of patients' oral cavities, facilitating meticulous pre-surgical planning and ensuring superior patient outcomes. Recent advancements in artificial intelligence and augmented reality promise to further refine photogrammetric applications, making dental procedures more predictable and aesthetically pleasing.The integration of photogrammetry in dental practices signifies a leap towards personalized, patient-centric care.
Keywords: Photogrammetry, Dental Implantology, 3D Modeling, Non-Invasive Technique, Artificial Intelligence, Augmented Reality, Patient Outcomes.

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INTRODUCTION

Advancements in dental technology have continuously reshaped the landscape of modern dentistry, enhancing precision, efficiency, and patient outcomes. In the ever-evolving landscape of dental technology, photogrammetry has emerged as a pivotal innovation, transforming the way practitioners capture and utilize dental images. This technique, rooted in the science of obtaining reliable measurements through photographs, offers a leap forward from traditional impression methods to a digital realm of precision and efficiency. This method of capturing detailed three-dimensional data through photography has revolutionized the way dental professionals approach implant procedures, offering unparalleled accuracy in measuring implant positions and aiding in the transfer of these coordinates into clinical practice[1]. With over a million implant procedures conducted annually worldwide, the integration of photogrammetry with virtual implant planning systems and cone beam computed tomography (CBCT) data has significantly enhanced the project planning phase for dental implants[2]. Research has shown that photogrammetry devices are more accurate for complete-arch implant rehabilitation than intraoral scanners and traditional impression methods[3].

PRINCIPLES OF PHOTOGRAMMETRY

Photogrammetry is a technique that involves the application of photographic images to measure and map the dimensions and spatial relationships of objects. This technique allows for the accurate interpretation of photographic images to provide detailed information about real-world objects and its surrounding space [4]. This technique has been applied into clinical dental research as a non-invasive tool that uses photographs to create three-dimensional models of teeth and oral structures, providing a detailed visual representation that is crucial for accurate diagnostics and treatment planning[5].

The fundamental principles of photogrammetry involves the following process[4,6,7,8].

Image Acquisition

- **Photography**: Photogrammetry begins with capturing multiple overlapping photographs of the subject from different angles. In dental

applications, intraoral scanners or cameras are used to take detailed images of the patient's oral structures.

- **Lighting**: Proper lighting is crucial for obtaining high-quality images. Consistent and adequate illumination helps to minimize shadows and reflections, ensuring that the photographs accurately represent the dental structures.

Image Processing

- **Feature Detection**: Specialized software identifies and extracts unique features from the images, such as edges, corners, and textures. These features serve as reference points for aligning and matching the images.
- **Image Matching**: The software matches corresponding features across multiple images, establishing a network of points that relate the photographs to each other spatially.

3D Reconstruction

- **Triangulation**: By using the matched points, the software performs triangulation to calculate the 3D coordinates of each point. Triangulation involves determining the location of a point in 3D space by measuring angles from known reference points.
- **Model Generation**: The calculated 3D coordinates are used to generate a detailed digital model of the dental structures. This model can be visualized, manipulated, and analyzed using various software tools.

Accuracy and Precision

- **Calibration**: To ensure accuracy, photogrammetry systems must be calibrated. Calibration involves defining the parameters of the imaging system, such as camera position, orientation, and lens distortion.
- **Error Minimization**: Techniques such as bundle adjustment are employed to minimize errors and improve the precision of the 3D model. Bundle adjustment refines the 3D coordinates by optimizing the alignment of all images in the dataset

EQUIPMENT AND TECHNOLOGY IN PHOTOGRAMMETRY

The technological backbone of photogrammetry in dentistry is comprised of advanced equipment and software that work in tandem to produce accurate 3D models. The primary tool used in this technique is a photogrammetry camera, which is specifically designed to capture high-resolution images with precise calibration to ensure measurement accuracy. These cameras are often accompanied by a series of coded targets placed on the object of interest, which serve as reference points for the software during image processing.

In addition to the camera, photogrammetry uses sophisticated software that can do intricate calculations to create a 3D model from 2D photos. This software utilizes algorithms that identify and match patterns across multiple photographs, permitting the development of a digital model that precisely captures the geometry of the oral cavity[10].

In recent times, photogrammetry systems have also incorporated facial scanning technologies.Facial scanners provide a comprehensive view of the patient's face, which is essential for procedures that require a detailed understanding of both dental and facial structures. These scanners have been evaluated in terms of their importance, applications, limitations, and future directions within dental practice.

The combination of these technologies has proven to be a game-changer in implant dentistry. By leveraging virtual implant planning systems alongside CBCT data, dental professionals can now plan implant projects with a level of precision previously unattainable[12].

APPLICATION IN DENTISTRY

Orthodontics: Photogrammetry is employed in orthodontics for precise measurements and evaluation of facial profiles, which are necessary for diagnosing malocclusions and planning treatment strategies. This technology aids in the accurate assessment of tooth movement, alignment, and occlusion, critical for designing custom orthodontic appliances and braces. The precision of photogrammetry ensures that these appliances are tailored to the unique contours of each patient's oral cavity, leading to improved treatment outcomes and patient satisfaction. Chitra et al, based on their studies concluded that photogrammetry can be effectively employed as a tool to aid orthodontic diagnosis and treatment planning[10]. Normando *et.al* in their investigation, found that with the exception of the mesio-distal width of upper first molar, photogrammetric method on standardized occlusal photographs are a reliable instrument for clinical and scientific application to measure dental arch dimensions and tooth size[11].

Prosthodontics: In prosthodontics, photogrammetry has been transformative in verifying occlusal contacts and analyzing jaw relations. It allows for a non-invasive and distortion-free capture of complete arches, which is essential for creating precise prosthodontic devices such as crowns, bridges, and dentures. The technology also facilitates the assesment of tooth preparations to ensure that prosthetic components fit accurately within the patient's existing dental structure. By providing a detailed 3D reconstruction of teeth and facial anatomy, photogrammetry assists prosthodontists in achieving a higher level of aesthetic and functional restoration. [12,13,14].

Implantology: The application of photogrammetry in implantology has significantly enhanced the precision of implant placement. By creating detailed three dimensional models of the oral cavity, implantologists can plan surgical interventions with greater precision. This technology allows for the assessment of bone quality and quantity, as well as the spatial orientation

needed for optimal implant positioning. Photogrammetry also supports the virtual transfer of implant locations to CAD software, streamlining the design and fabrication process for implant-supported restorations. The application of this technology minimizes errors and improves the predictability of implant procedures[1,2].

Oral Surgery: In oral surgery, photogrammetry provides surgeons with a comprehensive view of the surgical site. This level of detail is vital for complex procedures such as bone grafting or corrective jaw surgery, where spatial orientation and measurements must be exact to ensure successful surgical outcomes[15].

ADVANTAGES OF PHOTOGRAMMETRY

Photogrammetry stands out in the field of dentistry for its precision and efficiency. Here are a few specific benefits that have been proven by research

1. **Precision in Data Acquisition:** High accuracy in getting 3D data is a well-known feature of photogrammetry. This is especially helpful in implantology, where accurate measurements are necessary to achieve favourable results[16].
2. **Non-invasive Nature:** The contactless application of photogrammetry ensures a non-invasive experience for patients. This is a significant advantage over traditional impression methods that can be uncomfortable, especially for those with a sensitive gag reflex[5].
3. **Rapid Processing Capabilities:** Photogrammetry allows for the digital processing of vast amounts of information swiftly, which is necessary in today's fast-paced clinical settings. The acquisition of virtual models with high accuracy in a short period is essential component in reducing the treatment duration[17].
4. **Cost-Effectiveness:** The simplicity and affordability of photogrammetry make it a cost-effective alternative to other more complex imaging techniques. This is especially crucial in environments with limited resources and concerns about budgetary restrictions[18].

CHALLENGES AND LIMITATIONS OF PHOTOGRAMMETRY

While photogrammetry offers numerous advantages in dentistry, it is not without its challenges and limitations. The following are some main imitations that are backed up by research:

1. **Limited Recording Capabilities:** Photogrammetry primarily records the position information of implant abutments but requires additional procedures to capture soft tissue information. This limitation can affect comprehensive treatment planning[1].
2. **Photographic Challenges:** The process of recording the surface shape of a living tooth in the mouth presents significant photographic challenges, such as achieving adequate lighting and managing patient movement during image capture.
3. **Precision Concerns:** Although photogrammetry can achieve levels of trueness and precision comparable to conventional methods, there is limited assessment on the accuracy when combining screw-retained optical markers with photogrammetry technology for recording implant positions[16].
4. **3D Representation Limitations:** Conventional dental photography, which provides high degree of spatial resolution and color, is limited to 2D information. Without a comprehensive 3D representation, diagnosis and treatment can be complicated, necessitating multiple photos from different angles[18].
5. **Need for Further Studies:** While photogrammetry is accurate for transferring implant positions during multiunit implant prostheses treatment, further research are required to enhance its 3D scanning capabilities and address its limitations.

CONCLUSION

Photogrammetry has emerged as a transformative technology in dentistry, offering unparalleled precision in 3D modeling and implant placement. Its non-invasive nature, combined with the capacity to produce highly accurate dental records, positions it as a valuable tool for clinicians and patients alike. The integration of AI and AR into photogrammetric systems promises to further enhance treatment planning, patient outcomes, and collaborative efforts among dental professionals. As we look to the future, the continued evolution of photogrammetry is poised to revolutionize dental practices, making procedures more efficient, predictable, and aesthetically pleasing. With ongoing research and clinical studies validating its efficacy, photogrammetry stands at the forefront of dental innovation, ready to deliver the next level of care in oral health.

REFERENCES

1. Hussein MO. Photogrammetry technology in implant dentistry: A systematic review. J Prosthet Dent. 2023 Sep;130(3):318-326.
2. Ma B, Yue X, Sun Y, Peng L, Geng W. Accuracy of photogrammetry, intraoral scanning, and conventional impression techniques for complete-arch implant rehabilitation: an in vitro comparative study. BMC Oral Health. 2021 Dec 10;21(1):636.
3. Lie A, Jemt T. Photogrammetric measurements of implant positions.Description of a technique to determine the fit between implants and superstructures. Clin Oral Implants Res. 1994;5 Mar;5(1):30–6.
4. Jemt T, Back T, Petersson A. Photogrammetry: an alternative to conventional impressions in implant

dentistry? A clinical pilot study. Int J Prosthodont. 1999;12:363–8.
5. Chadwick RG. Close range photogrammetry--a clinical dental research tool. J Dent. 1992 Aug;20(4):235-9.
6. Mitchell HL, Chadwick RG. Challenges of photogrammetric intra-oral tooth measurement. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Kyoto, Japan. 2008 Jan 1:779-82.
7. Deepika B. Capturing Precision: The Growing Role of Photogrammetry in Implant Dentistry. IOSR J Dent Med Sci. 2023;22(4):46-49
8. Yang B, Schinke J, Rastegar A, Tanyeri M, Viator JA. Cost-Effective Full-Color 3D Dental Imaging Based on Close-Range Photogrammetry. *Bioengineering*. 2023; 10(11):1268.
9. Divya B, Deshraj J, Mukesh S, Neelam N. Photogrammetry in Prosthodontics - A Review - IJFMR Volume 5, Issue 4, July-August 2023. DOI 10.36948/ijfmr.2023.v05i04.4155
10. Chitra P, Prakash A. Photogrammetry as a tool to aid orthodontic diagnosis and treatment assessment. Journal of Contemporary Orthodontics. 2017;1(2):46-51.
11. Normando D, da Silva PL and Mendes ÁM, 2011. A clinical photogrammetric method to measure dental arch dimensions and mesiodistal tooth size. Eur J Orthod, 33(6):721-6.
12. Matsuo M, Mine Y, Kawahara K, Murayama T. Accuracy Evaluation of a Three-Dimensional Model Generated from Patient-Specific Monocular Video Data for Maxillofacial Prosthetic Rehabilitation: A Pilot Study. Journal of Prosthodontics. 2020 Oct;29(8):712-7.
13. Unkovskiy A, Spintzyk S, Beuer F, Huettig F, Röhler A, Kraemer-Fernandez P. Accuracy of capturing nasal, orbital, and auricular defects with extra-and intraoral optical scanners and smartphone: an in vitro study. Journal of Dentistry. 2022 Feb 1;117:103916.
14. Vukovic A, Jakupovic S, Zukic S, Secic S, Bajsman A. computer aided Photogrammetry for evaluation of facial and Dental symmetry. Acta Informatica Medica. 2010 Apr 1;18(2):88.
15. Korol DM, Kindiy DD, Kindiy PD, Odzhubeiska OD, Toncheva KD. Photogrammetry in dentistry: A literature review. The Medical and Ecological Problems. 2022 Apr 15;26(1-2):32-6.
16. Revilla-León M, Att W, Özcan M, Rubenstein J. Comparison of conventional, photogrammetry, and intraoral scanning accuracy of complete-arch implant impression procedures evaluated with a coordinate measuring machine. J Prosthet Dent. 2021 Mar;125(3):470-478.
17. Magnani M, Douglass M, Schroder W, Reeves J, Braun DR. The digital revolution to come: Photogrammetry in archaeological practice. American Antiquity. 2020 Oct;85(4):737-60.
18. Yang B, Schinke J, Rastegar A, Tanyeri M, Viator JA. Cost-Effective Full-Color 3D Dental Imaging Based on Close-Range Photogrammetry. Bioengineering (Basel). 2023Oct31;10(11):1268.