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# Automated Facial Symmetry Assessment for Orthognathic Surgery: Utilizing 3D Contour Mapping and Hyperdimensional Computing-Based Machine Learning

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**Abstract :** This study aimed to improve the evaluation of facial symmetry, which is crucial for planning and assessing outcomes in orthognathic surgery (OGS). Facial symmetry plays a key role in both aesthetic and functional aspects of OGS, making its accurate evaluation essential for optimal surgical results. To address the limitations of traditional methods, a different approach was developed, combining three-dimensional (3D) facial contour mapping with hyperdimensional (HD) computing to enhance precision and efficiency in symmetry assessments. The study was conducted at Chang Gung Memorial Hospital, where data were collected from 2018 to 2023 using 3D cone beam computed tomography (CBCT), a highly detailed imaging technique. A large and comprehensive dataset was compiled, consisting of 150 normal individuals and 2,800 patients, totaling 5,750 preoperative and postoperative facial images. These data were critical for training a machine learning model designed to analyze and quantify facial symmetry. The machine learning model was trained to process 3D contour data from the CBCT images, with HD computing employed to power the facial symmetry quantification system. This combination of technologies allowed for an objective and detailed analysis of facial features, surpassing the accuracy and reliability of traditional symmetry assessments, which often rely on subjective visual evaluations by clinicians. In addition to developing the system, the researchers conducted a retrospective review of 3D CBCT data from 300 patients who had undergone OGS. The patients' facial images were analyzed both before and after surgery to assess the clinical utility of the proposed system. The results showed that the facial symmetry algorithm achieved an overall accuracy of 82.5%, indicating its robustness in real-world clinical applications. Postoperative analysis revealed a significant improvement in facial symmetry, with an average score increase of 51%. The mean symmetry score rose from 2.53 preoperatively to 3.89 postoperatively, demonstrating the system's effectiveness in quantifying improvements after OGS. These results underscore the system's potential for providing valuable feedback to surgeons and aiding in the refinement of surgical techniques. The study also led to the development of a web-based system that automates facial symmetry assessment. This system integrates HD computing and 3D contour mapping into a user-friendly platform that allows for rapid and accurate evaluations. Clinicians can easily access this system to perform detailed symmetry assessments, making it a practical tool for clinical settings. Additionally, the system facilitates better communication between clinicians and patients by providing objective, easy-to-understand symmetry scores, which can help patients visualize the expected outcomes of their surgery. In conclusion, this study introduced a valuable and highly effective approach to facial symmetry evaluation in OGS, combining 3D contour mapping, HD computing, and machine learning. The resulting system achieved high accuracy and offers a streamlined, automated solution for clinical use. The development of the web-based platform further enhances its practicality, making it a valuable tool for improving surgical outcomes and patient satisfaction in orthognathic surgery.

**Keywords :** facial symmetry, orthognathic surgery, facial contour mapping, hyperdimensional computing
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