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Tool for Maxillary Sinus Quantification in Computed Tomography Exams

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Abstract : The maxillary sinus (MS), part of the paranasal sinus complex, is one of the most enigmatic structures in modern humans. The literature has suggested that MSs function as olfaction accessories, to heat or humidify inspired air, for thermoregulation, to impart resonance to the voice and others. Thus, the real function of the MS is still uncertain. Furthermore, the MS anatomy is complex and varies from person to person. Many diseases may affect the development process of sinuses. The incidence of rhinosinusitis and other pathoses in the MS is comparatively high, so, volume analysis has clinical value. Providing volume values for MS could be helpful in evaluating the presence of any abnormality and could be used for treatment planning and evaluation of the outcome. The computed tomography (CT) has allowed a more exact assessment of this structure, which enables a quantitative analysis. However, this is not always possible in the clinical routine, and if possible, it involves much effort and/or time. Therefore, it is necessary to have a convenient, robust, and practical tool correlated with the MS volume, allowing clinical applicability. Nowadays, the available methods for MS segmentation are manual or semi-automatic. Additionally, manual methods present inter and intraindividual variability. Thus, the aim of this study was to develop an automatic tool to quantity the MS volume in CT scans of paranasal sinuses. This study was developed with ethical approval from the authors' institutions and national review panels. The research involved 30 retrospective exams of University Hospital, Botucatu Medical School, São Paulo State University, Brazil. The tool for automatic MS quantification, developed in Matlab®, uses a hybrid method, combining different image processing techniques. For MS detection, the algorithm uses a Support Vector Machine (SVM), by features such as pixel value, spatial distribution, shape and others. The detected pixels are used as seed point for a region growing (RG) segmentation. Then, morphological operators are applied to reduce false-positive pixels, improving the segmentation accuracy. These steps are applied in all slices of CT exam, obtaining the MS volume. To evaluate the accuracy of the developed tool, the automatic method was compared with manual segmentation realized by an experienced radiologist. For comparison, we used Bland-Altman statistics, linear regression, and Jaccard similarity coefficient. From the statistical analyses for the comparison between both methods, the linear regression showed a strong association and low dispersion between variables. The Bland–Altman analyses showed no significant differences between the analyzed methods. The Jaccard similarity coefficient was > 0.90 in all exams. In conclusion, the developed tool to quantify MS volume proved to be robust, fast, and efficient, when compared with manual segmentation. Furthermore, it avoids the intra and inter-observer variations caused by manual and semi-automatic methods. As future work, the tool will be applied in clinical practice. Thus, it may be useful in the diagnosis and treatment determination of MS diseases. Providing volume values for MS could be helpful in evaluating the presence of any abnormality and could be used for treatment planning and evaluation of the outcome. The computed tomography (CT) has allowed a more exact assessment of this structure which enables a quantitative analysis. However, this is not always possible in the clinical routine, and if possible, it involves much effort and/or time. Therefore, it is necessary to have a convenient, robust and practical tool correlated with the MS volume, allowing clinical applicability. 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Thus, it may be useful in the diagnosis and treatment determination of MS diseases.

Keywords : maxillary sinus, support vector machine, region growing, volume quantification
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