Algorithm to automatically quantify maxillary sinus using computed tomography images

MSc. Guilherme Giacomini, MSc. Ana Luiza Menegatti Pavan, PhD. João Maurício Carrasco Altemani, PhD. Sergio Barbosa Duarte, PhD. Carlos Magno Castelo Branco Fortaleza, PhD. José Ricardo de Arruda Miranda, PhD. Diana Rodrigues de Pina*

Abstract

Description of the automated tool, which was developed for quantifying the total and air-free volume of the maxillary sinus based on computed tomography images. The quantification tool seeks to standardize maxillary sinus volume measurements, thus allowing better comparisons and determinations of factors that influence maxillary sinus size. The automated tool utilized image processing techniques.

Please contact PhD. Diana Rodrigues de Pina (drpina@fmb.unesp.br) for additional information regarding this protocol.

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Guidelines

Please contact Dra. Diana Rodrigues de Pina (drpina@fmb.unesp.br) for additional information regarding this protocol.

Protocol

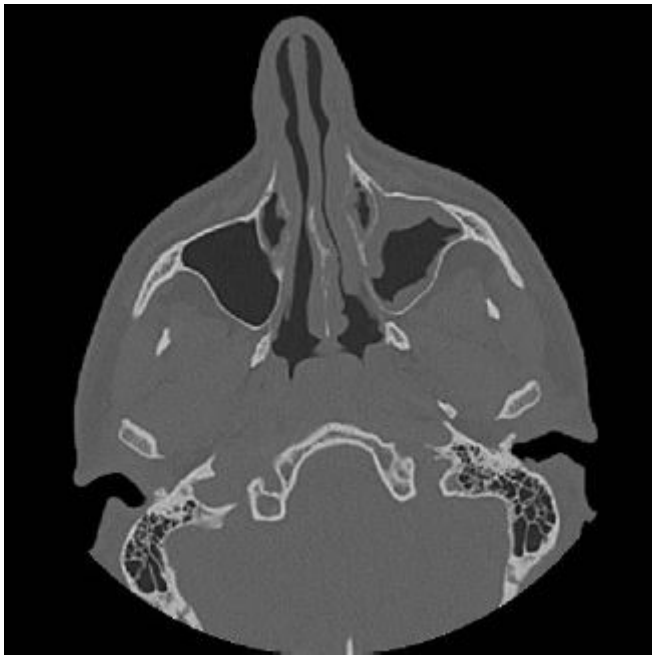
Maxillary sinus volume quantification algorithm

Step 1.

The algorithm reads paranasal sinus CT exam of the patient (CT slices and DICOM information). We recommended CT exams with 0.5 mm of slice thicknesses.

Step 2.

Algorithm selects the central slice of the exam. An example is shown in Figure 1.



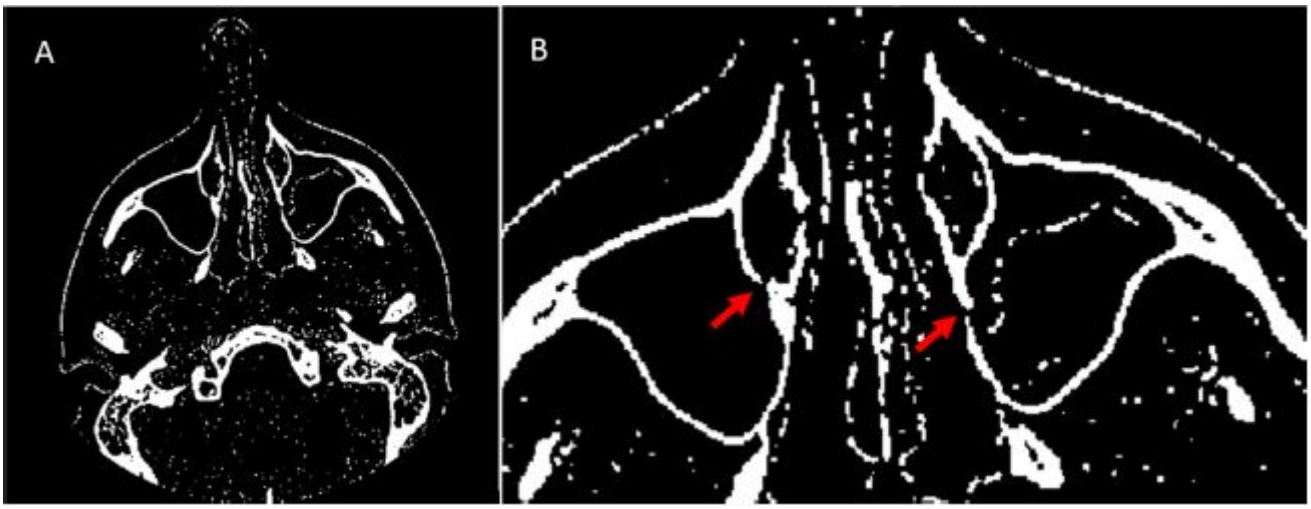
Step 3.

The central slice is thresholded (threshold = 150 HU). This step highlights bone structures and remove soft tissues. An example is shown in Figure 2.

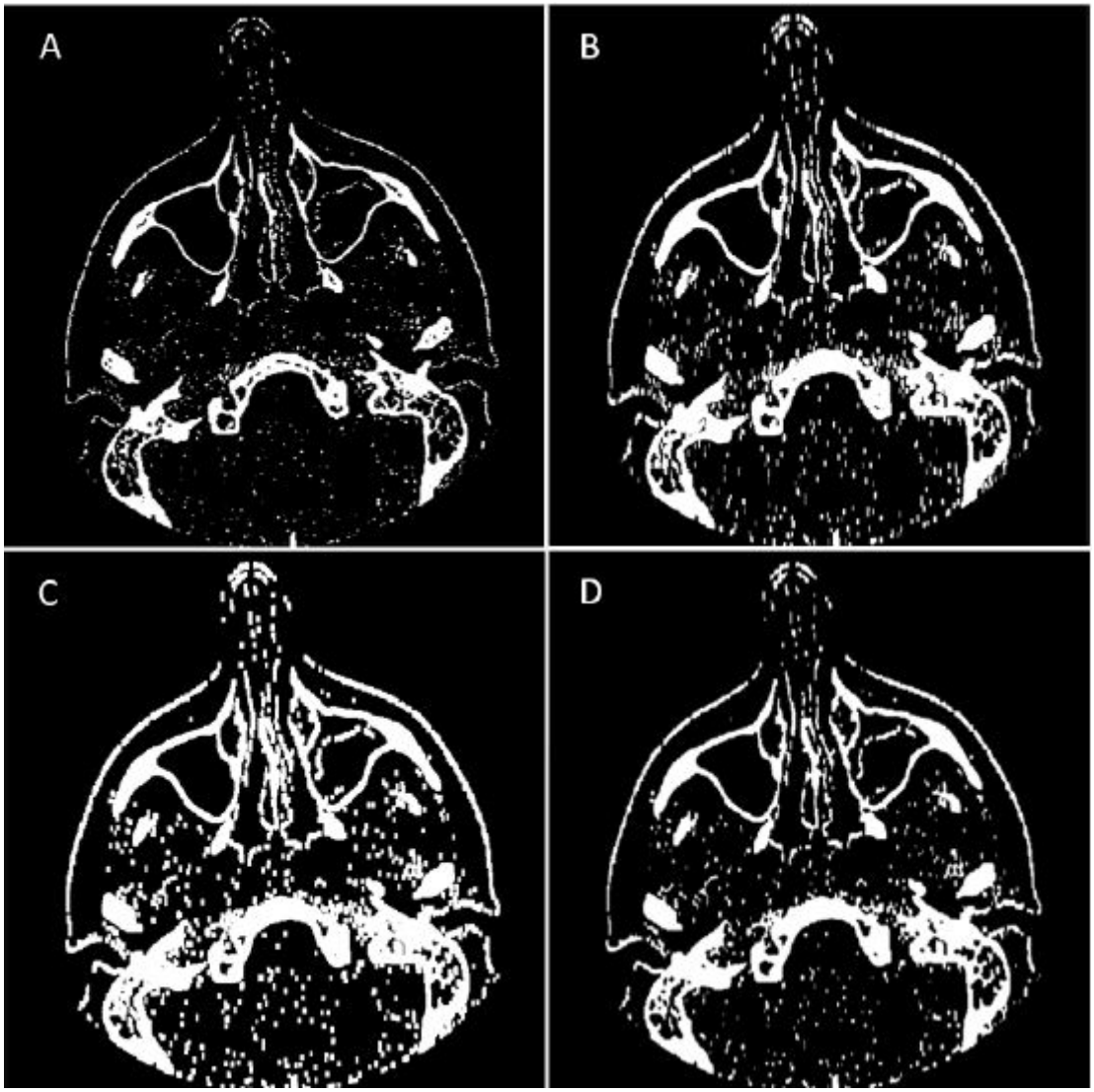
Step 4.

Thresholded image is adjusted by applying morphological operators. First, an erosion technique is applied in order to remove small areas, which were erroneously segmented as bone structures. After

this step, in some slices it is possible to notice small discontinuities in the limits of maxillary sinus, as shown in Figure 3, indicated by the arrows.

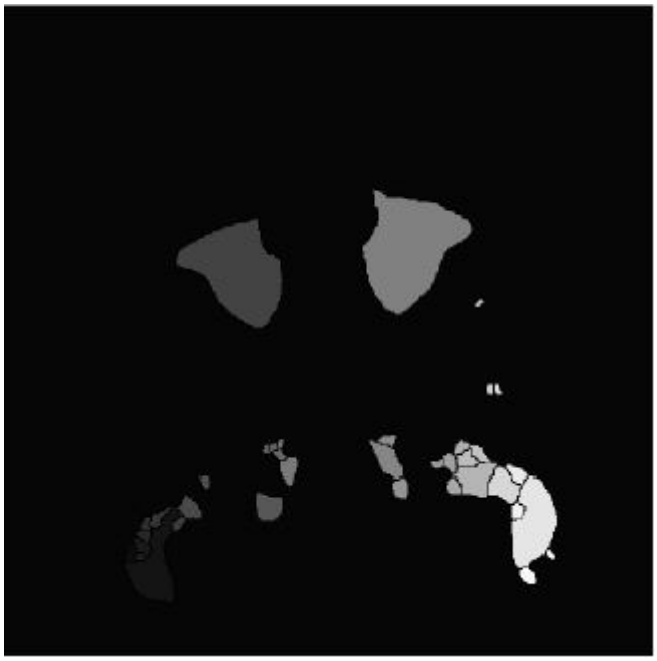


In order to fill discontinuities of the maxillary sinus bone edges, a sequence of dilation and erosion techniques in different directions is applied. An example of this sequence of morphological operators to fill the edges is shown in Figure 4.



Step 5.

Watershed technique is applied. Figure 5 shows the segmentation by the watershed technique, where each gray level represents a detected region.



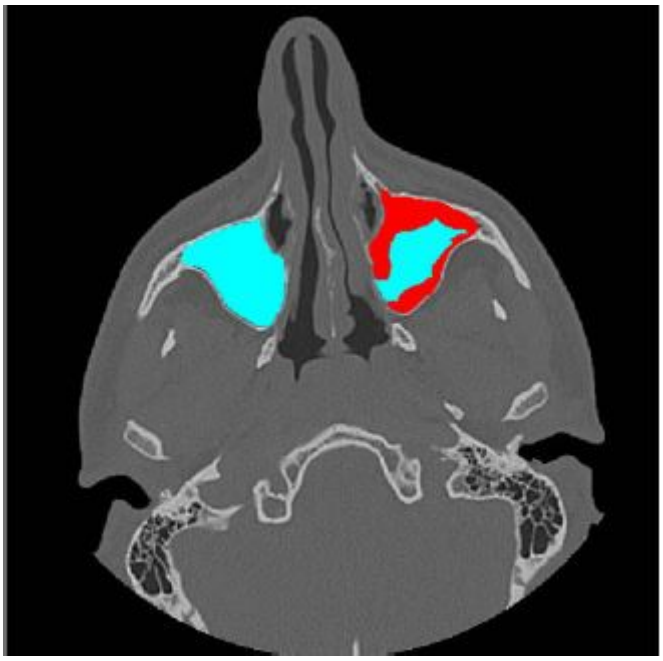
Step 6.

An rule-based system is applied, using information previously inserted during the algorithm development. The rule-based system compares the largest segmented areas, by evaluation of position, shape and symmetry features, selecting only the two areas of maxillary sinus. An example is shown in Figure 6.

Step 7.

The free-air and involvement (mucous membrane thickening, cysts, and/or fluid) areas are classified. This process was performed using the threshold technique. The range of attenuation of air in the

maxillary sinus was set between -200 and -1200 HU. An example of this step is shown in Figure 7, where air-free and involvement regions are represented by blue and red regions, respectively.



Step 8.

The steps 2-7 are repeated for the other slices (upper and lower).This process is repeated until the rule-based system was no longer satisfied. Thus, the entire CT exam was assessed, resulting in a volumetric region of interest.

Step 9.

The total and air-free volumes of the MS are measured by multiplying the number of voxels in the volumetric region by the voxel volume, which could be reconstructed into a three-dimensional (3D) image (Figure 8).