Optimization of 2D CT Data Sets for Three-Dimensional

Craniofacial Imaging and Modeling

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Computer-generated anatomic modeling using radiologic data is a well-known entity. Currently, state of the art 3D modeling systems lack the variable thresholding, user interactive, capabilities of 3D imaging software.[1] We investigated clinical parameters - CT scan plane, 2D filter algorithm, surrounding medium - and tested a simple mathematical thresholding algorithm based upon experimentation with a CT phantom, to evaluate a semiautomated approach to 3D craniofacial imaging and model generation. (Figure 1)

Our investigation indicated that CT scan orientation is a significant determinant of accuracy in 3D image generation. In addition, we propose a simple thresholding algorithm to optimize threshold selection under conditions where only a single threshold value may be utilized - i.e., the generation of anatomic models from craniofacial osseous structures as visualized on CT. This algorithm provides a flexible framework for refining semiautomated thresholding; that is, a coefficient may be modified after further clinical trials (e.g., substituting 0.10 for 0.16 in Appendix I) to better approximate operator-selected thresholds.

The most significant subjective element in this semiautomated approach is the selection of representative target and background tissues. This task is partially simplified by restricting the anatomic region of interest, and could be theoretically improved by using cluster plot analysis[2]. Since this type of analysis is also subject to variation based upon population distribution of pixel densities, we are confident that an experienced technician or radiologist can select representative target and background densities based upon display options available on current CT scanners

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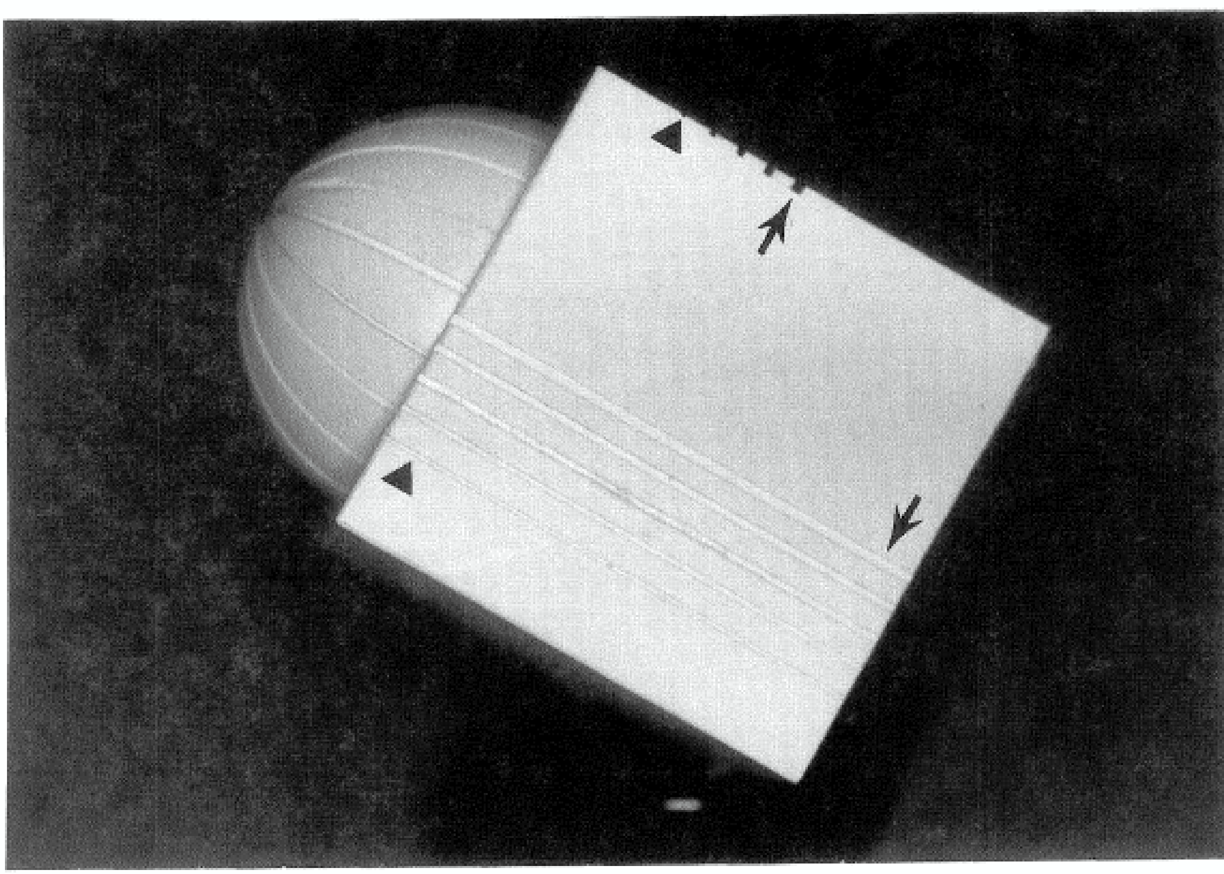
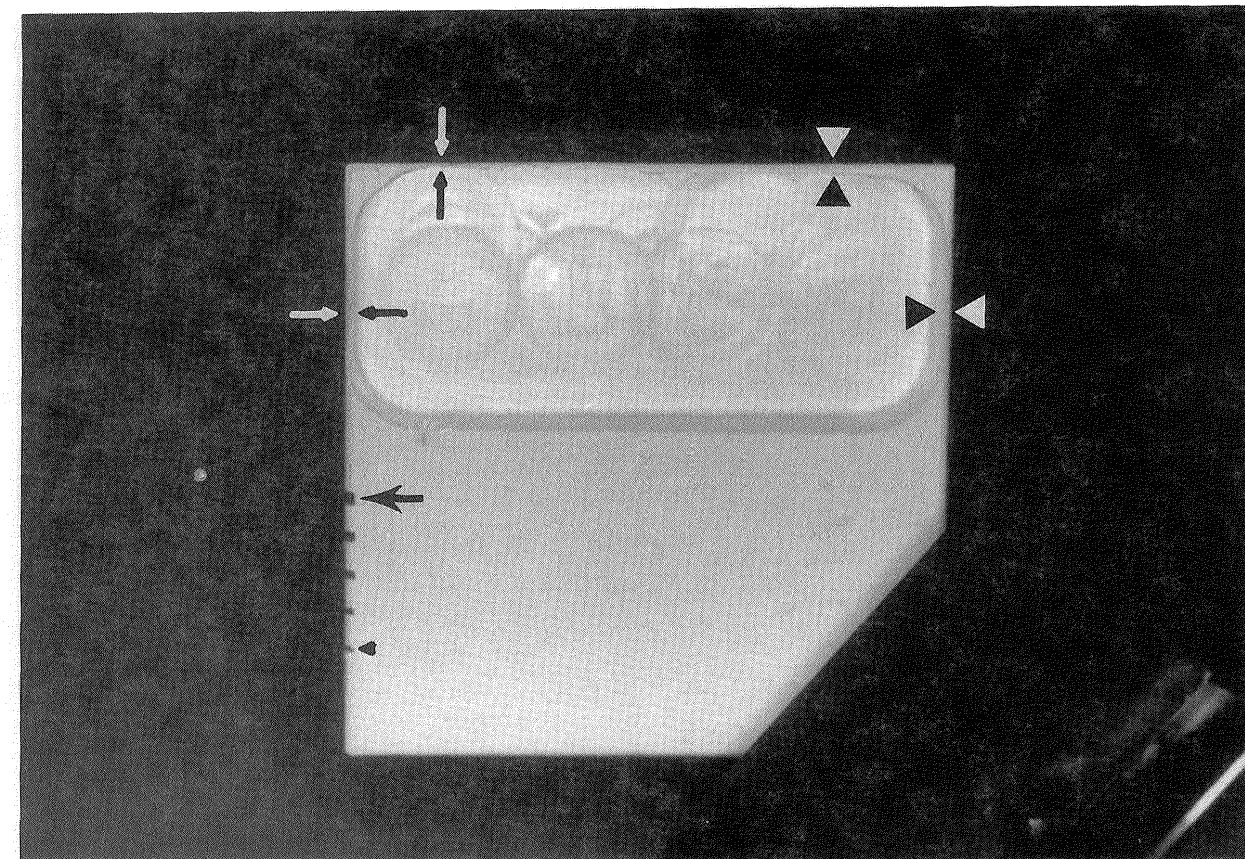
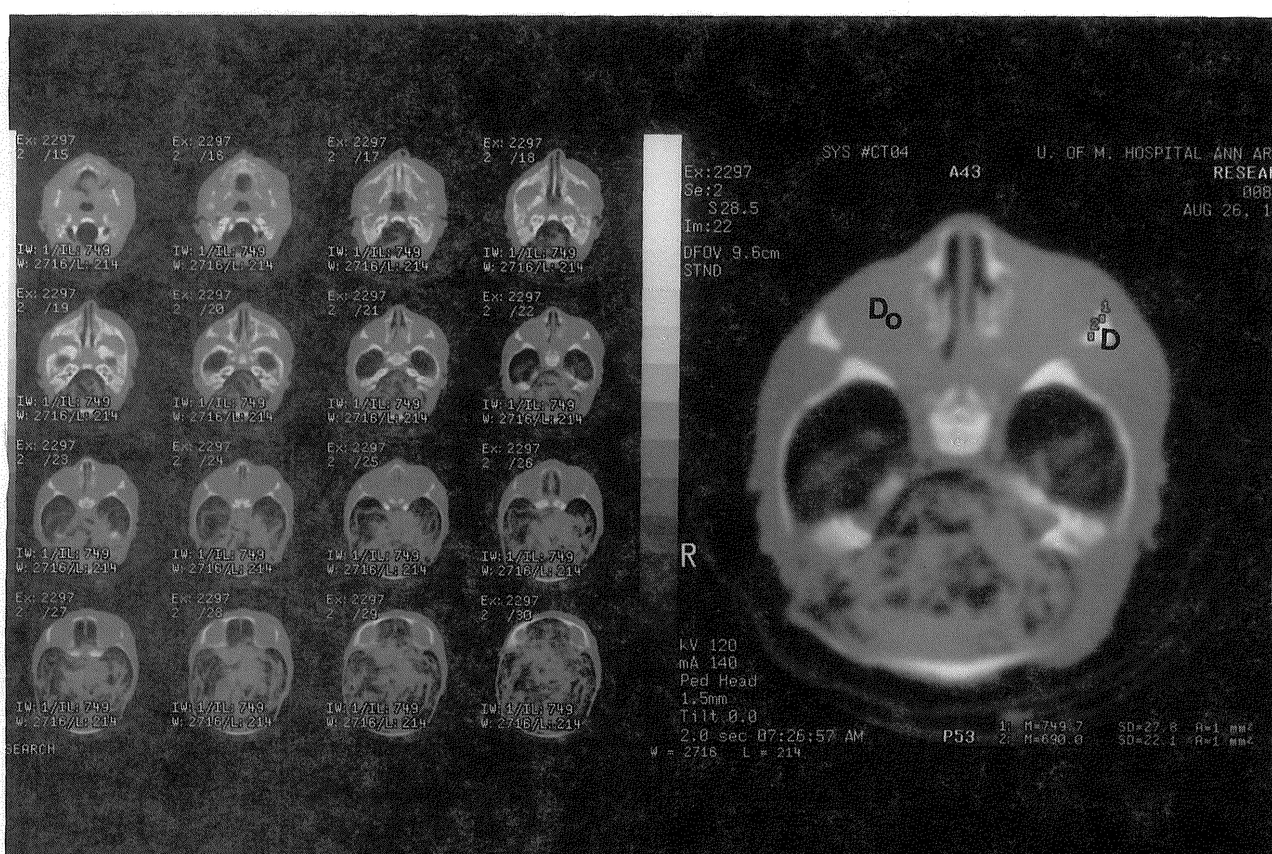
(Figure 2). When advances in imaging technology permit instantaneous cluster plot-type analyses of entire CT data sets, our thresholding algorithm could be applied to yield near real-time evaluation of CT data sets for craniofacial modeling.

We conclude that experimentation with a CT phantom can lead to semiautomated three dimensional craniofacial imaging and modeling. Further investigation of 2D CT craniofacial data sets is justified.



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U. OF M. HOSPITAL ANN ARB
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AUG 26, 19
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kV 120
mA 140
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2.0 sec 07:26:57 AM
W = 2716 L = 214
P53
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Legend to Figures

Figure 1a Photograph of a lateral view of the PVC phantom. Black arrowhead indicates slit of 0.375 mm width. Black arrow indicates slit of 1.1 mm width. Intermediate slits range from 0.55 to 0.94 mm.

Figure 1b Small black arrowhead and single black arrow correspond to slits in Figure 1a. Paired double black and white arrows indicate 0.375 mm-thick "shelves" forming one corner of the phantom base. Paired large black and white arrowheads indicate 0.75 mm-thick "shelves" forming another corner of the phantom base.

Figure 2 Generation of 16 two-dimensional CT slices for the purpose of selecting D, the highest density target tissue in the anatomic region of interest. The "Identify" and "Multiply Display" options are used to initially select D which is verified via an ROI cursor (magnified CT image on the right.) In this setting, Do = the highest density background tissue in the anatomic region of interest (intraorbital soft tissue), was also selected using the "Multiple Display" option and measured with a ROI cursor.

References

1. Levy RA, Guduri S, Crawford RH. Preliminary experience with selective laser sintering models of the human temporal bone. AJNR (in print)
2. Kohn MI, et al. Analysis of brain and cerebrospinal fluid volumes with MR imaging. Radiology 1991; 178:115-122.

Appendix I

Since $T = (0.16)\,|D\text{-}Do| + Do$ for $|D\text{-}Do| > 200$ HU

and $T = (0.5)\,|D\text{-}Do| + Do$ for $|D\text{-}Do| < 80$ HU

a parametric expression for $80 \leq |D\text{-}Do| \leq 200$ combining the above expressions was developed:

Thus $T = (t)\,[(0.16)(|D\text{-}Do|) + Do] + (1-t)\,[(0.5)(|D\text{-}Do|) + Do]$ for $80 \leq |D\text{-}Do| \leq 200$

* Let $C = |D\text{-}Do|$

Then $T = C[(0.5) - (0.34)(t)] + Do$

When $t = 0$, $C \leq 80$

When $t = 1$, $C \geq 200$

Thus $t = (0.008)\,(C) - 0.64$ and

$T = C[(0.5) - (0.34)[(0.008)\,(C) - 0.64]] + Do$

$= Do + (0.73)\,(C) - (0.003)\,(C)^2$

$= Do + (0.73)\,(|D\text{-}Do|) - (0.003)\,(|D\text{-}Do|)^2$

for $80 \leq |D\text{-}Do| \leq 200$

HU = Hounsfield Units