ASSISTING ACUTE INFARCT DETECTION FROM NON-CONTRAST CT USING IMAGE ADAPTIVE WINDOW SETTING

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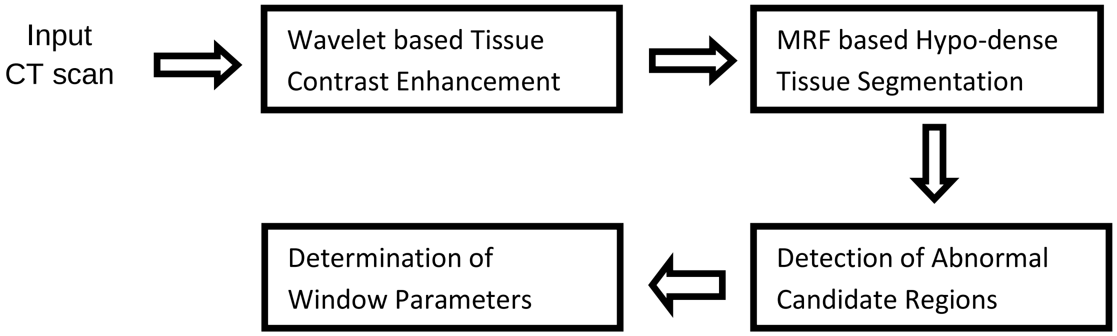
Background and purpose: During the initial stages (0-6 hrs.) of ischemic stroke, the affected tissues show very subtle hypo-attenuation (~4-6 H.U.) which can be missed by the radiologist due to the low tissue contrast offered by Computed Tomography (CT). This stage of stroke is known as Acute Infarct. The ability of a radiologist to detect these subtle changes depends on the accurate selection of view window (on the Hounsfield scale). The window selection is generally a trial and error process, which largely depends on the experience of the radiologist. Automatic determination of appropriate window settings can be very helpful in detection of acute infarcts. The purpose of this study is to determine automatically the appropriate view window width and examine if this would improve the diagnosis performance. The window setting determination is based on the characterization of acute stroke as a distortion in the otherwise symmetrical distribution of hypo-dense tissues in the left and right hemispheres. This distortion occurs due to a gray matter structure becoming isoattenuating to adjacent white matter structures in the event of a stroke.

Method: We provide an overview of the novel algorithm using which the automatic window settings are determined before moving on to the clinical study to test its efficiency.

Determination of Window Settings: A flowchart depicting the major steps involved is shown below. Since during the early hours of stroke, the affected tissues behave like white matter, the first aim is to segment the hypo-dense tissues. This is done by modeling the energy of tissues based on Markov Random Field (MRF) and then minimizing the energy to obtain the hypo-dense regions in the scan. The hypo-dense regions are then analyzed for any asymmetrical distribution in left and right hemispheres thereby obtaining suspected stroke regions.



The idea is to place the window center such that the candidate regions and their counterparts in the other hemisphere appear on either side of the window center. This ensures that the algorithm provides the best available tissue contrast for any window width (usually selected by radiologist based on the tissue information required).

Perception Study:

Experimental Setup: Non-contrast CT scans were acquired for 5 patients with hyper-acute infarct and 5 control patients. 15 slices were selected from the experimental group and 15 slices from the control group and were rated by 4 radiologists in a blind review for the presence or absence of hyperacute infarct.

Radiologists viewed each slice under two window settings – standard window setting (W_s, Width 80 HU and centre 40 HU) and window setting determined by our proposed method (W_a). The slices were presented on 17" monitors and presentation order was randomized.

Participant Details: The participating radiologists were deliberately chosen in a way to accumulate a varied degree of experience (mean=14 years, SD = 12.2) to study the efficiency of W_a in relation to the expertise. The radiologists were named (#1-4) in decreasing order of their experience.

Results: The reviews of the radiologists were validated against the follow-up CT scans of the same patients taken after 1-2 days and marked by a separate radiologist. Sensitivity, specificity and accuracy were computed for reviews by individual radiologists and over-all and shown in Table-1. The radiologists in (#1-4) have been ordered in decreasing order of experience. The results show significant improvement in over-all sensitivity (p=0.028), specificity (p=0.037) and accuracy (p=0.03). The average viewing time per slice reduced from 9 to 6 seconds (p=0.04, two tailed *t* test).

Reader	1		2		3		4		Overall	
Window Setting	W_s	W_a	W_s	W_a	W_s	W_a	W_s	W_a	W_s	W_a
Sensitivity	73.3	100	66.6	93.3	50	66.6	50	86.6	59.97	86.66
Specificity	78.9	100	75	93.7	63.6	75	50	88.2	66.88	89.24
Accuracy	86.6	100	83.3	96.6	73.3	83.3	66.6	93.3	77.4	93.3

Table 1 Results of Perception Experiment

The results of the Window determination steps are shown graphically in Figure. 1. We can see from the follow-up scans that the algorithm correctly predicts the core of the infarct region where the distortion is maximum.

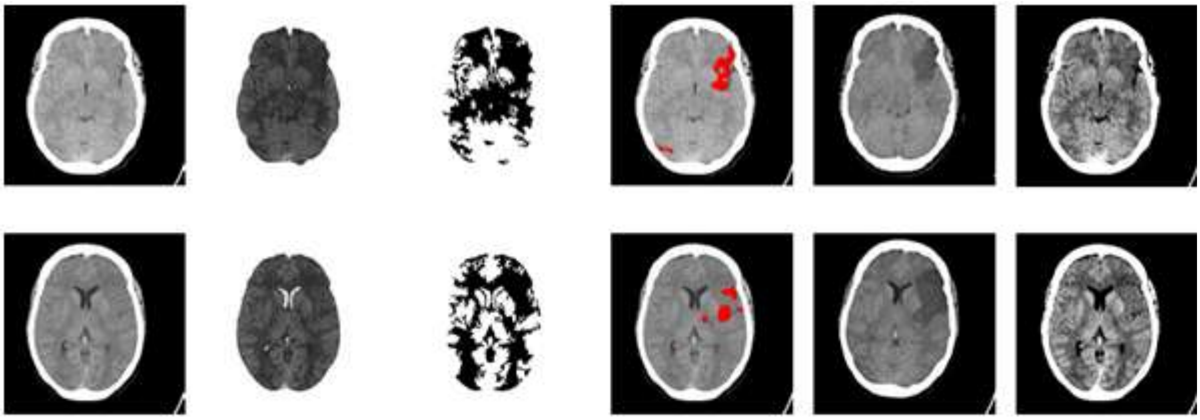


Figure 1: Result of proposed algorithm on acute slices. Column 1-6 show the input image, enhanced image, segmented hypo-dense tissues, suspect stroke regions, corresponding follow-up scan and original image under modified window setting(window width: 25 H.U.).

Conclusion: Automatically determined window settings can facilitate the detection of hyper-acute infarct in unenhanced CT of the brain by increasing the perceptual contrast between the normal and affected tissues. The main reason for improved performance is that the algorithm produces the maximum possible contrast between the contra-lateral regions which the doctors make use of while reviewing the test cases for presence of infarct. The improvement in decision making is more pronounced in doctors with lesser experience in the field as the room for improvement is greater in case of inexperienced radiologists. Also the use of standard windowing technique rather than non-linear contrast enhancement techniques makes it much more resistant towards introduction of artifacts which can adversely affect the judgment of radiologists Moreover, the reduction in time required for decision making also helps in quicker diagnosis.