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3D Differential Descriptors For Improved Computer-aided Detection (CAD) of Colonic Polyps in Computed Tomography Colonography (CTC)

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PURPOSE: To develop and validate a post-processing method for improved CAD of colonic polyps in CTC.

METHOD/MATERIALS: The initial detection is done by a Hough Transform-based detector (HTD). HTD generates 3D HTmaps proportional to the sphericity of local surface patches on the colon wall and applies a threshold to HTmaps (HT_score) for polyp detection (HT_hits). We computed 3D gradient fields of HTmaps, located the minimum divergence point (most spherical) in the vicinity of HT_hits and characterized the local topology using the Jacobian (J) of the gradient field at that point. We computed: *i*) Eigenvalues of J ($\lambda_3 \geq \lambda_2 \geq \lambda_1$) *ii*) Distance to circularly symmetric (star-like) topology in each eigen-plane (D_{32} , D_{31} , D_{21}). We used a Mahalanobis distance-based classifier with different combinations of: HT_score, λ_3 , λ_1 , $\lambda_{3D} = \text{mean}(\lambda_3, \lambda_2, \lambda_1)$, $\lambda_{2D} = \text{mean}(\lambda_3, \lambda_1)$, $\lambda_{3/1} = \lambda_3 / \lambda_1$, $D_{\text{max}} = \max(D_{32}, D_{31}, D_{21})$, $D_{3D} = \text{mean}(D_{32}, D_{31}, D_{21})$. We used 3D CTC data, acquired in the supine position from 8 patients (7 male, age 41-85) with 19 polyps (3mm - 27mm) confirmed by fiber-optic colonoscopy. Typical acquisition parameters for single- (4-) detector row CT were 3mm(2.5mm) collimation, pitch 1.5-2.0(3.0), 1.5mm(1.0-1.5mm) reconstruction interval, 120KVp, 200MAS(56MAS).

RESULTS: We performed FROC analysis on the set of 4946 HT_hits corresponding to a low HT_score threshold. We analyzed separately: *a*) only the 7 polyps $\geq 10\text{mm}$, *b*) all 19 polyps, via statistical cross-validation. Results of the HT_score alone, and the best performing combinations of classification parameters were: for the large polyps, at 6/7 (and 7/7) sensitivity, HT_score alone had 5 (and 5.5) FPs/patient, respectively, while [HT_score, D_{max} , D_{3D}] had 1 (and 2.3) FPs/patient, respectively. For all polyps, at 18/19 (and 19/19) sensitivity, HT_score alone had 155.8 (and 163.3) FPs/patient, respectively, while [HT_score, λ_{2D}] had 97.5 (and 151.5) FPs/patient, respectively. The dependence on the sizes of targeted polyps suggests that small polyps should be characterized differently. Nevertheless, almost all of the proposed descriptors improve performance of HTD at 95% sensitivity.

CONCLUSIONS: These initial results suggest that the proposed method can substantially improve the performance of HTD. These or similar 3D descriptors can be applied to other 3D maps or CTC data directly for CAD in CTC.